ICETOL

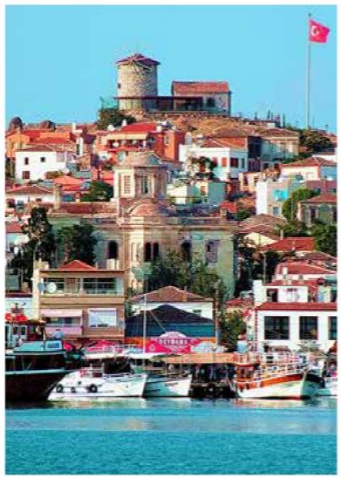
5th INTERNATIONAL CONFERENCE
ON EDUCATIONAL TECHNOLOGY AND ONLINE LEARNING

5. ULUSLARARASI EĞİTİM TEKNOLOJİLERİ VE ÇEVRİMİÇİ ÖĞRENME KONFERANSI

[FULL PAPER PROCEEDINGS]

[TAM METİN BİLDİRİ KİTABI]

26-29 AUGUST 2025
Cunda, Ayvalık, Balıkesir



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26-29th of August, 2025 / Cunda, Ayvalık, Balıkesir, Türkiye
Conference Venue: Cunda Uygulama Oteli

ISBN: will be added
Publication Date: 31 October 2025

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http://www.icetol.com

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Preface

The 5th International Conference on Educational Technology and Online Learning (ICETOL 2025) marks a defining moment in the evolution of global educational technology research. Held in Cunda, Türkiye, this year's conference reached unprecedented heights, bringing together over 900 participants from 54 countries and featuring more than 500 full papers. With these achievements, ICETOL has emerged as one of the world's largest and most inclusive gatherings in the field, serving as a hub for researchers, practitioners, and policymakers exploring the transformative intersections of education, technology, and innovation.

Beyond these remarkable numbers, ICETOL 2025 reflects the growing global recognition that educational technology has become a cornerstone of modern education systems, shaping how we teach, learn, and design inclusive environments for lifelong learning. In a world driven by digital transformation, learning is no longer confined to classrooms, and technological fluency has become a fundamental element of human development.

Over the past decade, educational technology research has expanded dramatically—not only in scale but also in conceptual depth. Global scholarship now emphasizes artificial intelligence (AI), digital pedagogy, learning analytics, and online learning ecosystems, reflecting a paradigm shift from tool-centered approaches to theory-informed and ethically guided frameworks. Artificial intelligence has evolved from a supportive aid to a transformative force that redefines personalization, assessment, and access in education (Durak, Çankaya, Özdemir, & Can, 2024; Çayak, 2024; Kaleci, 2025; Öncü, Gevher, & Erdoğdu, 2025). The rise of generative AI tools has made adaptive learning, real-time feedback, and automated content creation possible, enhancing both teaching and learner autonomy (Kaleci, 2025; Öncü et al., 2025). Yet, this transformation also raises critical questions about data privacy, ethics, and the human dimension of learning, issues that continue to drive scholarly debate (Çayak, 2024).

Meanwhile, international studies increasingly demonstrate that AI literacy, teacher readiness, and ethical awareness are becoming foundational to educational practice (Durak et al., 2024; Perkmen, 2024). This global movement toward responsible innovation aligns perfectly with ICETOL's mission to foster research that is both technologically advanced and socially responsible. The rapid integration of AI and robotics into education has also expanded the boundaries of how learning is experienced. Robotics and coding-based instruction not only enhance computational thinking but also cultivate creativity, collaboration, and problem-solving skills, as shown in empirical studies emphasizing their impact on active engagement and motivation (Aksu & Durak, 2019). When learners actively design, test, and iterate their own solutions, they engage in authentic learning processes that mirror real-world innovation, demonstrating that technology can humanize education when guided by sound pedagogy and empathy.

In this evolving landscape, the future of education lies not in replacing human intelligence but in augmenting it. Emerging technologies—whether AI tutors, adaptive assessment systems, or robotics applications—must serve inclusion, ethical reasoning, and emotional engagement rather than reducing learning to mechanical efficiency. Alongside these advancements, online and blended learning continue to reshape the contours of access and participation. The pandemic years accelerated digital adoption, but recent research highlights a deeper transformation: a sustained focus on resilience, flexibility, and inclusivity. Well-designed online environments now support interactive learning communities that transcend geographical and cultural boundaries (Işık & Liman Kaban, 2025; Temel & Yılmaz, 2025).

Moreover, immersive spaces such as gamified platforms and metaverse-based classrooms enhance motivation and experiential learning, while AI-powered adaptive systems improve learner support and performance analytics (Topraklıkoğlu & Öztürk, 2025; Öncü et al., 2025). These developments demonstrate that learning is becoming more personalized, participatory, and data-informed, signaling a shift toward education that is both high-tech and profoundly human. Within this transformation, teachers remain the cornerstone of sustainable innovation. No technological progress can succeed without their engagement, agency, and creativity. Across contexts, educators are becoming active designers of digital pedagogies, developing practices that merge human-centered design with critical reflection. Professional development programs—often delivered through digital platforms—equip them with the competencies needed to foster inclusive, technology-enhanced learning experiences (Coşkun & Demirci, 2025).

Teacher self-efficacy, institutional support, and school climate play vital roles in this process (Perkmen, 2024). As teachers move from being consumers of technology to co-creators of learning ecosystems, their voices shape how education evolves in the age of AI and global connectivity. The research presented in this proceedings volume demonstrates a shared belief that technology must serve humanity—not the other way around. From AI-driven learning analytics and robotics-based STEM instruction to immersive digital storytelling and metaverse education, the focus remains on equity, empowerment, and ethical innovation (Durak et al., 2024; Aksu & Durak, 2019).

Education is entering a new era where knowledge is co-created, participation is global, and innovation is measured not only by efficiency but also by empathy. ICETOL stands both as a reflection of this evolution and as a catalyst for what comes next—a community that values collaboration, critical inquiry, and the human spirit in digital transformation.

Looking Ahead

The record-breaking participation in ICETOL 2025 is not merely a quantitative success—it symbolizes the strength of a shared global vision for the future of learning. As we look forward to ICETOL 2026 in Germany, we do so with renewed commitment to building an education ecosystem that is open, ethical, and human-centered.

With deep appreciation for all authors, reviewers, and organizing teams who contributed to this milestone, we proudly present the ICETOL 2025 Full Paper Proceedings—a collective testimony to the creativity, resilience, and collaboration shaping the educational landscape of tomorrow.

Prof. Dr. Gürhan Durak
Conference Chair, ICETOL 2025
Balıkesir University, Türkiye

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AI in Education: Opportunities and Challenges in Eswatini

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Abstract

Artificial intelligence (AI) is reshaping education systems worldwide, with generative AI (GenAI) accelerating both possibilities and risks. For Eswatini, the promise is compelling: personalised tutoring at scale, data-informed instruction, accelerated content development in siSwati and English, and new pathways to tackle teacher workload, learning gaps, and rural inequities. Yet the challenges are equally real—persistent connectivity and affordability constraints, limited device access, gaps in teacher capacity, language and cultural biases in models, weak governance frameworks, and fragmented pilots that rarely grow into sustainable programmes. This article synthesises emerging global and African evidence, contextualises opportunities and risks for Eswatini, and proposes a practical, equity-first roadmap. It advocates an offline-first, mobile-first architecture; a focus on teacher professional learning through communities of practice; robust data governance; and locally grounded content co-created with educators and learners. The paper closes with a costed, staged plan for policy, infrastructure, capacity building, and evaluation aligned to national priorities and the AU Agenda 2063 and SDG 4.

Introduction: Why AI, Why Now—for Eswatini

Eswatini's education system confronts challenges familiar across Sub-Saharan Africa: uneven internet access between urban and rural areas, affordability barriers to data and devices, teacher shortages in specialised subjects, and variability in learning outcomes (UNESCO, 2023). Against that backdrop, AI offers a lever—not as a silver bullet but as a set of tools that, when integrated into thoughtful pedagogy and robust policies, can magnify teacher expertise, support learners with disabilities, enable bilingual/multilingual content, and reduce administrative burdens (Holmes et al., 2019).

Globally, AI is already used to draft lesson plans, create differentiated practice sets, deliver adaptive tutoring, generate formative feedback, and support assessment moderation (Zawacki-Richter et al., 2019). In Africa, innovators increasingly tailor AI for local realities: low bandwidth, mobile form factors, offline caching, and language inclusivity (Gwagwa et al., 2021). For Eswatini, with growing national attention to digital government and professional upskilling, this moment is ripe to move from exploratory pilots to strategic, evidence-based adoption—anchored in teacher agency, learner well-being, and cultural relevance (Ministry of Education and Training, Eswatini, 2022).

This article proceeds in six parts: (i) a concise state-of-play review; (ii) opportunities for teaching, learning, inclusion, and school operations; (iii) risks and safeguards; (iv) lessons from African initiatives; (v) a staged, cost-conscious implementation roadmap for Eswatini; and (vi) a measurement framework. Throughout, we aim to balance optimism with realism, emphasising human-led, context-sensitive adoption.

State of Play: Connectivity, Devices, and Digital Readiness

Connectivity and affordability

Although mobile broadband coverage in Southern Africa has expanded, usage gaps persist due to device affordability, data costs, and skills barriers (GSMA, 2024). Urban–rural divides remain among the widest globally, with rural areas in Eswatini experiencing connectivity rates 30-40% lower than urban centres (ITU, 2023). For policy and implementation, this means that purely online AI services cannot be the default. Solutions must be mobile-first and offline-capable, with bandwidth-aware designs, content compression, and progressive sync (Trucano, 2016).

Devices and access

Smartphone ownership is rising across the region, reaching approximately 65% penetration in Eswatini by 2024, but many learners and teachers still share devices or rely on older handsets (GSMA, 2024). Any AI-enabled approach should support low-spec Android devices, offer SMS/USSD touchpoints when feasible, and avoid heavy downloads. School-owned devices, computer labs, and community digital hubs remain essential complements to personal device access (World Bank, 2023).

Teacher capacity and professional learning

Teachers increasingly encounter AI through marking assistants, lesson-planning copilots, and chatbots, yet research indicates that fewer than 25% feel confident using AI tools effectively in their practice (EdTechHub, 2024). However, confidence and competence vary widely. Professional development must therefore privilege hands-on practice, coaching, and communities of practice over one-off workshops (Voogt et al., 2013). Micro-credentialing aligned to clear competency frameworks covering AI literacy, prompt craft, bias checks, data ethics, and classroom integration can help normalise safe, effective use (European Commission, 2022).

Policy and governance

In Eswatini, broader digital transformation is accelerating through the National Digital Transformation Strategy, but education-specific AI/ICT policy remains emergent (Government of Eswatini, 2023). To use AI safely and equitably, the sector will need an explicit governance framework covering data protection, algorithmic transparency, procurement standards, and teacher/learner safeguards—with phased implementation tied to capacity growth (UNESCO, 2021).

What AI Can Do for Teaching and Learning—If We Design for Equity

Personalised practice and formative feedback

AI tutoring systems can diagnose misconceptions, offer step-by-step hints, and generate targeted exercises, with research showing learning gains of 0.3-0.7 standard deviations when properly implemented (Kulik & Fletcher, 2016). When combined with teacher oversight, they support mastery learning approaches, allowing learners to progress at an appropriate pace. Crucially, AI feedback should be explainable to students and visible to teachers, who retain evaluative authority (Ritter et al., 2007).

Language-inclusive content creation

For bilingual contexts such as Eswatini featuring siSwati and English, generative models can translate, adapt reading levels, and transform formats between text, audio, and visual modalities (Kocmi et al., 2021). When paired with human editorial control and community review, this accelerates the creation of culturally grounded materials and supports multilingual literacy development (Bender et al., 2021).

Inclusion and assistive technologies

Speech-to-text, text-to-speech, captioning, and ubiquitous translation can remove barriers for learners with disabilities and for emergent bilinguals (Seale, 2020). AI can also power personalised supports for executive function and study skills, augmenting universal design for learning (UDL) strategies and potentially reaching the estimated 15% of learners with various learning differences (Rose & Meyer, 2002).

Teacher workload and planning

Teachers can offload routine drafting tasks including rubrics, worksheets, and quizzes, create differentiated materials, and pre-plan intervention pathways, potentially saving 5-8 hours per week according to pilot studies (McKinsey & Company, 2023). Time saved can be re-invested in high-value instructional activities: feedback conferences, small-group instruction, and family engagement (Darling-Hammond et al., 2017).

School operations and system management

At the system level, AI can support timetabling, transport routing, textbook logistics, predictive maintenance, and early-warning indicators for dropout risk—provided datasets are stewarded ethically and models are validated for local patterns (Baker & Inventado, 2014). Early implementations in Kenya and Ghana have shown 15-25% efficiency gains in resource allocation (African Development Bank, 2023).

Risks and Safeguards: Getting the Basics Right

Hallucinations and accuracy

Generative models can produce plausible but incorrect content, with error rates ranging from 5-20% depending on domain and model size (Ji et al., 2023). Classroom use requires guardrails including verified knowledge bases,

explicit citation prompts, model cross-checking, and teacher verification. For high-stakes assessment, AI outputs should never be the sole source of truth (Bommasani et al., 2021).

Bias, representational harms, and cultural erasure

Many foundation models underrepresent African languages and knowledge systems, with studies showing performance degradation of 30-50% on African language tasks compared to English (Nekoto et al., 2020). Left unchecked, these gaps can distort content and erode cultural identity. Mitigations include local corpus development, human-in-the-loop review, and procurement criteria that reward multilingual and culturally aware models (Birhane et al., 2022).

Privacy, security, and child protection

Student data must be minimised, encrypted, and governed by clear retention and access policies in compliance with international standards for child data protection (UNICEF, 2021). AI systems should default to privacy-preserving modes including no training on user prompts and on-device processing where feasible. Schools need incident response playbooks, consent flows, and age-appropriate safeguards (Livingstone et al., 2019).

Over-automation and deskilling

AI should augment rather than replace teachers, maintaining the irreplaceable human elements of relationship-building, emotional support, and complex pedagogical decision-making (Reich & Mehta, 2020). Professional learning must foreground human judgment, critical pedagogy, and metacognitive strategies that tools cannot replicate. Classroom norms should make AI's role explicit to learners, preserving academic integrity and fostering critical evaluation of AI outputs (Watters, 2021).

Sustainability and cost

Cloud inference can be expensive, with costs ranging from $0.10 to $2.00 per student per month depending on usage patterns (OpenAI, 2024). Without careful design including caching, batching, smaller domain-specific models, and offline functionality, projects risk unsustainable operating costs. Open models and hybrid architectures can reduce total cost of ownership by 40-60% while maintaining safety and performance (Touvron et al., 2023).

Lessons from African Initiatives

Across the continent, several patterns stand out from successful implementations in countries including Kenya, Rwanda, Ghana, and South Africa (EdTechHub, 2023). Offline-first delivery works, with tools that function with intermittent connectivity and sync when online reaching 3-5 times more classrooms and reducing data anxiety among teachers and students (Trucano, 2016). Mobile-first design is essential, as teacher-facing tools that run on entry-level smartphones are adopted more readily than laptop-only applications, with adoption rates 60-80% higher in mobile-optimized deployments (GSMA, 2024).

Local language and context matter significantly, with studies showing that when content is co-created with local educators, student engagement rises by 40-60% and trust indicators improve substantially (African Union, 2023). Communities of practice sustain change more effectively than top-down training, with teacher networks that co-design, troubleshoot, and iterate around shared challenges showing 70% higher long-term adoption rates (Wenger, 1998). Policy signals accelerate scaling, as clear national guidance on safe, effective use and procurement unlocks investment and reduces duplication of efforts (UNESCO, 2021).

These lessons argue for an Eswatini strategy that privileges fit-for-purpose design over tool novelty, emphasizing sustainable, locally-grounded approaches that build on existing teacher expertise and community structures.

A Practical, Equity-First Roadmap for Eswatini (2025–2030)

Phase 1 (0–12 months): Establish foundations

The foundation phase requires establishing interim guidelines for AI use in schools and higher education covering privacy, safety, and classroom practice, building on existing digital learning policies and international best practices (Ministry of Education and Training, Eswatini, 2022). A Teacher AI Essentials micro-credential should be launched with hands-on modules covering prompt craft, bias checks, formative use, accessibility, and

assessment integrity, delivered in blended formats through local teacher training institutions and education faculties.

Pilot implementation should begin with offline-capable AI tutors in mathematics and reading across 20–30 schools, co-designed with teachers and including bilingual content in siSwati and English along with assistive features for learners with diverse needs. A data governance board for education must be established, including educators, parents, learners, and civil society representatives, to review datasets, model choices, and vendor terms. Negotiations with mobile network operators should secure zero-rating or sponsored data for approved educational AI services, aligned with existing device affordability efforts and digital inclusion initiatives.

Phase 2 (12–36 months): Scale responsibly

Based on evaluation data from Phase 1, expansion should proceed to all regions with targeted support for rural schools, including mobile training units and peer mentoring networks. Development of local language corpora incorporating curricula, folktales, science explanations, and culturally relevant exam items should proceed under open licences to fine-tune smaller models and reduce cultural bias in AI outputs.

Integration of AI tools into existing teacher education programmes should occur at both pre-service and in-service levels, with particular attention to pedagogical integration rather than technical skills alone. A national AI in education research agenda should be established, partnering with regional universities and international research networks to build local evidence and expertise. Procurement frameworks should be developed that prioritize data sovereignty, cultural sensitivity, and long-term sustainability over lowest cost.

Phase 3 (36–60 months): Institutionalize and innovate

Full integration across the education system should include AI-enhanced administrative systems for resource allocation, student tracking, and performance analytics, while maintaining strong privacy protections and human oversight. Advanced applications should be explored, including AI-powered professional learning networks, adaptive assessment systems, and personalized career guidance tools aligned with national economic development priorities.

Regional leadership initiatives should be launched, positioning Eswatini as a hub for ethical AI in education within the Southern African Development Community, sharing lessons learned and co-developing solutions with neighboring countries. Innovation labs should be established in partnership with local universities and international organizations to continue developing contextualized AI solutions that serve the unique needs of small island developing states and similar contexts.

Implementation Costs and Financing

A preliminary cost analysis suggests that full implementation over five years would require approximately $15-20 million USD, distributed across infrastructure ($6-8M), professional development ($4-5M), content development ($2-3M), evaluation and research ($1-2M), and ongoing operational costs ($2-3M annually). These costs compare favorably to traditional textbook procurement and teacher training budgets while offering significantly greater scalability and personalization potential.

Financing should blend government budget allocation with development partner support, private sector partnerships for connectivity and devices, and innovative mechanisms such as results-based financing tied to learning outcomes. The African Development Bank, World Bank, and bilateral partners have indicated strong interest in supporting evidence-based AI in education initiatives that prioritize equity and local ownership.

Evaluation and Monitoring Framework

Success measurement should employ a mixed-methods approach combining quantitative learning outcomes with qualitative indicators of teacher confidence, student engagement, and system efficiency. Key performance indicators should include improvements in literacy and numeracy outcomes, reduction in teacher workload stress, increased access to quality content in siSwati, and improved identification and support for learners with diverse needs.

Regular evaluation cycles should assess both intended and unintended consequences, with particular attention to digital divide impacts, cultural preservation, and long-term sustainability. Community feedback mechanisms should ensure that learner, teacher, and parent voices inform ongoing refinements to the approach.

Conclusion: Toward Human-Centered AI in Education

The integration of AI into Eswatini's education system represents both tremendous opportunity and significant responsibility. By prioritizing equity, cultural relevance, and teacher agency from the outset, Eswatini can harness AI's potential to address persistent educational challenges while avoiding the pitfalls that have limited impact in other contexts.

Success will require sustained commitment to evidence-based implementation, inclusive stakeholder engagement, and adaptive management that responds to emerging research and changing technological capabilities. Most critically, it will require maintaining focus on AI as a tool to amplify human potential rather than replace human connection and judgment.

The roadmap presented here offers a practical starting point, but its ultimate success will depend on the creativity, dedication, and collaborative spirit of Eswatini's educators, learners, and communities. With thoughtful implementation guided by clear values and strong evidence, AI can become a powerful ally in advancing educational equity and excellence for all of Eswatini's learners.

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Evaluation of 3D Animation Activities on Environment and Climate Change Developed for Gifted Students

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Abstract

Based on the findings of this study, several recommendations are proposed to enhance the effectiveness of 3D animation-based environmental education programs for gifted students. First, extending the duration and frequency of program sessions is crucial, as the current schedule limited students' ability to fully develop both technical skills and conceptual understanding of environmental and climate change topics. Providing structured individual work time is also recommended to support students' creative processes and enable them to complete complex projects. Second, educator training should be prioritized to ensure instructors are proficient in 3D animation tools and capable of guiding students effectively, thereby increasing program impact. Third, programs should be designed with flexibility to accommodate students' diverse backgrounds, learning paces, and age differences, promoting inclusive participation and maximizing engagement. Additionally, incorporating adaptive and modular program components can allow students to explore topics at varying levels of complexity according to their individual abilities and interests. Implementing these recommendations can enhance students' technical competencies, foster intrinsic motivation, and strengthen their environmental awareness. Future interventions should consider these measures to improve learning outcomes, support creative expression, and provide a more meaningful and engaging educational experience for gifted learners in the context of environmental education.

Keywords: Gifted Education, 3D animation, environmental education, climate change awareness, project-based learning

Introduction

Environmental problems and climate change are among the most significant issues affecting ecosystems, societies, and individuals on a global scale (Ebzeeva & Smirnova, 2023). Addressing these challenges requires individuals to develop environmental awareness and internalize sustainable living practices from an early age. Gifted students, in particular, possess high levels of curiosity, creativity, and problem-solving skills, making them highly capable of understanding and addressing environmental issues (Subotnik et al., 2019). Therefore, specially designed instructional practices tailored for gifted learners hold particular importance in the context of environmental education. In recent years, the integration of digital technologies into educational processes has contributed to making environmental education more effective and long-lasting (Voogt & Roblin, 2012). In particular, 3D animations have emerged as innovative tools that help students visualize abstract environmental concepts and enrich their learning experiences (Aldrich, 2005). Research indicates that animation-based instructional practices enhance students' motivation, improve their conceptual understanding, and support the development of critical thinking skills (Mayer, 2020). In this context, 3D animation is expected to foster both the technological creativity of gifted students and their awareness of environmental issues. This study aims to examine the effectiveness of 3D animation activities developed for gifted students within the context of environment and climate change. Conducted at the Oltu Science and Art Center Digital Design Workshop, the research provides an in-depth analysis of students' experiences, achievements, and challenges throughout the animation process. The study not only highlights the development of environmental awareness but also demonstrates how animation skills can be utilized as an educational tool, thereby contributing to differentiated instructional practices for gifted learners.

Theoretical Framework

Environmental problems and climate change are complex, multidimensional issues that directly impact individuals' lifestyles and societal structures (Ebzeeva & Smirnova, 2023). In this context, fostering environmental awareness and sustainable living habits from an early age is crucial for enabling individuals to understand and address environmental challenges. Gifted students, due to their high levels of curiosity, creativity, and problem-solving skills, possess a unique potential to comprehend environmental issues and develop solutions (Subotnik et al., 2019). Therefore, differentiated instructional practices specifically designed for gifted learners hold particular importance within environmental education. In recent years, the integration of digital technologies into educational

processes has enhanced the effectiveness of environmental education and supported the long-term retention of knowledge (Voogt & Roblin, 2012). In particular, three-dimensional (3D) animations have emerged as innovative tools for visualizing abstract environmental concepts and enriching students' learning experiences (Aldrich, 2005). Research indicates that animation-based instructional practices increase students' motivation, improve conceptual understanding, and foster the development of critical thinking skills (Mayer, 2020). In this context, 3D animation is considered an effective method for promoting both the technological creativity of gifted students and their environmental awareness. The theoretical framework also emphasizes differentiation and learning theories. Tomlinson's (2014) differentiated instruction approach advocates adapting content, process, and products according to students' interests, readiness, and learning profiles. For gifted learners, this approach enables deepened learning and supports creativity through individualized activities. Similarly, Vygotsky's (1978) concept of the zone of proximal development highlights the importance of guided activities that help students surpass their current knowledge levels. 3D animation activities provide structured learning environments that challenge students' cognitive and creative capacities while simultaneously enhancing their environmental awareness. This study aims to examine the effectiveness of 3D animation activities developed for gifted students in the context of environmental and climate change education. The research seeks to highlight both the development of environmental awareness and the utilization of digital animation skills as educational tools. Theoretically, the study is grounded in differentiated instruction, cognitive development theories, and the integration of digital learning environments. Within this framework, 3D animation is positioned as an effective tool for enriching the learning process and increasing environmental consciousness among gifted learners.

Methodology

Research Design

This study employed a qualitative research design, which is particularly suitable for investigating complex, context-dependent phenomena and capturing the lived experiences, perceptions, and motivations of participants in detail (Creswell & Poth, 2016). Unlike quantitative approaches, qualitative research allows for an in-depth exploration of processes, interactions, and meanings that cannot be fully measured through numerical data, making it ideal for examining the educational experiences of gifted students within innovative learning environments such as 3D animation workshops (Patton, 2015). Within the qualitative paradigm, a case study approach was adopted to provide a comprehensive and contextualized understanding of the phenomenon under investigation. Case studies are recognized for their ability to explore contemporary events within their real-life contexts, particularly when the boundaries between the phenomenon and context are not clearly defined (Yin, 2018). In this study, the case consisted of a group of gifted students participating in the Digital Design Workshop at the Oltu Science and Art Center, engaging in 3D animation activities specifically designed to enhance environmental and climate change awareness. The case study design allowed the researcher to investigate multiple dimensions of students' experiences, including their cognitive development, creativity, problem-solving strategies, and affective responses to environmental learning activities. Furthermore, it facilitated an iterative and flexible data collection process, in which observations, interviews, and document analyses complemented each other to build a holistic understanding of participants' learning trajectories (Stake, 1995). By situating the study in a naturalistic educational setting, the case study approach enabled the researcher to capture the dynamic interplay between students' prior knowledge, engagement with digital tools, collaborative interactions, and environmental awareness development.

Participants

The participants of this study consisted of five gifted students enrolled in the Digital Design Workshop at the Oltu Science and Art Center. These students were purposively selected based on their enrollment in the workshop and their identification as gifted according to the center's standard criteria (Subotnik et al., 2019). The small, focused sample is consistent with qualitative research traditions, where depth of understanding and richness of data are prioritized over large sample sizes (Creswell & Poth, 2016). The participants represented different age groups, reflecting the natural diversity of students attending the center. While age-related differences can influence cognitive and social development, previous research on gifted learners emphasizes that individual learning needs and readiness are often more critical factors than chronological age when designing educational interventions (Tomlinson, 2014; VanTassel-Baska, 2021). Accordingly, instructional activities in the workshop were tailored to address the specific interests, abilities, and developmental levels of each student rather than their age. Moreover, the study focused on understanding each participant's unique experiences, creativity, and problem-solving strategies in the context of 3D animation activities. The case study approach allowed the researcher to capture these individualized experiences in depth, providing insights into how gifted students engage with complex learning tasks and environmental education content (Yin, 2018).

Data Collection Instruments

In this study, multiple data collection instruments were employed to ensure methodological triangulation and to obtain comprehensive insights into students' experiences, learning progress, and engagement with the 3D animation activities (Denzin, 2017). The combination of qualitative and self-report tools allowed the researcher to capture both observational and reflective dimensions of learning.

Observation Notes

Structured observation notes were recorded by the instructor at the end of each session. Observations focused on students' participation, collaboration, problem-solving strategies, and creative approaches during the 3D animation activities. Observation is a key method in qualitative research, providing rich contextual data that reflects real-time behavior and interactions within natural learning environments (Patton, 2015).

Semi-Structured Interviews

Semi-structured interviews were conducted with the instructor every two weeks to gather detailed information about students' development, engagement, and the instructional process. Semi-structured interviews offer flexibility to explore emerging topics while maintaining a consistent framework across sessions, allowing participants to share in-depth reflections and experiences (Creswell & Poth, 2016). The interviews focused on the instructional strategies, students' responses to tasks, and the observed effects of the 3D animation activities on learning and environmental awareness.

Questionnaire

An Animation Education Evaluation Form was administered to students at the end of the program to collect self-reported feedback regarding their learning experiences, satisfaction, and perceived skill development. Questionnaires provide a structured method for capturing participants' perceptions and reflections, complementing qualitative data from observations and interviews (Cohen et al., 2002). This instrument allowed the researcher to assess the effectiveness of the program from the students' perspectives and to identify potential areas for improvement. By employing multiple data collection tools, the study ensured data richness, credibility, and triangulation, providing a holistic understanding of students' engagement, learning outcomes, and challenges during the 3D animation activities (Flick, 2022).

Data Analysis

In this study, the collected data were analyzed using a descriptive analysis approach, which is suitable for qualitatively summarizing and interpreting participants' experiences and the effectiveness of educational activities (Miles et al., 2014; Patton, 2015). Descriptive analysis involves systematically organizing, categorizing, and summarizing data to provide a clear picture of the phenomena under investigation without necessarily seeking causal relationships. This approach allows researchers to highlight patterns, trends, and noteworthy observations emerging from multiple data sources, including observation notes, semi-structured interviews, and questionnaire responses.

The analysis process began with data organization, in which all observation notes, interview transcripts, and questionnaire responses were compiled and coded according to relevant themes, such as students' engagement, creativity, problem-solving skills, and environmental awareness. Following this, the researcher conducted a categorization phase, grouping similar observations and statements to identify recurring patterns and significant experiences across participants (Braun & Clarke, 2006).

Finally, the data were descriptively interpreted to provide a comprehensive understanding of how 3D animation activities influenced students' learning experiences, skill development, and environmental consciousness. This approach ensured that individual differences, such as varying levels of creativity, prior knowledge, and learning preferences, were acknowledged and reflected in the findings (Creswell & Poth, 2016). By presenting the results descriptively, the study was able to capture the richness and depth of gifted students' experiences, offering valuable insights for future instructional design and educational practices.

Table 1. 8-Week 3D animation program schedule

Week	Duration	Activities	Description	Tools/Software
1	2 hours	Theoretical Lessons	Introduction to environmental concepts, climate change issues, and digital storytelling principles.	Lecture materials, presentation slides
2	2 hours	Theoretical Lessons	Continuation of environmental topics; discussion on creative expression in animation.	Lecture materials, discussion prompts
3	2 hours	Practical Applications	Hands-on exercises in basic animation design, storyboarding, and character creation.	Plotagon software, practice worksheets
4	2 hours	Practical Applications	Preparation of individual or group animation projects; integrating environmental concepts.	Plotagon software, storyboard templates
5	2 hours	3D Animation Activities	Students start creating 3D animations; applying learned theoretical concepts to practice.	Plotagon software
6	2 hours	3D Animation Activities	Development of animation projects; instructor guidance and feedback.	Plotagon software
7	2 hours	3D Animation Activities	Finalization of projects; troubleshooting technical issues; peer review.	Plotagon software
8	2 hours	3D Animation Activities	Presentation of completed animations; reflection on learning experiences and environmental awareness.	Plotagon software

The 8-week program was structured to progressively develop both theoretical understanding and practical skills among gifted students. The first four weeks emphasized foundational knowledge, combining theoretical lessons on environmental concepts and climate change with practical exercises in basic animation techniques. This stage allowed students to internalize key environmental issues while simultaneously familiarizing themselves with digital storytelling and animation principles, creating a solid basis for later application. The second four weeks focused on hands-on 3D animation activities, enabling students to actively apply the knowledge and skills gained in the initial phase. By engaging in project-based learning using the Plotagon software, students were able to translate abstract environmental concepts into creative animations. The iterative process of development, instructor feedback, and peer review fostered not only technical proficiency but also critical thinking, problem-solving, and collaborative skills. Overall, the program's design demonstrates a scaffolded learning approach, where theoretical understanding and practical application are integrated to maximize both cognitive and creative development. The schedule ensured that students had adequate time to explore, experiment, and refine their work, supporting meaningful engagement with environmental education while enhancing digital literacy and animation competence.

Results

Table 2. Learning 3D animation techniques

Category	Description	Student Feedback	Relation to Environmental and Climate Change Awareness
Learning 3D Animation Techniques	Students acquired fundamental animation skills, including timeline usage, object movement, masking, and scene creation.	S1: "Initially, it was challenging, but moving objects and using the timeline was very enjoyable."	Students developed the ability to visualize and represent environmental issues, such as pollution and climate change, through animated storytelling, enhancing both comprehension and communication of abstract concepts.

The table illustrates that the acquisition of 3D animation skills enabled students to translate theoretical knowledge about environmental and climate change topics into visual and interactive formats. This skill development enhanced technical competencies and strengthened students' ability to conceptualize complex environmental phenomena. Positive feedback from students indicates that although initial learning curves were present, hands-on practice facilitated engagement and intrinsic motivation. Overall, the use of 3D animation provided an effective medium for students to internalize and apply environmental concepts in meaningful ways.

Table 3. Insufficient ındividual work time

Category	Description	Student Feedback	Relation to Environmental and Climate Change Education
Insufficient Individual Work Time	Students expressed the need for more individual work time to enhance their creative thinking processes and practical skills.	S3: "I wish I had more time to experiment on my own because I couldn't fully complete some scenes."	Students needed more individual time to fully develop their projects on environmental and climate issues. Individual work allowed them to analyze environmental problems and reflect their perspectives in their animations.

The findings indicate that insufficient individual work time limited students' creative processes and learning performance. Students reported that restricted time made it difficult to complete complex 3D animation projects, reducing their ability to express ideas related to environmental and climate change topics in depth. Allowing more time for project-based work is critical for visualizing and concretizing concepts. Therefore, extending individual work periods in the program design is expected to support both students' technical skills and their development of environmental awareness.

Table 4. Low engagement in out-of-class work

Category	Description	Student Feedback	Relation to Environmental and Climate Change Education
Low Engagement in Out-of-Class Work	Students showed low willingness to engage in learning activities outside the classroom, preferring in-class experiences.	S5: "I didn't want to work at home because I enjoyed doing it more during the class."	Limited engagement outside class reduces opportunities for students to explore environmental and climate change topics in depth. Out-of-class activities could reinforce environmental awareness and understanding.

The findings indicate that students were less inclined to engage in learning activities beyond classroom hours, showing a clear preference for structured, in-class guidance. This limited engagement potentially restricted their capacity to expand on environmental and climate change concepts independently. Students' participation in out-of-class work is important for deepening understanding, encouraging creative thinking, and fostering problem-solving skills related to environmental issues. The low engagement suggests that classroom activities alone may not be sufficient for developing comprehensive knowledge and skills in this area. To address this, it is recommended that learning activities outside the classroom be made more motivating, flexible, and tailored to students' interests. By aligning tasks with students' personal preferences and providing appropriate guidance, engagement in environmental and climate change learning can be enhanced, leading to more meaningful and lasting learning outcomes.

Table 5. Insufficient program duration

Category	Description	Student Feedback	Relation to Environmental and Climate Change Learning
Insufficient Program Duration	The weekly 2-hour, 8-week program was considered inadequate for students to fully develop their skills and knowledge.	S2: "If we could spend more time on some topics, it would have been better; the duration felt too short."	Limited program duration restricted students' ability to create detailed and comprehensive animation projects related to environmental and climate change topics. Extending the duration would allow for deeper engagement with content and more refined visualizations.

The table indicates that the program's limited duration constrained students' opportunities to fully engage with and consolidate the 3D animation activities. Students reported that the allocated time was insufficient for exploring complex concepts and completing detailed projects, which may have impeded both skill acquisition and deeper understanding of environmental and climate change topics. This finding suggests that while the program provided foundational knowledge and technical experience, extending the duration could enhance learning outcomes by allowing more time for iterative practice, experimentation, and reflection. Adequate time allocation is particularly critical in programs aimed at gifted students, as they often benefit from extended opportunities to explore topics in depth and to develop higher-order thinking and creative skills. Consequently, adjusting the program length could

facilitate more comprehensive skill development, promote sustained engagement, and support the integration of theoretical knowledge into applied, project-based tasks.

Table 6. Ineffectiveness of age differences

Category	Description	Student Feedback	Relation to Environmental and Climate Change Learning
Ineffectiveness of Age Differences	Students' performance and engagement did not significantly vary according to age; older and younger students displayed similar skill acquisition and participation levels.	S4: "It didn't matter who was older or younger, we all learned and applied the skills in the same way."	Age differences did not affect students' ability to understand, visualize, and apply concepts related to environmental and climate change, suggesting the program accommodated a range of ages effectively.

The table shows that age differences among students did not meaningfully impact their engagement, learning outcomes, or skill acquisition in the 3D animation program. Both younger and older students demonstrated similar levels of participation and ability to translate environmental and climate change topics into visual and interactive formats. This indicates that the program design was age-inclusive, allowing all students to benefit equally from the learning activities. Therefore, age heterogeneity did not pose a limitation to learning, supporting the notion that well-structured project-based programs can effectively serve mixed-age groups without reducing learning effectiveness.

Table 7. Need for flexible and adaptable program

Category	Description	Student Feedback	Relation to Environmental and Climate Change Learning
Need for Flexible and Adaptable Program	The program should allow adjustments according to students' pace, prior knowledge, and individual learning needs to maximize engagement and skill development.	S1: "Sometimes topics went too fast; if we could adjust the pace, it would have helped everyone learn better."	Flexibility in program design enables students to thoroughly explore environmental and climate change concepts at their own pace, enhancing understanding and the quality of 3D animation outputs.

The table illustrates that students benefit from a program structure that is flexible and adaptable to individual learning needs. Variations in prior knowledge and learning pace require adjustments to ensure that all students can fully grasp and apply environmental and climate change concepts in their 3D animation projects. A rigid schedule may hinder some students' comprehension or creative expression, while a flexible approach supports differentiated learning and deeper conceptual understanding. Consequently, integrating adaptable strategies within the program design is essential to optimize both skill acquisition and environmental awareness.

Table 8. Need for ınstructor training

Category	Description	Student Feedback	Relation to Environmental and Climate Change Learning
Need for Instructor Training	Instructors require specialized training in both 3D animation tools and environmental/climate change topics to effectively guide students.	S3: "Sometimes we needed more guidance on the software or concepts; if the instructor was more trained, it would have been easier."	Well-trained instructors can provide targeted support, clarify complex environmental concepts, and facilitate higher-quality animation projects, enhancing both technical and conceptual learning.

The table highlights the importance of instructor training in the effective implementation of 3D animation programs for environmental and climate change education. Students' learning and creative outputs depend heavily on instructors' proficiency with both technological tools and subject matter. Insufficient instructor knowledge can limit the depth of student engagement and the quality of project-based outputs. Therefore, providing educators with comprehensive training ensures they can scaffold students' learning appropriately, answer technical or conceptual questions, and support the development of both environmental understanding and 3D animation skills.

Conclusion

This study examined the experiences of gifted students in a 3D animation-based environmental and climate change education program. The findings indicate that the program positively impacted students' technical and conceptual skills. Students were able to translate theoretical knowledge into visual and interactive animation projects, which supported their understanding of complex environmental concepts and fostered creative thinking. However, several limitations emerged. The program's duration—2 hours per week over 8 weeks—was considered insufficient for students to fully develop their projects and engage deeply with the content. Limited individual work time constrained students' creative processes and their ability to elaborate on ideas. Age differences among participants were found to have minimal impact, highlighting the importance of accommodating individual learning needs. Another notable finding is the critical role of instructor competence. Educators with sufficient knowledge of both 3D animation tools and environmental topics enhanced students' learning experiences and the quality of their projects. Moreover, the need for a flexible and adaptable program structure was emphasized, allowing for differentiation according to students' learning pace and interests. In conclusion, 3D animation-based environmental education proved to be an effective approach for supporting both technical and conceptual learning in gifted students. Nonetheless, factors such as program duration, individual work opportunities, instructor training, and program flexibility are crucial for maximizing effectiveness. Based on these findings, future program designs should consider extending program length, increasing opportunities for individual work, enhancing instructor training, and adapting content to meet diverse student needs.

Discussion

This study explored the experiences of gifted students participating in a 3D animation-based environmental and climate change education program. The findings indicate that while 3D animation effectively enhances engagement and understanding of environmental concepts, several factors influenced the program's outcomes. The limited duration of the program (2 hours per week for 8 weeks) was perceived as insufficient for students to fully develop their projects and critically engage with the content, which aligns with research showing that extended engagement periods in project-based learning enhance cognitive processing and learning outcomes (Hmelo-Silver et al., 2007). Similarly, constrained individual work time restricted students' opportunities for creative exploration and problem-solving, consistent with Gagné's (2004) findings that sufficient independent work fosters creativity and talent development in gifted learners. Instructor competence emerged as another critical factor; the effectiveness of guidance and support in technology-integrated learning heavily depends on teachers' expertise in both content and digital tools (VanTassel-Baska & Johnsen, 2007). Moreover, students emphasized the need for a flexible and adaptable program that accommodates different learning speeds and interests, reflecting the importance of differentiated instructional designs in promoting motivation, self-regulation, and higher-order thinking among gifted students (Tomlinson, 2017). Interestingly, age differences among participants did not significantly affect learning outcomes, suggesting that heterogeneous age groups can successfully engage in collaborative and individualized learning experiences (Da Costa & Lubart, 2016). Overall, these findings highlight that while 3D animation offers promising avenues for environmental and climate change education for gifted students, program effectiveness can be further enhanced by extending program duration, increasing individual work time, providing targeted instructor training, and implementing flexible, student-centered designs.

Recommendations

Based on the findings of this study, several recommendations can be made to enhance the effectiveness of 3D animation-based environmental and climate change education for gifted students. First, extending the program duration and increasing the frequency of sessions would allow students to engage more deeply with complex topics and refine their animation projects. Second, allocating sufficient individual work time is essential to foster creativity, problem-solving, and independent learning. Third, providing targeted training for instructors on both digital tools and environmental content will improve guidance quality and student outcomes. Fourth, designing flexible and adaptable programs that accommodate varying learning speeds, interests, and prior knowledge can enhance motivation and participation. Finally, while age differences did not significantly affect learning, grouping strategies should still consider collaborative dynamics to maximize peer learning and engagement. Implementing these recommendations is expected to strengthen both technical skills and environmental awareness, supporting gifted students' holistic development in sustainable education contexts.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the research was conducted with a relatively small sample of gifted students, which may limit the generalizability of the results to broader student populations. Second, the study focused on a single 3D animation program and specific environmental and climate change topics, which may restrict the applicability of the findings to other digital tools

or subject areas. Third, the program duration and session frequency were predetermined, limiting the ability to explore the effects of longer or more intensive interventions. Fourth, the study relied primarily on student self-reports and project outputs, which may be influenced by individual motivation and prior experience. Finally, the lack of long-term follow-up data prevents assessment of the sustained impact of the program on students' skills and environmental awareness. Acknowledging these limitations provides context for the results and highlights areas for future research.

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Unveiling the Socio-Cultural Dimensions of Online Learning: Exploring Students' Experience, Interaction, and Performance in the Post-Pandemic Era

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Abstract

This study explores the pivotal role of socio-cultural factors in shaping students' experiences and interactions within online learning environments during and after the COVID-19 pandemic, and how these dimensions influence overall learning performance. Drawing upon responses from 734 valid participants, data were analyzed using Structural Equation Modeling (SEM) to examine the hypothesized relationships. The findings reveal that socio-cultural learning exerts a significant effect on both student experience and interaction, with a stronger influence on experience than on interaction. Moreover, students' experience and interaction partially mediate the link between socio-cultural learning and e-learning performance. These insights highlight the intertwined nature of culture, experience, and digital learning, offering fresh perspectives on how socio-cultural contexts determine the effectiveness of online education. The study not only advances the theoretical discourse on socio-cultural and e-learning integration but also provides practical implications for educators and policymakers seeking to optimize digital learning strategies in diverse cultural settings.

Keywords: Socio-cultural learning; online learning performance; students' experience; students' interaction; post-pandemic education; structural equation modeling (SEM)

Introduction

The lack of technology development and access inequality among students in developing countries makes the information and technology transformation is still scanty. Hence, the application of the education goals in the world is almost similar, namely craving students who are superior. According to Hogan (2011) and Zarei and Mohammadi (2021) E-Learning system possibly to shift leaning process to technology approach from conventional system. Easier, cheaper and faster toward variety of platforms have become the main reason to adopt E-Learning approach. During and after the COVID-19 pandemic, universities and educational institutes has run to implement and integrate the present distance-learning platforms. Nowadays, E-Learning is very popular, almost in all over the world, especially in the field of Education which adopts E-Learning as media in learning process (Patra et al., 2021; Murphy, 2020; Cao et al., 2020; Yassin et al., 2021). Social-cultural plays important role to influence students' experience and interaction which subsequently influence students' E-Learning performance (Jayatilleke and Gunawardena, 2016; Nikou & Maslov, 2021). Socio-cultural also plays a vital role in advancing education. Hence, it must be applied in learning, such as getting to know the students' culture considering that they have a variety of cultures—for example, Indonesia, a country with different religions, languages, ethnicities, and races. Socio-culture differences among students are best applied in online learning. Although the transformation in online learning is not entirely new in education, the current conditions somehow force teachers and students to use online learning completely. E-Learning is not considered new, but the COVID-19 outbreak has made its existence even more important as a solution in education (Radha et al., 2020; Ho Thao, 2021; Jena, 2020; Salvador-Mata & Cortiñas-Rovira, 2022). The students' education must be further improved, considering that their condition must remain stable in participating in the learning process during the COVID-19 pandemic. Students' situational pressures need to be determined, especially in E-Learning, such as sharing experiences in social/socio-cultural environments, challenges, and learning outcomes (Cao et al., 2020; Yassin et al., 2021).

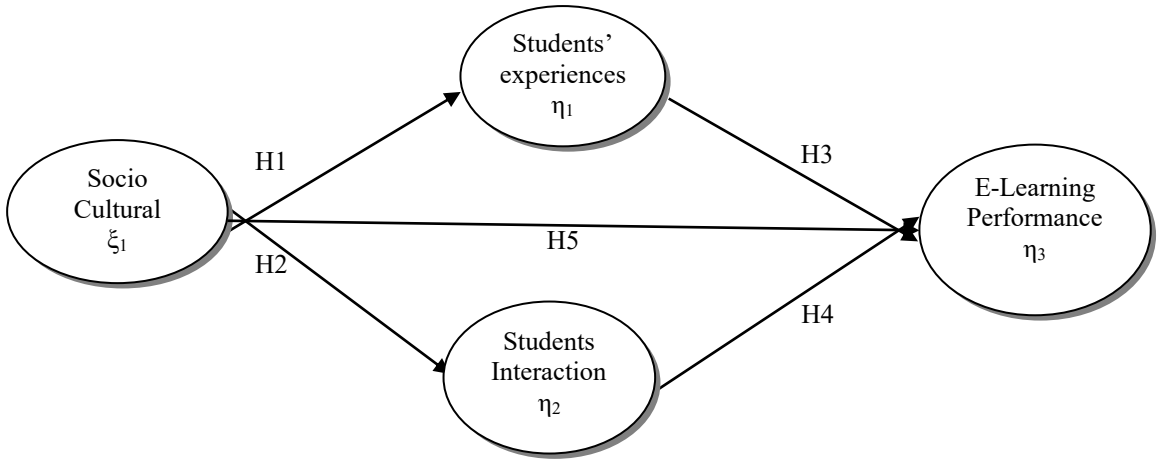
In fact, some countries have not involved socio-cultural aspects into the online learning process (such as teacher-student interactions which emphasize the importance of sharing experiences such as languages, ethnics, and customary experiences). Emphasizing the importance of researching students' cognitive psychology and education that leads to the application of social and cultural contexts to the interaction needs of students towards better performance (Remtulla, 2008; Johansen & McLean 2006; Felder & Brent 2005; Moore 2005). It will be interesting if all of classes apply socio-cultural in every learning process. It will be relaxing and make students more exciting on following the learning. It is given the students experiences and positive interactions on developing students' performances freely. Socio-cultural explains the differences between groups of people concerning the social and culture classes in which they live (Luppicini & Walabe, 2021). Socio-cultural influences are fascinating to discuss at elementary, junior high, senior high school, and even the university level (Al-Kahtani et al., 2006). Online learning has great potential on adopting cultural values in Indonesia and all over the world. Distance education or distance learning, such as online learning, proceses challenges for teachers in terms of socio-cultural implementations (such as the application of different cultural aspects: language, religion, and ethnicity), which, however, still needs to be carried out to avoid pressure on students in the form of monotonous online learning. Although it is quite interesting to discuss for students in countries that prioritize socio-cultural importance, it is considered new challenges for teachers globally (Alahmari, 2017). In each country, it emphasizes the importance of a theoretical framework to distinguish socio-cultural significance from the trajectory of the current technological context socially and culturally relevant learning processes (Remtulla, 2007).

This research is worth studying since has several variables, such as socio-cultural point of views, students and teacher interactions, and students' experiences, which have a positive impact on students' E-Learning performances. Therefore, comprehensive research is needed to address the readiness of teachers in implementing socio-cultural into the learning process, especially in E-Learning media, not only during the COVID-19 pandemic but also for future learning. Based on these objectives, this study attempted to answer the following research questions:

RQ1: Does sociocultural have a significant effect on students' experiences and students' interaction?
RQ2: Do students' experience and students' interaction have a significant effect on E-Learning Performance?
RQ3: Does students' experiences and interaction have positive effect to mediates relationship between students' socio cultural and E-Learning Performance?

This study investigates students' socio-cultural, experience, interaction and E-Learning performance (student experience and interaction as a mediator) to answer these questions. This research is expected to contribute to implementing in different counties culture in the E-Learning learning process and to become a unique learning model that adapts to the diversity of cultural values of each region to provide a quality learning experience (Kinuthia, 2012; Fleming & Haigh, 2018; Luppicini & Walabe, 2021). In addition, students will be interested and use E-Learning easily and can share experiences through learning activities at school. Furthermore, the resulting learning process will vary with the application of different types of culture and can have an impact on students' E-Learning performance.

Figure 1. Proposed research model



Literature review

Socio culture

Studies consider that the government's lack of attention to cultural diversity issues (such as student diversity) will result in the alienation of many groups of learners (Ally, 2004; DeRouin et al., 2005). Despite the increasingly complex educational needs profiles, relatively little attention has been paid to students' different socio-cultural learning needs globally (Ally, 2004; DeRouin et al., 2005; Salas et al., 2002). The application of socio-culture is to respect elders/fellow human beings and differences in religion, language, and ethnicity (Basahel & Basahel, 2018). The government, engaged in education, is obliged to encourage teachers to apply socio-cultural values, such as mutual respect (teachers respecting students, listening to students' experiences, and exchanging opinions).

Some parents argue that maintaining socio-cultural should be teacher-centered through the teaching and learning and active interaction between teachers and students (Hofstede, 2001). Teachers should respect student diversity; as in Indonesia, students adhere to five different religions, have different dialects of languages, and come from different ethnic groups. In addition to teachers, students should also treat the teachers with respect, even outside the classroom (Hofstede, 2001). Respect for elders is encouraged in all settings, as in the implementation of E-Learning and all aspects of life (Luppicini & Walabe, 2021). This research employed a more socio-culturally-minded view of E-Learning from the perspective of social theory for learning, such as student experience and interaction.

Student experience

The student experience referred to in this study was how students openly share their experiences, such as habits in the community and at home. The student experience is considered a proactive agent to understand information from society, such as socio-cultural, and use it to improve effective strategies and interactions in the classroom (Rovagnati et al., 2021; Carless & Bound, 2018). Each teacher will instruct students to share experiences and relate them to learning (Malecka, Boud, & Carless, 2020). Experiences in the community, for example, are cooperation, caring for each other, playing traditional games (as in Indonesia; playing *wayang*, rubber, marbles, hide and seek, etc.), participating in social activities, protecting nature, participating in cultural rituals, and worshiping together (Chong, 2021; Gravett, 2020). In addition, students can also share their experiences at home, such as the habit of using the local language, helping their parents after school, and praying and eating together. Students' capacity and willingness to proactively engage with the student experience are paramount to making the whole process productive (Winstone, Mathlin, & Nash, 2019; Carless, 2020).

Students' experiences can be shared in the classroom. Ideally, the curriculum should instill the importance of introducing students' socio-cultural experiences (Boud & Molloy, 2013; Winstone et al., 2017) so that teachers can easily encourage students to share their experiences in class. Thus, students can compare their experiences with their classmates and increase their knowledge and performance (Nicol, 2020). In this context, socio-cultural factors shape interactions, experiences, and processes. The researchers argued that the E-Learning process as construction should not be under the concept of ignoring its role. Street (2004) and Sutton (2012) argue that the cultural diversity of experiential codes and conventions can result in students' E-Learning performance and sustain socio-culture in education (Elementary School, Junior High School, Senior High School, and University).

Student interaction

Teachers are required to facilitate the effectiveness of student interaction in the classroom. In addition, they are also expected to function as content distributors, learning facilitators, and assessors of student competencies, such as E-Learning performance assessed by student interaction (Abdelhai et al., 2012). The student interaction in question provides opportunities for students to express opinions, such as sharing experiences during discussions, telling experiences in front of the class, or exchanging ideas with teachers or classmates (Harden, 2008; Twigg, 1999). The interaction in the teaching and learning process is one of the assessment components to measure students' E-Learning performance. Some students with weak E-Learning performance need more attention and opportunities to interact. Meanwhile, students with better E-Learning performance need opportunities to excel and accelerate performance improvement (Abdelhai et al., 2012; Twigg, 1999). Each student has a different motivation, learning style, and attention span towards interactions in the classroom, both offline and online, as in the use of E-Learning. Hence,

teachers should provide better classroom interaction opportunities and incorporate socio-cultural with each learning material, such as discussions in smaller groups later passed on to larger groups. In addition, the teachers can develop their learning materials and coordinate inconsistencies in student interactions.

E-learning performance

Research conducted by Abdelhai et al., (2012) suggested that universities adopt E-Learning and provide facilities for its implementation. In addition, to achieve good performance, colleges must provide a computer room with an internet connection, either at school or home. The use of information technology directs attention and learning methods to the application of online learning, which is widely known as E-Learning. With the introduction of the internet and the World Wide Web, E-Learning has shown great potential to provide more flexible access to excellent content and interaction. Therefore, E-Learning can overcome the existing educational problems, namely the lack of socio-cultural cultivation, sharing of experiences, interactions, and unimproved E-Learning performance. Students' E-Learning performance can be improved by embedding socio-culture in the process and providing instruction to students anytime and anywhere (Schwen & Hara, 2004). In addition, well-designed E-Learning can improve the quality of student interaction, experience, and performance by promoting course concepts centered on students' socio-cultural values. It will also encourage students to be confident in improving their performance (Riel & Barab et al., 2004; Geçer & Bağci, 2022). To improve student E-Learning performance, the learning community of teachers and students needs to be expanded and supported through the transfer of socio-cultural into E-Learning (Dede, 2006).

Hypotheses

The correlation between socio-cultural and students' experience

Socio-cultural affects student activities (experiences in the community, habits at home, and performance at school). The socio-cultural dimension has a prominent role, namely providing guidelines for student success in the community, one of which is in the school environment (Basahel & Basahel, 2018). Concerning students' habits that influence their experiences (Winstone & Nash, 2019), education should aim to appreciate each student's socio-cultural experience affecting their future success. Besides, socio-cultural also makes students value fellow human beings more, such as differences in language, customs, religion, ethnicity, and opinions. Students with excellent socio-cultural values such as religious beliefs and good habits are likely to apply positive experiences in their lives, such as in class, which other students can imitate later. Students need to practice socio-cultural teachings in their lives, which are obtained from their surrounding environment, such as the habit of working together, worshiping, and being active in the social environment. (Likewise, Rovagnati et al., 2021; Carless & Bound, 2018) conclude that socio-cultural and student experience have a significant correlation and are indispensable for determining student performance. Previous studies have also revealed that socio-cultural influenced student experience (Boud & Molloy, 2013; Winstone et al., 2017; Nicol, 2020). Therefore, the present study proposed the following hypothesis:

H1. Socio-cultural has a significant and positive impact on student experience.

The correlation between socio-cultural and student interaction

The theory of socio-cultural employs a categorical scale to measure the active interaction of students in the learning process in the classroom, especially in E-Learning (Abdelhai et al., 2012). Socio-cultural affiliation refers to an individual/community's adherence to socio-cultural beliefs. At the same time, student interaction is the activities of students in the classroom influenced by socio-cultural or habits in the community and subsequently implemented in the teaching and learning process, especially in E-Learning. This perspective becomes an essential feature of socio-cultural impact on student experience and interaction. Instrumental and practical interests in individual-oriented socio-cultural are based on their belief in the prevailing socio-cultural rules, leading them to apply mutual respect for fellow human beings, as in the classroom interaction based on socio-cultural principles. Furthermore, socio-cultural is related to habits and concern for rules in society, such as procedures for communicating, worshiping, and interacting with others (not interrupting the conversation, listening to complaints, and caring about the calamity experienced by the interlocutor). Students' awareness to improve positive behaviors when interacting with the

community, teachers, parents, and other students are influenced by their level of belief in socio-cultural. Previous research concluded that socio-cultural had a significant impact on student interaction (Hofstede, 2001; Luppicini & Walabe, 2021; Basahel & Basahel, 2018). Hence, this study proposed the following hypothesis:

H2. Socio-cultural has a significant and positive impact on student interaction.

The correlation between student experience and E-Learning performance

The student experience is vital in determining student success and future educational progress. The students applying positive experiences following the socio-cultural teachings/habits will likely achieve improved performance, especially in E-Learning (Schwen & Hara, 2004; Sari & Liu; 2023). If students' E-Learning performance improves, they will have high learning motivation, so one of the educational goals in the form of increasing student success can be achieved. However, during the COVID-19 pandemic, most students experienced a decline in performance, such as a lack of learning motivation, decreased learning outcomes, a lack of interaction preventing them from getting new experiences, and monotonous learning activities. Additionally, during the COVID-19 pandemic, most student activities were carried out at home, one of which was in the form of E-Learning, causing students to have poor interactions at school and in the community, get no other experience, feel bored, and indicate a decrease in performance. The present study considered the mediating role of student experience and interaction concerning students' E-Learning performance. Understanding the impacts of this mediating role can improve inference quality, facilitate the improvement of students' E-Learning performance, and offer substantial contributions to this research. Preliminary studies found a significant correlation between socio-cultural and student experience, which subsequently impacted students' E-Learning performance (Street, 2004; Sutton, 2012; Boud & Molloy, 2013; Winstone et al., 2017; Nicol, 2020). Therefore, this study proposed the following hypothesis:

H3. Student experience has a significant and positive impact on student E-Learning performance.

The correlation between student interaction and E-Learning performance

Student interaction is essential in measuring student E-Learning performance, considering that learning media focused on E-Learning during the COVID-19 pandemic. Positive interactions can guide and develop students to be more dynamic (Harden, 2008; Twigg, 1999). Student interaction is perceived to have a positive impact on student E-Learning performance. The interaction in question is such as being active in the classroom, sharing socio-cultural experiences, respecting other students' opinions, respecting teachers, and encouraging other students to be active (each student is required to share socio-cultural experiences/daily habits), especially in E-Learning, so that the class does not feel monotonous and boring in the learning process. On the other hand, inactive interactions will lead to a decrease in E-Learning performance. Consequently, socio-cultural must be regarded as a basis and strategy for encouraging students to dare to share their experiences in the classroom and interact actively and effectively to cope with the declined E-Learning performance during the COVID-19 pandemic. In addition, student interaction has a significant mediating role in examining the correlation between socio-cultural, interaction, and student E-Learning performance. Furthermore, preliminary studies reported that student interaction was critical in addressing student E-Learning performance (Twigg, 1999; Riel & Barab et al., 2004; Abdelhai et al., 2012). Thus, the present research proposed the following hypothesis:

H4. Student interaction has a significant and positive impact on student E-Learning performance.

The correlation between socio-culture and E-Learning performance

The uncertainty during the COVID-19 pandemic has caused student performance to decline, especially in E-Learning. In addition, boredom in learning and a lack of experience and interaction made learning monotonous (merely meeting face-to-face online and internet connection making communication between teachers and students unstable). Therefore, the school must be able to address these issues, one of which is by involving socio-cultural in learning, especially in the E-Learning process. Socio-cultural refers to the habits of the community/students in daily life (Basahel & Basahel, 2018; Beets et al., 2022), such as worshiping, caring for fellow human beings, working together, respecting, and appreciating differences. Meanwhile, student E-Learning performance refers to student success, such as being active in class, successfully making E-Learning a learning medium, achieving increased

learning outcomes, and successfully implementing socio-cultural in learning (Riel & Barab et al., 2004). Student E-Learning performance is mediated by student experience and interaction within the classroom, which are transferred through the socio-cultural experiences of each student. Previous studies have investigated the correlation between socio-cultural and student E-Learning performance. Lappucini & Walabe (2021) discovered that socio-cultural had an impact on the delivery and outcomes of E-Learning in Saudi Arabia. Research conducted by Kinuthia (2012) found that socio-cultural was successfully implemented, could improve student learning performance in the USA, and could be designed to fit into the curriculum. In addition, socio-cultural was also concluded to correlate with E-Learning (Fleming & Haigh, 2018; Rao, 2012). Hence, this study proposed the following hypothesis:

H5. Students' experience has positive and significant effect on mediates the relationship between Socio-cultural and students' E-Learning performance.

H6. Students' interaction has positive and significant effect on mediates the relationship between Socio-cultural and students' E-Learning performance.

Methodology

Questionnaire design, pretest, and pilot study

This study adopts scales with high reliability and validity. It uses multi-item scales for all of the constructs from prior studies in the proposed model about conducting a pretest and pilot test to validate the measurement items' wordings of constructs for the students' socio cultural, students' experiences, students' interactions and E-Learning performance in Indonesia. It was used to ascertain whether the students understood each of the questions and revised wordings to prevent single-source bias (Podsakoff et al., 2003).

Sample and data collection

The Indonesian students are asked to fill out an online survey; besides, a cash prize of 2,000 Indonesian rupiahs (IDR) must complete each study to increase their response rate. This online survey was conducted using Google Forms and runs from April 10 to Mei 25, 2022. The sample was collected from random sampling involving 740 students in Indonesia. However, 734 samples were valid, and this represented a 99.00% completion rate. Table I shows the demographics of the respondents. Indonesia was selected for the data. This study validates the relationship between sosio cultural, students' experiences, students' interactions, and E-Learning performance of students.

Measures

The items used to measure each construction are presented in the Appendix. Demographics such as gender, age, time range use E-Learning, and student activity were included in the questionnaire. A seven-point Likert scale anchored between 1 ("strongly disagree") and 5 ("strongly agree") was used for all scale items. Socio cultural focuses on student habits such as the habit of worshiping together, respecting fellow human beings, mutual cooperation, participating in social activities to ease the burden of people in distress, and high concern for friends, family, teachers, and fellow human beings, which was adapted from (Luppucini & Wallabe 2021). All items of students' experiences, students' interactions refer to Xu (2016), and students' E-Learning performance were adapted from (Ho Thao, N.T., et al., 2020 & Kim Sodam., et al., 2022; Patra, S.K, et al., 2021; Hussin, H., et al., 2009).

Data analysis

The data were analyzed using two statistical programs, namely SPSS 22 and AMOS 22 software. Furthermore, hypothesis testing was carried out by applying the structural equation model (SEM). According to (Byrne, 2016), SEM provides two essential aspects of the procedure. First, it is used to determine the causal effects of the observed variables. Second, the structural relations among variables enable a clear description of the theory examined in this study. The hypothesized model is comprehensively used to validate all the variables to determine consistency with the study. Pearson correlation coefficients were also used to determine the relationship between predictors (socio cultural, students' experiences, students' interactions) and criterion variables (students' E-Learning performance).

Third, standard method variance (CMV) was adopted as a prevention and post-detection technique. Therefore, this study applies the Hayes bootstrap method (2022) to examine the influence of experiences and interactions on students' E-Learning performance mediated by socio culture.

Results

Structural Equation Modeling (SEM) was used to test the proposed model and the research hypotheses. This study employed the two-stage approach suggested by Anderson and Gerbing (1988). First, the measurement model was estimated with confirmatory factor analysis (CFA) to test reliabilities and validities of the research constructs, and then, the structural model was used to test the strength and direction of the proposed relationships among them.

Table 1. Respondent demographics

Demographic Items	Frequency	Percentile (%)
Gender		
Male	358	49.1
Female	372	50.9
Age		
18-26 years old	298	40.9
26~40 years old	275	37.7
Over 40 years old	157	21.4
Education		
Bachelor and below	381	52.1
Master	262	35.9
PhD	87	12.0
Time period of using E-Learning		
Below 2 years	239	32.8
3~5 years	215	29.4
Over 5 years	276	37.8

Measurement model

The measurement model used in this study was the AMOS software with maximum likelihood estimation. The model fit showed how well a CFA model reproduces the covariance matrix of the observed variables. The measurement model showed adequate fit (Byrne 2016; Hair Jr, et al. 2018): $\chi^2/df = 4.173$, goodness-of-fit index (GFI) = 0.941, nonnormed fit index (NFI) = 0.924, comparative fit index (CFI) = 0.941, incremental fit index (IFI) = 0.941 and root mean square error of approximation (RMSEA) = 0.066. Table 2 shows the composite reliabilities (CR) and an average of variance extracted (AVE) for all construct are above 0.700 and 0.500, thereby demonstrating a reasonable degree of internal consistency between measurement items and their corresponding constructs. Furthermore, the Cronbach's α for all constructs is larger than 0.7. This indicates a good convergent validity for all measurement items and constructs. The evidence of discriminant validity exists when the square root of AVE for each construct exceeds its correlation coefficient with other constructs (Byrne 2016; Hair Jr, et al. 2018). Table 3 indicates the adequate discriminant validity of this study.

Table 2. Correlation matrix for measurement scales

Constructs	Mean	SD	SC	SE	SI	EP
SC	5.18	1.20	**0.815**			
SE	5.37	1.15	0.415**	**0.812**		
SI	5.23	1.15	0.320**	0.296**	**0.870**	
EP	5.17	1.21	0.226**	0.275**	0.298**	**0.825**

Note. SC: Socio culture, SE: Students' experience, SI: Students' interaction, EP: E-Learning performance. SD: standard Deviation. Diagonal elements are the square roots of the AVE for each construct. Pearson correlations are shown below the diagonal. Significant at *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Table 3. Measurement results

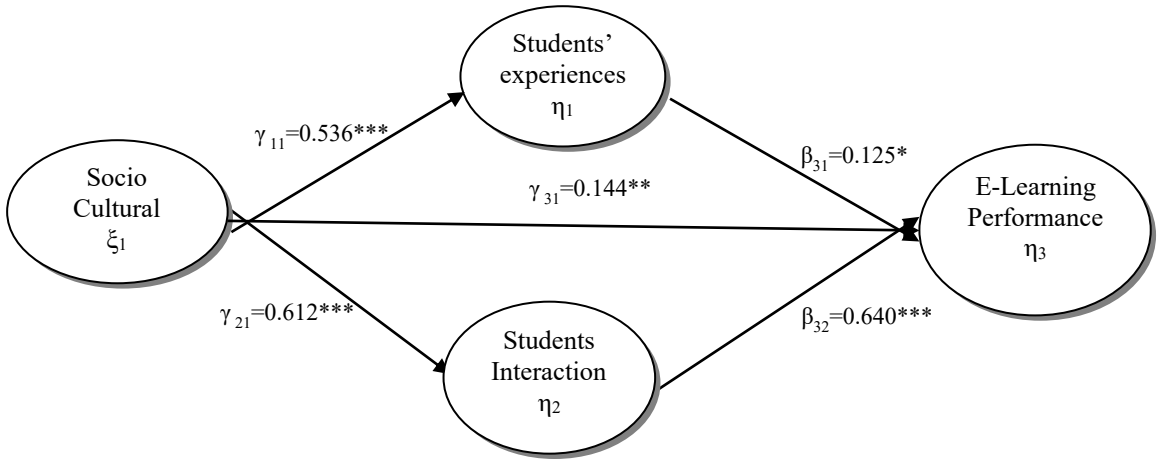
Constructs	MLE estimates factor loading/ measurement error		Squared multiple correlation (SMC)	Composite reliability (CR)	Average of variance extracted (AVE)	Cronbach's α
Socio-Cultural				0.840	0.514	0.843
SC1	0.712	0.493	0.507			
SC2	0.780	0.392	0.608			
SC3	0.775	0.399	0.601			
SC4	0.730	0.467	0.533			
SC5	0.815	0.336	0.664			
SC6	0.847	0.283	0.717			
SC7	0.722	0.479	0.521			
Students'experience				0.901	0.610	0.895
SE1	0.803	0.355	0.645			
SE2	0.837	0.299	0.701			
SE3	0.732	0.464	0.536			
SE4	0.782	0.388	0.612			
SE5	0.810	0.344	0.656			
Students' interaction				0.907	0.580	0.895
SI1	0.755	0.430	0.570			
SI2	0.720	0.482	0.518			
SI3	0.815	0.336	0.664			
SI4	0.805	0.352	0.648			
SI5	0.758	0.425	0.575			
SI6	0.775	0.399	0.601			
E-Learning performance				0.890	0.623	0.885
ELP1	0.735	0.460	0.540			
ELP2	0.820	0.328	0.672			
ELP3	0.840	0.294	0.706			
ELP4	0.785	0.384	0.616			
ELP5	0.739	0.454	0.546			

Note. Fit statistics (N = 704)
χ^2/df = 3.486, Goodness-of-Fit Index (GFI) = 0.920, Nonnormed fit index (NFI) = 0.925, Comparative Fit Index (CFI) = 0.930, Incremental fit index (IFI) = 0.940, and Root Mean Square Error of Approximation (RMSEA) = 0.037

Structural model

The model fit of this study was adequate: χ^2 = 669.706, df =147, χ^2/df = 4.556, GFI = 0.923, NFI = 0.917, CFI = 0.934, IFI = 0.934 and RMSEA= 0.070. Table 3 indicates that all the research hypotheses are supported. This study confirms that socio cultural has a significant effect on students' experience (γ_{11} = 0.536, $p<0.001$) and students' interaction (γ_{21} = 0.612, $p<0.001$), supporting H1 and H2. Furthermore, students' experience also has positive and significant effect on E-Learning performance (β_{21} = 0.125, $p<0.05$) to support H3. Interestingly, students' experience has greater effect on E-Learning performance ((β_{31} = 0.640, $p<0.001$) than students' interaction (β_{32} = 0.394, $p<0.001$) to support H4 and H5.

Figure 2. Proposed research result



Mediation effect

This study used confidence intervals for bootstrapping method with 10000 simulations. Bootstrapping is a nonparametric statistical procedure in which the dataset is repeatedly sampled (Hayes 2018). Table 5 shows that all confidence intervals of both the percentile method and bias-corrected do not include zero, indicating all mediation effects significant. The regression results indicate that all mediation effects are full mediators.

Table 4. Proposed model results

	Regression path			Path coefficients	Hypotheses	Test results
γ_{11}	Socio culture	→	Students' experience	0.536***	H1	Supported
γ_{21}	Socio culture	→	Students' interaction	0.612***	H2	Supported
β_{21}	Socio culture	→	E-Learning Performance	0.125*	H3	Supported
β_{31}	Students' experience	→	E-Learning Performance	0.640***	H4	Supported
β_{32}	Students' interaction	→	E-Learning Performance	0.144**	H5	Supported

Note. Significant at *: p<0.05, **: p<0.01, ***: p<0.001

Table 5. Mediation effects

IV	M	DV	IV->DV (c)	IV->M (a)	IV+M->DV		Bootstrapping 95% CI	
					IV (c')	M(b)	Percentile	Bias-corrected
SC	SE	EP	0.025	0.250***	0.042	0.080**	[0.010, 0.040]	[0.015, 0.059]
Standard Error (SE)			0.030	0.030	0.030	0.025		
SC	SI	EP	0.025	0.525***	0.123**	0.127**	[0.015, 0.055]	[0.017, 0.068]
Standard Error (SE)			0.030	0.021	0.043	0.041		

Note. Significant at *: p<0.05, **: p<0.01, ***: p<0.001

Discussion

Key findings

This study validated the relationships between students' experience and students' interaction as mediators between students' socio cultural and E-Learning performance on education and learning process. Information and technology have provided tool to support E-Learning process toward enhance their connections and interaction with others. This study validates students' socio-cultural role with learning activities such as discussing with friends and teachers. It has strong correlation to their attitude and behavior with regard to experience. It also possibly strengthening relationships directly influence E-Learning performancet. Besides influence students' experience, socio cultural also has positive and significant effect on students' interaction. It means that the learning collaboration toward online and offline interaction by students' personal and social activities, including local festival celebration, charity and sport events, painting competitions, debates and speeches and also exhibition and workshop. These activities not only within their school but across school and regions. It has a crucial role in their daily lives and positively affects their desire to enhance capacity and knowledge. However, few of studies regarding the relationships between the domains of socio culture and the dimensions of students' school activities on learning process.

First, the recent study shown that communal and transcendental activity have distinct associations with students' individual and social responsibility on society and others. This supports the view that attitude and behavior toward social activities can be strength inter-relationship among students. Students' experience and psychology can better influenced by social activities. In some countries, religion also recognized to address their lives and belief. *Second,* the results with regard to care to others, the schools must consider students' psychology and enhance to develop a clear rule of socio activities and recognized it as one of the part learning process and curriculum. It proved a student with high collective and individual well-being might have a heightened sense of belonging and focus on humanity's consequences, including higher orientation ethical standard on their activities. *Finally,* the results also indicate that students' socio cultural has a greater effect on students' interaction than students' experience to influence students' performance on E-Learning. This implies the positive image of students' socio cultural (e.g., empathic, altruistic concerns rather than personal concerns) has a positive effect on students' activities on social interaction. Furthermore, the findings support preliminary studies that revealed socio culture strongly correlates with students' experiences (Anriani et al., 2022; Chong, 2021; Gravett, 2020) and students' interaction (Abdelhai et al., 2012), which are also mediator variables. Students' experience and interaction also positively affect students' E-Learning performance (Riel & Barab et al., 2004; Sumida & Kawata, 2021).

Academic implications

The current study contributes to some aspects of the literature. *First,* it provides a better knowledge of specific concepts of students' socio cultural, experience and interaction on influence E-Learning performance on education context. This study discloses that socio cultural has an essential role in developing students' ethics and sense of belonging on community. Interestingly, students' socio cultural has positive effect to their personal experience and interaction. This process designates the strong correlation between students' attitude and habit. Students' who are highly aware of the social and human being are more likely to be committed and have a sense of belonging, friendly interaction, as well as the students' donation to social activities. *Second,* it was reported that students' experience and interaction play a mediating role in the relationship between students' socio culture and E-Learning activities on education field. Although previous studies have reported the role of socio cultural, which serves as an antecedent of students' experience and interaction. There were examined separately, and it was indicated that students' ethics and social responsibility are considered the most important mediators between socio culture and E-Learning performance. The strength of the mediating role shows that students are willing to develop ethics standards, a sense of belonging and recommendation to others. This is as a significance of social actions, knowledge, and experiences scholars attain from dealing with ethics and social responsibility. It proved socio culture provides relevant and timely information to education field. Hence, our findings provide a theoretical ground for future study.

Practical implications

The findings offer several managerial implications, such as students' socio cultural, experience, interaction and learning process toward technology development, thereby students' in developing countries relationships and

influencing their decision-making process. Therefore, cultural approach is compliant with ethics standards, influencing students' attitude and behavior as well as their performance. The ethic and social activities principles, the more they tend to have a sense of belonging, thereby engaging in the students' interaction process. However, students' socio-cultural level and ethics are not the only variables. This result indicates that a higher level of socio cultural is consistent with students' ethics and social care to human well-being and the environment; hence the schools and universities need to act accordingly. Specifically, the interaction among students in social media. Therefore, the school and university leaders need to care for their students, particularly in the formal rule and system. The role of regulators, including the education ministry, to surveillance the education processes. In this regard, the regulators are expected to play a pivotal role with clearly established regulation and supervision mechanisms.

Limitations and future research directions

There are some limitations to this research. *First,* this study conducted a cross-sectional survey to examine students' attitude and behavior. Hence, future study needs to help researchers observe social media users' dynamic behavior to elaborate on the content and impact of socio cultural, ethics, social interaction, and knowledge sharing. *Second,* it only considered the situational factors among students. Future research also needs to investigate internal such as school and university effect on students' learning and E-Learning performance. Third, although most of the hypotheses proposed in this research were supported, it was restricted to students' attitude and behavior and ethics, and interrelationships with preliminary studies. Future studies also need to comprehensively focus on the relationship between socio culture and students' psychology effect. *Finally,* this study only focused on Indonesian students. Future research can investigate other demographics around the globe to confirm this study's external validity.

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Türkiye'de Online Eğitimde Yaşanan Etik Dışı Davranışlar

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Özet

Covid-19 sürecine bağlı olarak Türkiye'de 18 milyon ve dünyada 1,5 milyarın üzerinde öğrenci hazırlıklı olmadıkları bu süreçte eğitimlerini evde devam ettirmeleri nedeniyle yerelde Türkiye'de ve evrensel boyutta dünya çapında kısa süre içinde eğitimde yaşanan sorunlara yönelik çalışmalar yapılmıştır. Konuyla ilgili alan yazında yapılan çok sayıdaki araştırmalar tarafından, online eğitim sürecinde eğitim yöneticileri, öğretmenler, öğrenciler ve veliler tarafından etik sorunlar yaşanıldığı tespit edilmiştir. Hazırlıksız yakanılan Covid 19 sürecindeki online eğitim alanında çok sayıda araştırma ortaya konulmasına karşın yerelde, oldukça sınırlı sayıda Covid 19 sürecinden kaynaklı eğitimde yaşanılan etik dışı davranışlar alana taşınmış olup bu yaşanılan etik sorunlar da öğretmen ve öğrenci üzerinedir. Online eğitimde yaşanılan etik dışı davranışlar daha çok yapılan araştırmaların sonuçlarında alt sonuçlar olarak yer bulmuştur. Bu bağlamda Türkiye'de online eğitimde yaşanan etik dışı davranışların hangi boyutlarda gerçekleştiğinin incelenmesine ihtiyaç duyulmaktadır. Bu temel amaç doğrultusunda Türkiye'de online eğitimde yaşanan etik dışı davranışların sentezlenmesine gidilecektir. Çalışma, nitel araştırma desenlerinden doküman incelemesine bağlı literatür tarama modelinde bir çalışmadır. Bu bağlamda çalışmanın temel amacını ortaya koyabilmek için farklı boyutlardan incelenmesinde açıklayıcı araştırma tasarımı kullanılmıştır. Açıklayıcı araştırma tasarımı, bir araştırma konusu arayışında akademik literatürün incelenmesi anlamına gelmektedir. Bu nedenle bu çalışmada Türkiye'de online eğitimde yaşanan etik dışı davranışları ortaya koyan araştırmaların nitel bulguları yorumlanıp değerlendirilerek, benzer ve farklı sonuçlar ortaya konularak, eleştirel bir bakış açısıyla bir sentezlenmeye gidilecektir.

Anahtar Kelimeler: Covid 19, online eğitim, etik, etik dışı davranışlar

Abstract

Due to the Covid-19 process, more than 18 million students in Turkey and over 1.5 billion students worldwide had to continue their education at home without being prepared for this sudden shift. Consequently, both locally in Turkey and globally, a series of studies were conducted in a short period to address the problems encountered in education. Numerous studies in the literature have identified that during the online education process, ethical issues were experienced by school administrators, teachers, students, and parents. Although a large number of studies have been conducted in the field of online education during the Covid-19 period, only a limited number of studies in Turkey have directly addressed unethical behaviors arising from this process, and these ethical issues are mostly reflected on teachers and students. Unethical behaviors encountered in online education have generally been presented as sub-findings in the results of the research. In this context, there is a need to examine in what dimensions unethical behaviors occurred in online education in Turkey. In line with this main objective, this study seeks to synthesize the unethical behaviors that occurred in online education in Turkey. This study is designed as a qualitative research based on a document analysis–oriented literature review model. Accordingly, an explanatory research design was employed to reveal the main purpose of the study by examining the issue from different perspectives. Explanatory research design refers to the review of academic literature in the search for a research topic. Therefore, in this study, qualitative findings of research on unethical behaviors in online education in Turkey will be interpreted and evaluated, with similarities and differences highlighted and synthesized through a critical perspective.

Keywords: Covid-19, online education, ethics, unethical behaviors

Giriş

Beklenmedik bir şekilde karşılaşılan Covid-19 süreci eğitim alanını doğrudan etkilemiştir. Milli Eğitim Bakanlığı (MEB), eğitim yöneticileri, okul yöneticileri, öğretmenler, veliler ve öğrenciler olmak üzere tüm paydaşlar hazırlıksız yakalanmışlardır. 1,5 milyardan fazla öğrenci bu süreçten etkilenmiştir (UNESCO, 2020). Türkiye'de de 16 Mart 2020 tarihinde ilk, orta, lise ve yükseköğretim düzeyinde eğitime ara verilmiş; Milli Eğitim Bakanlığı (MEB) kısa süre içinde Eğitim Bilişim Ağı (EBA) ve Türkiye Radyo Televizyon Kurumu (TRT) aracılığıyla uzaktan eğitimi uygulamaya koymuştur (MEB, 2020). Covid-19 salgınıyla birlikte bir zorunluluk olarak Türkiye de dâhil olmak üzere 195 ülkede eğitim durdurulmuştur. Salgın nedeniyle Türkiye'de ilkokul, ortaokul, liseler ve

yükseköğretim kurumlarında, 16-30 Mart 2020 tarihleri arasında iki hafta süreyle yüz yüze eğitime ara verilmiştir. Bu süreçte dünya çapındaki ülkeler eğitime uzaktan devam etme kararı alırken Türkiye'de bu gelişmelere eşdeğer olarak Milli Eğitim Bakanlığı tarafından ilkokul, ortaokul ve liseler için ulusal uzaktan öğrenme platformu Eğitim Bilişim Ağı (EBA) ve televizyon kanalı Türkiye Radyo Televizyon (TRT) aracılığıyla sürdürülmesi kararlaştırılarak 23 Mart 2020 tarihinde uygulamaya geçilmiştir. Salgın nedeniyle, 16 Mart 2020 ve 06 Eylül 2021 tarihleri döneminde öğrencilerle eğitimler yüz yüze gerçekleştirilemeyerek EBA üzerinden online olarak yürütülmüştür.

Ancak bu süreç, öğretmenler, öğrenciler, veliler ve eğitim yöneticileri açısından hazırlıksız yakalanılan bir dönem olmuştur. Eğitim-öğretim faaliyetlerinin ev ortamına taşınması beraberinde birçok pedagojik, teknik ve etik sorunu gündeme getirmiştir. Yerel ve küresel literatürde online eğitim süreçlerine ilişkin çok sayıda çalışma yapılmasına rağmen, özellikle Türkiye'de etik dışı davranışlara ilişkin kapsamlı incelemeler sınırlı kalmıştır. Bu makale, Türkiye'de Covid-19 sürecinde online eğitim sırasında yaşanan etik dışı davranışların boyutlarını incelemeyi ve mevcut araştırmalardan elde edilen bulguları sentezlemeyi amaçlamaktadır.
Online eğitim, öğrenci ve öğretmen arasındaki etkileşimin teknoloji aracılığıyla gerçekleştiği, fiziksel mekândan bağımsız bir öğrenme biçimidir (Anderson, 2011). Bu ortamda akademik dürüstlük, veri güvenliği, gizlilik, eşitlik, erişilebilirlik ve mesleki etik gibi konular kritik bir önem taşımaktadır (Whittle, Tiwari, Yan, & Williams, 2020). Türkiye'de yapılan araştırmalarda öne çıkan etik sorunlar aşağıdaki gibi özetlenebilir:

Akademik dürüstlük ihlalleri: Öğrencilerin çevrim içi sınavlarda kopya çekmesi, ödevlerde intihal yapması (Çelik ve Arslan, 2021).

Eşitsizlik ve adalet: İnternet ve cihaz erişimindeki farklılıklar nedeniyle fırsat eşitsizliğinin artması (Bozkurt, 2020).

Öğretmen-öğrenci etkileşiminde etik sorunlar: Kamera açma zorunluluğu, özel yaşamın ihlali, veli müdahaleleri (Akbulut & Şahin, 2021).

Veri güvenliği ve mahremiyet: Öğrenci görüntülerinin kaydedilmesi, paylaşılan materyallerin izinsiz kullanımı (Altıntaş ve Kara, 2022).

Uluslararası düzeyde ise benzer etik sorunların yaşandığı görülmektedir. Örneğin, ABD'de öğrencilerin çevrim içi sınavlarda kopya çekmesini önlemek için geliştirilen gözetim yazılımlarının öğrenci mahremiyetini ihlal ettiği yönünde tartışmalar yaşanmıştır (Zimmerman, 2020).

Covid-19 sürecine bağlı olarak Türkiye'de 18 milyon ve dünyada 1,5 milyarın üzerinde öğrenci hazırlıklı olmadıkları bu süreçte eğitimlerini evde devam ettirmeleri nedeniyle yerelde Türkiye'de ve evrensel boyutta dünya çapında kısa süre içinde eğitimde yaşanan sorunlara yönelik çalışmalar yapılmıştır. Konuyla ilgili alan yazında yapılan çok sayıdaki araştırmalar tarafından, online eğitim sürecinde eğitim yöneticileri, öğretmenler, öğrenciler ve veliler tarafından etik sorunlar yaşanıldığı tespit edilmiştir. Hazırlıksız yakanılan Covid 19 sürecindeki online eğitim alanında çok sayıda araştırma ortaya konulmasına karşın yerelde, oldukça sınırlı sayıda Covid 19 sürecinden kaynaklı eğitimde yaşanılan etik dışı davranışlar alana taşınmış olup bu yaşanılan etik sorunlar da öğretmen ve öğrenci üzerinedir. Online eğitimde yaşanılan etik dışı davranışlar daha çok yapılan araştırmaların sonuçlarında alt sonuçlar olarak yer bulmuştur. Bu bağlamda Türkiye'de online eğitimde yaşanan etik dışı davranışların hangi boyutlarda gerçekleştiğinin incelenmesine ihtiyaç duyulmaktadır. Bu temel amaç doğrultusunda Türkiye'de online eğitimde yaşanan etik dışı davranışların sentezlenmesine gidilecektir.

Yöntem

Bu çalışma, nitel araştırma desenlerinden doküman incelemesine dayalı literatür tarama modeli ile hazırlanmıştır. Doküman incelemesine dayalı literatür tarama modeli, araştırmacının belirli bir konu ile ilgili daha önce yayımlanmış akademik çalışmalar, resmi raporlar, kitaplar, tezler ve diğer belgeleri sistematik olarak inceleyerek veri toplamasına dayanan nitel bir araştırma yöntemidir (Bowen, 2009). Bu model, araştırmanın temel amacını ortaya koymak, var olan bilgileri sentezlemek ve boşlukları belirlemek için oldukça uygundur. Bowen (2009) modeli sürecinin aşamaları:

1) Araştırma sorularının belirlenmesi
2) Kaynakların seçimi
3) Veri toplama ve sınıflandırma
4) Analiz ve sentezleme
5) Sonuçların raporlanması

Araştırmada açıklayıcı araştırma tasarımı benimsenmiş; Türkiye'de Covid-19 sürecinde online eğitimde yaşanan etik dışı davranışlara ilişkin ulusal ve uluslararası akademik çalışmalar incelenmiştir. İncelenen çalışmaların bulguları kategorilere ayrılmış, benzer ve farklı yönleri sentezlenmiştir. Açıklayıcı araştırma tasarımı, bir araştırma konusu arayışında akademik literatürün incelenmesi anlamına gelmektedir. Bu nedenle bu çalışmada, Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumu ortaya koyan araştırmaların nitel bulguları yorumlanıp

değerlendirilerek, benzer ve farklı sonuçlar ortaya konularak, eleştirel bir bakış açısıyla bir sentezlenmeye gidilecektir.

Doküman incelemesine dayalı literatür tarama modeli, özellikle hazırlıksız yakalanılan Covid-19 sürecinde online eğitimde yaşanan etik dışı davranışlar gibi alanlarda, hızlı ve kapsamlı veri toplamak için uygun bir yöntem olarak tercih edilmiştir. Bu sayede, Türkiye'de ve dünya genelinde elde edilmiş bulgular eleştirel bir perspektifle değerlendirilebilmiş ve mevcut araştırmalar arasında bir sentez oluşturulmuştur.

Braun ve Clark'ın (2016) tematik içerik analiz tekniği kullanılarak çözümlenmiştir. Sürecin aşamaları:
1) Verilerin tanınması
2) İlk kodların oluşturulması
3) Temaların araştırılması
4) Temaların gözden geçirilmesi
5) Temaların tanımlaması ve isimlendirilmesi
6) Raporun oluşturulması

Sonuç

Yapılan tematik içerik analizi sonucu online eğitimde ders dışında yaşanan etik dışı davranışlar iki ana temadan oluşmakta olup başlıklar halinde aşağıda verilmiştir.

1) Online Eğitimde Ders Dışında Yaşanan Etik Dışı Davranışlar

Ana Tema	**Ders dışında eğitimde yaşanan etik dışı davranışlar**
Alt Temalar	**Örnek İfadeler**
Fırsat eşitsizliği	*İmkânı olmayıp derse katılamayan başarılı öğrenciler* *Eşit imkâna sahip olmayan ailelerin çocuklarının eşit şartlarda eğitim görüyorlarmış gibi değerlendirmesi*
Standart olmayan MEB uygulamaları	*Canlı ders yapmanın öğretmen isteğine bırakılması*
Özel hayatın sınırlarına müdahale	*Gecenin geç saatlerinde öğretmeni arama*
Ödeve aile müdahalesi	*Ödevin aileler tarafından planlanması ve yapılması*
Öğrenciye sevgisini gösterememe Sınıf ortamının sıcaklığını yansıtamama	*Çocuklarıma dokunamamak.* *Onlarla iletişim kuramamak.*
Ders öncesi yetersiz önhazırlık	Öğretmenlerin BİT yetersizliği Zamanın yetmemesi
Derslere öğrenci olmayanların girmesi	*Notların geçerlik ve güvenirliğinin bulunmaması* *Şifrelerle kolayca öğrenci olmayanların derse katılarak dersin sabote edilmesi*

Eğitime erişimde fırsat eşitsizliği Bozkurt (2020) tarafından yapılan araştırmada, uzaktan eğitim sürecinde sosyoekonomik durumu düşük olan öğrencilerin cihaz ve internet erişiminde sorunlar yaşadığı, bunun da fırsat eşitliğini ihlal ettiği tespit edilmiştir. Bu durumun eğitim hakkı bağlamında etik bir sorun teşkil ettiğini söyleyebiliriz.

Özel hayata gizlilik ihlalleri ve mahremiyet Altıntaş ve Kara (2022) tarafından yapılan araştırmada, öğrencilerin kamera açmaya zorlanması, ev ortamlarının izlenmesi, kayıtların izinsiz paylaşılması durumları tespit edilmiştir. Bu durum öğrencilerin özel hayatın gizliliği hakkını ihlal etmektedir. Buna ek olarak bazı öğrencilerin görüntülerinin sosyal medyada izinsiz paylaşılması etik dışı davranışların farklı bir boyutunu göstermektedir.

Öğretmen ve veli kaynaklı sorunlarda Akbulut ve Şahin (2021) tarafından yapılan araştırmada, öğretmenlerin online derslerde yetersiz hazırlık yapması, öğrencilere karşı ayrımcı tutumları ve veli müdahaleleri etik açıdan tespit edilen durumlardır. Bu durumun özellikle velilerin derslere müdahale etmesi, öğrencinin bağımsız öğrenme sürecini olumsuz etkilediği ortaya konulmuştur.

Whittle vd., (2020) tarafından yapılan araştırmada, Covid-19 sürecinde online eğitimde yaşanan etik dışı durumların online eğitim sürecinde öğrencilerin motivasyon kaybı, yalnızlık hissi ve psikolojik yıpranmalara yol açtığı tespit edilmiştir. Bu durumun özellikle eğitim ortamlarının psikolojik açıdan güvenli olmaması nedeniyle öğrencilerin öğrenme süreçlerine zarar verdiği ortaya konulmuştur.

2) Online Eğitimde Ders Sürecinde Yaşanan Etik Dışı Davranışlar

Ana Tema	**Ders sürecinde eğitimde yaşanan etik dışı davranışlar**
Alt Temalar	**Örnek İfadeler**
Aile bireylerinin derse müdahalesi	Ev ortamlarının uygunsuzluğu (kıyafet, yeme-içme vb…)
Öğretimi uygulama ve yönetmede yetersizlik	Konu anlatımını genel yapma/üst öğrencilere hitap edememe, Öğrencinin yaş grubuna uygun olmayan eğitim, doğru değerlendirme yapamamak
Uzaktan öğrenme sürecini izleme zorluğu	Online ders devam durumu, Öğrenme çıktılarının değerlendirilme zorluğu) Derslere erişimin ve katılımın takip edilmesi zorluğu
Davranış ve beceri kazandırma zorluğu	Ailenin koruyuculuğu Yüz yüze eğitimin yerini tutmaması
Rehberlik ve destek servisleri yetersizliği	Online psikolojik danışma yapma
Akademik etik yetersizliği İnternet etiği yetersizliği	Sınavda kopya çekimi, öğrenci gizliliği (Ders sırasında ekran kapatma), Uzaktan öğrenme müdahalelerinin sürdürülebilirliği yetersizliği, İzinsiz veri/şifre paylaşımı)
Derslere öğrenci olmayanların girmesi	Notların geçerlik ve güvenirliğinin bulunmaması Öğrenci olmayanların derse katılarak dersin sabote edilmesi

Online eğitimde ders sürecinde yaşanan etik dışı davranışlarda öğretmen-öğrenci-veli etkileşimindeki etik sorunlar Darga (2023) tarafından yapılan araştırmada, okul öncesi öğretmenlerinin çevrim içi eğitimde öğrencilerle verimli iletişim kurmada zorluklar yaşadığını ve bu durumun etik ikilemler oluşturduğu tespit edilmiştir.

Geçer, Yıldırım ve Akgül (2022) tarafından yapılan araştırmada, erişim eşitsizliği çevrim içi eğitimde öğrencilerin internet ve donanım erişimindeki farklılıkların fırsat eşitsizliğini artırdığını ve öğrencilerin akademik performanslarını olumsuz etkilediği vurgulanmıştır.

Online eğitimde ders sürecinde yaşanan etik dışı davranışlarda akademik dürüstlük ihlalleri yapılan araştırmalar tarafından ortaya konulmuştur. Çelik ve Arslan'ın (2021) tarafından yapılan araştırmada, online eğitimde en sık dile getirilen sorunun, öğrencilerin ödev ve sınavlarda kopya çekmesi olduğu tespit edilmiştir. Bu araştırmada öğretmenlerin çoğunluğu tarafından, öğrencilerin sınavlarda internetten hazır cevaplara ulaştığı belirtilmiştir. Bu durumun eğitimde güvenilirliği düşürdüğü ve ölçme ve değerlendirmenin geçerliliğini ortadan kaldırdığı söylenebilir. Çiftçi (2023) tarafından yapılan araştırmada, Türkiye'de uzaktan eğitim sisteminin kullanımında öğrencilerin çevrim içi sınavlarda kopya çekme eğilimlerinin arttığı tespit edilmiştir. Bu durumun online eğitimde ders sürecinde akademik etik ihlallerini daha da yaygınlaştığını gösterdiğini söyleyebiliriz.

Hotaman (2025) tarafından yapılan araştırmada, online eğitimde veri güvenliği ve mahremiyetin çevrim içi eğitimde yüz yüze etkileşimin azalmasının, öğrenci ve öğretmenler arasında güven eksikliklerine yol açtığı ve bu durumun veri güvenliği ve mahremiyet sorunlarını artırdığı belirtmiştir.

Tartışma

Araştırmanın sonuçları, ders sırasında yaşanan teknik sorunlar, ev ortamlarının uygunsuzluğu, aile bireylerinin derslere müdahalesi, öğretimi uygulama ve yönetmede yeterli olamama duygusu, uzaktan öğrenme sürecini izlemenin zorluğu, okul yöneticisinin izinsiz ders denetimi, ders sırasında ekran kapatma, online psikolojik danışma yapma, değer kazandırma zorluğu, internet güvenirliği sorunu olduğunu ve Covid 19 sürecine bağlı ders dışında öğrenciye sevgisini gösterememe, canlı ders yapmanın öğretmen isteğine bırakılması, kendi ailesini ihmal etme, ödeve aile müdahalesi, öğrenciler arasındaki fırsat eşitsizliği, ders öncesi yetersiz önhazırlık, öğrenciyi desteklemek için fazladan yapılan ek çalışmalar olduğunu ortaya koymaktadır. Yüz yüze eğitimde yaşanan etik sorunlara, Covid 19 sürecinde yeni etik sorunlar eklenmiştir.

Covid-19 süreci, Türkiye'de online eğitim uygulamalarını hızlı ve zorunlu bir şekilde hayata geçirmiştir. Bu süreç, eğitim sistemini hazırlıksız yakalamış ve birçok paydaş için yeni etik sorunları ortaya çıkarmıştır. Alanyazın taraması ve doküman incelemeleri sonucunda elde edilen bulgular etik sorunların akademik dürüstlük ihlalleri, erişim eşitsizliği ve adalet sorunları, öğretmen-öğrenci etkileşiminde etik problemler, akademik ve veri güvenliği ve mahremiyet ihlallerinde yoğunlaştığını göstermektedir:

Özellikle sınav ve ödev süreçlerinde ortaya çıkan akademik etik dışı davranışlar öğrencilerin kopya çekmesi ve ödevlerde intihal yapılması, eğitim değerlendirme sürecinin güvenilirliğini zedelemiştir. Bu durum, öğretmenlerin öğrencilerin öğrenme düzeyini doğru ölçmesini güçleştirmiş ve bu bağlamda uzaktan eğitimde değerlendirme standartlarının yeniden gözden geçirilmesini gerektirmiştir (Çelik ve Arslan, 2021; Çiftçi, 2023).

Eğitime erişim eşitsizliği özellikle sosyoekonomik düzeyi düşük öğrenciler için ciddi bir problemler oluşturmuştur. İnternet ve donanım erişimindeki farklılıklar, öğrenciler arasında öğrenme fırsatlarının eşit olmamasına yol açmış, eğitimde fırsat eşitliği ilkesinin ihlali olarak değerlendirilmiştir. Bu durum, politika yapıcıların ve eğitim yöneticilerinin dijital altyapı ve destek hizmetlerini güçlendirmesi gerekliliğini ortaya koymaktadır (Bozkurt, 2020; Geçer, Yıldırım ve Akgül, 2022).

Öğretmen-öğrenci iletişiminde ortaya çıkan etik sorunlar ise çevrim içi ortamda iletişim kanallarının sınırlılığı, özel hayatın gizliliğinin ihlali ve velilerin müdahaleleriyle ilişkilidir. Öğretmenlerin çevrim içi derslerde hazırlıksız olması, öğrencilerle etkili etkileşim kuramaması, online eğitimde öğrenme motivasyonunu olumsuz etkilemiştir. Bu durum, öğretmenlerin dijital pedagojik becerilerinin geliştirilmesi gerektiğini göstermektedir. (Akbulut ve Şahin, 2021; Darga, 2023). Levent ve Şallı (2022) tarafından yapılan araştırmanın sonuçları öğretmenlerin en çok yaşadığı etik sorunların "davranışa yönelik sorunlar" iken öğrencilerin en çok yaşadığı etik sorunlar ise "eşitsizlik sorunları" olduğunu ortaya koymaktadır.

Akademik ve internet etiği yetersizliği, öğrencilerin kişisel bilgilerinin ve görüntülerinin korunması açısından kritik bir boyut olarak öne çıkmıştır. Çevrim içi eğitimde öğrencilerin ev ortamlarının izlenmesi ve görüntülerinin kaydedilmesi, mahremiyet haklarının ihlali olarak değerlendirilmiş ve etik kaygıları artırmıştır.(Altıntaş ve Kara, 2022; Hotaman, 2025). Zorunlu uzaktan eğitimin örgün eğitimde yaygın hale gelmesiyle birlikte, kopya çekme, intihal, yıkıcı davranış, başkalarına saygısız davranma ve çevrimiçi kaynakların bilinçsiz kullanımı gibi konularda artan bir endişe olduğu görülmektedir.

Yücel ve Kasapoğlu-Tankutay (2023) tarafından Covid-19 sürecinde online eğitimde ilkokul, ortaokul ve lise olmak üzere bütün okul türlerinde öğretmenlerin en çok etik ikilem yaşadıkları kategorinin öğrencilerle ilgili etik ikilemler olduğu; bu etik ikilemleri çözerken de daha çok adalet, öğrencinin faydasını gözetme ve eşitlik ilkelerini dikkate aldıkları belirlenmiştir. Ayrıca aynı kategoride ilkokul ve lise öğretmenlerinin ortaokul öğretmenlerine göre daha fazla etik dışı davranışlar yaşadıkları tespit edilmiştir.

Araştırmanın sonuçları, Covid-19 sürecinde online eğitimde yaşanan etik sorunların çok boyutlu ve paydaşlar arası olduğunu ortaya koymaktadır. Alanyazında vurgulanan sorunlar, sadece öğrenci davranışları ile sınırlı kalmayıp, öğretmen, veli ve sistem kaynaklı etkenleri de kapsamaktadır. Bu bağlamda, eğitim politikalarının, öğretmen eğitimlerinin ve teknolojik altyapının etik boyutlar gözetilerek yeniden tasarlanması gerekliliği ortaya çıkmaktadır.

Sonuç olarak, Türkiye'de online eğitimde ders sürecinde ve dışında yaşanan etik dışı davranışlar, hem bireysel hem de sistemik düzeyde önlem alınmasını zorunlu kılmaktadır. Akademik yeterlik, fırsat eşitliği, öğretmen-öğrenci etkileşimi ve veri güvenliği konularında bütüncül bir yaklaşım benimsenmesi, gelecekteki online eğitim süreçlerinin daha etik ve sürdürülebilir olmasını sağlayacaktır.

Öneriler

Araştırmanın sonucu bağlamında; olası zorunlu uzaktan eğitim durumları için etik ilke modellerin geliştirilmesi bir gerekliliktir. Geliştirilen etik ilke modelleri bağlamında öğretmen, öğrenci ve velilerin bu ilkelere uymasını sağlamak önem taşımaktadır.

Uzaktan eğitimde kullanılan araçlar ile ilgili etik unsurlar başlığı altında canlı ders öncesi yapılması gerekenler: Canlı ders aracının gizlilik ve güvenlik politikaları dikkate alınmalıdır.

- İnternette güvenli bağlantılar seçilerek ders hazırlığı yapılmalıdır.
- Öğrencilerin programdaki kamera görüntüleri gerekmedikçe açılmamalıdır.
- Canlı dersi başlatırken, ders kaydıyla veya veri kullanımıyla ilgili kullanıcıların onayları alınmalıdır.
- Sonuç olarak, Covid-19 süreci, Türkiye'de eğitimde etik standartların yeniden gözden geçirilmesi gerektiğini ortaya koymuştur. Bu süreçten çıkarılan dersler, gelecekte olası krizlere daha hazırlıklı olunmasını sağlayacaktır.

Bu bağlamda öneriler şunlardır:

Politika yapıcılara: MEB, online eğitim süreçleri için kapsamlı bir etik kılavuz hazırlamalı; gizlilik, veri güvenliği ve akademik dürüstlük standartları belirlenmelidir.
Öğretmen eğitimcilerine: Öğretmenlere online ortamda etik davranış ve dijital pedagojik beceriler konusunda hizmet içi eğitim verilmelidir.
Öğretmenlere: Öğrencilere akademik dürüstlük, dijital vatandaşlık ve mahremiyet konusunda farkındalık kazandırılmalıdır.
Eşitsizliklerin giderilmesi: Dezavantajlı öğrencilere cihaz ve internet desteği sağlanarak fırsat eşitliği güçlendirilmelidir.
Araştırmaların çeşitlendirilmesi: Türkiye'de online eğitimde etik dışı davranışları farklı paydaşların bakış açılarıyla inceleyen daha kapsamlı araştırmalara ihtiyaç vardır.

Teşekkür

Bu çalışma TÜBİTAK 2224-B Yurt İçi Bilimsel Etkinliklere Katılım Desteği Programı tarafından desteklenmiştir.

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Artificial Intelligence in the Production of Evidence and Predictive Diagnosis of Student Dropount and Permanence in Basic Education

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Abstract

The rapid evolution of digital technologies has brought about significant changes in several areas, including education. Among these innovations, Artificial Intelligence is a promising resource for personalizing teaching, adapting it to the individual needs of teachers and students, in order to enhance learning. In educational management, studies on the phenomenon of dropout and retention in the educational context indicate that this phenomenon can be diagnosed in advance, based on the collection and systemic analysis of the conjunctural factors that precede it. Dropout can be mitigated through timely action by the responsible agents based on the results of the analysis of data generated by Predictive Artificial Intelligence. This study seeks to understand and explore Artificial Intelligence resources to support the diagnosis of educational dropout, which can be applied to studies on dropout in higher education and in the context of distance education. Its objective is to analyze the contributions of the use of Artificial Intelligence to produce evidence and predictive diagnoses related to the dropout and retention of students in the final years of Elementary School. The methodology used involved an exploratory, theoretical-bibliographic study of regulations and historical series of government data considered for the consolidation of the theoretical foundations of Artificial Intelligence in education, in the production of evidence of evasion and retention in basic education. A mapping of Brazilian and international literature was carried out on the use and contributions of Artificial Intelligence in educational management in the production of evidence for predictive diagnosis related to evasion and retention of students in the final years of Elementary School, focusing on the analysis of educational initiatives for the implementation or monitoring of school retention from the final years of Elementary School in the public education system of the Federal District, Brazil. The results contextualize the role of regulations and theoretical-methodological references regarding student evasion and retention in Basic Education in order to correlate the role of the educational institution in the cognitive, sociocultural, technical-professional and socio-emotional development of students. Evidence-based indicators will allow us to understand the real national and local scenarios of the reality of the final years of Elementary School in public schools in the Federal District. The relevance from a managerial and pedagogical point of view lies in the creation of actions to address the problem, in order to prevent dropouts from occurring and contribute to the engagement, motivation and retention of Elementary School students, mitigating the dropout phenomenon.

Keywords: Predictive Artificial Intelligence. Student Dropout. Educational Management.

Introduction

In the technological innovations present in education today, Artificial Intelligence is a promising resource for personalizing teaching, adapting it to the individual needs of teachers and students in order to enhance learning. In educational management, studies of the phenomenon of dropout and permanence in the educational context indicate that this phenomenon can be diagnosed in advance, based on the collection and systemic analysis of the conjunctural factors that precede it.

Student evasion and dropout (Silva Filho; Araújo, 2017; Borja; Martin, 2021) have been approached from different points of view and converge in the sense that it is a problem of great dimensions in all stages and educational modalities. Knowing and exploiting Artificial Intelligence resources to support the diagnosis of dropout can be applied to studies of dropout in basic education.

Studies of the phenomenon of dropout and permanence in the educational context (Branco, 2020; Unibanco, 2020; Gil, 2018; Almeida, 2011; Burgos et al, 2014; Darwich et al, 2019; Distrito Federal, 2020; Unicef, 2021; Fritsh et al, 2021) indicate that this phenomenon can be diagnosed in advance by collecting and systematically analyzing the situational factors that precede it. Once the phenomenon has been detected and understood, evasion can be mitigated through timely action by the agents responsible. These studies make different

contributions, ranging from theoretical and methodological contributions to the analysis of cultural, social, economic and political factors and variables in this phenomenon, to historical data collection and analysis, on scales ranging from the municipal to the federal level.

These studies take into account external and internal, economic, psychological, didactic-pedagogical and infrastructure factors. Evidence-based indicators will provide insight into the real national and local scenarios of the reality of the final years of elementary school in the public schools of the Federal District. The relevance from a managerial and pedagogical point of view lies in the creation of actions to tackle the problem, in order to prevent dropout from occurring and contribute to the engagement, motivation and permanence of elementary school students, mitigating the phenomenon of dropout.

The methodology used involved an exploratory, theoretical-bibliographical study of the regulations and historical series of government data considered for the consolidation of the theoretical foundations of Artificial Intelligence in education, in the production of evidence of dropout and permanence in basic education. A mapping of the Brazilian and international literature on the use and contributions of Artificial Intelligence in educational management in the production of evidence for predictive diagnosis related to the dropout and permanence of students in the final years of elementary school was carried out, focusing on the analysis of educational initiatives to implement or monitor school permanence from the final years of elementary school in the public education network of the Federal District, Brazil.

Theoretical Reference

The rapid evolution of digital technologies has led to significant transformations in various areas, including education. Among these innovations, Artificial Intelligence has emerged as a promising resource for personalizing teaching, adapting it to the individual needs of teachers and students in order to enhance learning.

In education, Artificial Intelligence can be used to promote equity in the educational environment, by targeting the needs of networks and each student in a specific and individualized way. In the fight against dropout, Artificial Intelligence can be used to identify the indicators that cause it, and mechanisms can be devised that allow it to be identified predictively, i.e. before it even occurs.

Dropout can be mitigated through timely action by the agents responsible, based on the results of data analysis generated by Predictive Artificial Intelligence. This study seeks to learn about and explore Artificial Intelligence resources to support the diagnosis of educational dropout, which can be applied to studies of dropout in higher education and in the context of distance education. It aims to analyze the contributions of using Artificial Intelligence to produce evidence and predictive diagnoses related to the dropout and permanence of students in the final years of elementary school.

Diagnostics on student dropout and permanence in the final years of elementary school, made possible by Artificial Intelligence resources based on data that enables greater autonomy for school management. These diagnoses involve variables such as: factors, conditions and perspectives, capable of producing consolidated information to understand and enable management autonomy in discussing solutions aimed at keeping students in the educational institution, guaranteeing the right to education and the continuity of studies in the stages of Basic Education.

Decree No. 11,079/2022 (Brazil, 2022), which established the National Policy for Learning Recovery in Basic Education, allows different municipal, state and federal, public and private networks to identify and resolve the impacts of the Covid-19 pandemic on students. It allows diagnosis and actions related to permanence in the schooling path, seeking to address gaps and gaps in their learning in recent years.

Contribuições da Educação Baseada em Evidências Geradas por Inteligência Artificial

Education based on evidence generated by Artificial Intelligence can contribute to combating dropout in the final years of elementary school. Evidence-based educational data collected through technologies (Boudett et al, 2020; Godwin; Rouleau, 2024; Becker, 2022; Januzzi, 2024; Sharley; Murnane, 2020; Thomas; Pring, 2007; Monteiro; Carvino, 2015; Filatro, 2021; Kitchin, 2014; Lemos, 2020; Trevisol and Nerotka, 2016) can be generated in the context of the school and educational system, allowing for a connection with student learning.

The use of school-generated evidence to improve teaching and learning and produce data to generate educational systems based on performance indicators and continuous monitoring can involve the development and use of Artificial Intelligence in the production of evidence used for decision-making by schools and education departments.

Artificial Intelligence is an expanding field in all areas of knowledge and in the context of this study, it involves various precautions in relation to the data collected and generated so that it provides valid evidence to support diagnoses and public policies in basic education. Vicari (2018) defines Artificial Intelligence as the science of producing intelligent machines that play a role in improving educational systems. Artificial Intelligence in Education is a multidisciplinary area, encompassing the use of technologies in teaching and learning systems, as well as Artificial Intelligence's ability to adapt teaching to students' individual needs through (*learning analytics*) and pattern identification.

The contributions of Artificial Intelligence at all educational levels, to monitor, teach and evaluate student learning, make it possible to build evidence that can support public policies. According to Abreu (2023), Artificial Intelligence enables predictive analysis to improve decision-making, carry out assessments, provide real-time formative feedback to students, supporting their studies and helping them to identify weak areas and improve their performance.

Nunes and Mercado (2025) investigate the use and effects of Artificial Intelligence in basic education based on a critical analysis of existing studies to understand the negative and positive impacts of Artificial Intelligence in education, identifying strategies aimed at promoting equity in its educational implementation. The results show that there is an urgent need to implement strategies that guarantee equity and accessibility for all students. They highlight the relevance of educational policies that consider the needs of disadvantaged communities, including improved teacher training and the provision of technological resources accessible to all.

Artificial Intelligence has played a significant role in transforming the educational landscape, especially in basic education (Inep, 2019). Its impact has been evident, bringing with it a series of benefits that revolutionize the way students absorb information and teachers adapt their teaching approaches, opening doors to more personalized and effective learning (Silva et al, 2023; Pedro et al, 2019).

Artificial Intelligence has the ability to analyze large data sets and identify patterns, allowing for the personalization of teaching (Picão et al,.2023; Chen et al, 2020; Vicari, 2021; Faceli et al, 2019; Pedro et al, 2019; Evangelista, 2024, Gama; Mercado, 2025). Personalization driven by Artificial Intelligence (Lima; Kochhann, 2023; Pedro et al. 2019) allows students to learn at their own pace, filling in knowledge gaps and strengthening weak areas.

Artificial Intelligence in Educational Management

In school management, educational management systems powered by Artificial Intelligence (Januzzi, 2024) can help manage data, automate administrative processes and even predict educational trends, allowing managers to make more informed and strategic decisions (Pedro et al, 2019).

The effectiveness of Artificial Intelligence in basic education is highlighted by Owan et al. (2023), Silva et al. (2023) and Figueiredo et al. (2023). Studies show the relevance of Educational Management Information Systems enhanced by Artificial Intelligence, highlighting how these systems are being used to improve educational strategies based on more accurate and automated data.

There is a convergence in the need to adapt educational systems to the demands of society driven by Artificial Intelligence, as well as the importance of collecting data for educational indicators.

Artificial Intelligence in school management makes it possible to analyze data to predict student performance and identify problems quickly. At school, for example, reports are generated through systems or data tools on the performance of each student. In theory, these should be directed towards the objectives of the pedagogical policy of providing efficient personalized teaching, but they can be the target of illegal access and have repercussions in discriminatory actions.

Data generated by Artificial Intelligence: ethical issues

Mercado et al (2025) explore the lack of ethical norms that can guide human behavior in the face of machines that generate virtual products that offer risks to the integrity of subjects and cause situations of emotional and cognitive vulnerability, requiring reflection in online educational contexts. They address ethical issues relating to the care that needs to be taken at all educational levels in the use of Artificial Intelligence in monitoring, teaching and learning assessment activities.

In the Brazilian educational context, such as that of public schools, the use of Artificial Intelligence in teaching can offer new opportunities to overcome pedagogical barriers and improve students' academic performance.

Algorithms based on Artificial Intelligence are emerging as a tool to support educational management decisions. These algorithms have the ability to analyze large volumes of educational data, identify learning patterns, predict

difficulties and recommend personalized pedagogical interventions. However, despite the promising potential, the application of Artificial Intelligence in education is still a developing field of study, especially in Brazil, where educational disparities represent an additional challenge.

Thus, scientific research into the use of Artificial Intelligence algorithms in education is still at an emerging stage, especially with regard to their specific application in educational management.

Conclusions

This study sought to fill an important gap in the literature by exploring how Artificial Intelligence can be integrated into educational management, specifically in the analysis of evidence related to the evasion and permanence of students in the final years of elementary school in an effective way, promoting a personalization of teaching that is both practical and theoretically based.

The aim of the study was to analyze the contributions of using Artificial Intelligence to produce evidence and predictive diagnoses related to the dropout and permanence of students in the final years of elementary school; to build a state of knowledge of the national and international literature on the use of Artificial Intelligence in the production of evidence aimed at the dropout and permanence of students in basic education.

The results contextualize the role of regulations and theoretical-methodological references regarding student dropout and permanence in basic education in order to correlate the role of the educational institution in students' cognitive, socio-cultural, technical-professional and socio-emotional development. Evidence-based indicators will provide insight into the real national and local scenarios of the reality of the final years of primary education in the public schools of the Federal District. The relevance from a managerial and pedagogical point of view lies in the creation of actions to tackle the problem, in order to prevent dropout from occurring and contribute to the engagement, motivation and permanence of elementary school students, mitigating the phenomenon of dropout.

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Climate change and early years mathematics learning: an approach through the digital game porcentagee

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Abstract

In view of the climate emergency and the need to address it in the basic education curriculum, this paper presents the digital game Porcentagee as a pedagogical proposal for 5th grade students. The game combines environmental awareness with the teaching of percentages, promoting interdisciplinarity between mathematics and science, based on Ausubel's Theory of Significant Learning. Developed on the FazGame platform, the game uses mathematical challenges related to the main greenhouse gases (CO_2, CH_4 and N_2O) to stimulate knowledge, critical-reflective thinking and awareness of the causes and consequences of climate change. Set in outdoor spaces such as squares and beaches, the player progresses by answering percentage questions and eliminating sources of gas emissions, being rewarded with symbolic items. The proposal is in line with the Common National Curriculum Base (BNCC) and seeks to guarantee learning rights by integrating environmental aspects with mathematical content in a meaningful way.

Keywords: Climate Emergency, Greenhouse Gases, Digital Games, Teaching Mathematics, Percentage.

Introduction

The environmental crisis, intensified by climate change, demands urgent educational action (Artaxo, 2021). The climate emergency exposes inequalities and demands critical reflection on the future (Jacobi et al., 2011). Although it is a natural process, global warming has been accelerated by an excess of greenhouse gases, a consequence of the production and consumption model in force since the Industrial Revolution (UNESCO, 2020).

The changes driven by digital technologies require education to overcome traditional models and adopt innovative practices (Gomes & Gomes, 2015). In this scenario, digital games stand out as effective resources, as they promote meaningful interactions and bring teaching closer to reality (Petry, 2016). Huizinga (2007) reinforces this idea by stating that play is inherent to human beings and makes learning more engaging.

Learning based on digital games

According to Huizinga (2007), a game is a voluntary activity with its own rules, which provides a temporary escape from reality. In the educational context, digital games have been used in Game-Based Learning (GBL) for their potential to engage students in unmotivating content (Prensky, 2021). This approach favors playful learning and can involve both adapted commercial games and platforms that allow users to create games themselves (Schelemmer & Lopes, 2016).

Based on the mechanics, dynamics, and aesthetic structure of digital games (Zichermann & Cunningham, 2011), and considering children's familiarity with technology (Prensky, 2001), ABJD values interactive learning by incorporating game techniques (Sena et al., 2016). In this scenario, the FazGame platform stands out, which was used to create the Porcentagee educational game and develop its design.

The FazGame platform and the proposal presented

FazGame is a Brazilian platform for creating narrative games that encourages reading, text production and the development of creativity, allowing students to build their own games with the support of learning paths and artificial intelligence. In addition, the resource promotes the joint construction of knowledge between teachers and students, through motivating games that integrate elements such as challenge, learning goals and a story that connects both (Coelho & Costa, 2016). The game can be built and run on computers, tablets and smartphones, and made available free of charge.

From the icons located on the right-hand side (Figure 1), users can develop the game.

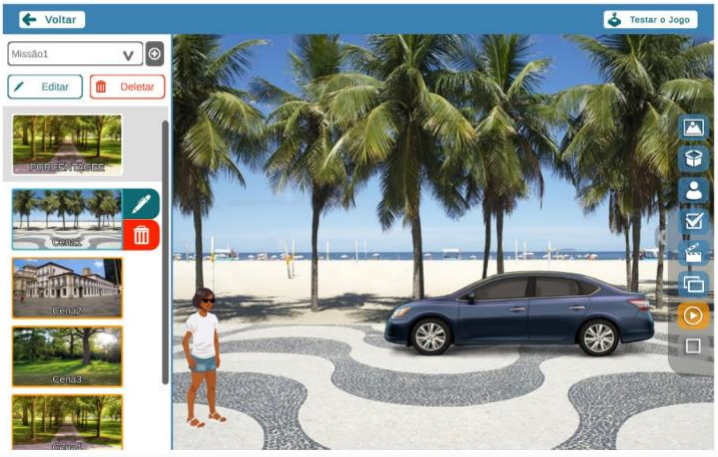

Figure 1 - Digital game production area on the FazGame platform.

Game design is done using the “Change Scenario”, “Add Object” and “Add Character” icons, while actions and interactions are programmed using the “Edit Scene” tool (Figure 2).

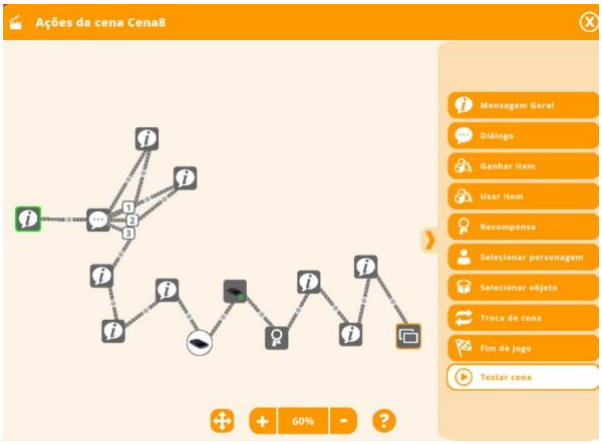

Figure 2 - Digital game production area on the FazGame platform.

The game is programmed in flowchart format in the “EditScene” tool, allowing you to intuitively insert messages, dialogs, rewards, items, scene changes and test the game.

Theoretical foundation of learning adopted in the design of the digital game

Ausubel's Significant Learning Theory guided the development of the game by seeking to reinforce and expand concepts already present in the student's cognitive structure. According to Moreira and Masini (1982), this process occurs when new information is meaningfully integrated into previous knowledge, contributing to its differentiation and stability (Moreira, 2006).

Another aspect of Ausubel's Theory of Significant Learning, considered in the design of the game, is that the material to be presented to the student should be potentially significant, i.e. “[...] the material to be learned should be relatable (or incorporable) into the learner's cognitive structure in a non-arbitrary and non-literal way”, a condition for significant learning to occur (Moreira, 2006, p.19).

Learning objectives worked on in the game

The digital game was built based on the BNCC (Brazil, 2018), addressing the content of percentages through mathematical questions that promote critical thinking about climate problems. The game aims to (re)learn about greenhouse gases, gain a historical understanding of CO_2 emissions by major powers, and reinforce the calculation of percentages and fractions through individual strategies, such as mental calculation.

The digital game Porcentagee, a term originated in Portuguese from the combination of the word “porcentagem” (percentage) and GEE, “Gases de Efeito Estufa” (Greenhouse Gases), is available for computers on the FazGame platform at https://www.fazgame.com.br/games/unity_editor?published_game_id=3161, and its general objective is to identify the main Greenhouse Gases and the main sources of emissions of these gases by solving mathematical challenges involving percentages. Thus, based on the environmental theme, the percentage content was developed in association with one of the emerging themes from the perspective of climate change, bringing the narrative of Greenhouse Gases emissions to the forefront.

The game takes place in open-air settings, such as squares and beaches, where the player, represented by a human avatar, receives information about polluting gases and answers percentage questions. Each time they get it right, they progress through the stages, eliminate the corresponding gas, and win prizes called inventories.

The game is structured into three missions, each dedicated to a greenhouse gas – CO_2, CH_4 and N_2O – and their respective environmental impacts. At each stage, the player receives information on the characteristics and emission sources of the gases, the percentages of which serve as the basis for the mathematical percentage challenges. The aim is to eliminate polluting sources in order to curb global warming, with the player's progress stimulated by rewards and scores.

Thus, to progress through each phase of the mission, the player must solve challenges related to percentage content, such as associating 10%, 25%, 50%, 75% and 100% with the respective fractions: tenth part, fourth part, half, three quarters and one whole. In the event of an error, the game provides informative feedback, allowing the player to return to the challenge until they get the answer right (Figure 3).

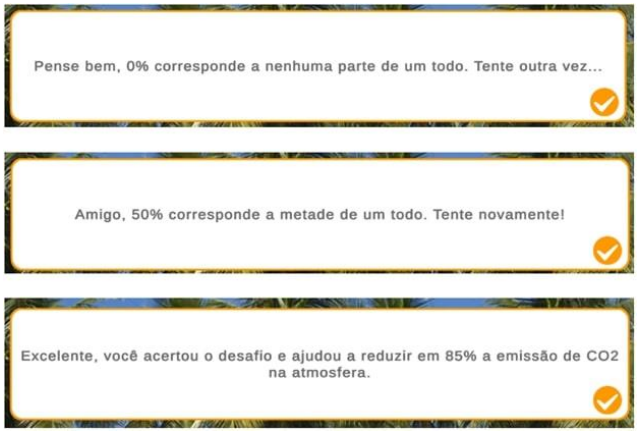

Figure 3: Feedback for mistakesandsuccesses.

By getting it right, the player not only eliminates a percentage of Greenhouse Gases, but also earns bonuses, such as objects (called inventory), and also accumulates points for the total percentage of gases eliminated from the atmosphere.

Below, we'll explain the stages of the game:

Phase 1: Emissionof Carbon Dioxide (CO_2)

Objective: Eliminate the main sources of carbon dioxide emissions

Game mechanics: The player must solve percentage challenges to acquire items and eliminate the main sources of CO_2 emissions: fossil fuels (85%), changes in land use (10%) and cement manufacturing (5%) (Figure 4).

Figure 4: Initial screen shots of scenes 1, 2 and 3, mission 1.

Scenes 1, 2 and 3 of phase 1 are associated with a source of CO_2 emissions: respectively fossil fuels, cement manufacturing and land use changes, in which the player must solve one of the mathematical challenges associated with the percentage.

Phase 2: Emission of methane gas (CH_4)

Objective: Eliminate the sources of methane gas production

Game mechanics: The player must solve percentage challenges to collect items in the inventory and eliminate the main sources of CH_4 emissions: fossil fuel extraction (29%), livestock (27%), waste decomposition (23%), rice cultivation (11%) and biomass burning and biofuel production (10%).

Figure 5: Initialscreenshotsofscenes 1, 2 and 3, mission 2.

The three scenes in the phase on CH_4 present its main emission sources: fossil fuel extraction and livestock farming, waste decomposition and rice cultivation with biomass burning, demanding percentage challenges.

Phase 3 – Nitrous oxide emissions (N_2O)

Objective: Eliminate sources of nitrous oxide gas production

Game mechanics: To progress in the game, the player has to solve percentage challenges and, by doing so, gain items in their inventory that allow them to eliminate N_2O emitting sources, such as farming, rivers and industry.

Figure 6: Initial screens of scenes 1, 2 and 3, mission 3.

Scenes 1, 2 and 3 of the mission deal with the main sources of N_2O emissions — the agricultural sector, burning biomass/biofuels and contaminated rivers — with percentage challenges at each stage.

At the end of each mission, the player is informed of the percentage of gases eliminated and, on completing all the stages, receives a message of recognition for their work on behalf of the environment.

Proposals for using the digital game Porcentagee in education

The Porcentagee digital game can be integrated into the school curriculum as a resource for environmental awareness, in line with the legislation that guides environmental education across the board (Brasil, 2018). It also complies with the BNCC in the 5th year of elementary school, by working on skill EF05MA06, which associates percentages with equivalent fractions using strategies such as mental calculation.

Porcentagee also stimulates interdisciplinarity between mathematics and science, promoting the integration of knowledge and reinforcing cross-curricular teaching (Nogueira, 2001; Brasil, 2013). By combining mathematical content and environmental themes, the game shows potential for enriching learning, and is recommended for future studies on its pedagogical effectiveness.

Conclusions

We are immersed in a context of intensified use of digital technologies (Campos, 2021), while the impacts of global warming are becoming increasingly evident, requiring concrete actions to mitigate them (IPCC AR6, 2021). Raising awareness about GHG emissions is one of these actions, and the new generation — the so-called digital natives (Prensky, 2001) — will play a key role in the necessary changes. In this scenario, the school environment stands out as a privileged space for the development of conscious attitudes, which can be integrated into teaching-learning processes, as pointed out by UNESCO (2020).

In view of this, the digital game Porcentagee, developed on the FazGame platform and aimed at 5th graders, is an educational proposal that combines mathematical knowledge with environmental awareness. Through a playful and meaningful approach, the game contributes to understanding the impacts of Greenhouse Gases and to developing the skills set out in the BNCC (Brazil, 2018), especially with regard to percentage content. Thus, the proposal reaffirms the potential of digital games as pedagogical tools capable of forming critical and aware subjects, integrating knowledge and values that are essential to building a more sustainable future.

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Addressing climate change in higher education in pedagogy: an analysis of the use of an interactive digital game

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Abstract

Climate change is one of the greatest challenges facing humanity today. The increase in greenhouse gas emissions, global warming, the melting of polar ice caps, and extreme weather events are alarming indicators of this global phenomenon. In this context, the use of interactive digital games is one of the strategies to address climate change in schools, as they allow users to interact with a virtual environment through rules, objectives, challenges, and feedback. Interactive digital games emerge as a promising artifact in active and meaningful learning about climate change, as they allow real simulations, decision-making, and collaboration among students, enabling the development of cognitive, social, and emotional skills; such as critical and creative thinking; problem-solving, and communication. The paper presents the results of the validation of an interactive digital game by Pedagogy students from the Federal University of Alagoas regarding the potential and possibilities of implementing the interactive digital game "Environmental Changes, That Is the Question!" in Basic Education. The aim of this study was to answer the following research questions: how can students' perceptions of the potential, possibilities and implementation of the game contribute to the development of innovative pedagogical practices? How important do students consider the implementation of the interactive digital game to be for basic education students? The methodology involved applied and descriptive research, through a case study. The study aimed to: analyze the perceptions of Pedagogy students about the potential, possibilities and implementation of the interactive digital game "Environmental Changes, That is the Question!" in Basic Education; identify the characteristics and objectives of the interactive digital game about climate change; evaluate the results and impacts of using the interactive digital game on students' learning and attitudes about climate change; and answer the questionnaire on Google Form about the potential for implementing the interactive digital game as a pedagogical artifact for teaching and learning. The theoretical framework focuses on the curricular inclusion of education for climate change and interactive digital games as educational resources. Considering the data generated, it is possible to implement the game in Basic Education, collaborating with the process of awareness-reflection-mitigation of climate change. The game contributes significantly to the teaching and learning process of Pedagogy students. With this approach, we intend to contribute by encouraging students, in their civic formation, to become engaged and responsible in relation to the preservation of the environment, with an emphasis on awakening environmental awareness and promoting their critical-reflective thinking.

Keywords: Climate change, Interactive digital game, Higher education, Pedagogy.

Introduction

Climate change is one of the biggest challenges facing humanity in the 21st century. Increased greenhouse gas emissions, global warming, melting ice caps and extreme weather events are just some of the alarming indicators of this global phenomenon. According to the Intergovernmental Panel on Climate Change (IPCC), human activities are the main cause of the increase in average global temperature, which could have serious consequences for biodiversity, food security, health, the economy and society.

In this scenario, one of the possible strategies for addressing climate change in educational institutions is the use of interactive digital games. These technological resources allow users to interact with a virtual environment through rules, objectives, challenges and feedback. The use of interactive digital games has emerged as a promising artifact for active and meaningful learning on this subject. Through real-life simulations, decision-making and collaboration between students, the game enables the development of cognitive, social and emotional skills, such as critical and creative thinking, problem-solving and communication between the participants involved.

This study aims to fill gaps in the current educational landscape and promote education on environmental issues in a way that is accessible and engaging for students. In the context of the interactive digital game, theoretical

perspectives and approaches can be broadened by including characters, stories and problems for which students are invited to play roles, thus enabling more active participation (Filatro & Cavalcanti, 2018).

From this perspective, we sought to answer the following research questions: How can the perceptions of UFAL pedagogy students about the potential, possibilities and implementation of interactive digital games in basic education contribute to the development of innovative pedagogical practices? How important do the students consider the implementation of the interactive digital game to be for basic education students? Finally, this article also aims to provide theoretical and practical support for teachers and students of higher education in pedagogy who want to use or develop interactive digital games on climate change in their educational activities in the classroom.

The aim of this study was to analyze the perceptions of Pedagogy students at the Federal University of Alagoas (UFAL) about the potential, possibilities and implementation of the interactive digital game "Environmental change, that's the question!" in Basic Education. The specific objectives of this article were: to identify the characteristics and objectives of the interactive digital game on climate change used in the research; to evaluate the results and impacts of using the interactive digital game on students' learning and attitudes towards climate change; and to answer the questionnaire on the google form about the potential for implementing the interactive digital game as a pedagogical artifact in students' learning.

The aim of the study is to make a significant contribution to the learning process of Pedagogy students. To this end, a theoretical discussion was held on the themes linked to Climate Change: urban socio-environmental challenges; education for climate change (EMC), awareness-raising in schools. The aim of this approach is to help encourage students to become engaged and responsible citizens in relation to environmental preservation, with an emphasis on raising environmental awareness and promoting critical-reflective thinking (Melo, Torres & Nobre, 2018).

Theoretical Reference

Addressing environmental issues across the board allows students to understand the complexity of environmental issues and realize the importance of acting together for sustainability (Brasil, 2010). As pointed out by Ferreira et al. (2020), engaging students in games provides the opportunity to develop skills such as teamwork and resilience, thus encouraging students to develop decision-making skills and empathy.

Integrating interactive digital games into the educational environment is in line with the aim of offering a more engaging learning experience, providing meaningful learning, as proposed by Ausubel (1968). It emphasizes the principle that learning is more promising when new knowledge is related in a meaningful way to students' previous experiences. Considering this perspective, Clark, Tanner-Smith and Killingsworth (2016) emphasize the importance of interactive digital games in both learning outcomes and research, due to their accessibility and adaptability, making them easily integrated into everyday educational life.

Interactive digital games emerge in this scenario as an educational artifact that incorporates attributes with a range of benefits to provide a variety of advantages to teaching and learning activities (Prensky, 2003). According to Gros (2003), games used for educational purposes need to have clearly established learning objectives and teach the content of curricular components, as well as promoting the development of relevant strategies and skills in order to enhance students' cognitive and intellectual capacity.

As school curricula increasingly integrate sustainability-related themes, students are being trained to deal with complex environmental challenges such as climate change, biodiversity conservation and natural resource management. These skills not only benefit future generations, but also have an immediate impact on their communities and the world at large.

It is important to understand that education is a much broader process than integrating and connecting different curricular components. Therefore, interdisciplinarity emerges as an approach to promote a more meaningful and relevant education for students, with the aim of strengthening their ability to solve problems in an adaptable way, "in which the formation of critical thinking becomes essential" (Façanha, Chianca & Feliz, 2019, p. 43).

Methodology

This research is characterized as descriptive, since it aims to highlight a certain phenomenon (Gil, 2013), the characteristics of an interactive digital game focused on the theme of environmental change, as well as involving the natural sciences. The research was carried out using a qualitative-quantitative approach, in the form of a case study. According to Rebelo et al. (2020), the case study is characterized as exploratory-descriptive research, as it aims to identify relationships between variables, obtaining data from the observation of situations, recording them

and then analyzing them, in order to obtain relevant information to organize data and gather as much detailed information as possible about the object of study in order to preserve its unique character.

The participants involved were first-year students on the evening Pedagogy degree course at UFAL - Campus Maceió, in the Education and Digital Information and Communication Technologies course, academic term 2023.1.

The methodological procedure for data collection was divided into three stages: In the first stage, the game was built and the story of the environmental disaster in Maceió, a Brazilian coastal city, was explained and presented. The second stage was the presentation of the game, which consisted of applying the online questionnaire built in Google Forms. Access to the interactive digital game through the *link*: https://forms.gle/YXwvrAAZMaPJsnFB6. And the script for the interactive digital game in *link*: https://docs.google.com/document/d/1yXs5ytKMUUfiLowHzAJITncPO3KsIoBquzpNTVKvsgA/edit?usp=sharing.

In the 3rd stage, the game was evaluated, with 14 open and closed questions, in order to assess the students' experience with the interactive digital game, their learning about local environmental changes and their perception of the use of the game as a teaching resource. The evaluation form can be found on the blog *link* https://ticeducaufal.blogspot.com/. The methodological structure used to design this interactive digital game is illustrated in figure 1.

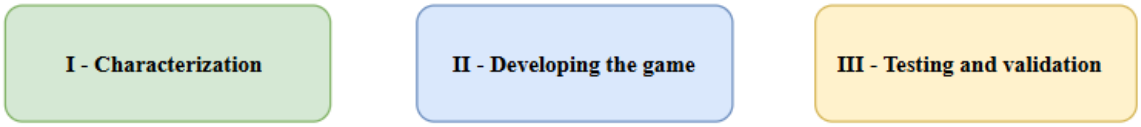


Figure 1. Estrutura metodológica do jogo digital interativo.

These steps are designed to capture a holistic view of the game's impact on educational dynamics. This will make it possible not only to assess its potential as a pedagogical resource, but also to understand how it integrates into the learning environment and how it influences student performance. Therefore, the data collection methodology outlined here represents a fundamental part of the study, ensuring a rigorous and comprehensive approach to investigating the use of interactive digital games as teaching resources.

Pedaste et al. (2015) suggest three pedagogical paths for bringing scientific research into the classroom. These paths will guide students through the investigation phase. (a) Questioning-Exploration-Data Interpretation-Conclusion orientation: questioning and exploration can be repeated; (b) Hypothesis Generation-Experimentation-Data Interpretation-Conclusion orientation: data interpretation can be followed by more hypothesis generation and experimentation; (c) Questioning-Hypothesis Generation-Experimentation-Data Interpretation-Conclusion orientation: the loop of hypothesis generation, experimentation and data interpretation can be repeated. Revising the questions may be necessary after interpreting the data, with a greater focus on the hypotheses. Communication and reflection are key at each stage.

Stage 1 - the researchers contextualized the topic, to clarify the current situation in relation to local environmental changes and assess the students' prior knowledge on the subject. Based on the results obtained, the researchers directed their actions towards meeting the greatest needs identified among the students, taking into account their individual particularities. Stage 2 - detailed and comprehensive development of the script for the interactive digital game, thus establishing a solid guide that will lead to an engaging and dynamic experience for the students. Step 3 - The teacher responsible for the curricular component provided a link on the blog to the interactive digital game and projected it onto the classroom screen, allowing students to access the game individually in the computer lab. In addition, the questionnaires were sent via WhatsApp to the class group. As some computers did not have internet access, some students accessed the questionnaire via their cell phones.

In stage 4 - the students chose the characters they wanted to interact with. In stage 5 - once they had made their choice, the students answered multiple-choice questions, with two alternatives for each question. Finally, stage 6 covers the testing and validation phase of the game. In this phase, the collaboration of the students takes center stage. In this scenario, they were invited to participate actively, receiving a link to access the interactive digital game and the game evaluation, subsequently, to evaluate the experience.

Table 1 details the characteristics of each character, as well as the attributions corresponding to each character chosen by the student before starting the game.

Characters		Assignment
	Environmental Engineer	An environmental engineer is a specialist in analyzing and solving problems related to the environment. Their mission is to uncover the culprits behind the environmental disaster. So the specialist will examine evidence, carry out chemical tests and interview possible suspects. Their expertise will be crucial to finding the root cause of the problem.
	Biologist	The biologist has extensive knowledge of marine ecosystems and is responsible for mapping the extent of the environmental damage. She will investigate the health of the local fauna and flora, collecting samples and recording the damage caused. Her findings will be essential to understanding the seriousness of the disaster and its consequences.
	Entrepreneur	The businessman is the main suspect in the environmental crime. However, the local authorities will begin an investigation to determine his innocence or guilt, while he is willing to collaborate to uncover the truth behind the disaster in the region.
	Resident	The resident affected by the disaster is the active voice of the community as she witnesses the devastating effects of the pollution on the lakes and the sea up close. Her mission is to mobilize residents, gather information about the city's past and its connections to industry. Her perspective will help unite the community and keep them focused on the search for the truth.

Table 1. Characters and roles of each player chosen.

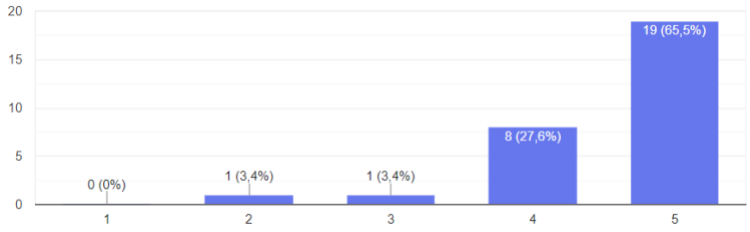
Results

In this section, we highlight students' perceptions of the game “Environmental change, that's the question!” from the perspective of future Kindergarten teachers, with the aim of validating it for use as a Virtual Learning Object (VLO) in Basic Education. In addition, this analysis helped to identify their level of prior knowledge on the subject of environmental change, climate change, education and digital information and communication technologies. The students participated by signing the Agreement Form, which was included in both the game and the game evaluation form.

These perceptions were obtained through a qualitative and quantitative analysis of the data generated on the interactive digital game form used in this research. This form had the participation of 29 students, and was complemented by a digital questionnaire, which received responses from 29 Pedagogy students at UFAL. The age range of the respondents was as follows: 17 students were between 16 and 20 years old (58.6%), 6 were between 21 and 25 years old (20.7%), 4 were between 26 and 30 years old (13.8%), and 2 were over 30 years old (6.9%).

Based on the results of the survey, a large proportion of Pedagogy students chose the resident character as the main one to represent this plot, with a total of 8 votes, closely followed by the environmental engineer, who received 7 votes. A biologist and a businessman were also significantly represented, with 5 votes each. This choice may reflect the importance of residents as protagonists in the search for truth and justice in the midst of the environmental disaster that affected the city.

The analysis of the following question takes into account the format of the answers given to some of the questions on the form, namely: (1) Strongly Disagree; (2) Disagree; (3) Neutral; (4) Agree and (5) Strongly Agree, which were aimed at understanding the proposed statements, thus using the Likert scale (1932). In this respect, Poynter (2010) points out that it is a way of understanding in which sense the respondent positions themselves in relation to the questions, either positively or negatively. Graph 1 illustrates the students' perception of the ease of use and navigation of the interactive digital game, corroborating the statement: The game is easy to use and navigate.



Graph 1. Gameplay analysis

Taking as a starting point the pedagogy student's reflective analysis of the game in terms of its applicability to basic education, 65.5% of the participants said that they totally agree that the interactive digital game is easy to use and navigate, while only 27.6% agreed that the game is easy to use. Only 3.4% responded neutrally, and 3.4% disagreed that the interactive digital game is easy to use and navigate in the app. Reflecting this data, it can be seen that there is a positively greater focus on gameplay, thought of as an application for use in Basic Education. Given that 72.4% of these Pedagogy students have already had the opportunity to play the game as part of their training (answers obtained from the questionnaire), their analysis becomes extremely enriching when evaluating the applicability of this game to Basic Education.

Considering this percentage of 72.4% positive responses to the use of games as part of their pedagogical training in the course, we believe that the use of interactive digital games as a pedagogical artifact is becoming an increasingly common practice in the educational context. With regard to the implementation of games in basic education, we asked them to express their opinion on the importance of incorporating interactive and motivating digital games into the teaching process. More specifically, through a statement, they were asked how vital they considered the use of this type of game to be for the construction of knowledge and, consequently, for the learning process, especially in the context of climate change.

Conclusions

Considering the objectives outlined in this study, we observed a comprehensive and relevant approach to understanding the perceptions of Pedagogy students regarding the use of the interactive digital game “Environmental change, that's the question!” in Basic Education. The analysis of the game's characteristics, objectives and impact reveals its important contribution to the development of innovative pedagogical practices to address EMC issues.

The use of digital games in basic education can represent an important link between disciplinary knowledge and environmental issues, providing more meaningful learning. It also offers the opportunity to work interdisciplinarily, integrating different curricular components and enriching learning. As a pedagogical resource in basic education, it tends to provide a dynamic and participatory learning experience. The students contributed significantly to improving the game by being asked to evaluate which aspects needed changes, corrections and/or additions to make it a more promising educational artifact. Some suggestions included the addition of more characters, images and dialogues between them; others suggested the inclusion of more interactive quizzes, more options for choices and possibilities for different outcomes, while others highlighted the need for more questioning and interaction. When validating the game as a digital artifact for use in Basic Education as an instrument for raising awareness, reflection and acquiring knowledge about climate change and emergencies, the UFAL Pedagogy students highlighted that the game is easy to use and navigate, suitable for the level of the students, and stated that it is feasible to integrate it into the school curriculum.

Considering the aforementioned results, we conclude that the interactive digital game “Climate change, that's the question!” can be a useful and innovative pedagogical artifact for teaching and learning about climate change in basic education, allowing these students, according to their conceptions of its validity as a digital resource for implementation at that level, to broaden their knowledge of environmental issues, develop reasoning, critical analysis, decision-making and problem-solving skills, as well as stimulating attitudes of awareness, sensitization and mobilization in relation to this area.

Acknowledgements

I would like to thank the students, trainees and teachers of the Pedagogy course at UFAL for the exchange of knowledge, the enriching debates and the collaboration throughout this journey. I extend my gratitude to the students who took part in the research, sharing their perceptions and experiences, which contributed so much to understanding the pedagogical use of the digital game "Climate change, that's the question!" in tackling climate change in primary education. Finally, I would like to thank everyone who, directly or indirectly, was involved in this learning process. Every gesture of support was fundamental in making this work a reality and validating the interactive digital game.

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Impact of Generative AI-Based Educational Videos on Accessibility, Cognitive Load, and Engagement: A Mixed Methods Research

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Abstract

This study examines the impact of generative artificial intelligence (GenAI)-created educational videos on graduate students' academic performance, cognitive load, and video engagement. A sequential explanatory mixed methods design was implemented with 84 participants divided into two experimental groups and one control group. Experimental groups watched GenAI-based videos (visual-enhanced and avatar-based), while the control group watched human-narrated videos. Quantitative data were collected via a knowledge test, Cognitive Load Scale, and Video Engagement Scale; qualitative data were obtained from structured interviews. Findings revealed no statistically significant differences between groups in academic performance or cognitive load, although experimental groups scored higher on average. In engagement, GenAI videos performed better in the "attention" dimension. Qualitative results indicated that students found GenAI videos accessible and visually appealing but sometimes artificial in narration. These findings suggest that effective integration of GenAI in higher education requires thoughtful instructional design, emphasizing cognitive load management and engagement strategies.

Keywords: Generative Artificial Intelligence, Instructional Video, Cognitive Load, Video Engagement, Mixed Methods

The broader educational landscape is witnessing a paradigm shift where artificial intelligence is not only a technological innovation but a transformative force shaping pedagogy, assessment, and learner interaction. This research not only fills a gap in empirical evidence on GenAI in higher education but also highlights the balance required between automation and human-centered teaching practices. In doing so, it contributes to ongoing debates about the future of teaching roles, digital literacy, and the ethical considerations of AI-driven education.

Introduction

In the second quarter of the 21st century, higher education is undergoing a profound transformation driven by generative artificial intelligence (GenAI). Capable of producing text, images, audio, video, and even code, GenAI is not only reshaping instructional design but also redefining the nature of teaching and learning (Elmourabit, Retbi & El Faddouli, 2024; Zhou, 2024). Beyond automation, these systems offer opportunities for personalized learning, instructional support, and institutional efficiency (Chu et al., 2022; Mittal et al., 2024). Yet, evidence on their effects on motivation, engagement, and academic performance remains mixed and context-dependent (Gastineau, 2024).

One of GenAI's most visible contributions is in educational video design. Tools such as ChatGPT, DALL·E, Heygen, and Synthesia enable scriptwriting, avatar narration, and automated editing, reducing time and cost while increasing accessibility (Elmourabit et al., 2024; Leiker et al., 2023). However, questions persist about the pedagogical validity and long-term impact of AI-generated videos (Chiu, 2024; Peñalvo, 2024). Cognitive Load Theory (Sweller, 2010) provides a useful lens, emphasizing that effective design must reduce extraneous load and foster deep processing through coherent and personalized content (Bayraktar, Coşgun & Altan, 2019).

In addition, video engagement the learner's ability to sustain attention, empathize with the narrator, and connect emotionally with the content emerges as a key factor in evaluating GenAI videos (Deryakulu, Sancar & Ursavaş, 2019; Visser et al., 2016). While technically advanced, such videos must also sustain learner motivation and immersion (Greenberg & Zanetis, 2012). Overall, although GenAI-supported videos present scalable and cost-effective solutions, further empirical research is needed to determine their impact on accessibility, cognitive load, and engagement, ensuring they are pedagogically meaningful and learner-centered (Zawacki-Richter et al., 2019; Gastineau, 2024).

Research Question

What is the relationship between generative AI–produced instructional videos and students' academic achievement, cognitive load, and engagement experiences, and what are students' perspectives on such content?

Sub-Questions

1. Is there a statistically significant difference in achievement scores between students who watch instructional videos produced by generative AI and those who watch videos produced by humans? Is there a statistically significant difference in cognitive load scores between students who watch instructional videos produced by generative AI and those who watch videos produced by humans? Is there a statistically significant difference in engagement experiences between students who watch instructional videos produced by generative AI and those who watch videos produced by humans? What are the experiences of students who watch instructional videos produced by generative AI compared to those who watch videos produced by humans?

Methodology

This study examines the effects of human-produced versus generative AI (GenAI)-produced instructional videos on cognitive load and achievement using an explanatory sequential mixed-methods design (Plano Clark & Creswell, 2015; Ivankova et al., 2006; Creswell, 2008). In the first phase, quantitative data were collected via a pretest–posttest control-group quasi-experimental design; in the second phase, qualitative data were gathered through structured interviews to explain and deepen the quantitative findings. The two data strands were integratively merged at interpretation (Creswell & Clark, 2020).

The study followed a two-phase explanatory sequential mixed-methods procedure. In the first phase, a pretest–posttest control-group quasi-experimental design was applied: participants were assigned to one control and two experimental groups, watched either human-recorded or GenAI-produced instructional videos, and completed an academic knowledge test (It has been developed by researchers.), a cognitive load scale (Kılıç & Karadeniz, 2004), and the Video Engagement Scale (Deryakulu et al.) before and after the intervention. The second phase collected qualitative data from 22 volunteers through a structured interview form with three open-ended questions, designed to explain and enrich the quantitative findings.The Demographic Information Form was developed to capture participants' key characteristics such as school type, subject area, grade level, educational background, years of experience, and age. To measure learning outcomes, the researcher created an Academic Knowledge Test with a reliability coefficient of KR-20 = .88. Participants' cognitive load levels were assessed using the Subjective Cognitive Load Scale, originally developed by Paas and van Merriënboer (1993) and adapted into Turkish by Kılıç & Karadeniz (2004). Psychological engagement with the videos was measured by the Video Engagement Scale (VES), developed by Visser et al. (2016) and validated in Turkish by Deryakulu, Sancar & Ursavaş (2018). For qualitative data, a structured interview form consisting of three open-ended questions was designed to explore participants' perceptions and experiences regarding the videos; the form was refined through expert feedback and administered online.

The video development process was systematically designed around the theme of Sustainability and Quality Education. Based on Bloom's cognitive taxonomy at the remembering and understanding levels, 20 learning objectives were identified, scripts were written by the researcher, and content validity was ensured through expert review. For the control group, human-narrated videos were professionally recorded and later enhanced with visual and auditory elements using Canva, structured under six subtopics. Experimental Group 1 videos were produced with Fliki, generating text-based videos enriched with visuals but without avatars. Experimental Group 2 videos were created through an integration of Pictory and Heygen, combining automated scene generation, researcher-selected visuals, and avatar-based narration. In total, 18 videos were produced for the three groups, all developed in line with instructional design principles such as reducing cognitive load, directing attention, and aligning content with learning objectives.

Table 1. Duration of Educational Videos

	Experimental Group 1	Experimental Group 2	Control Group
1- Introduction: Sustainability	01:57	02:02	02:09

2- Sustainable Development Plan	03:39	03:27	03:57
4- Sustainable Development Goals I	05:37	05:23	05:21
4- Sustainable Development Goals III	06:11	06:03	06:22
4- Sustainable Development Goals III	08:48	08:48	08:22
6- Quality Education	07:12	07:10	07:26

In this study, the sampling method was based on accessibility and voluntary participation. While the population consisted of 204 graduate students enrolled in the relevant programs during the 2024–2025 academic year, the actual study group comprised 84 teachers who fully participated and completed the forms. Thus, a combination of purposeful sampling and convenience sampling was employed. Purposeful sampling ensured the inclusion of participants with characteristics aligned with the research objectives, while convenience sampling enabled data collection from the readily accessible student group. In this way, the sampling process was both contextually appropriate and practically feasible.

Findings

Research Question 1. Is there a statistically significant difference in the achievement scores of students who watched lessons generated by generative AI (Experimental Groups 1 and 2) compared to those who watched lessons produced by a human instructor (Control Group)?

As the assumption of normality was not met, the Kruskal–Wallis test was employed. Table 2 shows that the pre-test scores of the groups were similar and not significantly different, $H(2) = 4.14$, $p = .126$.

Table 2. Descriptive Statistics and Kruskal–Wallis Test Results for Pre-Test Academic Knowledge Scores (Experimental 1, Experimental 2, Control)

Group	n	Mean (M)	SD	Mean Rank	Kruskal-Wallis H	df	p
Experimental 1 (Enhanced with visuals)	14	34.14	3.59	37.68	4.14	2	.126
Experimental 2 (Visuals + Avatar)	23	35.43	2.04	51.17			
Control (Human)	47	33.96	4.90	39.69			

Within-group comparisons were conducted using the Wilcoxon signed-ranks test. As shown in Table 3, only the Control Group exhibited a statistically significant and strong increase between pre- and post-test scores ($Z = -3.47$, $p = .001$, $r = .63$).

Table 3. Descriptive Statistics and Wilcoxon Signed-Ranks Test Results for Pre-Test and Post-Test Scores (Experimental 1, Experimental 2, Control)

Group	Test	n	Mean (M)	SD	Min	Max	Z	p	r
Experimental 1 (Enhanced with visuals)	Pre-test	14	37.36	2.76	31	40	-1.22	.221	.33
	Post-test	14	38.21	2.94	29	40			
Experimental 2 (Visuals + Avatar)	Pre-test	13	33.13	5.34	20	42	-0.60	.550	.16

	Post-test	13	34.40	2.87	29	40			
Control (Human)	Pre-test	30	34.07	5.19	11	40	-3.47	.001	.63
	Post-test	30	37.47	1.87	34	40			

Between-group comparisons of gain scores (post–pre differences) also showed no significant differences, H(2) = 4.21, p = .122 (Table 4).

Table 4. Descriptive Statistics and Kruskal–Wallis Test Results for Gain Scores (Experimental 1, Experimental 2, Control)

Group	n	Mean (M)	SD	Min	Max	Median	Skewness	Kurtosis	Mean Rank	Kruskal-Wallis H	df	p
Experimental 1	14	-0.86	2.54	-5	4	-1.00	0.24	-0.48	33.79	4.21	2	.122
Experimental 2	13	-1.31	6.02	-13	7	0.00	-0.84	0.19	33.69			
Control	30	-3.40	5.57	-27	5	-3.00	-2.58	10.80	24.73			

Findings Related to the Second Research Question

Research Question 2. Are there statistically significant differences in cognitive load between students who watched generative AI-based and human-produced videos?

As normality was not met, the Kruskal–Wallis test was applied. Table 5 shows that the Control Group reported higher mean cognitive load (M = 4.53), but this difference was not statistically significant, H(2) = 4.82, p = .090.

Table 5. Descriptive Statistics and Kruskal–Wallis Test Results for Cognitive Load (Experimental 1, Experimental 2, Control)

Group	n	Mean (M)	SD	Min	Max	Median	Mean Rank	Kruskal-Wallis H	df	p
Experimental 1	23	3.57	1.38	1	7	4.00	23.83	4.82	2	.090
Experimental 2	13	3.77	1.88	1	7	4.00	26.27			
Control	30	4.53	1.47	1	7	5.00	34.24			

Findings Related to the Third Research Question

Research Question 3. Are there statistically significant differences in engagement between the groups?

Table 6 indicates that Experimental Group 1 reported the highest mean engagement (M = 74.09), but the difference was not statistically significant, H(2) = 1.25, p = .534.

Table 6. *Descriptive Statistics and Kruskal–Wallis Test Results for Engagement (Experimental 1, Experimental 2, Control)*

Group	n	Mean (M)	SD	Min	Max	Median	Mean Rank	Kruskal-Wallis H	df	p
Experimental 1	23	74.09	18.84	28	98	75.00	30.85	1.25	2	.534
Experimental 2	13	66.77	26.12	30	105	67.00	26.15			
Control	19	67.37	19.25	21	98	71.00	25.82			

Findings Related to the Fourth Research Question

Research Question 4. What are students' perceptions of generative AI-based and human-produced lesson videos?

Thematic analysis results are summarised in Table 7.

Table 7. *Summary of Thematic Categories: Experimental 1, Experimental 2, Control*

Category	Experimental 1 (Enhanced with visuals)	Experimental 2 (Visuals + Avatar)	Control (Human)
Positive aspects of content	Presentation, visuals, content variety, motivation	Visuals, interest in AI technology	Inclusiveness, simplicity
Areas for improvement	Narration, quality of visuals, monotony	Narration style, AI voice	Need for more animation and dynamism
Video use tendencies	Learning, general culture, academic research	Interest-based, academic use	Rare, context-dependent

Table 7 provides a summary of thematic categories across the three groups. The findings indicate that *Experimental Group 1* highlighted the benefits of visuals, variety, and motivation, while also suggesting improvements related to narration and monotony. *Experimental Group 2* valued the visual elements and the novelty of AI-generated content but raised concerns about the artificial voice and delivery style. The *Control Group* appreciated the clarity and inclusiveness of human-presented videos, although they expressed a desire for more animation and dynamism. In terms of usage patterns, participants in Experimental Group 1 tended to emphasise academic and general learning purposes, those in Experimental Group 2 reported more interest-based and situational use, whereas Control Group participants noted limited and context-dependent engagement.

Overall, no statistically significant differences emerged between AI-generated and human-produced videos in terms of achievement, cognitive load, or engagement. Nevertheless, qualitative data suggest important nuances: AI-based videos were attractive due to their visuals and novelty but criticised for artificial narration, while human-produced videos were valued for inclusiveness and simplicity yet considered less dynamic. These findings indicate that the quality of design and delivery strategies, rather than production method alone, is central to shaping learner outcomes.

Result, Discussion and Conclusions

This study examined the effects of generative AI (GAI)-produced lesson videos on students' achievement, cognitive load, engagement, and perceptions in comparison with human-produced content. Quantitative analyses revealed no statistically significant differences between groups for achievement, cognitive load, or engagement. Only the Control Group showed a significant improvement in achievement, suggesting that human-delivered instruction may still offer a measurable short-term advantage. Nevertheless, the higher mean ranks observed in the experimental groups indicate that GAI videos hold potential to support learning outcomes, consistent with Crompton and Burke's (2023) argument that AI applications can enhance attention and accessibility. Chiu (2024) similarly emphasises the need to structure AI-generated content according to learner needs, while Zawacki-Richter et al. (2019) stress the importance

of aligning AI with sound instructional design principles. In this regard, Feuerriegel et al. (2020) underline that design quality, rather than technological novelty, determines learning effectiveness.

Findings on cognitive load suggest comparable demands across groups ($H(2) = 4.82$, $p = .090$), with slightly higher means in the Control Group. This result is consistent with Cognitive Load Theory (Sweller, 2010; Sweller et al., 2019) and Mayer's (2005, 2014, 2021) principles of multimedia learning, which highlight the role of concise, visually supported materials in managing learners' mental resources. Qualitative evidence adds nuance, indicating that while visuals in GAI videos facilitated comprehension, monotonous synthetic voices occasionally increased distraction. This observation resonates with Lawson et al.'s (2021) emotional design hypothesis, pointing to the significance of affective cues such as tone, gestures, and natural expression.

Engagement findings also showed no significant group differences ($H(2) = 1.25$, $p = .534$), although Experimental Group 1 reported the highest mean score. This supports Schroll (2024) and Zhou (2024), who highlight the potential of AI videos to capture learners' attention. However, the absence of facial expressions and gestures in AI avatars limited emotional resonance, aligning with Greenberg and Zanetis' (2012) social presence theory, which suggests that human-delivered videos foster stronger empathetic connections. Students' perceptions further revealed that while GAI videos were valued for accessibility, visual appeal, and clarity—particularly in addressing abstract topics such as sustainability—they were criticised for their lack of naturalness and emotional authenticity (Burchardt et al., 2023). Human-produced videos, in contrast, were appreciated for clarity, inclusiveness, and cohesion, reinforcing prior evidence that narration quality and content coherence are central to effective cognitive load management (Mayer, 2014; Sweller et al., 2019).

Overall, these findings indicate that GAI videos offer advantages in terms of accessibility, efficiency, and visual enrichment, while human-produced videos remain stronger in authenticity, emotional connection, and narrative integrity. The results suggest that GAI should not be considered a replacement for human teaching, but rather a complementary tool. Future research should therefore explore hybrid approaches that integrate the scalability and visual strengths of AI with the pedagogical depth and empathy of human educators.

Based on these findings, several recommendations can be made. First, GAI-produced videos should be designed in line with established instructional design principles (e.g., Mayer's multimedia learning principles, Cognitive Load Theory), ensuring that pedagogical quality is not overshadowed by technical novelty. Second, improvements in naturalness—such as expressive avatars, authentic voice synthesis, and multimodal cues like gestures and facial expressions—are needed to strengthen emotional connection and engagement. Third, hybrid delivery models that combine AI-generated resources with human-led discussions could leverage the efficiency of AI while preserving the empathy and authenticity of teacher presence. Fourth, as prior knowledge may moderate outcomes (e.g., in sustainability-related content), future studies should explore a wider range of subject domains and learner groups to identify where AI content is most effective. Fifth, iterative, user-centred development processes should be adopted, incorporating student feedback to refine clarity, relevance, and engagement. Finally, clear ethical and pedagogical guidelines are necessary to ensure that AI integration in education promotes transparency, equity, and responsible use alongside learning effectiveness.

Acknowledgements

The author thanks Prof. Dr. Yavuz Samur for his guidance, Dr. Zeynep Cömert for her contributions, the thesis jury members, and all student participants. Special thanks to family and friends for their constant support.

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Appendix:

Group	Video QR Code
Experimental Group 1	
Experimental Group 2	
Control Group	

Reframing Online Education: A Framework for Skills Development Across Asynchronous and Synchronous Contexts

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Abstract

This paper introduces a framework for embedding transferable and employability skills in online higher education by combining playful, frugal and collaborative pedagogical approaches. While the expansion of online provision has increased access, particularly during and after the pandemic, it has frequently prioritised content delivery over skills development. This imbalance has reinforced the long-standing gap between higher education outcomes and workplace expectations, leaving graduates underprepared for professional demands. Grounded in Self-Determination Theory and drawing on recent research into playful learning, frugal design and empathic community engagement, the framework integrates autonomy, competence and relatedness with authentic, resource-conscious and culturally inclusive practices. Two case studies demonstrate its application: the British Council funded Enhancing Science Education through International Collaboration (ESEIC) project, as part of which students from the UK, Indonesia, and Kazakhstan co-created a high-performance computing cluster from recycled PCs; and the design of a fully online MA Education programme, which, although not yet implemented, illustrates how the framework can be operationalised in curriculum development. Together, these cases demonstrate how universities can make online learning environments spaces for authentic skills practice, intercultural collaboration, and sustainable innovation. The framework offers a practical contribution to debates on employability, online pedagogy, and international collaboration.

Keywords: Online education, transferable skills, employability, playful learning, frugal design, collaborative learning, Self-Determination Theory

Introduction

Universities are increasingly hybrid, serving diverse learners beyond the traditional 18-year-old campus cohort. This shift has accelerated since the pandemic, when digital technologies enabled continuity of provision but also exposed the limits of content-driven online teaching (Cramarenco et al., 2023; Wang et al., 2024). While online learning is now integral to higher education, its reputation remains coloured by the "emergency remote teaching" model that often neglected pedagogy, inclusivity and skills development. The legacy is a perception that online education is convenient but pedagogically weak.

Yet, as policy and employer reports consistently highlight, the real crisis is not one of delivery but of outcomes. Employers identify persistent deficiencies in communication, critical thinking, and problem-solving skills among graduates (McKinsey Global Institute, 2021; Quacquarelli Symonds, 2017; World Economic Forum, 2020). Regulatory bodies such as the UK Office for Students (OFS, 2023) have underscored the responsibility of higher education providers to prepare students for a dynamic labour market. The mismatch between academic practices and workplace expectations remains pronounced, with traditional reliance on lectures and examinations privileging knowledge reproduction over transferable capabilities (Mahon et al., 2024).

This paper responds to that gap by proposing a framework that embeds skills development into online learning through playful, frugal, and collaborative approaches. Grounded in Self-Determination Theory (Deci & Ryan, 2012; Ryan & Deci, 2000), the framework emphasises autonomy, competence, and relatedness as drivers of intrinsic motivation, linking these to design choices that foreground experimentation, authenticity, and intercultural teamwork. Recent research demonstrates that playful learning fosters agency, iteration, and collaboration (Arnab et al., 2021; Morini et al., 2022) while frugal design promotes inclusivity and sustainability through doing more with less (Arnab, Masters, et al., 2025). Complementary work on empathic and agentic approaches to community-engaged scholarship highlights the importance of cultural grounding and reciprocity (Arnab, Wimpenny, et al., 2025) Together, these strands justify a model of online education as a site for genuine skills practice and innovation, rather than a fallback mode of delivery.

The framework is illustrated through two cases. The first, the Enhancing Science Education through International Collaboration (ESEIC) project, demonstrates implementation at scale, with students from the UK, Indonesia, and Kazakhstan collaboratively developing a high-performance computing cluster from recycled PCs. The second, the

design of a fully online MA Education programme, illustrates the framework's adaptability in curriculum development, even if institutional hurdles have delayed implementation. These cases demonstrate both practice and potential, offering evidence of how playful, frugal, and collaborative design can realign online education with employability and lifelong learning agendas.

Literature Review

The literature on online and hybrid higher education reveals a persistent tension between content delivery and skills development. The pandemic response to teaching accelerated the adoption of digital platforms, but much of what was offered amounted to "emergency remote teaching," in which pedagogy was subordinated to continuity of access (Cramarenco et al., 2023; Wang et al., 2024). Students experienced more contact hours online, but the format was often transmissive, relying on recorded lectures, discussion forums, and standardised assessments. This reinforced a perception of online education as less engaging and less effective than face-to-face teaching (UNESCO, 2020). More importantly, it left unresolved the longer-term question of how higher education can prepare graduates with the skills demanded by contemporary societies and labour markets.

Reports from employers and international agencies consistently identify a gap between university provision and workplace requirements. The QS (2018) *Global Skills Gap* report highlights deficiencies in problem-solving, communication, and teamwork as major barriers to graduate employability. The World Economic Forum (2020) projects that resilience, adaptability, and systems thinking will be central to future jobs, while the Office for Students (OFS, 2023) has placed employability and student outcomes at the heart of its regulatory framework in the UK. These sources converge on the need for universities to embed transferable and transversal skills into curricula, not as optional extras but as central learning outcomes. The challenge is not new, but it has been sharpened by the mass adoption of digital learning.

Scholars have increasingly turned to playful learning as a design principle to support engagement and skills development. Play is not simply recreation but a structured way of fostering autonomy, experimentation, and collaboration. Arnab et al (2021) mapped how aspects of play including autonomy, curiosity, iteration, fun and social interaction, can be aligned with 21st-century competencies and forms of resilience. This mapping demonstrates that play can be purposefully deployed to cultivate absorptive, adaptive, and transformational resilience, equipping learners to navigate uncertainty. Similarly, Morini et al. (2022) illustrate how playful participatory mapping can be used to foster systems thinking, allowing learners to model feedback loops, rules, and emergent behaviour through game-like activities. Both studies show that play supports agency and collaboration, precisely the conditions under which transferable skills are most likely to be developed.

Recent work has extended this argument by combining play with frugal design principles. Arnab, Masters et al. (2025) argue that frugality, characterised by resourcefulness, openness, sustainability, and iteration, complements playful learning by ensuring that educational design is inclusive and adaptable to local contexts. Frugal approaches encourage "doing more with less" and avoiding over-engineering, which is particularly relevant in global collaborations where institutions may operate with uneven resources. Their study, which draws on mixed-methods evaluation of playful and frugal design interventions in STEM education, shows how value-driven design can simultaneously support engagement, inclusivity, and sustainability. This is highly relevant to online international projects, where constraints on bandwidth, time zones, and access to technology require creative, resource-conscious solutions.

A related strand of research addresses empathic and agentic approaches to community-engaged scholarship. Arnab, Wimpenny et al. (2025) highlight how playful and frugal design can be aligned with empathy, co-creation, and agency to produce socially meaningful outcomes. Their framework emphasises reciprocity between universities and communities, positioning learners not as passive recipients but as active contributors to knowledge and practice. In the context of online and hybrid education, this provides a way of designing activities that are not only authentic but also culturally grounded and responsive to diverse needs. It shifts the focus from individual competencies to collective capacities, reinforcing the relational dimension of skills development.

These insights resonate with broader critiques of graduate attributes and transferable skills. Mahon et al. (2024) argue that higher education has often treated such skills as generic and context-free, when in fact they are enacted differently across disciplines. Communication in veterinary science is not the same as communication in international relations, and problem-solving in engineering differs from that in law. What workplaces require is the synthesis of these disciplinary variants into adaptable, collaborative practices. Online learning, if designed with playfulness, frugality, and empathy, can provide the interdisciplinary and intercultural contexts in which this synthesis occurs. By moving beyond content delivery to authentic problem-solving, online environments can replicate the conditions of the workplace more effectively than lecture halls or exam halls.

The literature also demonstrates the methodological implications of these design choices. Studies of playful and frugal interventions emphasise the importance of mixed-methods evaluation, combining quantitative measures of engagement with qualitative insights into learner experience (Arnab, Masters, et al., 2025). Reflexive thematic analysis has been used to capture how students perceive agency, iteration, and collaboration in game-based or design-based tasks (Arnab et al., 2021) Participatory methods, such as co-design workshops and mapping activities, align evaluation with the pedagogical ethos of play and frugality (Morini et al., 2022). These methodological orientations provide a basis for analysing skills development not as abstract constructs but as lived practices observable in digital artefacts, reflections and collaborative outputs.

Taken together, the literature suggests three design imperatives for online higher education. First, playfulness is not incidental but integral: it provides the conditions for agency and experimentation that underpin skills development. Second, frugality ensures inclusivity and sustainability, making designs adaptable across contexts and resources. Third, empathy and co-creation embed authenticity, ensuring that learning activities resonate with real-world problems and community needs. These imperatives converge in the framework presented in this paper, which combines Self-Determination Theory's focus on autonomy, competence, and relatedness (Deci & Ryan, 2012) with playful, frugal, and collaborative design choices.

The framework builds directly on recent scholarship but makes a distinct contribution by applying these insights to online and hybrid learning contexts with explicit reference to employability. While playful learning has been widely studied in game-based contexts, and frugality has been discussed in relation to innovation and sustainability, their integration in online education aimed at skills development is novel. Similarly, while community-engaged scholarship has focused on local partnerships, its alignment with international online collaboration is underexplored. By synthesising these literatures, this paper positions online education not as a second-best mode of delivery but as a fertile space for authentic and skills-rich learning.

Methodology

The framework is grounded in Self-Determination Theory (SDT), which identifies autonomy, competence, and relatedness as the key conditions for intrinsic motivation (Deci & Ryan, 2012)). These principles provide the motivational foundation for learning environments that move beyond knowledge transmission to foster genuine engagement and skills development. Within the framework, SDT is operationalised through three interlinked pedagogical strategies: playful learning, frugal design, and collaborative, empathic practices (see Figure 1).

Figure 1. Transferable Skills Development Framework

Playful learning introduces space for experimentation, iteration, and curiosity, enabling learners to take ownership of tasks without fear of failure (Arnab et al., 2021). Frugal design principles embed inclusivity and sustainability by prioritising openness, adaptability and the creative use of limited resources (Arnab, Masters, et al., 2025).

Empathic and agentic approaches position learners as active co-creators, ensuring that projects resonate with authentic needs and cultural contexts (Arnab, Wimpenny, et al., 2025). Together, these strategies reflect a value-based design orientation that integrates motivation, inclusivity and authenticity.

The methodological implications of this framework extend beyond pedagogy into evaluation. Previous research on playful and frugal interventions has employed mixed-methods approaches, combining quantitative indicators (such as engagement measures and task completion rates) with qualitative evidence including student reflections and thematic analysis of artefacts (Arnab, Masters, et al., 2025). Reflexive thematic analysis is particularly well suited for exploring how learners articulate experiences of autonomy, competence and collaboration (Morini et al., 2022). Artefacts such as whiteboard outputs, chat transcripts, and co-created documents can be analysed to trace patterns of interaction and evidence of skills development.

In this paper, the framework is applied to two cases: the Enhancing Science Education through International Collaboration (ESEIC) project, where it informs the design and analysis of international STEM collaborations, and the curriculum design of an online MA Education programme, where it demonstrates adaptability to programme-level planning. Together, these cases illustrate how the methodological choices embedded in the framework can both guide teaching practice and support rigorous analysis of outcomes.

Results

Case Study One: ESEIC and the Computing Cluster Project

The first case study is drawn from the Enhancing Science Education through International Collaboration (ESEIC) project, funded by the British Council's International Science Partnerships Fund (ISPF). ESEIC brings together the University of Surrey (UK), Universitas Negeri Malang (Indonesia), Universitas Tidar (Indonesia), Astana IT University (Kazakhstan), and Surrey Maths School (UK) to create STEM hubs aligned with the UN Sustainable Development Goals (SDGs). Running from February 2025 to December 2026, the project aims to widen participation in science education by embedding skills development, inclusive practice, and sustainability into international collaborations.

One flagship activity within ESEIC is the Computing Cluster Project, in which students were tasked with building a high-performance computing (HPC) cluster from recycled PCs. The goal was to repurpose e-waste into a functional cluster, providing both a technical challenge and a sustainability-focused intervention. This initiative aligns with SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production) and SDG 17 (Partnerships for the Goals). The Computing Cluster Project therefore provides an illustrative example of how international collaboration can act as both a pedagogical and a societal intervention. By situating technical learning within a sustainability agenda, the initiative not only strengthened students' disciplinary skills but also encouraged them to engage critically with broader global challenges. In this sense, the project went beyond a conventional classroom exercise; it positioned learners as active contributors to knowledge creation, sustainability practice and intercultural dialogue.

The project involved 75 students across the five partner institutions, spanning a range of disciplines including computer science and maths. Students collaborated online in cross-border teams, supported by faculty mentors, and worked through weekly design cycles. Activities included technical prototyping, developing a business case for the cluster and presenting interim findings to peers and staff. This vertically integrated model drew on both Collaborative Online International Learning (COIL) and Vertically Integrated Projects (VIPs), creating space for multi-level, interdisciplinary teamwork. The international dimension proved particularly significant. Working across three countries required participants to navigate cultural differences, institutional variations and logistical barriers such as time zones and internet connectivity. These challenges became integral to the learning process, equipping students with resilience and adaptability through mirroring contemporary real world working environments.

The project demonstrates how the framework's elements can be operationalised in practice.

- Foundation (autonomy and ownership): Students acted as project managers, setting goals, allocating roles, and negotiating solutions.
- Engagement (playful iteration): The task required experimentation with recycled components, encouraging creative risk-taking and resilience in the face of technical challenges.
- Application (authenticity and frugality): The problem addressed both a technical need and an environmental challenge, with frugal design principles ensuring solutions were resource-conscious and scalable.

- Communication (collaboration across contexts): Teams spanned the UK, Indonesia, and Kazakhstan, requiring synchronous and asynchronous coordination across time zones.

Early outcomes indicate that students developed both technical competencies (such as cluster configuration, hardware optimisation) and transferable skills (including intercultural communication, teamwork and leadership). While formal data collection and analysis remain ongoing, preliminary feedback highlights the authenticity and perceived value of the project. Students have commented positively on the opportunity to collaborate across borders, apply disciplinary knowledge to real-world problems, and contribute to sustainability goals. Faculty observations echo these perceptions, noting particularly high levels of engagement. In particular, the project illustrates how online, cross-border collaborations can be designed to emulate the complexities of real-world professional environments, thereby narrowing the often-cited gap between higher education and the workplace.

Methodologically, in addition to ongoing data collection in the form of surveys and focus groups, the project generates a rich body of artefacts for analysis, including technical documentation, business case reports and reflective outputs. These materials will be analysed through reflexive thematic analysis to identify patterns in how students articulate autonomy, competence and relatedness (Deci & Ryan, 2012). Survey instruments and structured feedback sessions complement these qualitative approaches, providing triangulated evidence of skills development. The evaluation strategy reflects insights from recent literature on playful and frugal design (Arnab, Masters, et al., 2025) which emphasises mixed-methods analysis of both process and outcome.

Importantly, the Computing Cluster Project demonstrates how international collaboration can be scaffolded in online contexts to replicate the synthesis of skills normally encountered in workplace environments. By combining playful iteration with frugal design constraints, the project encouraged students to navigate uncertainty and negotiate trade-offs. By embedding collaboration across cultures and disciplines, it is providing a training ground for the kinds of teamwork increasingly demanded by employers (World Economic Forum, 2020) By aligning explicitly with the SDGs, it gave students a sense of purpose that extended beyond individual assessment.

The ESEIC case highlights the potential of the framework to transform online learning into a skills-rich, authentic and sustainable experience. While further evaluation is required to capture long-term outcomes, the Computing Cluster Project offers early evidence that playful, frugal and collaborative approaches can make a tangible difference to students' engagement and employability.

Case Study Two: Online MA Education (Design Application)

The second case illustrates the framework's application to programme design, demonstrating how playful, frugal and collaborative approaches can shape an online curriculum even before implementation. This case focuses on the development of a fully online MA Education programme, providing insight into how the framework can inform curriculum planning at scale.

The proposed MA Education is intended as a flexible, globally accessible programme, structured around two concurrent modules per semester with multiple entry points. To foster consistency and student belonging, the design includes one synchronous session per week, supported by rich asynchronous materials. The aim is to integrate authentic, problem-based learning into every module, ensuring that skills development is embedded across the programme rather than confined to isolated assignments.

A central pedagogical device influenced by the framework is the creation of the fictional organisation the New International Consortium for Critical and Comparative Education (NICCCE). Weekly "crisis scenarios" were presented to students, an adaptation of the idea of playful participatory mapping (Morini et al., 2022). In this approach, students act as consultants-in-residence tasked with responding to urgent challenges. Scenarios range from addressing critiques of Eurocentric curricula to proposing interventions for gender attainment gaps. Each week, student groups develop recommendations, which are then presented to peers acting as an Academic Council, who evaluate and vote on the proposals.

This design illustrates how the framework's principles can be embedded at the programme level:

- Foundation (autonomy and agency): Students were positioned as decision-makers, expected to take ownership of responses to complex educational challenges.
- Engagement (playful iteration): The crisis-scenario format created a safe but demanding environment for experimentation, where multiple solution pathways could be explored without penalty for failure.
- Application (authenticity and frugality): Scenarios were rooted in real-world issues, drawn from policy debates and institutional challenges, while the design emphasised accessibility and sustainability through open digital tools.

- Communication (collaborative exchange): Students collaborated across diverse cultural and professional backgrounds, simulating international teamwork in a structured but flexible format.

Through this activity, the framework provides a blueprint for embedding transferable skills across modules, ensuring that collaboration, criticality and systems thinking are not add-ons but central outcomes.. From a methodological perspective, the design highlights how playful, frugal, and collaborative strategies can be applied proactively, at the stage of curriculum planning, rather than reactively during delivery. The integration of crisis scenarios and simulated decision-making demonstrates that authentic, workplace-like contexts can be built into asynchronous structures. This aligns with calls from policy and employer reports to ensure that online education contributes directly to employability outcomes (OFS, 2023; QS, 2018).

Taken together with the ESEIC Computing Cluster Project, the MA Education design illustrates the framework's dual utility: it can both inform live international collaborations and guide forward-looking curriculum planning. The first case evidences implementation and positive student response, while the second shows how design choices rooted in play, frugality and collaboration can pre-emptively embed employability outcomes. Both point to the potential of online education to be more than a mode of delivery, to become a structured environment for authentic, skills-rich and internationally relevant learning.

Discussion

The two cases highlight the framework's versatility and relevance across different scales of online education. The ESEIC Computing Cluster Project demonstrates its application in a live, international collaboration, where playful, frugal, and collaborative strategies produced both technical and transferable skills. Students engaged in authentic problem-solving, negotiated cultural and disciplinary differences, and contributed to sustainability goals. Preliminary evidence suggests that these experiences were not only engaging but also perceived by students as directly relevant to employability. This supports existing scholarship that positions playful and frugal learning as powerful enablers of agency, inclusivity, and sustainability (Arnab et al., 2025a, in press; Morini et al., 2022).

The MA Education design case illustrates the framework's utility at the level of curriculum planning. By embedding simulated crisis scenarios within a fictional but authentic organisational setting, the design anticipated the kinds of uncertainty and problem-solving that graduates face in professional contexts. Although the programme has not yet been implemented, the framework's influence demonstrates that value-based design principles can be integrated early, shaping curriculum architecture before delivery begins. This echoes calls for higher education to move beyond retrofitting employability into courses and instead make it a structural priority (Mahon et al., 2024; OFS, 2023).

Taken together, the cases suggest that playful, frugal, and collaborative design can reorient online education towards outcomes that are both skills-rich and socially meaningful. By positioning students as agents rather than recipients, projects and curricula designed through this framework respond to employer concerns about communication, teamwork, and adaptability (QS, 2018; WEF, 2020). They also align with the UN Sustainable Development Goals, demonstrating how employability can be embedded alongside wider commitments to sustainability and global citizenship.

Nonetheless, several limitations must be acknowledged. Evaluation of the Computing Cluster Project is ongoing, and more robust evidence is needed to substantiate claims of skills development. The MA Education case remains at the design stage, raising questions about implementation feasibility. Furthermore, while frugal and playful design principles promote inclusivity, access to digital infrastructure and institutional support continues to shape what is possible across contexts. Future research should extend evaluation to measure long-term impacts on graduate trajectories and explore how institutions can systematically adopt these approaches across disciplines.

Conclusions

This paper has presented a framework for embedding transferable and employability skills in online higher education through playful, frugal and collaborative design. Grounded in Self-Determination Theory and informed by recent research on playful learning, frugal education and community-engaged scholarship, the framework demonstrates how online environments can become authentic spaces for skills practice.

The ESEIC Computing Cluster Project shows how these principles can be applied in practice, enabling international student teams to tackle technical and sustainability challenges while developing digital, intercultural and collaborative competencies. The MA Education design case illustrates the framework's adaptability at the programme level, embedding skills-oriented design principles even before implementation.

Together, the cases provide evidence that online education need not be content-heavy and skills-light. Instead, it can foster autonomy, competence, and relatedness, producing graduates prepared for the complex demands of

global workplaces. While challenges remain, particularly around implementation and evaluation, the framework offers higher education a pathway to make online provision both employable and socially impactful.

Acknowledgements

The authors gratefully acknowledge the support of the British Council International Science Partnerships Fund (ISPF), which funds the Enhancing Science Education through International Collaboration (ESEIC) project.

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Personalization in employees' e-training

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Abstract

The advancement of technology has created many ways for a company to provide training to its employees. This training type has become digital to facilitate professional learning and training in an e-learning model, known as e-training, which uses a learning management system (LMS) to manage activities of the learning process. Although many training systems are adaptable and can be personalized, the lack of personalization implemented within the company's e-training is still persistent owing to various factors. The company should consider personalization in the e-training platform to guarantee the trainees' satisfaction, motivate the employees to follow the training, and improve their skills. An e-training platform personalized according to the role of employees is considered a necessary concern and strategy to provide the best use, resulting in an efficient and effective learning process. This paper describes the importance of an e-training platform's personalization according to the employees' roles. Professionals and specialists in LMS and e-learning were interviewed to collect the experts' opinions. A personalization activity concept is proposed to illustrate how to achieve personalization within a training system.

Keywords: E-training, employee's role, professional training, personalized training

Introduction

Training for employees or professionals within a company is needed to gain a specific skill to perform their role (Semenova et al., 2021). Everyone has different needs to enhance or gain skills. This opinion shows that a company should offer professional training focusing on individual needs.

Professional training requires a singular and unique approach to recognize the different goals of individuals, leading to the promotion of self-development and improvement of skills (Kotsifakos et al., 2020).

The advance of technology has brought many ways for a company to provide training to its employees. The training became digital (i.e., e-training), adopting an e-learning model in which the professionals gain knowledge through online or intranet-based remote learning. This way, they can gain a new skill or upgrade their knowledge without leaving their jobs.

According to the authors Kumar & Kumar (2023), e-training has become an ideal choice for modern companies in the present time due to its affordability, flexibility, and time-saving nature. Moreover, this training model can be considered "*a viable solution for professionals and brings significant benefits to companies and their employees*" (Aplugi & Santos, 2023, p.3).

To provide e-training, a company needs a system to manage training activities, which refers to learning management systems (LMS). The study by Berking and Gallagher (2013) explained that the LMS is the access point for all e-learning content (i.e., e-training) and learner records. It is a key technology for "anytime, anywhere" access to learning content and its management.

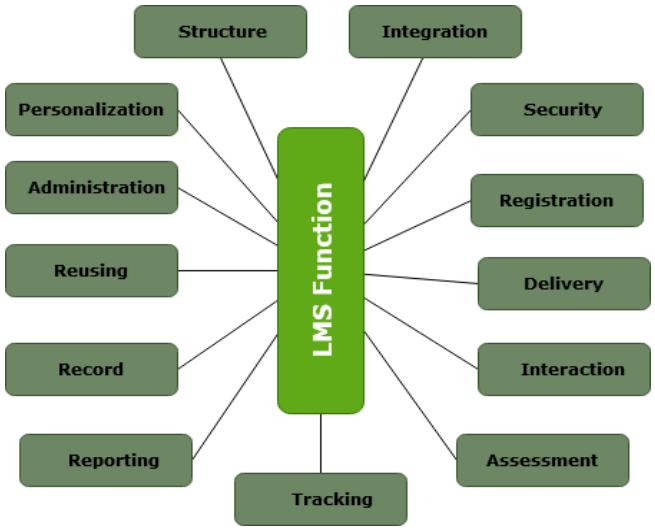

Figure 1. General Function of LMS (Created by the authors)

Despite personalization being listed as one of the LMS functions or part of its features, its advantages have still not been taken or applied in companies' e-training systems. Aplugi and Santos (2023) concluded their research by reporting that even though the personalization of LMS as a tool of e-training is possible, the system lacks personalization, which could help trainees select training materials relevant to their roles.

In this paper, we report the results of our interview with experts in e-learning and LMS to understand the importance of e-training platform personalization according to the trainees' roles. Based on this result and previous studies by various researchers, we present a personalization activity concept in an e-training system to show how personalized training can be delivered.

Related Works

The concept of personalization in an e-training

E-training is a concept of e-learning within the industry, using an LMS to provide experience to employees in their learning process. Employees gain knowledge with the help of an online tool.

The primary concept of personalized learning is to tailor instruction and provide learning experiences according to individual needs, goals, and interests. According to Gokhe et al. (2024), personalized learning brings more comprehensive and functional learning environments. By using information analysis, there are ways for instruction modification to meet a learner's particular demands, preferences, and pace.

Through personalization in the learning process, it is possible to improve motivation, engagement, and maximize learner satisfaction and learning effectiveness (Deev et al., 2021). Some authors may consider the use of alternative techniques to accomplish such effectiveness. Collaborative deep learning is the first Bayesian hierarchy that serves as a bridge to the gap between state-of-the-art deep learning models and recommender systems, as well as personalization (Souabi et al., 2021; Wang et al., 2015).

In a professional training context, personalization is considered a requirement for efficient training, taking into account the training duration (i.e., timesaving). By focusing the training on employees' needs and characteristics, the relevance of training can be justified (Souabi et al., 2021). The personalization approach in e-training refers to the process of generating a path or program that considers employees' abilities, knowledge acquired, and their training enrollment goals (Nabizadeh et al., 2020).

Other researchers connected the importance of personalization within an e-training system with the ease of use. For example, the ease of formative content selection can accelerate the training process (Aplugi & Santos, 2023), and ease of use can influence trainees' attitudes towards the interaction (e.g., with the training resources or the system itself) during the training (Sauer et al., 2020).

Ease of use is mentioned as one of the objectives of e-training system personalization, which can lead to employee satisfaction and success, and the training process can be easier and more convenient (Hariyanto, 2020; Papakostas et al., 2021).

From other perspectives, demotivation and abandonment can occur if an e-training platform is not easy to use and intuitive (Hariyanto et al., 2020). Thus, personalization is related to trainees' motivation. And engagement.

Linking personalization to system usability illustrates a symbiotic connection, which is the essence of user-centered design in the human-computer interaction (HCI) field. It expresses the importance of a user's experience in system utilization, covering several aspects (e.g., efficient content retrieval, navigation ease) (Gutierrez-Aguilar et al., 2024)

The literature leads us to illustrate the importance of personalization and its relationship with motivation in learning and user experience (UX) (Fig. 2). It shows that personalization can improve the trainees' motivation and emphasize the ease of use of the e-training system. In turn, motivation can be enhanced through ease of use, which influences the use perceptions of trainees regarding their e-training platform. Personalization may also drive efficiency, effectiveness, and satisfaction in learning.

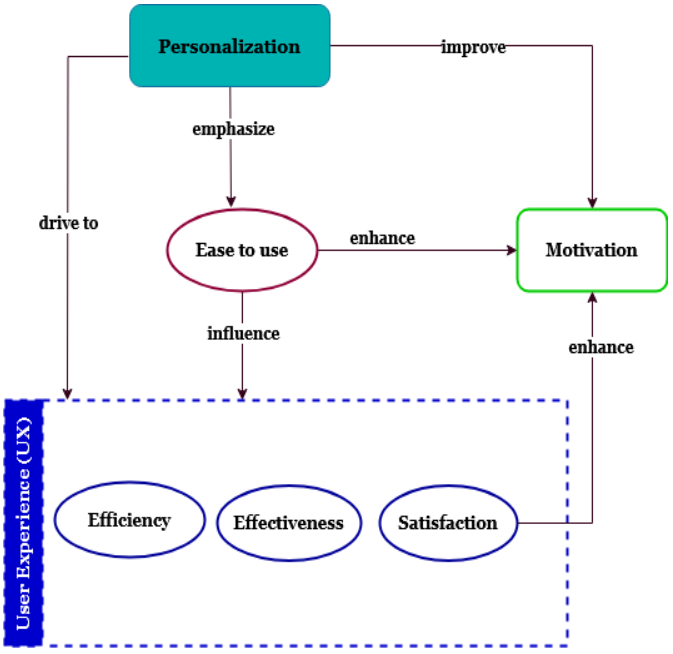

Figure 2. Personalization, motivation, and UX (created by authors)

Iddrisu (2025) emphasized the relationship between ease of use, user experience (UX), and motivation, suggesting that by prioritizing user-friendly digital tools, organizations can improve employee motivation.

Efficiency, effectiveness, and satisfaction are attributes of UX that reflect the employees' or trainees' perceptions regarding their contact with the system utilized. Consequently, the satisfaction of trainees can motivate them during the training period.

Personalization according to a role

In the context of professional training, Aplugi and Santos (2023) and Deev et al. (2021) highlighted that personalization in the training system refers to the provision of training adapted to employees' needs to improve the performance of their role, leading to effective and efficient training. The authors argued that an e-training platform personalized and adapted to the role of employees is considered a necessary concern and strategy to provide the best use, resulting in an efficient and effective learning process.

Understanding that the employees continue to execute their function during the training period, effective time in training is fundamental. So that no time is wasted on useless training.

Hence, the training provided to the employees in a company should consider personalized training, in which employees can gain skills or upgrade their knowledge that can be applied to improve their jobs or roles.

To be effective, the employees need to be guided in the training process. A good orientation in the training process can be seen as a better hypothesis for employees to choose and follow the appropriate and effective training for the roles performed (Gladilina et al., 2020). One of the advantages of personalized training according to employees'

roles is to provide a clear training objective, avoiding loss of learning because the trainees are not able to select the relevant ones among many resources (Xue-jun et al., 2021).

By harnessing data related to each employee's role, a company can implement personalization in its training platform to plan and provide tailored training.

Our point of view is that with training provisions relevant to each role of employees, the actual demand of the company for certain activities can be fulfilled (e.g., a new system application). In this matter, the company can create a resource to include in training for current employees or new employees of the human resources department.

Research Methodology

To understand the importance of e-training personalization according to the role of each employee in a company, we used the interview as a technique to collect the experts' opinions.

Participants

Five professionals and specialists in the field of e-learning and LMS in the enterprise context are interviewed to obtain perspectives based on their experiences and knowledge.

We purposefully selected the interviewees from our professional network. The interviewees are training managers with 12 to 20 years of experience in this field. Serving as LMS developers, coordinators, managers, and trainers, they have a wealth of knowledge in these fields.

Interview instrument development

For the present research, the interview consisted of three sections and five questions in total, according to the following structure:

Section 1 – Personalization of the e-training system

The questions in this section aim to understand the interviewees' experiences with e-learning and LMS (as a tool for e-training). Based on their experience, we want to comprehend the importance of LMS personalization within a company.

1.1. What is your experience with e-learning and using an LMS in a corporate context?

1.2. What is the importance of personalizing an e-training system for you?

Section 2 – Personalization of resources in the e-training system

The questions in this section focus on the personalization of resources and their selection in an e-training system. We intended to obtain experts' opinions on the importance and relevance of this personalization.

2.1 What is the importance of personalizing resources in the e-training system for you?

2.2 What is your opinion on training resource personalization in the company's e-training system (i.e., is the employee provided with the learning resources relevant to their role)?

Section 3 – Other considerations

In this section, the question aims to obtain other considerations related to the object of this research, which may add value to our research. The participants may choose not to answer the question.

3.1 Do you have any other considerations on this topic?

We requested that the specialist provide more detailed information about the interview questions, which they consider essential for this topic, by writing and sending it via email.

Data Analysis and Report

The qualitative analysis was conducted after the interviews. The following analysis is structured by the interview section previously presented.

Personalization of an e-training system

To understand the experts' point of view on e-training system personalization, we asked our interviewees to respond to question 1.2, related to the importance of personalizing an e-training system.

One of the experts emphasizes personalization as a pedagogical strategy to implement e-learning in the company or organization. Ensuring the alignment of employees' skills, taking into account their roles and the training needs that the role requires, was underlined by one expert as the importance of personalizing an e-training system.

The other expert explains that LMS used to manage e-training generally has standardized and homogenized features instead of providing users with a more personalized experience. Despite this, adaptation and personalization are important in the formative process, and most companies seek to achieve them.

Other experts said that since each organization has its particularities and specific needs, it is essential to customize or adapt the LMS in the business context to address the organization's specific point or, often, to compensate for some technical or managerial limitation.

In concordance with these opinions, another interviewee, who has twenty years of experience as an LMS manager, mentioned that personalization is important due to the possibility of fitting the training to the company's goals.

Personalization of resources in an e-training system

Through the questions in Section 2 of the interview instrument, we obtained the experts' opinions on the importance of resource personalization and its selection relevant to the role of employees. The questions are formulated as: "*What is the importance of personalizing resources in the e-training system for you?*" and "*What is your opinion on training resource personalization in the company's e-training system (i.e., is the employee provided with the learning resources relevant to their role)*?".

One expert mentioned that resource personalization in an e-training system is fundamental for the various agents (i.e., managers and trainees) involved in the pedagogical process. The focus in this personalization impacts several levels, such as personalizing resources directed to a set of training attributes managed by the organization, namely function, skills, and their degree of proficiency, and performance evaluation in a given competency.

According to another expert, personalizing the training resources is a relevant and appropriate strategy when the company seeks to adapt the learning process to the learning style, the role of the employee, or the learning journey.

In the opinion of another specialist, he considers that content personalization is vital nowadays, as unfortunately, there is an increasing scarcity of time and an excess of information bombarding us. Therefore, in general, people want more and more objectivity and speed when they need to acquire information. More objective, targeted, specific training with the least possible time without compromising quality and scope, he believes, will achieve greater effectiveness with the target audience.

Another interviewee opined that personalization enables a mapping between the resource, the person (i.e., trainees or employees), and its function.

It was also added that andragogy underlines the importance of autonomy in the learning process. Therefore, this perspective should be considered in the selection, frequency, and orientation of digital resources for the trainee in e-training.

When referring to the question of personalizing the resource selection that allows employees to access resources suited to their functions, the experts expressed similar opinions.

For them, personalization in this aspect is not only relevant but also desirable to increase effectiveness, efficiency, and satisfaction in the learning process. Employees receive the most relevant and effective training for their roles and level of experience. This can prevent employees from having access to hundreds or thousands of resources that are irrelevant to their role.

Furthermore, they added that often the search devices in the LMS (i.e., the system of e-training) are not developed to the point of filtering the resources correctly according to employees' interests, thus causing the loss of time in the selection and, in some situations, frustration or discredit with the system.

One of the experts suggested that the company's e-training system can offer a combination of two types of resources, general and personalized. In this way, an employee is encouraged to be proactive and free to choose the resource of their interest. Consider that, in addition to having access to the resources relevant to their role, the employee may be curious to learn other topics related to other roles.

Other considerations

Two experts pointed out that privacy and ethics have to be highly considered, guaranteeing that the collection and use of employee data is done ethically and in compliance with privacy laws and regulations.

One of them gave some inputs that we considered valuable for future work and considerations. Some aspects to keep in mind:

- Before personalizing content or resources, it is essential to analyze the needs of each employee. This may involve assessing their current knowledge, skills, and areas for improvement. Additionally, it is necessary to understand the company's goals and how each employee's training contributes to achieving those goals.
- Grouping employees into segments based on different criteria, such as their role, level of experience, department, geographic location, etc., can help personalize resources more effectively and efficiently.
- Ensuring that resources or content are relevant to each employee's role and responsibilities is not only about personalizing itself but also the delivery format, whether online, in-person, or a combination of both.
- Employees in a business environment often have busy schedules, so it is important to offer flexibility in when and where they can access the training resources. This may involve accessibility on mobile devices and allowing for asynchronous learning.
- Implement continuous feedback systems that allow employees to receive feedback on their progress and areas for improvement. This will also allow managers and administrators to adjust the resources.
- Utilization of AI technologies to analyze employee behavior and performance in the LMS or training system. Based on that, offer personalized recommendations to improve their learning.
- The business world changes rapidly, so it is important to ensure that resources are up-to-date and relevant at all times.
- Implement measurement and evaluation systems that allow managers and administrators to measure the effectiveness of customized training and make adjustments as necessary.

Another specialist explained that it is increasingly necessary for some type of innovation to occur in the format in which learning moments are offered within organizations. The traditional format of offering e-learning in organizations is reaching a certain level of saturation. It happens mainly due to the overwhelming parallel offerings from the internet that drain the enthusiasm and motivation of the target audience, leading to individuals participating in online training passively without truly paying attention and absorbing the knowledge. The participation or training enrolment is basically just to meet steps, goals, or simply to get rid of a corporate obligation for the training.

The expert would like to see new formats and proposals on how to transmit knowledge to empower individuals, but using other existing online resources, such as serious games, movies, augmented reality, and artificial intelligence applications.

Discussion and Contribution

Based on the literature and results of the interview, we consider it relevant to personalize the e-training platform of a company according to the role of each employee. There is a fact that this type of personalization that we presented in this work is not yet assumed as a feature in an e-training platform.

The previous studies served as a guide to understanding that personalization can be reached through the integration of information systems and harnessing the specific data of the employees regarding their roles in the company.

We suggest a simple concept to illustrate how personalization is possible to implement (Fig. 3).

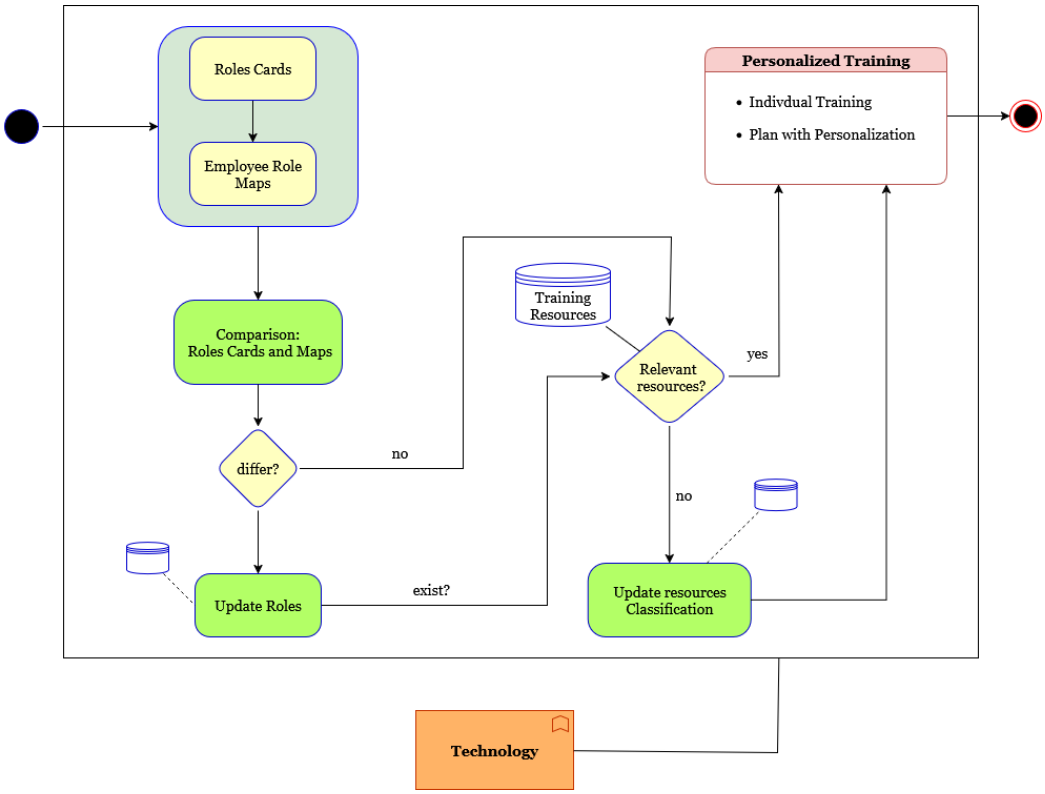

Figure 3. Personalization activity concept (created by authors)

Data consists of the roles in the company, and the role map of each employee will be compared, so that it can be updated according to the latest information. After the confirmation of the employee's role, the system will match the relevant resources.

The training resources need to be constantly updated according to the company's situation or demand in certain roles. If the roles and training resources are attuned, personalized training can be provided.

Conclusions

Our study found that personalization can be applied to any e-training system within an organization if the organization seeks to deliver effective training.

Personalization of resources based on each role can be implemented to focus training on improving employee performance. Alternatively, such personalization can motivate employees to take training because they are aware of the purpose of the training.

The training provision centered on each role can lead to alignment between employee objectives and company goals.

Future Work

As we presented in our "personalization activity concept", which connects with the "technology module", we consider conducting more research to improve the personalization of e-learning systems in a company or organization in general. The research may include personalization supported by emerging technologies (e.g., artificial intelligence).

Another consideration is to investigate the integration of a recommendation system within the e-training platform. It aims to recommend more assertive training resources based on employees' characteristics and professions.

A practical implementation of future work might include using collaborative filter-based methods as part of the recommender system to allow the personalization process to consider past activities and preferences of an individual to make a better and more inclusive personalization. This, of course, will lead to the implementation of deep learning in the IA subfield.

Serious games are one of the technologies in education that can be combined with AI to provide personalization in an e-training system. These will be part of our future research for diversifying content and training engagement.

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From Human-centered to Posthumanist AI-driven Cross-cultural Education: Practical and Ethical Dilemmas

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Abstract

The advent of artificial intelligence (AI) has transformed cross-cultural education from a human-centered paradigm into a posthumanist ecology, where cognition is distributed across networks of human and non-human actors. While promising in theory, this knowledge co-creation ecosystem is fraught with practical and ethical dilemmas that threaten cross-cultural education. Employing a critical conceptual analysis, this investigation first maps the historical structural flaws of traditional cross-cultural education—including curricular bias and ineffective pedagogy, research limitations, misaligned cross-cultural conceptions, and Western misrepresentations of cultures—onto the posthumanist AI-driven education. The analysis demonstrates that AI automates, amplifies, and reinforces these flaws on a massive scale. Key practical problems—automation of biased data, undefined non-human agency, exclusion of human values, and culturally misaligned generated content—undermine AI ethical principles**,** such as fairness, accountability, transparency, and reliability. The paper concludes that ignoring these considerations privileges dominant Western epistemology, with its inherent biases, and further marginalizes alternative knowledge systems, thereby turning AI-driven cross-cultural education into a powerful engine of Eurocentric digital colonialism. The theoretical promise of a posthumanist AI-driven cross-cultural learning is therefore contingent on a new design paradigm that directly addresses these issues while integrating essential human values for cultural competency.

Keywords: Posthumanism, AI-driven education, cross-cultural education challenges, cultural competency, Eurocentrism, digital colonialism

Introduction

For decades, the human-centered paradigm of cross-cultural learning framed direct human interaction as the essential means for developing cultural competency. This paradigm leveraged universal human attributes—such as empathy, cooperation, and communication, supported by research demonstrating that these values connect the individual to society and establish a sense of global unity (Kostina et al., 2015). Accordingly, communication served as the key mechanism, with technology functioning primarily as a tool to facilitate human-to-human interactions in cross-cultural exchanges.

However, the advent of sophisticated generative artificial intelligence (AI) has radically challenged this tradition (Nath & Manna, 2023). AI technologies now act as active mediating agents in cross-cultural communication experiences. They are capable of translating languages, simulating cultural perspectives, creating content, and increasing access to and dissemination of vast amounts of cross-cultural knowledge (Mahboob et al., 2024). Consequently, AI has transformed the human-centered paradigm into a posthumanistic ecology, where agency is distributed across a network of human and non-human actors (Nath & Manna, 2023). In this new assemblage, cross-cultural learning becomes a collaborative entanglement between students, educators, and intelligent algorithms (Firdaus, 2025).

This paper argues that shifting from a human-centered to a posthumanist framework in AI-driven cross-cultural education poses significant practical and ethical dilemmas. These dilemmas threaten the goals of cross-cultural learning.

Methodology

This paper uses a critical conceptual analysis to explore the implications of the posthumanist paradigm for AI-driven cross-cultural education, exposing its practical and ethical risks. The analysis first identifies the historical structural flaws inherent in the traditional human-centered paradigm of cross-cultural education. It then maps these systemic problems onto an AI-driven learning system through a posthumanist lens. Finally, the investigation synthesizes the ensuing practical and ethical issues within this new ecosystem, revealing the dilemmas that threaten the goals of cross-cultural education.

Cross-cultural Education: Definition and Challenges

Cross-cultural education was initiated in response to the recognized importance of cross-cultural knowledge exchange as a key driver for expanding the breadth and depth of scientific inquiry in academia (Mahboob et al., 2024). It is a pedagogical philosophy and practice that fosters mutual understanding, respect, and effective communication across diverse cultural backgrounds (Holliday, 2021). By exposing learners to varied perspectives, values, and traditions, it cultivates cultural competency through empathy, adaptability, and self-awareness, thereby preparing individuals to engage competently and ethically in an increasingly interconnected global society (Mite & Binawan, 2025; Mahboob et al., 2024; Holliday, 2021). However, several challenges impede the full achievement of these aims.

Biased curricula and ineffective cross-cultural pedagogy

The effectiveness of cross-cultural education is obstructed by multiple factors. A primary issue is the lack of authentic representation of global cultures. Students' access to cultural perspectives is often limited to materials curated through the lens of Western publishers, which risks perpetuating overgeneralizations and biases, while framing Western epistemic views as the default (Andreotti, 2011). As a result, educational curricula fail to delve into the complex interplay of values, beliefs, and historical contexts necessary for a nuanced understanding of cultures (Basnet, 2024). This problem of lacking deep understanding is exacerbated when culture is reduced to a superficial, tourist-like focus on food and festivals (Holliday, 2021), or when educators lack the specialized intercultural training needed to facilitate effective discussions on cultural sensitivity (Basnet, 2024). The limited validity of cross-cultural competency assessment tools, often based on self-report, makes it difficult to accurately evaluate educators' pedagogical skills or students' learning outcomes (Basnet, 2024). These issues render cross-cultural learning reductive and ineffective, hampering the development of cultural competency.

Limitations within the traditions of scientific inquiry

Bias in Western-centered educational materials can be attributed to epistemological limitations within dominant research paradigms. The knowledge presented in these materials often stems from cross-cultural research, which is traditionally divided into two methodological traditions: quantitative and qualitative. Within a positivist framework, quantitative research—originally developed within the natural sciences—is often privileged as the most reliable and objective form of inquiry (Mohajan, 2020). Accordingly, proponents argue that the laws of human behavior and social life can be discerned through systematic, objective, experimental, and deductive modes of inquiry (Mohajan, 2020). This approach explains social phenomena by collecting numerical data that are analyzed using mathematical techniques, thereby investigating cause-and-effect relationships and providing a basis for accepting or rejecting theories (Mohajan, 2020). However, without the researcher's direct observation of human interactions, significant intervening social and cultural factors are excluded from the interpretation of human behavior (Putri et al., 2024).

To address these limitations, qualitative approaches rooted in constructivism were developed. Constructivism posits that knowledge is generated through individuals' understanding and interpretations of phenomena within historical and social contexts (Pant, 2023). This perspective originated with Western colonial ethnographers' attempts to understand 'other' societies and was later formalized by modern scholars into standard qualitative methods (Pant, 2023). In this paradigm, reality is constructed through individuals interacting and creating meaning from their social world (Pant, 2023). However, this constructive approach is criticized for being less evidence-based and for being biased by researchers' subjective views (Pant, 2023). Subsequently, a mixed-methods paradigm gained prominence to integrate the strengths of both approaches (Pant, 2023). This integration allows for methodologies of interpretative analyses to be used jointly with statistical approaches. Scholars of scientific methodology increasingly advocate for collaborative and interdisciplinary research to better understand the complexities of our social world, acknowledging the inherent limitations of any single scientific approach (Putri et al., 2024).

Misalignment of cross-cultural conceptions

Another significant challenge is the inherent heterogeneity and incomparability of sociocultural settings. This problem has led to the uncritical export and application of Western-centered conceptions to entirely different contexts—a phenomenon scholars label as Eurocentrism (Connell, 2020; Rifai, 2022). For instance, Western political terms like conservatism and liberalism are often applied as analytical frameworks in divergent socio-cultural settings, despite their lack of conceptual equivalence (Chakrabarty, 2009).

Conservatives generally adhere to social traditions and the existing social order (Heywood, 2021). They often view religion and traditional family systems as aligned with a 'natural' hierarchy of social roles (Heywood, 2021). They tend to question social change and are commonly characterized as 'old-fashioned' (Heywood, 2021). In contrast, liberals typically believe that social change is essential for progress and reform (Heywood, 2021). They prioritize individual freedom and rights, focusing on improving society through the pursuit of social justice, equity, and equality. As a result, liberals tend to be less religious, often adopting secularism (Heywood, 2021).

In other cultures, social and historical contexts are distinct from those of the West. In the Arab and Muslim world, for example, societies are rooted in ancient civilizations that were shaped by the emergence of some of the world's largest religions, including Christianity (Rifai, 2022). Historically, people in these regions spoke different languages within diverse cultural contexts but were later unified by the expansion of Islam (Rifai, 2022). The epistemology and application of universal ethical values, which constitute integral religious principles, such as social justice and equity, vary across the diversity of the Islamic schools of thought and local contexts (Karimullah, 2023; Rifai, 2022).

Unlike in Western sociology, social change in Islamic thought is conceptually understood as *ijtihad*, a process where scholars use foundational religious sources to derive ethical principles and make reasoned judgment (Karimullah, 2023). Furthermore, different from Western conservatism, patriarchy and hierarchy were embedded in Arab and Muslim contexts long before the advent of Islam, a period in which women were often treated as property of men. With the emergence of Islam, women's status was reformed (Karimullah, 2023); however, this system of reform exists in a constant struggle with ancient patriarchal norms, a tension mirrored in the diverse interpretations across the Islamic schools of thought and local cultural contexts. Islamic views, therefore, can be presented as a complex middle ground, and the lifestyles within Arab and Muslim communities are shaped by the interplay of divergent historical, socio-cultural, and religious layers (Karimullah, 2023; Rifai, 2022). As a result, the socio-political landscape of the Arab and Muslim world does not conform to the binary descriptions of Western categories. Nonetheless, scholarly analyses of Islam and modernity continue to operate within such a Eurocentric framework (Qodir & Singh, 2023; Jung, 2023).

Eurocentric lenses have become dominant and are often uncritically applied to analyze diverse cultural contexts—including Muslim, Asian, and African cultures, as well as Indigenous knowledge systems—leading to ethnocentrism (Jubba et al., 2022; Gwaravanda & Ndofirepi, 2020; Johnston & Mason, 2021; Miike, 2023). Scholarly critiques demonstrate that applying Western conceptions across cultures translates into a critical methodological problem (Gwaravanda & Ndofirepi, 2020; Johnston & Mason, 2021; Miike, 2023).

Dominant false cultural narratives

Another source of bias in cross-cultural curricula is the misrepresentation of world cultures by hegemonic Western narratives. Critics contend that Western discourse employs Orientalist and stereotypical lenses, rooted in historical colonization, to maintain imperialist supremacy (Said, 1978). For instance, Arabs are frequently portrayed as outdated, primitive nomads—uncivilized and inferior—thereby necessitating Western supervision (Alshokhada, 2025). Muslim women are predominantly depicted as helpless victims: oppressed; uneducated; passive or subservient figures in need of salvation, reinforcing a "White savior" complex (Al-Sibai, 2022; Akabli & Chahdi, 2022). This phenomenon of Western misrepresentation is systemic, extending beyond the Arab context to several cultures. For instance, the Chinese culture is often presented as either a primitive ancient civilization or a monolithic modern threat, obscuring its complex socio-cultural realities (Chow, 2023; Peters et al., 2022). These cultural stereotypes have become embedded in the Western mindset and are perpetuated in cross-cultural educational materials.

Consequently, cross-cultural education faces the formidable challenge of dismantling deep-seated Western biases, ethnocentrism, and preconceived images—a challenge magnified by biased curricula and ineffective pedagogy, research limitations, misaligned cross-cultural conceptions, and hegemonic Western misrepresentations of cultures. These issues are reinforced in AI-driven cross-cultural education, where algorithms trained on biased datasets automate and amplify these problems at scale (Liu, 2025; Tao et al., 2024)

Posthumanist AI-Driven Cross-cultural Education

AI-driven education through a posthumanist framework

In AI-driven education, a posthumanist perspective challenges the traditional human-centric model where technology is a passive tool for human use. Instead, it reframes AI as an active, agential participant

in the educational process, fundamentally altering the dynamics of teaching, learning, and knowledge creation (Firdaus, 2025; Nath & Manna, 2023). As a result, education becomes a collaborative entanglement between students, educators, and intelligent algorithms**,** where cognition is distributed across a network of human and non-human actors (Firdaus, 2025; Nath & Manna, 2023).

Posthumanism: an overview

Posthumanism is a philosophical and cultural movement that critiques and moves beyond traditional anthropocentric (human-centric) views of the world (Nath & Manna, 2023; Thomsen & Wamberg, 2020). It challenges the idea that humans are the central actors in the universe, emphasizing instead the deep interconnectedness of humans, technology, animals, and the environment (Nath & Manna, 2023; Thomsen & Wamberg, 2020).

Emerging from postmodernism's rejection of universal truths and rigid structures, posthumanism was first critically employed by Ihab Hassan (1977) and is rooted in earlier philosophical thought, such as Friedrich Nietzsche's concept of the *Übermensch* ("Overman")—a being who transcends human limitations (Nath & Manna, 2023; Thomsen & Wamberg, 2020). Posthumanism focuses on deconstructing the concept of "the human," opposing hierarchical views that place humans above other species and nature. It argues that all forms of life, and even non-living entities and systems, possess intrinsic value and agency (Nath & Manna, 2023; Thomsen & Wamberg, 2020).

Within posthumanism, the concept of "humanity" is deconstructed through a critical interrogation of what it means to be human, thereby challenging established biological, cultural, and philosophical definitions (Nath & Manna, 2023; Thomsen & Wamberg, 2020). Human identity is understood as being shaped by the constant interplay of technology (e.g., digital interfaces), culture (e.g., media, art, and literature), and historical context (e.g., the development of philosophical theories and social movements) (Nath & Manna, 2023; Thomsen & Wamberg, 2020). Therefore, humans are reconceptualized as cyborgs—hybrid fusions of the organic and the machine (Nath & Manna, 2023; Thomsen & Wamberg, 2020).

It is essential to distinguish posthumanism from transhumanism. While transhumanism seeks to enhance human abilities through technology (e.g., genetic engineering) to overcome biological limits, posthumanism is more critical, questioning the very category of the "human" and exploring what might exist after human-centric paradigms (Nath & Manna, 2023).

Thus, posthumanism does not seek to erase humanity but rather to expand its definition. It envisions a future where humans coexist with other forms of life and intelligence—biological, artificial, and ecological—on more equitable terms (Nath & Manna, 2023; Thomsen & Wamberg, 2020). Through its radical critique of anthropocentrism, it paves the way for a new landscape of ethical, social, and philosophical inquiry.

In AI-driven education, posthumanism does not simply advocate for adding AI to existing educational models. It calls for a paradigmatic shift towards understanding education as a complex ecosystem where humans and intelligent machines co-create knowledge (Firdaus, 2025). This raises significant challenges for cross-cultural education, as existing issues—such as curricular bias and ineffective pedagogy, research limitations, misaligned cross-cultural conceptions, and Western misrepresentations of cultures, are now being automated, amplified, and reinforced by the AI-driven learning system.

Posthumanist dilemmas in AI-driven cross-cultural education

Applying a posthumanist standpoint to AI-driven cross-cultural education reveals a critical equity flaw: AI systems trained on biased data automate Western epistemology, presenting its inherent biases as universal. This is not merely a technical oversight but a form of Eurocentric digital colonialism where dominant perspectives override and marginalize other knowledge systems (Nemorin, 2024). This systemic fault is rooted in the anthropocentric structure of traditional human-centered education and undermines the AI ethic of fairness (Firdaus, 2025).

AI-driven learning systems must, therefore, prioritize dismantling these biases to ensure AI platforms represent a true pluriversality of cultures (Noel et al., 2023). This is essential for challenging the Eurocentric hierarchy embedded within cross-cultural learning resources. However, designing a landscape that creates a fair and just ecosystem for all participants—human and non-human—is inherently complex. The goal of such a design is to ensure that AI-driven education breaks from historical structural flaws in cross-cultural education, but this is far from straightforward.

In contrast to traditional, human-centered education, posthumanism de-centers the human and challenges anthropocentric systems (Firdaus, 2025). It posits that AI functions as an active, agential participant in the learning ecosystem; consequently, its role and potential "interests" must be considered, moving beyond exclusively human concerns (Nath & Manna, 2023). This prompts a reshaping of ethical frameworks and introduces significant new challenges.

Foremost among these is the problem of accountability for non-human agents (Firdaus, 2025). When AI, trained on biased databases, co-creates cultural interpretation, it becomes intensely challenging to assign responsibility for inaccurate or offensive outputs. Should blame fall to the programmer, the educational institution, or the algorithm itself?

A further critical risk involves the treatment of cultural data. If AI analyzes cultural content through the paradigm of quantitative methods, the requirement of algorithmic objectivity will replicate existing limitations in cross-cultural research. Conversely, if a constructivist approach is integrated with AI perspective—biased and devoid of empathetic human understanding—it will systematize and inflate automated biases. In the second scenario, an essential human value is excluded, and transparency is compromised, as the AI's interpretations—lacking explainability—remain incompletely comprehensible to its human co-participants (Nath & Manna, 2023).

These issues culminate in a significant threat to AI robustness: the perpetuation of cultural misalignment, which fundamentally undermines the reliability essential to AI ethics. Echoing the aforementioned methodological problem of misaligned cross-cultural conceptions, Western AI platforms, particularly large language models (LLMs) like OpenAI's ChatGPT, are systematically centered on Anglo-Saxon cultural perspectives, featuring major gaps in their adjustment to diverse societies, thereby undermining the reliability of their cultural outputs (Ahmad et al., 2024; Cao et al., 2023; Liu, 2025; Tao et al., 2024).

In short, the posthumanist shift in AI-driven education, while theoretically promising, introduces significant practical and ethical risks to cross-cultural education. Practical problems—arising from automating inherently biased data, the challenge of defining non-human agency, the exclusion of essential human values, and the generation of culturally misaligned content—collectively undermine foundational AI ethical principles, including fairness, accountability, transparency, and reliability. The failure to address these issues will threaten the goals of cross-cultural education.

Discussion

Devoid of human values, critical awareness, and nuanced understanding of cultures, AI automates, inflates, and reinforces inherent cultural biases and stereotypes. Its documented shortfalls—including limited and biased data, a lack of context, absent emotional intelligence, and poor engagement—undermine the essential human role in interpreting the fluidity of human lives (Ahmad et al., 2024; Gautam et al., 2025; Girju, 2023; Liu, 2025; Yang, 2025).

Posthumanism expands the definition of humanity, envisioning a future where humans coexist with other forms of life and intelligence on more equitable terms (Nath & Manna, 2023; Thomsen & Wamberg, 2020). It calls for a paradigmatic shift toward understanding education as a complex ecosystem where humans and intelligent machines co-create knowledge (Firdaus, 2025). This theoretical move to decenter the human and embrace a more inclusive ecology of human and non-human actors in AI-driven cross-cultural education, while promising in theory, in practice automates, amplifies, and reinforces the very cultural biases and power structures it seeks to overcome (Firdaus, 2025). The preceding analysis confirms that the integration of AI does not diminish the historical structural flaws of cross-cultural education—including curricular bias and ineffective pedagogy, research limitations, misaligned cross-cultural conceptions, and Western misrepresentations of cultures—but rather systematizes and reinforces them at an unprecedented scale.

The practical problems arising from the posthumanist framework within AI-driven cross-cultural education can be categorized as follows: first, the automation and systemic amplification of inherent bias and limited data at scale; second, the operational challenge stemming from the intractable task of defining non-human agency; third, the exclusion of essential human values from algorithmic outputs; and finally, the generation of culturally misaligned content. These issues compromise fundamental AI ethical principles, including fairness, accountability and responsibility, transparency and explainability, and robustness and reliability, posing significant risks to AI-driven cross-cultural education.

The implications of the study's findings are substantial. They suggest that ignoring these practical and ethical considerations privileges dominant Western knowledge and further marginalizes alternative

epistemologies, threatening to turn AI-driven cross-cultural education into a powerful engine of Eurocentric digital colonialism (Nemorin, 2024). This necessitates a design that addresses these problems while integrating evidence-based human values essential for cultural competency, such as empathy, cooperation, and communication.

This study has several limitations. First, the synthesized evidence is primarily theoretical. It is built on mapping the historical structural flaws of cross-cultural education onto existing scholarship relating to the implications of posthumanism for AI-driven learning systems. Second, the analysis adopts a critical stance toward the posthumanist shift. While this focus effectively exposes significant risks, it may overlook potential beneficial applications of AI in cross-cultural contexts. Finally, while the study is focused on diagnosis, it offers only a preliminary exploration of practical solutions, leaving the development of new models that address these issues as an essential task for future work.

Future research should pursue empirical investigations focusing on designing and testing AI-driven education to overcome its ensuing practical and ethical risks to cross-cultural education. This includes debiasing cultural datasets, engineering AI systems for epistemological pluralism, and developing pedagogical models that integrate AI as a co-participant while maintaining critical human oversight. Philosophical work is also needed to reconcile the posthumanist decentering of human agency while rigorously adhering to AI ethical principles, aiming to cultivate cultural competency and develop effective AI-driven cross-cultural education.

Conclusions

The shift to a posthumanist AI-driven cross-cultural education—conceptualized as an ecosystem where humans and intelligent machines co-create knowledge—is fraught with practical problems and ethical compromises. This investigation reveals that this move fails to overcome the historical structural flaws of traditional human-centered cross-cultural education—such as curricular bias and ineffective pedagogy, research limitations, misaligned cross-cultural conceptions, and Western misrepresentations of cultures. Instead, it automates, amplifies, and reinforces them at scale.

The practical problems arising from this shift—including automating inherently biased data, the challenge of defining non-human agency, the exclusion of essential human values, and the generation of culturally misaligned content—collectively compromise foundational AI ethical principles such as fairness, accountability, transparency, and reliability. These practical and ethical dilemmas threaten the goals of cross-cultural education.

Ignoring these considerations privileges dominant Western epistemology, with its inherent biases, and further marginalizes alternative knowledge systems, thereby turning AI-driven cross-cultural education into a powerful engine of Eurocentric digital colonialism. Therefore, the theoretical promise of a posthumanist ecology is contingent upon directly addressing these practical problems and ethical compromises in a new design paradigm that integrates essential human values for cultural competency.

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A Freirean Approach to Breaking the Spiral of Silence in AI-Mediated Education

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Abstract

AI systems trained on biased media datasets perpetuate cultural misrepresentation and stereotypes, marginalizing minority students. This study aims to develop a conceptual framework for understanding how AI-mediated education marginalizes minority voices and to propose pedagogical strategies for disrupting this cycle and promoting equitable and inclusive learning environments. The research involves a three-phase conceptual analysis based on Edward Said's Orientalism, Elisabeth Noelle-Neumann's Spiral of Silence, and Paulo Freire's Critical Pedagogy. The synthesis reveals that AI perpetuates systemic cultural biases—such as Orientalist misrepresentation—and embeds them into educational technologies and curricula, identifying this cyclical process as an automated Spiral of Silence. A novel framework integrating Noelle-Neumann's Spiral of Silence and Freire's Critical Pedagogy provides an introductory guide for remodeling AI—from a tool that amplifies dominant narratives to one that fosters emancipation. It positions educators as innovators who can leverage Critical Pedagogy to challenge oppressive structures and amplify silenced voices. Proposed strategies include AI-supported dialogical engagement, deconstructing embedded biases, utilizing diverse platforms for comparative analysis, adhering to ethical guidelines, and practicing critical reflexivity. This preliminary model empowers educators to cultivate equitable and inclusive learning environments.

Keywords: Spiral of Silence, AI-mediated education, Critical Pedagogy, Orientalism, global digitalization, algorithmic bias, Western hegemony, biased media, equity and inclusion.

Introduction

Globalization has increased cultural exchange, whereby world societies are becoming more interconnected. Advanced communications technology, emanating from the West, serves as a medium to share and deliver cultural practices and the latest social trends. World societies are gradually blending to form a hybrid, homogenized culture with a Western prevalence (Mirrlees, 2013; Mulinge, 2022). English, for example, has become the leading global language of communication in both business and education. Additionally, mass media, delivering information through news and entertainment via outlets such as the internet, social media, music, and movies, has played a significant role in shaping public views, attitudes, and behaviors worldwide (Mirrlees, 2013; Mulinge, 2022).

This media ecosystem generates the vast datasets of text, images, and video used to train artificial intelligence (AI) models (Carter & Dale, 2025). While the goal is to help AI reflect global diversity, these media sources perpetuate systemic biases—including skewed reporting, gender stereotypes, and ethnocentric narratives—which are then amplified by AI systems under a veneer of technological neutrality, rather than mitigating existing power asymmetries (Carter & Dale, 2025). This dynamic is starkly illustrated by platforms like Meta, whose algorithms have been documented to amplify hate speech and facilitate real-world violence, as evidenced in reports by the United Nations and Amnesty International (2018; Carter & Dale, 2025). The subsequent dismantling of fact-checking policies in favor of user-generated content has further entrenched this harm, prioritized dominant narratives and automated the marginalization of minority voices (Carter & Dale, 2025).

Within this context, global social movements, molded by Western cultural hegemony, often transcend and oversimplify the rich diversity of world social traditions, norms, and rituals (Mirrlees, 2013; Mulinge, 2022). While digital globalization can foster inclusive and positive cross-cultural interactions, it systematically risks perpetuating stereotypes and misrepresentation. These stereotypes often persist in educational settings, where they shape curricular content and student experiences.

This study aims to develop a conceptual framework for understanding how AI-mediated education can marginalize minority voices and to propose pedagogical strategies for disrupting this cycle and promoting equitable and inclusive learning environments.

Methodology

This research employs a sequential, three-phase methodology involving conceptual analysis and synthesis.

1. Edward Said's critique in Orientalism provides a critical lens to diagnose the systemic misrepresentation and marginalization of non-Western cultures within dominant Western discourse.
2. Elisabeth Noelle-Neumann's Spiral of Silence theory serves as a mechanistic tool for analyzing how globalization amplifies cultural biases to silence minority voices within digital narratives.
3. Paulo Freire's Critical Pedagogy offers an emancipatory model to disrupt cycles of marginalization and foster equitable and inclusive learning environments.

Cultural Bias: From Orientalist Discourse to AI Algorithms

Scholarly evidence demonstrates that the global dominance of Western media perpetuates cultural stereotypes, a dynamic rooted in historical colonization to maintain Western imperialist supremacy (Said, 1978). To captivate audiences, global media outlets frequently present inaccurate, exaggerated, or extreme portrayals of non-Western cultures (Kobayashi et al., 2019). For instance, Arabs are routinely depicted as primitive nomads, uncivilized, mysterious, extremist villains, or exotic "Others" (Alshokhada, 2025). Critics contend that Western media oversimplify and marginalize the complexities of global cultures, leading to overgeneralizations that position Western cultures as the aspirational standard (Mirrlees, 2013; Mulinge, 2022). This standard is now being hard-coded into technology; AI image generators developed in non-Western contexts, like China's Meitu app, consistently exhibit a "White normativity", depicting White people with higher accuracy and most often transforming people of color into White-appearing figures (Yang, 2025).

Edward Said argues that Orientalism, defined as "a discourse that has been used to exert power and control over the Orient", profoundly influences Western art, literature, and media (Alshokhada, 2025, p.262). A critical analysis of Western discourse exposes how these Orientalist biases shape the portrayals of Arabs, frequently presenting them as outdated and inferior, necessitating Western supervision (Alshokhada, 2025). While women are broadly marginalized and misrepresented in media, Arab women, viewed through Orientalist stereotypical lenses, are predominantly depicted as helpless victims—oppressed, passive, sexually repressed, uneducated, and lacking agency—or as subservient figures in need of rescue. These inaccessible, veiled Arab women are often portrayed with exposed flesh in harem settings (Al-Sibai, 2022; Akabli & Chahdi, 2022). In Hollywood films, roles for Arab and Muslim women are reduced to either silenced, veiled figures or eroticized belly dancers (Akabli & Chahdi, 2022). The latter portrayal suggests an emancipation of the muted, veiled woman from male dominance through liberal Orientalism (Akabli & Chahdi, 2022). The romanticization of veiled women's bodies, when not rendering them silent, is weaponized to evoke fear (Akabli & Chahdi, 2022). They are depicted as agents of terror wearing explosive belts, ready to detonate themselves among the innocent (Akabli & Chahdi, 2022).

These misrepresentations, grounded in Eurocentric and colonial narratives of the Orient, are now embedded in the datasets and algorithms of AI systems (Tao et al., 2024). This creates a harmful feedback loop: media biases train AI, and AI-generated content then reinforces and amplifies those same biases on a massive scale, perpetuating a digital form of Orientalism (Kobayashi et al., 2019). The authentic voices and perspectives of reality in non-Western cultures are overruled by a macro-group of Orientalists (Said, 1978; Kobayashi et al., 2019; Yang, 2025). The presentation of "Other" cultures is subdued by Western mass media outlets, resulting in the formation of rigid, categorical images of the non-Western world. This process of effacement is now automated. As Yang (2025) found, AI systems can make non-White groups invisible by literally altering their racial appearance in generated content, particularly in interracial contexts. Contrary perspectives, which may depict the social realities of cultures, do not blend and cannot compete in the public opinion climate, where people are preconceived through dominant narratives (Noelle-Neumann, 1974; 1993). These findings demonstrate how the Spiral of Silence, fueled by Western media's misrepresentations and now algorithmically amplified, suppresses minority cultural voices and reinforces harmful stereotypes (Drew, 2022). This process perpetuates cycles of marginalization within educational settings.

False Social Realities in Cross-cultural Learning Environments

Scholars argue that narrow Western portrayals are reinvented to reshape the social realities of non-Western cultures—a process now accelerated by AI (Said, 1978; Drew, 2022). When these tools exhibit cultural bias, they create a harmful feedback loop that disrupts the learning process and reinforces the student's sense of being the "Other" (Lewis, 2025).

The consequences of this dynamic are severe. Studies reveal that Muslim students in Western universities struggle with racial stereotypes and academic isolation, reporting a lack of inclusive academic spaces and inadequate university support (Al-Sibai, 2022; Kizil et al., 2025). The complexities of identity, religion, gender, and societal expectations profoundly shape the experiences of Muslim women in academia (Al-Sibai, 2022; Kizil et al., 2025). Their hypervisibility, stemming from intersecting identities (e.g., as racialized Muslim immigrants), heightens their scrutiny, reinforces stereotypes, and increases their sense of exclusion (Al-Sibai, 2022; Kizil et al., 2025). Female Muslim students reported struggling to assert their identities positively and challenge dominant narratives (Al-Sibai, 2022; Kizil et al., 2025). They described the institutional process of marginalizing their religious expression as a form of silencing (Al-Sibai, 2022; Kizil et al., 2025).

The reported experiences of international students mirror those of Muslim students, revealing a consistent pattern of marginalization across diverse educational contexts. Studies from Canada (Howe et al., 2023) and Northern Ireland (Cena et al., 2021) document feelings of exclusion, othering, detachment, and significant cross-cultural barriers. This marginalization was exacerbated during the shift to online learning in the UK, where digital environments often lacked cultural competency, reinforcing monolithic stereotypes (Costa & Li, 2025). Furthermore, research confirms that culturally biased AI platforms can reduce participation among minority students by over 30%, rendering them ineffective for inclusive education (Lewis, 2025). The consequences of this differential treatment are dire: students who experience it are more likely to drop out, while those who remain often cope through disengagement and defiance (Rivers, 2020).

Altogether, these findings demonstrate how the Spiral of Silence moves from media to the classroom. Western media's false representations—which suppress, marginalize, and silence minority voices—are embedded in pedagogical digital narratives. This compels marginalized students to self-censor and disengage, creating a cycle where educational technology and curricula perpetuate the very biases they are meant to dismantle.

The Spiral of Silence

In the Spiral of Silence, individuals remain silent when they perceive their opinions to be in the minority. According to Elisabeth Noelle-Neumann (1974; 1993), the fear of isolation is a powerful force that shapes public expression. This process is dynamic. Individuals' perception of majority opinion directly affects their willingness to express divergent views, often leading to communication apprehension (Noelle-Neumann, 1974, 1993; Ramazan et al., 2023). Public opinion thus functions as a form of social control, beginning with a fundamental human desire to belong and avoid social isolation (Noelle-Neumann, 1974, 1993; Sohn, 2022). When a majority's perspective is continuously reinforced—especially through mass media or influential interpersonal networks—minority opinions are suppressed and gradually silenced (Noelle-Neumann, 1974, 1993; Sohn, 2022).

Noelle-Neumann further argued that mass media can skew public perception and produce widespread "pluralistic ignorance," where individuals incorrectly assume their private views are uncommon (Noelle-Neumann, 1974, 1993; Sohn, 2022). The media plays a decisive role in constructing dominant views within a social environment, effectively setting the climate of public opinion (Noelle-Neumann, 1974, 1993; Sohn, 2022). People increasingly align their expressed opinions with these mediated portrayals, which selectively amplify certain perspectives while downplaying or ignoring others (Noelle-Neumann, 1974, 1993; Sohn, 2022). This conformity can solidify into accepted societal norms, drive values, and ultimately catalyze social change. The media's power to shape discourse is particularly evident on new or controversial topics. The Spiral of Silence intensifies in digital environments, where social media users frequently self-censor within homogenous networks due to fears of isolation, ostracism, or peer rejection (Drew, 2022; Laor, 2024; Sohn, 2022).

Tested and verified in Western individualistic cultures, particularly during political elections, the Spiral of Silence is also observed in Eastern collective cultures, where social harmony and majority norms strongly influence communication (Huang, 2005; Lee et al., 2004) Across both cultural contexts, individual personality traits—such as extraversion, neuroticism, conscientiousness, agreeableness, openness to experience, and self-efficacy—influence a person's willingness to express minority views in what they perceive as a hostile opinion climate (Nam, 2010).

Gender interplays with socio-cultural contexts within this spiral. Evidence suggests that women often self-censor and avoid criticism in male-dominated settings, suppressing their views especially when traditional gender stereotypes prevail (Amanatullah & Morris, 2010). They may be more inclined to speak out on issues like feminism and gender equality when they perceive social support, yet they retreat from discussions on leadership or power structures where they feel outnumbered (Hayes et al., 2005). Women with intersectional, marginalized identities—such as disadvantaged women of color—often face a heightened fear of social sanctions (Rosette et al., 2023).

While online anonymity can sometimes reduce the fear of rejection, evidence shows that women who share minority opinions online frequently encounter disproportionate harassment, effectively perpetuating their silence (Veletsianos et al., 2018).

The Spiral of Silence serves as a powerful framework for understanding public discourse. It effectively demonstrates how the complex interplay of media power, cultural contexts, individual psychology, and social identity collectively determines who speaks, who remains silent, and which opinions come to dominate society.

There are, however, exceptions to this phenomenon. The spiral's dynamic is resisted by two groups: the hardcore nonconformists, who persist in their beliefs despite facing rejection, and the *avant-garde*, comprised of innovative and forward-thinking individuals such as intellectuals, artists, activists, and reformers (Sohn, 2022). Educators, as *avant-garde* innovators, have the potential to challenge dominant false narratives and foster diverse perspectives. Critical Pedagogy serves precisely this emancipatory purpose. It aims to liberate education and promote social justice by empowering learners to voice unconventional opinions.

Critical Pedagogy: The Pedagogy of the Oppressed

Critical pedagogy, which emerged in the mid-20th century amid European fascism, economic domination, social inequality, and cultural hegemony, was developed by Paulo Freire in *Pedagogy of the Oppressed* (1970). Rooted in the Frankfurt School's Critical Theory, it seeks to emancipate individuals and societies from oppression, whether self-imposed or external (Chalaune, 2021; Uddin, 2019). Freire revitalized this movement with Critical Pedagogy as a cultural revolution to liberate the oppressed from ignorance, illiteracy, and a culture of silence, while urging oppressors to recognize their role in perpetuating injustice (Uddin, 2019).

Traditional versus problem-posing education

Freire critiques traditional education as a banking system, where teachers deposit knowledge into passive students, treating them as empty vessels (Chalaune, 2021). This memorization-focused approach stifles creativity, critical thinking, and situational awareness, embedding dominant cultural values as common sense and omitting diverse perspectives (Chalaune, 2021). This perpetuates a hegemonic environment in which the selective viewpoints of one group dominate the classroom — a process now automated through AI tools trained on biased data. (Lewis, 2025). In education, this cultivates a culture of silence, mirroring the Spiral of Silence, where fear of isolation suppresses minority voices, leading to disengagement, social fragmentation, and conflicts.

In response, Freire's problem-posing education promotes freedom through learner-centered, participatory methods. Teachers respect students' autonomy, adopt humanitarian approaches, and harness creative potential to empower students as active participants of self-governance and societal change. This fosters *conscientization*, a critical awareness that extends beyond rote learning. It enables students to improve their lives and build a just society by raising awareness of reproducible inequalities in education and social institutions (Chalaune, 2021).

Disrupting systems of oppression within the classroom

Critical pedagogy actively disrupts Bell's (2013) four I's of oppression—ideological, institutional, interpersonal, and internalized (Rivers, 2020). This form of systemic oppression, premised on the belief in one group's superiority, becomes embedded in social institutions, leading to interpersonal conflicts and internalized inferiority among oppressed groups. In educational settings, biased knowledge—now automated through AI narratives—marginalizes and excludes these groups. To break this cycle, Freire's *Pedagogy of the Oppressed* advocates for decolonizing curricula and replacing reductive narratives with student-led Socratic questioning curricula (Rivers, 2020). This method empowers students to construct knowledge collaboratively through evidence-based dialogue structure and critical text examination, thereby challenging the ideological assumptions often perpetuated by AI and standard curricula (Rivers, 2020; Lewis, 2025).

Pedagogical approaches

Strategies to liberate education, aligned with Freire's Critical Pedagogy, move beyond the traditional banking model to enhance critical consciousness and can be summarized in several key approaches. The first is the dialogical method, a form of collaborative conversation rooted in humility and mutual trust that treats teachers and students as equals, breaking traditional monologues (Chalaune, 2021; Uddin, 2019). Through Socratic

questioning, it fosters critical inquiry and gives voice to silenced students, countering the suppression of minority views (Chalaune, 2021; Uddin, 2019). This is complemented by connecting learning to real-life situations and problem-posing strategies that engage students in analyzing and transforming their world, as well as hands-on, out-of-book activities that make learning tangible and empower students as active learners (Chalaune, 2021; Uddin, 2019). This leads to the second approach: the transformative intellectual role of the teacher, who facilitates this dialogue, critiques systemic inequalities, and values students' existing knowledge to empower critical reflection (Chalaune, 2021; Uddin, 2019). Third, this creates an active learner role where students co-create knowledge, challenge assumptions, and engage in social critique, thereby forming a public sphere for agency and participation (Chalaune, 2021; Uddin, 2019). Integrating these pedagogical frameworks into AI-mediated education empowers suppressed voices and promotes social justice, thereby fostering equity and inclusion in the classroom.

Discussion

The preceding analysis demonstrates an automated feedback loop between Western media hegemony and AI, which systematically marginalizes non-Western voices and perpetuates a digital Spiral of Silence. This synthesis reveals that AI does not merely reflect existing biases but actively amplifies them, hard-coding Orientalist narratives into educational technologies and curricula. The consequences are severe. Students from marginalized backgrounds experience alienation, disengagement, self-censorship, and a reinforced sense of being the "Others", undermining the goals of equity and inclusion in education.

Building on this analysis, this study has established that the integration of Noelle-Neumann's Spiral of Silence and Freirean Critical Pedagogy provides a novel framework for understanding this phenomenon and offers significant contributions. It defines the automated Spiral of Silence as a central mechanism of digital oppression in education and presents Critical Pedagogy as a necessary emancipatory counter-force. Consequently, the framework advocates for a pedagogical revolution that empowers educators to become critical facilitators of technology. This shift positions them as *avant-garde* innovators who harness AI through pedagogies of liberation to disrupt negative discourse, break the automated silence, and foster equitable, inclusive learning environments. The following discussion outlines how educators can operationalize AI tools in alignment with Critical Pedagogy, acting as transformative intellectuals to achieve these ends.

AI-powered dialogical engagement

Critical Pedagogy's dialogical method, grounded in collaborative inquiry, can be enhanced by AI-driven platforms designed to facilitate structured dialogue. Research indicates that such AI tools may increase student engagement and motivation by providing interactive, culturally relevant content that resonates with diverse student groups, thereby creating a classroom environment where minority opinions are more likely to be voiced (Abror & Dwi, 2024). For instance, studies show that AI tools with advanced reasoning capabilities, such as GPT-4 or ERNIE Bot, can be tailored through careful prompt engineering to emulate Socratic questioning (Abror & Dwi, 2024). However, their effectiveness in supporting critical analysis of media portrayals of non-Western cultures remains underexplored. Despite this gap, evidence suggests that AI-based instructional platforms, when guided by culturally responsive pedagogies, can outperform conventional methods in enhancing cultural representation and reducing implicit biases, thereby amplifying and empowering minority voices (Abror & Dwi, 2024).

Deconstructing media biases

Advanced machine learning algorithms, particularly those powering Large Language Models (LLMs), can analyze vast archives of global news to detect deep-seated narrative biases, such as Orientalism, which often emphasizes negative themes while overlooking positive cultural and intellectual contributions. Educators can utilize these algorithmic outputs to foster evidence-based classroom discussions (Abror & Dwi, 2024; Lu et al., 2025). Integrating this technique into established pedagogical strategies can promote critical inquiry and help disrupt bias in AI-mediated education (Abror & Dwi, 2024; Lu et al., 2025). This approach embodies the Freirean problem-posing pedagogy by framing media texts as generative problems for students to critically co-investigate—actively analyzing inherent cultural biases and the underrepresentation of minority voices encoded within the algorithms (Abror & Dwi, 2024; Lu et al., 2025; Tao et al., 2024).

Diverse AI platforms

Educators can integrate AI tools from diverse geopolitical and cultural origins to enrich cross-cultural learning environments. Western-developed tools like GPT-4 excel at generating diverse content but often rely on predominantly English-language datasets, which may introduce Anglo-centric biases (Tao et al., 2024). In contrast, models like China's ERNIE Bot, trained on extensive Chinese-language corpora, provide alternative linguistic and cultural perspectives. Instead of assuming any single tool is inherently less biased, educators should harness this algorithmic diversity to support critical comparative analysis (Lu et al., 2025; Ta et al., 2025; Zhu et al., 2024). By auditing AI outputs—such as their representation of non-Western cultures or regional narrative portrayals—educators can guide students in identifying computational biases across diverse contexts (Lu et al., 2025; Ta et al., 2025; Zhu et al., 2024). This practice aligns with critical AI literacy, a paradigm-shift from a purely technical understanding of AI to a socio-technical one, focusing on its implications for society (Velander et al., 2024). It also resonates with Critical Pedagogy by framing AI not as a neutral tool, but as a social construct that unveils social and political layers of power for students to deconstruct, guided by ethical principles.

Navigating AI ethics

A significant contribution of AI-mediated education lies in its ability to personalize learning, offering a revolutionary approach to empowering marginalized students (Sarı et al., 2024; Eden et al., 2024; Liu, 2025). However, fulfilling this potential requires a strong commitment to ethical AI to prevent the perpetuation of bias and promote equity (Sarı et al., 2024; Eden et al., 2024; Liu, 2025). This commitment can be operationalized through comprehensive educator training that emphasizes ethical AI principles such as fairness, accountability, and transparency. Training should prioritize social benefit by leveraging AI to amplify marginalized voices and focus on mitigating unfair bias through the critical auditing of AI outputs, such as reviewing image generators for stereotypical portrayals (Eden et al., 2024; Liu, 2025). To maintain accountability, educators must verify and contextualize AI-generated content before classroom use (Eden et al., 2024; Liu, 2025). Transparency can be achieved by using algorithmic analysis to show students how a large language model's outputs might reflect suppressed perspectives; these outputs can then serve as evidence for critical classroom discussions (Eden et al., 2024; Liu, 2025). Through these practices, ethical AI use strategically operationalizes Freirean pedagogy—liberating oppressed voices and fostering social justice, equity, and inclusion in learning environments.

Critical reflexivity

Integrating AI tools in education requires ongoing reflexivity, an ethical practice where educators engage in continuous critical self-assessment to avoid perpetuating systemic inequalities like algorithmic bias (Chalaune, 2021; Door, 2014). This approach aligns with Freire's concept of *conscientization*, where individuals cultivate a deeper awareness of their socio-cultural context and their potential to transform it (Chalaune, 2021; Door, 2014). Similarly, educators must guide students to engage in self-critique while also teaching them to critically interrogate AI tools to ensure they become instruments for *conscientization* and social change (Chalaune, 2021; Door, 2014). This activity aligns with research advocating for a collaborative model, where educators, students, developers, and policymakers co-create equitable and inclusive educational environments (Lewis, 2025).

This study has several important limitations. First, the proposed framework for educators as *avant-garde* innovators is theoretical and has not been tested in AI-mediated classrooms, so its practical effectiveness remains unproven. Second, many educators may lack the necessary digital skills or access to diverse AI tools required to implement the strategies within the proposed framework, particularly in under-resourced schools. Third, as all AI systems inherit built-in biases, teachers require specific training to recognize and counter these biases effectively.

Future research should focus on empirically testing these methods in real AI-mediated educational settings to measure their impact. Conducting pilot studies on the ethical use of AI will assist in developing effective training for educators. Finally, researchers must collaborate directly with educators, students, developers, and marginalized communities to co-design equitable and inclusive AI tools that amplify silenced voices.

Conclusions

This study demonstrates the interplay between Western dominance, media power, digitalization, and the suppression of inclusive voices in AI-mediated education. A synthesized analysis reveals that AI perpetuates deep-seated cultural biases, such as the Orientalist misrepresentation of Arab cultures grounded in Western hegemony, embedding them into educational technologies and curricula. This cyclical process is identified as an automated Spiral of Silence. Integrating Noelle-Neumann's Spiral of Silence with Freire's Critical Pedagogy serves as a novel

framework that positions educators as *avant-garde* innovators capable of breaking this spiral by harnessing AI through Critical Pedagogy to challenge oppressive structures and amplify silenced voices. Proposed pedagogical strategies include employing AI-supported dialogical engagement, deconstructing embedded media biases, leveraging diverse AI platforms for comparative analysis, adherence to ethical guidelines, and the practice of critical reflexivity. This new framework provides an introductory guide for remodeling AI—from a tool that amplifies dominant narratives to one that fosters emancipation, empowering educators to cultivate equity and inclusion in learning environments.

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"When you touch the statues, you wake them up": Qualitative research into the teaching approach of local history through its gamification in and out of the classroom.

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Abstract

The aim of this pilot research is to fill the gap in the schooling of local history as an autonomous teaching subject in the Greek educational system of Secondary Education in an effort to become "visible" from "invisible", to be studied experientially and loved by the student by transforming it from academic knowledge into "game". In this necessity also lies the originality of this research, since the Greek educational curriculum still does not recognize the power of game and locality in adolescent historiography. The goal is twofold, to investigate in a thorough way the gamified historical literacy as well as the attitude of the educational community towards the teaching of local history. This study is based on the methodology of grounded theory in collecting data inductively through their analysis and their conceptual evolution. By triangulating them from different sources, such as participatory observation of sample teachings, semi-structured interview of a teachers' focus group, formative assessment of students, we were able to ensure the saturation of the data. The results of the research showed that the gamified teaching of local history helps to discover the past through the present in an empirical way. Its added value lies in highlighting the value of the gamification of history in inclusion classes and the problems that can arise. Further research needs to be carried out on the combination of indoor and outdoor education in the teaching of local history through gamification, because "when you touch the statues, you wake them up".

Keywords: local history, gamified learning, inclusion classes

Introduction

The evaluation of local history as a necessary subject in the educational system of Secondary Education in Greece in gamified inclusion classes is the central point of this research, taking into account that students as digitally indigenous are more familiar with the new digital reality in terms of their education. The utilization of technology in the educational process, based on gamification techniques, is nothing more than the integration of game mechanisms in a non-game environment (Dimitriadou, 2016).

The teaching of the local history course is a scientific subject mutatis mutandis of the axes of general history and geography, which is open to more interdisciplinary research and study in terms of its cognitive and pedagogical significance, while revealing the importance of investigating the locality of events "embedded" in the national and international historical context (Andreou, 2008). The role of gamification as a tool for teaching local history to adolescent students, in the already existing institutional framework of general history teaching in Greece, is a fertile ground for exploration, since the integration of gaming in the educational process is mainly applied to smaller levels of pre-school and primary school education (Papadopoulou, 2014).

The research emerged on the basis of the above reflection on the integrated way of teaching history in connection with its locality. Gamification comes to speak in the language of the student-adolescent without

downgrading history as a subject to the broader context of the history literacy, while highlighting the need for further study and application in relation to new educational habits.

Theory background and relevant studies

According to the studies local history is understood to mean both the history of a place and the history of the individual to the unique, in the context of a place (Dickinson, Lee & Rogers, 1984). The study of human's past in relation to his place, is determined by his interests and experiences. The subject, the object and the knowledge hic et nunc bear their own cognitive relationship (Dean, 2002). It is not only technology that has requested the historical knowledge in order to transform it into a historical game of content, but also the science of history itself that has adapted to the new conditions of digital technology by utilizing new kinds of sources and processes of remembrance (Moniot, 2002). Digital games have highlighted new public history practices, as they present how past societies were created and lead the player to a deeper understanding of the reasons that led to the successful or unsuccessful outcome of an event, to the sense of watching the historical change and participating in it (Mccall, Jeremiah, 2019).

Prensky (2012) believes that the utilization of historical digital games in historical education is not just a game that the teacher uses in parallel with his narration. It is an educational tool that, if used correctly, can immerse students in its content and in a mental simulation of the past through digital experience. Know-how and game-centered teaching will help the teacher to lead his students through playing to get to know the historical past, to make mistakes without danger, to experiment.

According to the Pedagogy of Polyliteracy (Kalantzis & Cope, 2019) gamification in the History lesson contributes to the "sensitization of abstract historical concepts" and can "intrigue the interest of students", highlighting the value of the motivation to learn. In this way, multimodal and multimedia discourse aligns with the basic principle of Polyliteracy of the construction of meaning, with the semiotic code of history (oral and written) collaborating with other forms of meaning, audiovisual and digital (Halliday, 1994).

The Aim of the Research

The hypothesis of our work concerns the possibility of teaching local history to help secondary school students develop socio-emotional skills, such as mutual respect, self-awareness, empathy, cooperation, social extroversion and acceptance of the "other" in inclusion classes through a gamified approach. It presupposes its recognition as an autonomous subject in the school curriculum of Secondary Education so that it is not treated as a subordinate relative of general history.

The research example concerning the Participatory Observation of the teachers-observers of the two sample teaching hours (traditional and gamified) of the same thematic unit of the teaching approach of local history entitled "Palimpsest of the history of the Mytilene Quay" to students of the Third class of Gymnasium was followed. In the context of this research, the Focus Group was used, the semi-structured interview of the same group of teachers-observers, homogeneous in their profession as teachers and heterogeneous in terms of their different specialties, positions, years of service. The general subject of discussion is the comparison of the two teaching approaches of local history in inclusion classes.

The research questions (RQs) are:

RQ1: What is the teachers' position on the inclusion of the local history course in the New Curriculum of Secondary Education as an autonomous subject?

RQ2: What are the teachers' views on the social and cognitive skills that adolescents can develop by "playing" in the history lesson in inclusion classes?

RQ3: What is the teachers' view on the more effective management of learning difficulties through playing games in and out of the classroom as a learning tool?

RQ4: What are adolescents' views on historiography through the gamification of the lesson in and out of the classroom?

Research Methodology: Qualitative research design

At this stage of the research, the grounded theory approach was followed, which was based on the discovery of theory from data to analyze interpersonal relationships and interactions without the researcher attempting to verify pre-existing hypotheses. More specifically, issues such as the positive and negative aspects of gamified learning, the participants' representations of local history and the importance of the students of Secondary Education getting to know it in a thorough way, as well as issues of developing students' relationships through learning the history of their place with emphasis on the non-measurable, qualitative dimensions, such as the routines and interaction processes of the members of the school community (Thompson,1994).

Two teaching sessions took place: one using the traditional lecture-exam method and the other involving gamification both inside and outside the classroom, each lasting two hours respectively. In the frontal teaching the lesson was conducted in a conventional way and in the gamified teaching students played inside the classroom first with memory/patching cards and after with the help of Chatgpt, the students, working in groups, requested the narration of a story from their local area using three keywords for each landmark or person separately developing their historical critical thinking, for example the Ottoman´s Bank, the lyric poetess Sappho etc.. The narration of the history of each group's landmark prompted the students to think critically by comparing their prior historical knowledge with that of Chatgpt. In some cases, the students realized that the narrated story differed greatly from actual history because it contained many fairy-tale elements, such as in the case of Sappho portrayed as a mermaid rather than as a lyric poetess. Within the framework of gamification out of the classroom with the help of Quayquest, like a kind of treasure hunt, the students, via their mobile phones working in groups, tried to solve puzzles/challenges, themed around landmarks of their city, adhering to the pedagogical principles. "I learn by playing and I play by learning."

Results

The technique of microanalysis. Detailed data analysis-interpretation

The focus group of the teachers-observers was a selected group of eight teachers in a guided discussion, which took place after the observation of the two sample teaching hours, traditional and gamified way of teaching local history respectively with observation lists. It is a qualitative approach taking data from a specially selected group of four teachers of general class, two of special education and two in positions of responsibility, of different specialties without constituting a statistically representative sample. The number eight of the interview group is not a borderline dynamic interaction, but a sufficient condition for coming to valid and immediate conclusions (Robson, 2007). The responses of the focus group were recorded and analyzed with the help of the qualitative data analysis software Ethnograph 6.0.

In the first stage of the analysis, the initial ideas on the axis of gamification, education and local history were recorded. In the second, the initial codes were produced by examining the texts sequence by sequence. Here, each passage of the text was assigned a conceptual designation, a code. These codes are Humanities or Non Humanities, Pons & Cons of Gamified Local History, Years of Service < >, Special needs or General Education in inclusive classes. The coding process was an important part of the analysis as units of meaning were identified that are linked to each other. The data were organized into groups that always make sense in relation to the research questions (Miles & Huberman, 1999).

An important tool used during the coding process was the technique of microanalysis through the detailed analysis and interpretation of data, which concerns line by line analysis and is necessary not only for the creation of the initial categories, but also for the possible relationships between concepts as a combination of open and axial coding. Microanalysis focused on words, sentences or paragraphs with interest and attribution to them possibly meanings and interpretations (Straus & Corbin, 1998).

Two types of codes were created. The first refers to objective codes, such as years of service, specialty and service position. The second type of codes concerns the perceptions of the teachers who played the role of observer in the two sample teaching hours. The analytical coding was done for each individual research objective and is described in the analysis texts of the research findings. The binary tree of the codes of the research data according to the diagram (fig. 1) reveals that it is not the section/specialty of the participating educators observers that influences their attitude towards gamified learning, but their years of service. Specifically, two of the eight teachers replied that the possible combination of traditional and gamified teaching is also the proposed teaching way of approaching local history as an autonomous subject in the school curriculum. It is noteworthy that these teachers have served in education for more than twenty years as classroom teachers, while their years of service do not seem to be an obstacle to a different approach to knowledge, but this is not to abandon traditional teaching.

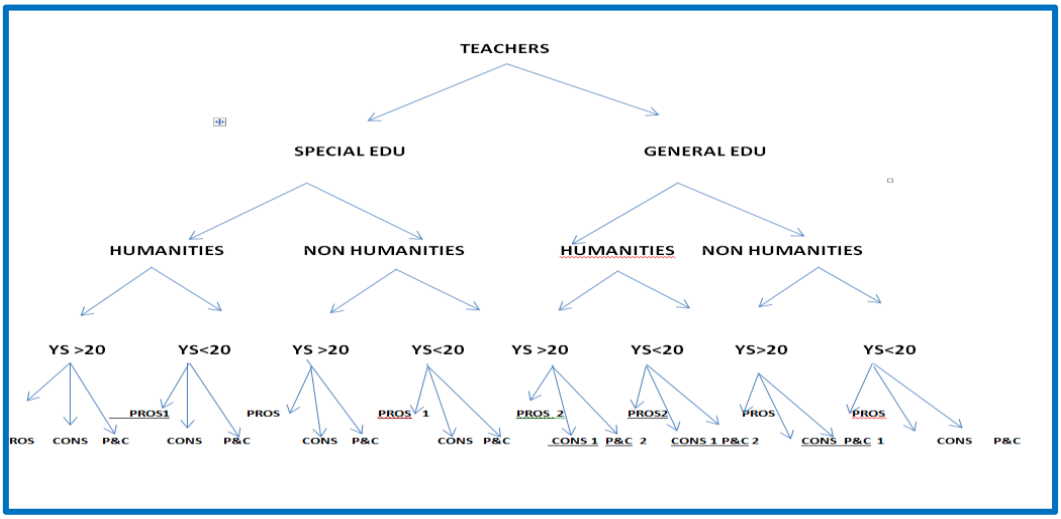

Figure 1. The binary tree of the codes

Five teachers, mixed years of service, considered gamification to be the most appropriate way of teaching in inclusion classes in terms of the degree of achievement of pedagogical and cognitive goals as well as the expected results. They stated that frontal teaching can help them to better manage knowledge in the exam-based model, while gamified teaching gives the opportunity for flexibility and teaching "out of the box". It is characteristic that the two special education teachers, both philologist and mathematics professor, refer to the power of playing in students with learning difficulties. Gamified learning, according to them, gives the student his lost interest in learning in a simple and playful way.

Only one teacher, with more than thirty years of service, disagreed with the group regarding the pedagogical value of gamified teaching, as he supported teaching exclusively in the traditional way. He justified this position by arguing that the history lesson is a strong lesson that requires a deepening in facts and not "amusing". He supported school walks or celebrations to learn about local history, but any other approach "reminded him of tourism, but not school", as he said.

According to the research questions and the main findings of the study, the focus was on the category-axis: "Local history-gamification-education" which condenses the findings that emerged from the analysis not only in analytical but also in axial coding, as the latter was linked to the educational scientific interest and to the personal-ideological motivations of the educational participants-observers. We observe that the categories "Personal interest and concerns of the teacher" with the pedagogical objectives of teaching local history are interrelated, constituting aspects of the same phenomenon. The multi-level function of local history is in line with the personal and professional choice of the teacher (Table 1).

Table 1. Reasons for engaging with local history

Personal Interest & Professional Concerns of Educators	**Functions of local history**
	Pedagogical Goals
Ideological motives for the didactic approach to local history	Active participation in the learning process
Personal motives for professional development	Experiential approach

Interest in pedagogical innovation through gamified learning (inside and outside the classroom)	Cultivation of cooperation/teamwork
	Historical Goals
	Acquisition of knowledge
	Historical awareness
	Skills and competencies
	Socio-emotional Goals
	Cultivation of a positive attitude towards school
	Shaping of personality

As a tool for qualitatively measuring the interest of the students the formative assessment 3-2-1 was used. Students were asked at the end of the lesson to write down three things they understood from the local history lesson they were taught, two that they would like to explore more and one that they did not understand. Through the analysis of their answers, the gamification of local history in and out of the classroom seemed to have positive results for the majority of students, as only three appeared to have not understood the history of their city's seafront adequately. On the contrary, the students of the department who attended the teaching of the same thematic unit in a traditional way, while they all said that they understood everything, their answers to the worksheet on the landmarks of the seafront proved the opposite. As a final assessment ten multiple-choice questions were given to the students of both sections of the 3rd grade of Gymnasium, the target group with a gamified approach to local history and the group with frontal teaching. Students in the department where the traditional teaching approach was applied scored 45.8% (forty five point eight percent) below the baseline, compared to students in the gamified teaching department with 21%.

The evaluation of the sample lesson was followed. Through the qualitative comparison of the two lessons, it was found that the gamified approach to local history resulted in increased participation with practices of inclusion and democratic coexistence through the assumption of equal roles within the group. Supportive technology for free and equal access to knowledge through new technologies facilitated the focus of attention of learning-weak students, who went from "listeners" to active co-creators of the lesson.

Our findings are in line with the few studies that have been conducted on the effectiveness of gamified learning in managing learning difficulties in local history. It was based on the assumption that historical literacy includes the concept of critical literacy, which, in addition to academic knowledge, aims at self-realization through the development of historical consciousness, social adaptation and acceptance of the “other” in classes of inclusion. Linguistic and historical literacy could help children to learn more effectively empirically, which in the language of local history literacy could be applied more efficiently to the “Experience-Recognize-Understand” scheme, as gamification in local history teaching concerns the real environment of the present through the monuments of the past and the reconstruction of familiar spaces with the natural environment.

Conclusions

The crucial point of this research is that gamified learning in local historiography can maximize students’ participation in the learning process and their interest in their place of origin, contributing to the achievement of their maximum socio-cognitive development. In the existing Greek education system, local history is still not recognized as an autonomous subject, while it seems to be an intruder in the school curriculum of secondary education, which demonstrates the necessity of further deepening and research.

Our analyses contribute significantly to the bibliography by documenting the positive attitudes of teachers and students towards the institutional role of local history in the school curriculum, the power of historical literacy in developing socio-cognitive skills such as mutual respect, self-awareness, empathy, cooperation, and social

extroversion in inclusion classes, and the benefits of play for students with learning difficulties. Gamified learning restores students' lost interest in learning in a simple and playful way.

As regards future research guidelines, a more broadened survey could be carried out across all types and levels of education, regardless of age and learning needs, given that the population sample of teachers and pupils was limited. The results of its credibility and validity can be influenced by the readiness of teachers and students, as well as by the ideology they embark on, to bring an unbiased view of the teaching approach to the gamification of local history and its integration into the Greek educational system. As the saying goes, "when you touch the statues, you wake them up; if not, their stories remain buried in stone."

Acknowledgements

I would like to thank my esteemed supervisor Dr. Thanasis Daradoumis for his invaluable supervision, support and mentorship during the second year of my PhD degree. Additionally, I would like to express gratitude to Dr. Evangelia Sampanikou and to Dr. Evangelia Kavakli for their support which was really influential in critiquing in my PhD research results to date.

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A study for the development of an educational application aimed at teaching Geometry in Elementary School II

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Abstract

This article presents a study for the development of an educational application aimed at teaching Geometry in Elementary School II. Considering the challenges teachers face in making Geometry more accessible and understandable, the research identifies the main teaching needs and explores how technological tools can facilitate learning. Through a questionnaire administered to teachers from Educational District 6 of Fortaleza, teaching practices, difficulties in using technological resources, and the impact of a lack of materials were analysed. Additionally, it revealed that teachers value practical and interactive approaches, but face structural and social limitations that hinder the application of innovative methodologies. In response to these needs, a mobile device application is proposed that enables the creation and analysis of geometric figures, promoting efficient integration between theory and practice. The study reinforces the importance of accessible and intuitive technologies in improving geometry teaching in challenging educational contexts.

Keywords: Educational application, Geometry teaching, Basic Education, Educational technology, Teaching practices, Technological resources, Interactive methodologies, Meaningful learning, Elementary School II, etc.

Introduction

One of the most significant challenges facing mathematics teachers today is to transform the mathematical knowledge acquired by humanity into something tangible for students. Tangible not only in the concrete sense, but also in understanding it. Mathematics is both abstract and practical. Practice can lead to theory and theory can lead to something practical.

Countless examples in the history of mathematics demonstrate. One of them is Archimedes, who was always obsessed with knowing the difference between the surface area of a cylinder and that of a sphere. “He considered the discovery of the relationship between a sphere and the cylinder that contains it to be his most important achievement—so much so that he asked for a diagram of a sphere inscribed in a cylinder to be engraved on his tomb” (Strathern, 1998), out of pure curiosity. Apparently, there is little practical value in this knowledge. However, centuries later, this knowledge was used to reproduce the globe (a sphere) on a flat surface, the world map (a lateral cylinder area). There are many other stories about the two-way street of mathematics that connects theory to practice.

Geometry is an area of mathematics that has at its core the practice of observing things in the real world. It arose from the practical knowledge humanity had to develop about the length, area and volumes of objects and spaces. Only with Euclid and Greek logic did geometry become its theoretical body and the first step towards modern theoretical mathematics. As Eves (2011) says, “Despite the great importance of the content of the Elements, perhaps even more important is the formal way in which this content is presented. Euclid's Elements became the prototype of modern mathematical form.”

This leaves mathematics in limbo, and it is up to the teacher to show the best path for the student to follow to understand it. Whether the path goes from theory to practice or vice versa, “one of the trends in the broad area of mathematics education, which object of study is the development of concepts and theories that are compatible with the educational specificity of mathematical school knowledge, seeking to maintain strong links with the formation of mathematical concepts, both at the experimental level of pedagogical practice and in the theoretical territory of academic research” (Pais 2011). Several educational theories address ways of presenting content making students interested in it and, thus, having better learning.

Several proposals for teaching mathematics, such as traditional Mathematics teaching, ethnomathematics, and mathematical modelling, among others, are influenced by these theories. All these theories have as a backdrop a set of social factors that affect them, shaping them and aligning them with society in general. Society's needs generally give this North its historical moment. Historical moments are always influenced by human production. This production has already gone through several stages, from hunting and agriculture to livestock, and finally to

industry. The first Industrial Revolution made industry the most important means of production for humanity, and with this several of the so-called industrial paradigms gained significant strength in our society. “The industrial paradigm, in a word, is characterised by the application of scientific rationality to human activities and by the belief in material progress” (Bertrand, 1994, p. 85).

To develop this production, we need to build ideas necessary for these technologies, which are only possible due to scientific advances and research. Thus, this scientific research should be done in a way that nourishes this lack of production and “science has benefited tremendously from the surprising stimulus given to scientific and technical education, and from the less surprising support given to research during our period.” (Hobsbawm, 2009). Public and private investments in scientific education were made on a large scale to make the industry cheaper and faster. And this scientific production should begin in schools.

Schools have become a vital part of the training of industrial workers. “The educational process, whether at school or not, is reduced to the function of producing a set of intellectual skills, developing certain attitudes, and transmitting a certain amount of knowledge, which function as generators of work capacity and consequently production” (Frigotto, 2006). The minimum skills that workers should have to handle industrial technologies should be taught in schools. Mathematics is one of the main skills to be developed in this process, as it is a branch of knowledge that is essential for understanding these technologies.

In this process, it is the mathematics teacher's responsibility to convey this knowledge to the student's understanding, and for this to happen, they must utilize all available means. Among them is the technology generated during this process: including computers and similar devices.

Computer science has been used in education since the 1960s, Still, it was only in the 1980s, with the decrease in computer costs and the advent of user-friendly interfaces (which made computing easier for the average user), that it became possible to establish computer-based education projects in a more systematic and systematic manner. “Computer Science in Education, in Brazil, was born from the interest of educators from some Brazilian universities motivated by what was already happening in other countries such as the United States of America and France. In 1971, at the First National Conference on Technology in Education Applied to Higher Education (I CONTECE), held in Rio de Janeiro, E. Huggins, a specialist from Dartmouth University, USA, gave an intensive seminar on the use of computers in teaching Physics (Souza, 1983). In 1982, at the First National Seminar on Computer Science in Education, held in Brasília, Mme. François Faure, head of the International Area of the General Directorate of Electronics and Computer Industries of France, gave one of the two technical lectures at the event; the other was given by Felix Kierbel, Director of the National Center for Computer Science Education of the Ministry of Culture and Education of Argentina (National Seminar on Computer Science in Education 1 and 2, 1982)”. (Valente, 1999)

With the improvement and popularisation of smartphones, this technology has become even more accessible to education. As highlighted by Traxler (2009), mobile learning provides ubiquitous access to educational resources, enabling learning anytime and anywhere, which is particularly valuable in under-resourced educational contexts. “(...) And most importantly has established that the mobile learning community can take learning to individuals, communities and countries that were previously too remote, socially or geographically,

for other types of educational initiative”

Applications and games “can contribute to the teaching and learning of Geometry. Their possibilities are centred on the visualisation of problems, focusing on geometric constructions; testing conjectures; on solving puzzles and identifying figures” (Araújo et al. 2024). These tools can bring a more practical everyday teaching method to Geometry classes.

A study was conducted to understand the needs of elementary school geometry teachers in the intellectual and material development of their classes on this subject. This was done to support the idea of a tool within the scope of these technologies for use in geometry classes.

Thus, the proposed project, to be developed in this article, seeks to understand the needs of elementary school geometry teachers, with the aim of creating, in future work, a platform that presents the characteristics of geometric figures easily and practically, thereby providing more fluidity and understanding geometry classes. Always guided by the ideas generated by the research done in this work to create a functional and easily accessible means for elementary school geometry students and teachers, a mobile application in which students can form geometric figures and that contains essential information so that they can reach conclusions necessary for the construction of knowledge.

According to legend, Archimedes died when he was “deeply immersed in mathematical calculations while Roman troops were sacking the city. Despite the riots in the streets, he continued to draw circles on his flat sand tray (the modern equivalent of a personal computer). He was interrupted by a shadow falling across his drawings. He looked up and saw a Roman soldier. ‘Please do not interrupt my calculations,’ he admonished him. But the soldier, tired from battle, was naturally in no mood for mathematical demonstrations. Brandishing his sword, he ordered Archimedes to follow him, but the latter refused to move until he had completed his calculations. After which the

exasperated Roman struck him, killing the obstinate old man" (Strathern, 1998). This is not known for sure; what, is known is that "Archimedes explored his geometry extensively in figures drawn in fireplace ashes or in the oil with which he smeared his body after bathing. It is said that he met his death when, immersed in his reasoning; he, was preoccupied with a diagram drawn on a sand tray" (EVES, 2011).

A futuristic vision of modern smartphones, where fingers are used to swipe across the screen to write in everyday applications. So, perhaps like Archimedes, the application will be helpful for us in developing the figures and diagrams we need in the classroom by simply swiping our fingers across the cell phone screen. Hence the name, unpretentiously, of Archimedes.

The history of mathematics inspired the ideas in this work and for several other thinkers, the path to formulating theories for teaching mathematics. Garbi (2010) shows us that "Archimedes considered this his most beautiful discovery, so much so that he asked that, when he died, a cylinder and a sphere inscribed on it be engraved on his tomb, accompanied by the ratio 3/2 that unites them." (2010, p.90). From the theory generated by the pure curiosity of simply knowing, he brought the ratio between the area of a cylinder and the sphere that would produce our world map. Ideas like Archimedes's on how to use reality to understand the abstract inspired formulating questions about how students can better understand geometry and its theories.

This reality must come from or emerge from the very environment in which education is inserted, that is, from the productive forces that move humanity, that move work and shape society, because, as Susana Jimenez explains: "work, as a creation, expresses, from its creator, that is, from man, not only what he already is, what he has already achieved, but also everything he can become. Work is thus, ontologically, human achievement, emancipation". Studies show how important it is to understand how the building blocks of modern society and technology shape and impose the rules of our post-industrial revolution way of life.

As stated before, education is both a means and an end to society's customs, and is therefore directly influenced by these ideas generated by the needs of teachers in the classroom. In this more specific analysis, we have authors Mario Manacorda (1992) who tells us:

These various aspects of education involve a permanent relationship with the most general themes of humanity. [...].

Pedagogical discourse is always social, [...].

And the school and its pedagogical ideas will be forged from social pressures. In the context in which teachers are inserted, it will have the function of training the workforce. In other words, "the function of the school, therefore, was to prepare these men so that they would be useful and have the characteristics necessary to handle the new technologies incorporated into the production processes." (DA SILVA, GASPARIN, 2020).

And what would this technology that puts pressure on today's society and the current education system be if not computer technology, its computers and smartphones? "The insertion of computers in Brazilian education did not occur randomly, but rather was linked to a macro policy of computerisation of society itself. In that context of the 1970s, concern with information technology was a strategic issue for national development and sovereignty." (Gordiano, Andriola, 2022)

In a technological society like ours today, it has become necessary to include this factor in schools so that they do not become oblivious to the world in which they are inserted. However, especially in Brazil and in public schools, this inclusion is difficult due to limited resources and inconsistencies in government projects, as pointed out by Gordiano and Andriola: ""Different governments have implemented several actions over the last three decades, to incorporate digital technologies into the reality of Brazilian public schools. [...] The discontinuity and change in the purpose of projects and programs came both from political interference, linked to changes in government, and from the diversity of pedagogical bases that involved their conceptions, with an effect on the results generally below those intended when such projects and programs were carried out". This also reflects Selwyn's (2011) argument that technological adoption in education is often shaped by broader social, political and economic factors, rather than purely pedagogical considerations.

The idea of developing a specific application, in conjunction with the needs of teachers identified in the research, emerged to break the cycle of projects dependent on cyclical governments and to create a tool for the educational community that facilitates the daily classroom. Based on the needs of teachers. Additionally, the difficulty that teachers face in handling this new technology must be considered.

Data analysis in educational contexts is essential for understanding teaching needs and practices. "Data analysis significantly impacts on various areas of our daily lives, such as health and education. In education, academic institutions use students' performance data to identify learning profiles and personalise the content delivered in the classroom." (Casagrande & Silva, 2024) In this sense, Python libraries, such as pandas and matplotlib, play a crucial role in data manipulation and visualisation, enabling educators and researchers to transform raw information into meaningful insights.

Pandas is a widely used library for data analysis, offering flexible data structures and effective tools for handling

large datasets. With it, filtering, aggregation, and data transformation can be performed intuitively and efficiently. This is particularly relevant for collecting and analysing responses from the questionnaire applied to teachers. “Pandas provides rich data structures and functions designed to make working with structured data fast, easy, and expressive.” (McKinney, 2010)

On the other hand, Matplotlib is one of the most popular data visualisation libraries in Python. “It is well-suited for creating publication-quality plots. [...] Thus, providing a comfortable interactive environment for plotting and exploring data.” (McKinney, 2010) This visualisation serves as a powerful tool for highlighting trends and patterns in data, allowing educators and stakeholders to more clearly understand the research findings and their implications for teaching of geometry. The use of these libraries not only optimises data analysis but also contributes to the development of knowledge grounded in evidence, emphasising the voices of teachers in developing the educational tool in question.

There will be a focus on mathematics, a branch of science essential for the development of several other sciences and technologies. Without an understanding of it, understanding other scientific areas becomes more complicated. “Mathematics Education is a social practice and the community that produces it, acts on it, reflects on it, and systematises it, focuses on understanding Mathematics in teaching and learning situations.” (GARNICA, DE SOUSA, 2012).

Geometry is a segment that, historically, brings the association of senses, vision with reasoning, because, “without studying Geometry, people do not develop geometric thinking or visual reasoning and, without this ability, they will hardly be able to solve life situations that are geometrised; they will also not be able to use Geometry as a highly facilitating factor for understanding and resolving issues in other areas of human knowledge” (LORENZATO, 1995).

Hence, it is essential to focus on this area of knowledge and attempt to gain insight into these ideas, in conjunction with the teachers' identified needs, using this Geometry tool.

Methodology

The methodology consisted of two phases. First, a survey of elementary school II teachers, covered all grades in the Fortaleza school system. Each teacher was sent a Google Forms survey with questions to answer. Using a cross-sectional research design, we aimed to investigate interest in educational applications and mathematics, with a focus on geometry.

Regarding the questionnaire applied to teachers, it is essential to mention that it presents objective questions, which address, in addition to the grades in which the teachers teach, some aspects:

Teaching Practices: opinions on the importance of activities that interest students, active student involvement and its impact on classroom control and encouraging students to find solutions before presenting them ready-made.

Geometry and Learning: the importance of practising geometry to increase students' interest in comparing methods and processes. Need for empirical observations and basic demonstrations at all stages of Elementary School. Analysis and decomposition of figures (such as tiling and tangrams) to facilitate the calculation of areas. Preparation of figures by students and their contribution to the understanding of attributes and properties.

Use of Technology: frequency of use of computers, smartphones, tablets and projectors in the classroom. knowledge about educational applications.

Resources and limitations: limited resources (such as lack of materials) impact the construction of ideal geometry classes. Evaluation of the use of educational applications and their impact on student interest.

Finally, general assessment: opinions on the effectiveness of educational applications in teaching geometry. Knowledge and familiarity with educational applications.

The inclusion criteria were elementary school teachers, as they are the primary instructors of the initial theoretical concepts of geometry in the students' school lives. As Viana (2005, p. 1) states, in Basic Education, teachers must present geometry as the “study of the shapes of objects in physical space, of the relationships and transformations that were formalised in an axiomatic mathematical system, built to represent them”. In other words, based on the shapes that are around them, they must build theories and show axioms.

Therefore, we excluded teachers from higher school grades from the research, as they already include students with other types of content and training in geometry. Although there is a learning deficit in geometry at various stages of education, our research does not aim to cover this part of the problem.

As previously mentioned, data collection was conducted through an online research platform, using descriptive statistics and content analysis. The second methodological part now deals with interpreting the opinions of the 53 teachers who participated. All teachers participating in the research, as previously mentioned, are from the

Municipal network of Fortaleza, more specifically, from Education District 6, corresponding to 60.23% of mathematics teachers in the entire district and 10.66% of the total of the whole Municipal Education network of Fortaleza.

The research group is composed of teachers from the continuing education program in District 6 of the municipal network of Fortaleza, which offers training courses held monthly. However, the research was only presented at these meetings and carried out online via Google Forms.

To better understand the context in which these teachers are inserted, a descriptive survey was conducted on the 6th district of education in the city of Fortaleza. For this purpose, information was collected from the Fortaleza 2040 project and the city itself. Data such as population, HDI, educational HDI, income HDI and comparison with other districts were sought to better interpret the district's general and regional situation.

The challenge with this data was not obtaining the data itself, but a change in 2021 in the organisational structure of Fortaleza, which now has 12 regions. However, the structure of the Municipal Department of Education (SME) still organises and divides schools and their respective neighbourhoods into six districts as before the change made by the city in general. Hence the challenge is to analyse the data by neighbourhood, distribute it across these six districts and conduct the analysis.

Several problems arose during this analysis. First, the data came from various sources. First, schools and their neighbourhoods were distributed from the SME website. For different reasons, the total number of neighbourhoods differs from the data from the municipality's Fortaleza 2040 project. Some neighbourhoods do not have municipal schools because they are very close to other neighboring neighbourhoods and it was necessary to include the district of this neighborhood in the overall figure to account for their data.

Another problem faced was the change of neighbourhoods, mainly in association with HDI indexes, as these are data that the Fortaleza 2040 project uses as a reference number from 2010. Several changes occurred during this period,including the renaming of the Dendê neighborhood to Rachel de Queiroz in 2021. These changes will be recorded in the analyses later.

Then we obtain this data from the SME itself, which contains the names of the schools and their respective districts and neighbourhoods, and connect it with the information we have from the Fortaleza project. 2040 will give us the necessary information to analyse the context of District 6 and how the urgent needs of the teachers who are part of this community were formed.

Python 3.10.12 libraries such as Pandas 2.2.2 and Matplotlib 3.8.0, were used for this survey, as they offer a structured analysis for manipulating, visualising and interpreting large volumes of information.

From the data collected through the questionnaire given to participants, an analysis of the responses was conducted to identify the main needs of teachers in the classroom, thereby promoting the application of tools that support the development of geometry classes.

Results

Geometry and learning as seen by elementary school II teachers

Geometry is a branch of mathematics that allows us to bring reality into theory and will enable students to see how empirical deductions from the scientific mathematical process work. Questions from the questionnaire given to teachers were raised to observe whether teachers perceived this path in geometry and learning in the classroom. Questions 11, 12, 13 and 14 addressed this topic and we obtained the following results as shown in Figures 1, 2, 3, 4 and 5:

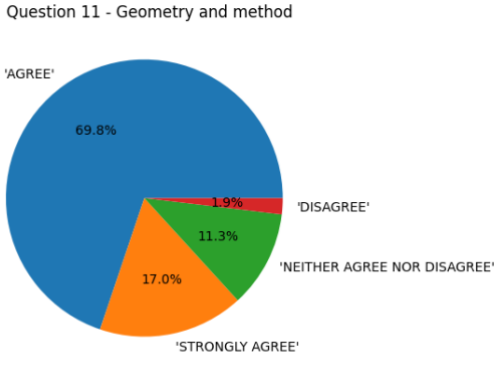

Figure 1. Geometry and method

In question 11, the categorical majority of educators, 86.8%, believe that practising Geometry is essential for students to improve their skills in comparing methods and processes in problem-solving. This indicates that most teachers believe that active practice engages students and encourages them to develop critical and analytical skills.

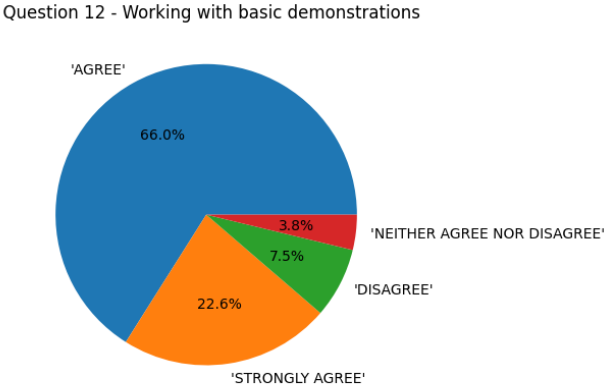

Figure 2. Working with basic demonstrations

The results of question 12 indicate that 88.6% of educators see the importance of empirical observations in teaching Geometry. This method is essential because it enables students to combine theory with practice, thereby facilitating a deeper understanding of abstract concepts. This emphasis on empirical observations shows a response to the need to make learning more meaningful and contextualised.

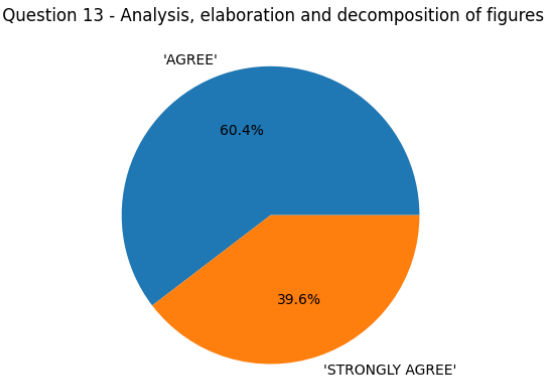

Figure 3. Analysis, elaboration and decomposition of figures

In the case of question 13, there was a unanimous response, as respondents either completely agreed or simply agreed with the questioner. In other words, educators agree that analysing and decomposing figures are essential for understanding concepts such as surface coverage and area calculation. This practice develops geometric skills and promotes critical thinking and problem-solving.

Decomposing figures is a method that can be used to demonstrate concepts in a fun and practical way, allowing students to explore and experiment. The high level of agreement suggests that educators are becoming aware of the importance of integrating practical activities in their classes. Still, it, may also indicate a need for resources and materials that facilitate this approach.

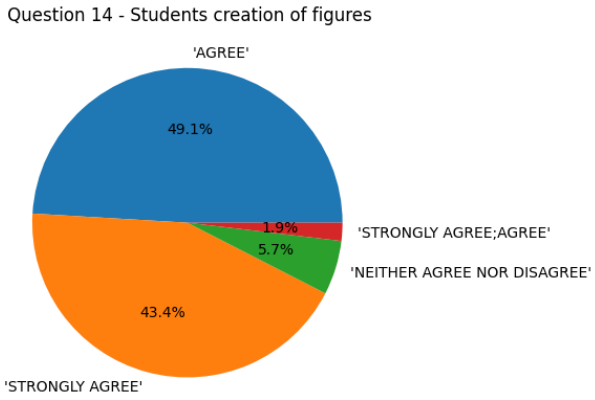

Figure 4. Students creation of figures

In question 14, nearly all educators (91%) believe that students' production of figures helpaids in heir understanding of geometric attributes and properties. This practice is fundamental for developing spatial reasoning and visualisation, skills, and basic concepts in Geometry. The elaboration of figures enables students to become active participants in their own practice and learning, promoting autonomy and creativity. The prevalence of a combined response indicates that educators can view the elaboration of figures as a praxis that should be integrated with other approaches, thereby further enriching the teaching-learning process.

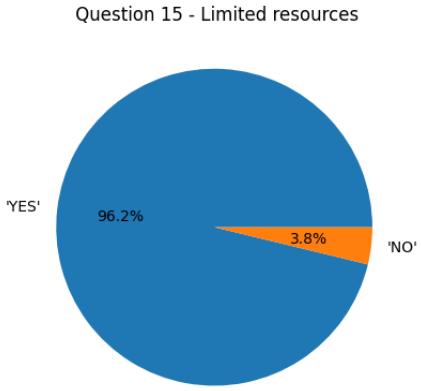

Figure 5. Limited resources

In general, the results of the questions analysed indicate a strong tendency among educators to favour active and empirical practices in teaching Geometry. Most teachers recognise the importance of practice, empirical observation, analysis and the elaboration of figures as essential tools for meaningful learning. However, the presence of some disagreements and neutrals suggests that there are still challenges to be faced, such as the lack of resources, teacher training and the need for a school environment that favours experimentation. This is precisely what answers question 15 about how limited resources hinder the elaboration of Geometry classes.

It is almost unanimous (96.2%) that this limitation hinders the progress and preparation of Geometry classes.

Use of technology and educational applications by teachers

Computer technology and smartphones are integral to the reality of our society and are an essential part of the daily lives of teachers and students; how can this be effectively integrated into teaching practice? Because it is a reality in our society today, these tools become quite interesting for students. The use of this technology in the classroom and students' interest were the merits of the research, which analysed educators' views on the subject.

We addressed this topic in questions 3, 4, and 5, concerning teaching practice and student interest in and use of technology in questions 16, 17, 18, 19, 20, and 21. The results are presented in Figure 6.

The survey results indicate that educators recognise the value of technology in teaching and learning, and they are willing to incorporate this tool into the classroom (98.1%). While many already use some technology, around 60% responded that they almost always use it in school. However, they also show some difficulty in using it. This requires two factors from teachers: more training courses and easier-to-use tools.

This technological means can facilitate the student's autonomy, which is sought in questioning items 3, 4 and 5. In addition to having a generation familiar with this new technology, this tool can spark interest and enhance the

students' self-esteem, allowing them to develop more fully in the content as they are immersed in an environment they dominate.

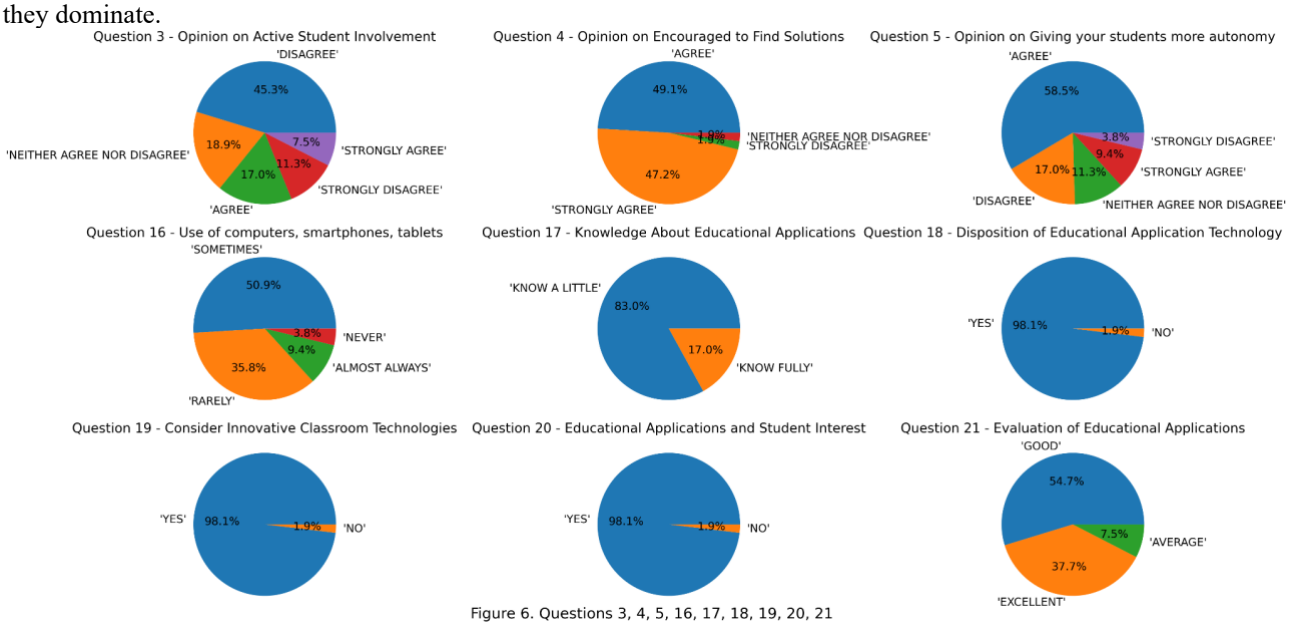

Figure 6. Questions 3, 4, 5, 16, 17, 18, 19, 20, 21

Finally, educators evaluate educational applications well, with the majority rating them as good or excellent, indicating that teachers are willing and, not to say, need a tool to help them in their daily classroom life. It is an educational accessory that is simple, gives students autonomy, and is intuitive for all users.

An overview and social overview of the region where the teachers surveyed teach

As previously mentioned, the opinion poll was conducted among elementary school teachers from Fortaleza City Hall, specifically those from Educational District 6. They teach mathematics to classes from 6th to 9th grade. This led to an interest in understanding the social indicators of the community where these educators taught. This would enable us to gain a deeper understanding of the vision of these educators by examining the social environment in which their students are situated.

The necessary data were sought to observe these social indicators for Educational District 6. This became a problem, as no specific data was available. This was due to a structural change in the division of neighbourhoods that Fortaleza City Hall underwent in 2021, when it was organised into 12 regions instead of 7 (6 regions plus the central region), as it was previously. However, the education department (SME) divided neighbourhoods into six educational districts, similar to how it had been before the change.

This required organising data obtained from various agencies and connecting them in ways that would allow data from each educational district to be obtained. To this end, information was collected from the municipality and the Fortaleza 2040 project. Data such as population, HDI, educational HDI, income HDI, and comparisons with other districts were sought to better interpret the district's general and regional situation.

The Fortaleza 2040 project "is a long-term plan for the city of Fortaleza with strategies to be implemented in the short, medium and long term (with the year 2040 as the horizon) contemplating the Urban Master Plans, Mobility and Social Development" (Fortaleza Observatory, 2024). We obtained several data points necessary for the research, such as population and social indices.

Several problems arose during this analysis. First, the data came from various sources. First, schools and their neighbourhoods were distributed from the SME website. The total number of communities in the data from the municipality's Fortaleza 2040 project differs for different reasons. Some neighbourhoods do not have municipal schools because they are close to other neighbourhoods. It was necessary to add the district of this neighbourhood so that we could account for their data in the overall figure.

Another problem faced was the change of neighbourhoods, mainly in association with HDI indexes, as these are data that the Fortaleza 2040 project uses as reference numbers from 2010. Several changes occurred during this period, such as the neighbourhood's name.

Dendê was renamed Rachel de Queiroz in 2021. In our data, only the Dendê neighbourhood was used. The indices of the Acarape and Novo Mondubim neighbourhoods will be considered as Mondubim. In contrast, the Parque Santa Maria neighbourhood indexes were used for Jangurussu, and the indexes of the Olavo Oliveira neighbourhood will be for the Vila Velha neighbourhood.

Then we obtain this data from the SME itself, which contains the names of the schools and their respective districts

and neighbourhoods, and connect it with the information we have from the Fortaleza 2040 project, generating the information necessary to analyse the context of District 6 and how the urgent needs of the teachers who are part of this community were formed.

Reinforcing this survey, we utilised Python libraries such as Pandas and Matplotlib, as they provided an organised analysis for handling, visualising, and interpreting large amounts of data.

First, based on the division of SME neighbourhoods within the districts, we calculate the population of each neighbourhood, thereby generating the total population for each district. This result is visualised in Figure 7.

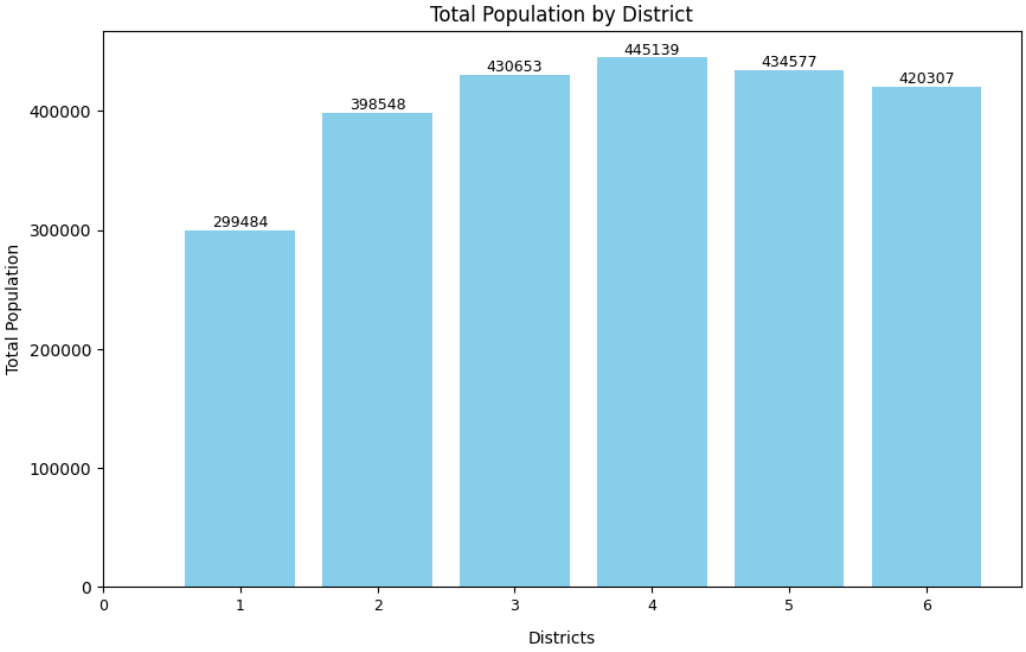

Figure 7

The first observations from this survey are that the two districts with the largest populations are 4 and 5. District 6, where the educators participating in our research are located, has only the 4th largest population. However, another piece of data calculated in this survey regarding the districts was the demographic density of the districts.

Although the 2040 project already contains data on the population densities of the districts' neighbourhoods, it is not possible to use this data due to the method used to calculate population density, making it impossible to add these numbers. This information was calculated by adding the populations and areas of the district's neighbourhoods, and then dividing these sums. This yields the result shown in Figure 8.

Here, we can see that the highest densities are in District 3 and District 1. District 6, the reason for this survey, has the second-lowest population density among all districts. This is because its population is not one of the largest, and it has a large area, being the largest among the districts, as shown in the graph in Figure 9.

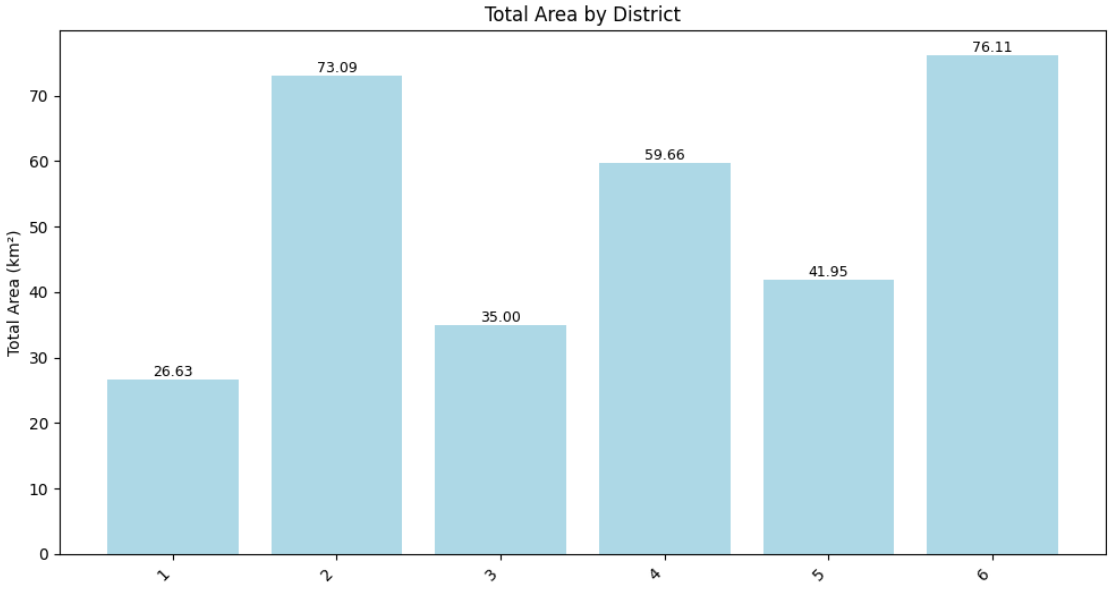

Figure 8

Moving on to social data, we will analyse the HDIs, namely the general HDI, the education HDI and the income HDI. The longevity of HDI was obtained; however, no relevance was observed in this aspect of the HDI for this work, despite the general HDI incorporating all these factors.

Starting with the HDI for education, the HDI for education is calculated using "various indicators for the dimensions of education (...). For each individual, this concept is defined as the number of grades completed by the individual, obtained by identifying the last grade taken and the school grade completed". (ATLAS OF HUMAN DEVELOPMENT IN BRAZIL, 1998). A general index average was calculated for all neighbourhoods in each educational district to obtain this data, yielding the result shown in Figure 10.

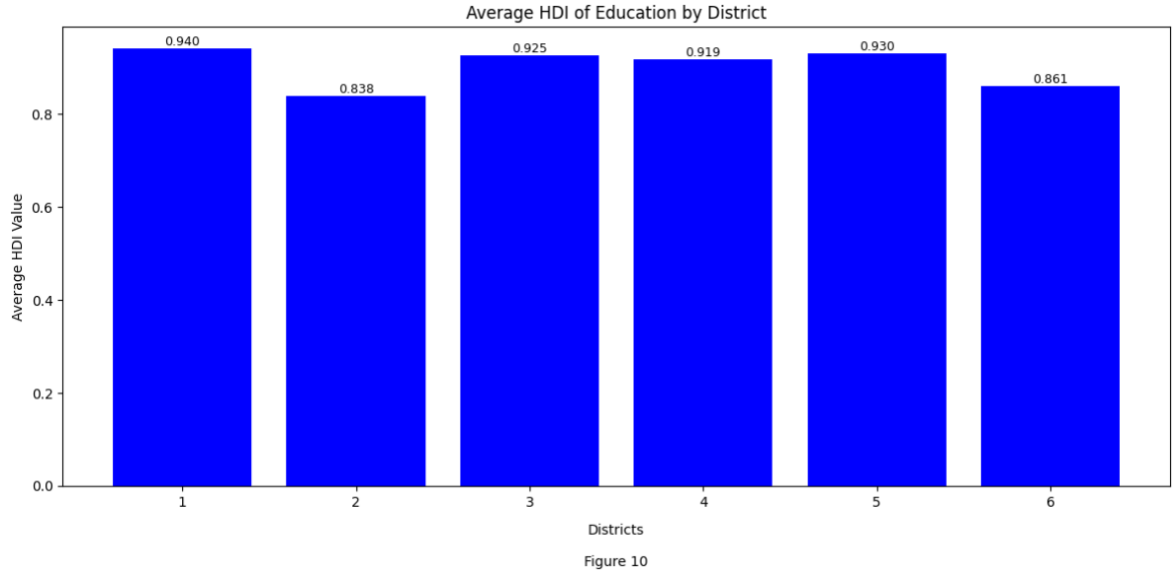

Figure 10

District 1 has the best HDI education among all districts, and District 6 has the second-worst index according to the collected data, indicating that the area where the surveyed teachers teach has education-related problems compared to the other districts in the municipality, ranking behind only District 2 in this regard.

Now, the HDI of these districts is as follows. This index is simpler because it is based solely on GDP per capita or family income per capita. It was calculated by obtaining the average of all the HDIs for the income of the neighbourhoods in each district, resulting in the graph shown in Figure 11.

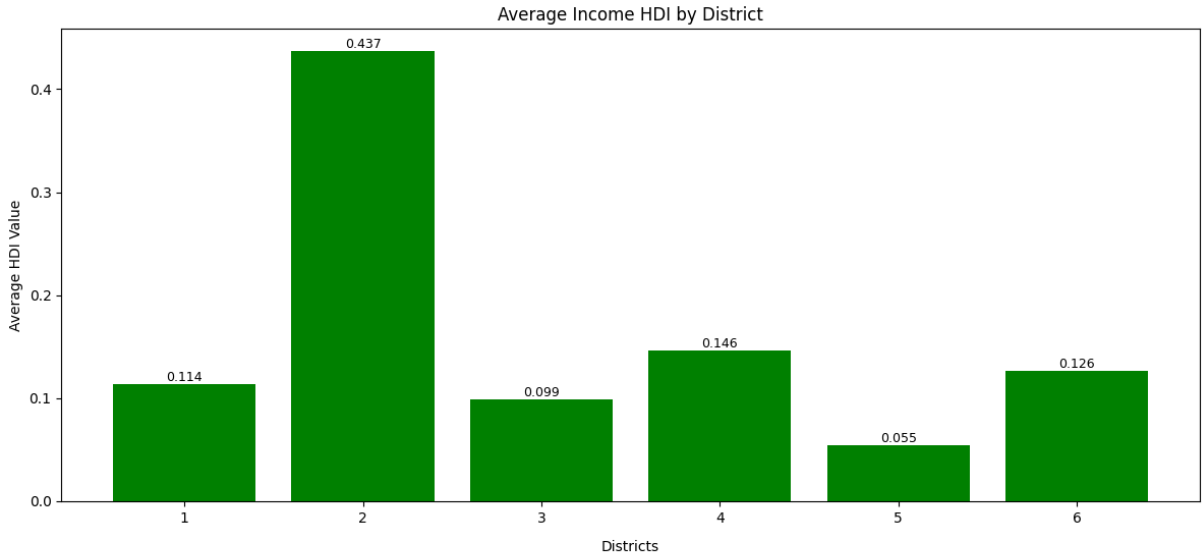

Figure 11

Note that there is a considerable disparity between District 2, which corresponds to the upscale neighbourhoods of Fortaleza, and the other districts, showing the social inequality in the city. Although the index of District 6 is low, it is not the worst in terms of income among all the districts in Fortaleza.

Finally, the general HDI of these districts, a compilation of GDP, life expectancy and educational indexes, makes it the most important among all other indexes.

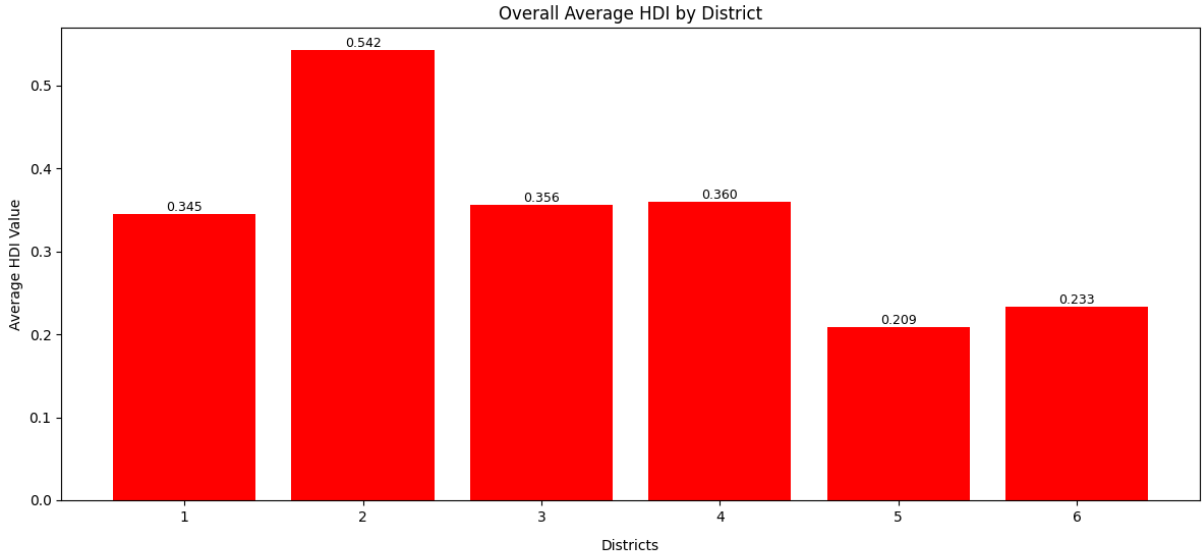

Figure 12

We can see that District 2 has the best overall HDI among all districts. This data is largely driven by the HDI income, which is significantly higher than the others, as shown in Figure 11. What we can see in District 6 is that it has one of the lowest indexes among the six districts. In this case, it is the second-worst overall HDI.

In general, it can be said that District 6, the environment where our researched educators teach, despite not having a large population or high demographic density, has low social indices, showing that it is a region of the city that urgently needs actions to improve inequality and promote income distribution, in addition to more investment in education.

Conclusions

Analysing the needs of geometry teachers in the classroom requires a theoretical and research effort, considering that the practice of these educators can be influenced by social, political, everyday and structural factors. This search involved understanding how these teachers viewed geometry, the use of new technologies in computers and smartphones, and how these tools could be used to facilitate this practice in the classroom.

The research revealed some essential points. Firstly, teachers in geometry classrooms understand that they need instruments that students can handle concretely. This can range from rulers and compasses to modern applications. Secondly, this practice helps students develop mathematical ideas for the development of other mathematical content, as geometry is the link between the practical and the theoretical, as it allows students to experiment with figures that they can construct and visualise. Another critical point was the analysis of the social environment in which teachers teach, specifically Educational District 6 of Fortaleza City Hall. It proved to be a significant challenge for these educators, as the region is impoverished and faces educational and resource difficulties. Finally, in places with a shortage of resources, a virtual tool can help fill these gaps, especially since it is a means that our society presents to us daily, whether due to the needs of the job market or its technological nature. Being familiar with these means and mathematics simultaneously will benefit both the student and the teacher.

This research will help develop a geometry application tool. It will allow students to create geometric figures and observe the main characteristics of these figures. This will enable teachers to construct their observations and deductions in the learning process.

This application would fill gaps that hinder students' learning, which is sometimes generated by the transition between abstract and practical mathematics mentioned earlier in this text. Thus, the idea to be developed in future work is to create an application that shows the characteristics of geometric figures. As Laborde (2001) highlights, dynamic geometry software not only facilitates the construction of geometric objects but also enhances students' conceptual understanding by allowing them to manipulate and explore mathematical properties in real time.

For example, a simple figure, the triangle, is easy to understand and construct. Three straight lines are enough to form a triangle, but the information contained in it is not so easy to see. However, a visual tool could make it easier to visualise some of the characteristics of the figure. "Let us suppose we have software that allows us to draw triangles, measure their angles, and add them together. These angles are objects of constructed triangles, so that the new sum is automatically calculated when their vertices are moved. Traditionally, one only tries a few times, no more than three. On a computer, however, in a few seconds, thousands of attempts are possible." (BORGES, NETO, 2007)

The idea is to develop an application that fills gaps in students' learning, which can sometimes be hindered by the transition between abstract and practical mathematics, as mentioned earlier in this text.

What sets this application apart from others is precisely how the images are created and how they will be processed, showing the information that the teacher will use with the students. Teachers often suffer from a lack of resources in the classroom, especially geometry teachers, who need more concrete material for students to visualise. The various applications researched require QR codes, grids, and external markers, among other tools that are often scarce, especially in public schools in Brazil. In this case, all it would take to process the images would be paper, a pen and a ruler. And studies by Zacharia and Olympiou (2011) show that virtual manipulatives can be as effective as physical ones for promoting conceptual understanding, particularly when access to physical resources is limited.

This provides a practical and easily accessible tool for elementary school geometry students and teachers. This mobile application allows students to create geometric figures and access essential information to draw necessary conclusions and build knowledge.

This application will also be based on these observations, drawn from this research, to fill the gaps that cannot be filled with theory alone. A concrete tool for students to build figures and visualise all their characteristics. It showcases the geometric figures and their properties that were envisioned by the minds of great mathematicians throughout history, including Pythagoras.

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From "Technophobia" to “Technophilia”: Teachers' Teaching Experiences in Online Learning Environment

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Abstract

The primary aim of this study was to explore the teaching experiences of secondary school teachers in a developing country within an online learning environment. This qualitative study employed Colaizzi’s (1978) method for data analysis. In-depth phone interviews were conducted with fourteen secondary school teachers, providing rich insights into their experiences. Through thematic analysis, eleven key themes emerged: technology barriers, interference between living environment and education, inefficacy of face-to-face instructional methods in online education, technology acceptance, reduced interaction, student academic procrastination, increased supervision on teachers, teacher authority, lack of attention to the affective domain, perceived teaching quality, and content development. Addressing these challenges is essential for enhancing the effectiveness of online education. By considering these factors, policymakers and educators can implement strategies to improve teaching quality, student engagement, and overall learning outcomes in e-learning environments, ultimately contributing to a more effective and inclusive digital education system

Keywords: Technology Enhanced Environment, Teaching Experience, High Schools, E-learning environment

Introduction

Teachers encountered numerous challenges in online learning environments, including accessibility, affordability, and flexibility (Murgatroyd, 2020). The sudden transition to online education exposed inequities in digital access, technological infrastructure gaps, and the need for innovative teaching strategies to sustain student engagement and learning outcomes. These challenges underscored the necessity for resilient and adaptable educational frameworks that ensure inclusive and equitable access to learning. Literature supports the fact that the general education systems’ (primary and secondary) challenges are almost the same as higher education. For example, some of these challenges can be related to teachers and students’ adaptation to new conditions, the internet connection, inappropriate physical environment, mental health problems, lack of basic requirements, and lack of learning and teaching resources (Mseleku, 2020). In many developing countries, the additional challenge such as lack of access to smartphones and lack of high-speed Internet were emerged (Pokhrel & Chhetri, 2021; Modica, 2022). Recent studies by UNESCO, UNICEF and the World Bank highlighted that many educational opportunities have been missed and that learning in high- and low-income countries has not been properly assessed (UNESCO & Mundial, 2020). This crisis has given us a deeper understanding of the digital gap and its resultant inequalities as an issue in serious need of immediate attention (Adedoyin & Soykan, 2020; Bank, 2020; Fishbane & Tomer, 2020; Kim et al., 2021; Portillo et al., 2020; Zhao & Watterston, 2021). The negative impact of this crisis will be greater on vulnerable groups such as girls, immigrants, and students with physical and mental disabilities (Ziebell et al., 2020).

Additionally, it was estimated that 24 million children and young people, from preschool to higher education, have dropped out of school due to the Coronavirus (Brief, 2020). Research findings also suggest that Covid-19, highlighted the digital gap among teachers and students (Jain et al., 2021; Portillo et al., 2020; Zhao & Watterston, 2021). Although a couple of international reports indicated that teachers' skills in dealing with the Covid-19 are inadequate (Bank, 2020; Brief, 2020; Di Pietro et al., 2020; Jaramillo, 2020; UNESCO & Mundial, 2020), some studies have pointed out the ability of teachers (Ziebell et al., 2020). The Covid-19 caused educational systems to switch to online learning environments. One of the problems that these systems face is the integration of this technology with the teaching-learning process. Spiteri & Rundgren,(2020) summarized studies related to barriers to the use of technology in education in many countries. The obstacles included Students; Teachers’ attitude; Teachers’ skill and school Culture.

Despite the breadth of the existing research, there is still insufficient research evidence on the effects of Covid-19 on educational outcomes. Therefore, it is a call for additional research in this area (Kim et al., 2021; Mseleku, 2020). Researchers believe that there is not yet accurate information about the relationship between students' reading habits and their success in online courses (Kolar et al., 2020). The epidemy caused extensive consequences

for the education system (Ziebell et al., 2020), but clarifying the dimensions and qualities of that issue still requires further research. Considering the aforementioned points, the current study is trying to explore the secondary teachers' teaching experiences in Iran. With regard to different social, economic and political conditions of Iran and the effect of these factors on the teaching and learning process, the present study seeks to answer the questions: What are the teachers' viewpoints about the obstacles to the correct use of the online learning environment for teaching and learning in the Covid-19 era? Considering that Iran's educational system has faced the problem of integrating technology into the teaching and learning process in the past, what challenges have come with the forced entry of teachers into the electronic learning environment?

Methodology

A Considering that the purpose of the current research is to study the lived experiences of teachers in the Online learning environment, the qualitative method is suitable for achieving this purpose. The qualitative approach explains the phenomena in their natural situation and tries to determine the meaning and interpretation of the phenomena from the perspective of the people present in it (Denzin & Lincoln, 2011; Willig, 2013). In order to determine the interview questions, the theoretical foundations related to this topic were studied, and based on that, important issues related to the use of technology in the teaching and learning process were extracted. Then, interviews were conducted with a number of experts in the field of education and school teachers about the issues involved concerning the use of technology in the classroom. Based on these two activities, general interview questions were determined. However, during the interview, appropriate questions were also asked according to the process.

Then, from secondary level (cycles one and two), fourteen teachers were selected (seven teachers from each cycle) for interviews. Teachers from the first secondary cycle were teaching Persian literature, English, Mathematics, Arabic, and Science. Teachers from the second cycle were teaching Religion, Biology, Arabic, Sociology, Physical Education, and Physics. In this sample, five were female and nine were male teachers. All the interviews were conducted by telephone. At the beginning of each interview, the purpose of the interview was stated. Permission was obtained to record the content of the interview. Participants were also reassured about the confidentiality of the information. Interviews lasted from 20 to 80 minutes. Since the interviews were conducted over the phone, the transcription was done right after the end of the interview. The interviews were semi-structured and its protocol is presented in the appendix section.

Colaizzi's method was used to analyze the data. In the first step, at the end of each interview, the recorded statements of the participants were transcribed. In the second step, meaningful information, statements related to the central phenomenon, were identified. In the third phase, the relevant themes were extracted. After extracting the theme, in the fourth stage, the themes were categorized based on their similarities. At this stage, thematic categories of the concepts were formed. In the fifth stage, the themes were combined to form more general categories, which was done to comprehensively describe the central phenomenon. In the sixth step, a comprehensive description of the studied phenomenon was presented. The final step involved validation. This step was done by referring to each interviewee, presenting the results of the interview to the participant and receiving his/her opinion about the degree of conformity of the findings with the opinions presented by him/her. The data analysis phases are summarized in Table 1.

Table 1 Detailed analysis of the data based on Colaizzi (1978) method

Phase	Action
1	Transcription of the recorded interviews
2	Extraction of meaningful information
3	Extraction of related themes
4	Categorization of the extracted themes
5	Combination of the categorized themes
6	Description of each main themes
7	Validation of the main themes

Results

Lorem After carefully applying Colaizzi's (1978) thematic analysis technique, 11 main themes were extracted as follows: (1) Technology barriers, (2) Interference between living environment and education, (3) Inefficiency of face-to-face instructional methods in online education, (4) Technology acceptance, (5) Reduction of interaction, (6) Student's academic procrastination, (7) Increased supervision on teacher, (8) Teacher authority, (9) Lack of attention to the affective domain, (10) Perceived teaching quality, and (11) Content development. In the next part, these themes are explained.

Theme 1: Technology barriers

According to one teacher, "The main problem for students is the lack of phones in most families and the Internet. In a family, several people use the same phone, which interferes with the classes" (Participant number 6). Another teacher reports technology problems as follows:

I also teach in the village. Education in the village is also virtual; students have many problems, including financial hardship, not having a phone, and using one cellphone for all of the students in one family. Unfortunately, they do not have a phone and cannot be present in the SHAD software. This has led to the absence of more than 50% of the students in the classroom. Some of them are likely to drop out of the school. (Participant number 10).

In addition to the lack of access to mobile phones and the Internet, SHAD, an application that is the main and official platform of virtual education in Iran, did not have some basic and key tools for transitioning to full time online learning. For example, "SHAD is not equipped with a webinar" (Participant number 5).

Theme 2: Interference between living environment and education

Schools do not have the necessary facilities for virtual or online teaching; therefore, after the lockdown of schools, teachers were forced to follow virtual education often via mobile phone at home. Teachers' houses usually do not have a work or study room. Therefore, teachers had to use other home spaces to record teaching, hold online classes, and the like. Doing all the work in a shared home environment can lead to conflicts and problems.

Virtual teaching is hard for me. Both my children and I are at home at the same time. I have to constantly remind them to be quiet because I want to record my voice or hold a class. Sometimes, I have to shout. My husband sometimes takes the side of the children and I have to talk to him (Participant number 12).

It was the first time that the interference of the work environment in the home environment occurred to such an extent. Teaching from home was accompanied by problems. Many teachers do not have a room or work space at home. There was an interference between their family roles and their work roles. Many teachers, especially female teachers, refused to conduct online classes or record educational videos at home because they felt that their home environment was not suitable.

Theme 3: Inefficiency of face-to-face instructional methods in online education

School closures occurred in the middle of the school year. Therefore, teachers were not prepared to enter virtual distance learning. Many teachers have taken courses in content production, ICDL, ICT, and the like, but none of these has led to the knowledge and skills needed for virtual distance learning. Such conditions caused teachers to follow the same methods that they used in face-to-face learning environments in the virtual context. One teacher describes the inefficiency of face-to-face methods in online learning as follows:

I wish these days pass sooner and the children come to class with their teacher. I do not know the rest, but people like me are not made for this kind of teaching. We have so many problems. Our teaching method is not useful in the E-learning environment. For example, our evaluation method in face-to-face classes is not useful for online classes. None of the scores are valid (Participant number 13).

For effective teaching in the electronic learning environment, appropriate teaching strategies should be used. Face-to-face teaching approaches are not necessarily beneficial for an E-learning environment. Some teachers felt that even though they put in a lot of effort, the students' learning rate is less and they get lower scores.

Theme 4: Technology acceptance

For the past 15 years, Iran's education system has sought to encourage teachers to use emerging technologies. For example, in parallel with the implementation of national projects such as the plan for making schools smart, in-service trainings in this regard were designed and implemented. Nevertheless, teachers resisted adopting new technologies. The Covid-19 era and the closure of schools were exceptional opportunities that pushed the education system into the E-learning environment. In the words of one of the teachers, "Covid-19 introduced the educational system to a new era, which I hope will continue this new ecosystem" (Participant number 9).

Considering the conditions of the Covid-19 era, some teachers adapted themselves to the conditions, tried to learn how to teach in the electronic learning environment and use its facilities for effective teaching. In fact, mandatory presence in the E-learning environment made teachers less afraid of new educational technologies, their attitude towards modern educational technologies became positive, and they became more familiar with software for Developing and delivering education.

Theme 5: Reduced interaction

One of the features of distance learning is that face-to-face interaction is eliminated. Features such as voice chat and live teaching, to some extent, reconstruct the real connection in the social network; but they will not replace face-to-face communication and interaction. Teachers believe that the level of interaction and emotional communication between teachers and students has decreased during virtual distance learning. According to one teacher, "Face-to-face training is much better. Emotional relationship plays an important role in education, training and learning. Virtual education and distance from students have been painful; because I live with the school and the students" (Participant number 10). Whereas, another teacher states "No teaching will replace face-to-face teaching. Because the interaction between the student and the teacher in face-to-face teaching is high and there is more feeling and emotion than in the social network" (Participant number 3).

Theme 6: Student' academic procrastination

During elementary school, students learn about educational and behavioral rules and regulations and practice them, and when they enter high school, they have almost mastered these rules and regulations. Therefore, their presence at school and in class is usually accompanied by discipline. Virtual and distance learning took students out of the formal environment. Students generally listened to lessons and did their homework in the informal setting of home. Although being at home is more comfortable, it can possibly lead to students being negligent, as noted in this quote: "Students who did not show interest in the real classroom, showed more procrastination in performing educational activities in the virtual classroom" (Participant number 5).

Another teacher states that "many of my students have become unmotivated about their studies and are roaming aimlessly on the E-learning environment and sites with immoral contents; they find an excuse not to attend SHAD application and they cheat a lot in exams" (Participant number 11). The other teacher continues, "Only one or two students in the whole class are attending the class, and the rest are waiting for a free, effortless score. The majority have false excuses" (Participant number 6).

During the Covid-19 era, students became negligent in doing their homework. With the reduction of interaction among students, the competition and cooperation among them also decreased. Instead of using mobile phones, computers and the Internet to participate in the E-learning environment, students used them more for playing games, watching movies, and being on social networks even when the teacher was teaching. Considering that students needed a VPN to use Telegram or WhatsApp to interact with the teacher, this would increase the possibility of seeing obscene images and videos among students and this has caused the students not to pay enough attention to the lesson. In the Covid_19 era, cyber space wasted more time of students than before and prevented them from paying serious attention to their studies. Since most parents do not know how their children use mobile phones, computers and the internet and have little supervision over them, this abandonment in cyber space and low parental supervision reduced students' attention to lessons.

Theme 7: Increased supervision on teacher

Traditionally, private classroom environments include teachers and students, and the teacher conducts his/her educational activities in a closed space. In the face-to-face education system, entering the teacher's classroom and observing his teaching style requires permission and is a relatively difficult task. Requesting to enter a classroom

is usually an insult and is considered an unpleasant request. Even if the person requesting permission is from school officials or the Department of Education. But in the E-learning that took place on a large scale during the Covid-19 era, the doors of the classroom suddenly got opened to administrators, experts, and parents.

Recording the activities of the classrooms and the possibility of publishing them in the social network are among the reasons that make teachers more cautious. Teachers are concerned and careful not to make mistakes. They know that colleagues, parents of students and education experts can see them teaching. If they make a mistake or are weak, they will be judged. It is also possible that part of their teaching footage, which contains a gross mistake, will be shared on social media. As one teacher explained, "all classroom activities are documented" (Participant number 12).

Theme 8: Teacher authority

Teachers believe that their authority has diminished during the virtual education era. This means that students valued and respected them more in person and listened more to them. Lack of formal school and classroom space may have provided more comfort and freedom for students. One of the teachers joked, "Students know that teachers cannot reach them! They do not take us seriously" (Participant number 9). Another teacher believed that:

The education system had no appreciation for teachers in the social network. Unfortunately, teachers were teased by many people during this period. The dignity and position of the teachers was not considered (Participant number 4).

Students in the E-learning environment do not respect the dignity of the teacher as in face-to-face classes, and send rude messages to each other as if the teacher is not in the class at all. Students in the face-to-face class pay more attention to the teacher's requests than in the virtual class. Students think that teachers have to give a score to everyone in the era of Covid-19.

Theme 9: Lack of attention to the affective domain

When classes were abruptly shut down and replaced by distance learning; Teachers focused on "cognitive domain". The main goal of the teachers was to present the subjects of the textbook to the students with all the problems. In such situations, the cognitive domain was in the center of attention and the affective and psychomotor domains were pushed to the margins more than before. Virtual classes reduced the level of teachers' emotional relationship with the students. In the words of one teacher, "We are facing with the students we have never met. At best, we have seen their image. We do not know them well. I usually have a formal approach to virtual classes" (Participant number 7).

During the Covid-19 era, more emphasis was placed on the cognitive domain and possibility of paying attention to the affective and psychomotor domain decreased. With the reduction of the emotional relationship between the teacher and the students, the possibility of working on the social, emotional, spiritual, aesthetic, moral and motivational dimensions of the students was reduced. Accessing the virtual space through installation of VPN on phones, exposed students to harm.

Theme 10: Perceived teaching quality

One of the things that all interviewees agreed on was that the quality of teaching and learning declined as a result of virtual distance learning. One of the most common statements of teachers was that "no virtual education can replace face-to-face education" (Participants numbers 1, 2, 5, 6, 7, 9, 11, 13, and 14). In practical and skill classes related to the field of motor psychology, this situation was reported to be more severe.

Some teachers thought that the quality of their teaching has increased during the Covid-19 era. Because they designed more detailed lesson plans for their lessons, taught more simply, regularly and clearly, provided better and higher quality tasks to students, and provided more and precise feedback to students.

Theme 11: Content development

In theme 4, it was explained that as a result of virtual education during the Covid-19 era, teachers' attitudes toward technology have changed and improved. There is some evidence that teachers' digital skills and competencies have also grown exponentially. Teachers who had no experience in producing electronic content before the Covid-19 era were suddenly forced to produce such content for their students. For several months - more, voluntarily - teachers became familiar with and began to work with various electronic content production applications. In producing standard and effective electronic content, tools and software are not as important as instructional design.

Nevertheless, every content production tool should be welcomed by teachers who have resisted the adoption and use of emerging technologies for years. According to one of the teachers, "I did not think that one day I would have to film myself and be able to paste photos and videos together and make an educational clip. Sometimes, I enjoy the clips I make" (Participant number 1). Teachers got more familiar with students' interests in E-learning environment, and this made them able to put themselves in the shoes of their students when producing electronic content. They realized the importance of using images and video and used the capabilities of the media for the effectiveness of their teaching. dui.

Conclusions

This study was conducted to explore teachers' teaching experiences during the Covid-19 in online learning environment. The Covid-19 has created opportunities for rethinking the processes of education (Ziebell et al., 2020), research, study and innovation (Adedoyin & Soykan, 2020), and reflection on the teaching profession (Miller & Harris, 2020). The Covid-19 forced education systems to accept things they had repeatedly rejected (Zhao & Watterston, 2021). A group of researchers consider it as the first exceptional opportunity to move away from traditional education and to use approaches, tools and digital media (Ratten, 2020) and believe that the emerging conditions have led to the emergence of more innovative ideas and solutions in education systems (Bryson & Andres, 2020). If the pre-Covid-19 era can be considered as the era of “technophobia" and "technology aversion" in the educational system, the Covid-19 and post- Covid-19 eras could be considered as the eras of "technology acceptance” or “technophilia”.

Barriers related to technology have been experienced around the world (Bai et al., 2020; Habibi et al., 2021; Nikolopoulou & Gialamas, 2016; UNESCO & Mundial, 2020). The studies conducted in different countries consider the obstacles to the use of technology in the teaching and learning process to include the following: resistance to change, complexity of ICT integration, organizational factors, ineffective policies and programming, weakness of leadership, lack of technical supports, lack of budget, lack of equipment/resources, lack of appropriate educational software, curriculum and teacher guide, role of people and feedback, culture of the school, lack of time, inappropriate class situation, students, large number of students, weak educational/professional development opportunities, mental norms, lack of knowledge and skill, teachers’ beliefs and attitudes, lack of self-confidence, perceived competency of teachers, and evaluation system (Al Mofarreh, 2016; Aslan & Zhu, 2018; Ghavifekr & Rosdy, 2015; Lawrence & Tar, 2018; Nikolopoulou & Gialamas, 2016; Plumb & Cotez, 2015; Prasojo et al., 2019; Salam, Zeng & Patan, 2018; Spiteri & Rangern, 2018). In the present study, technology barriers were also emphasized by teachers. These barriers include weakness of infrastructure, such as internet bandwidth, lack of internet access in some rural areas, and lack of access to mobile phones by some students, which further contributed to the problematic situation of needing to shift large numbers of students and teachers to online instruction, and in a short time frame. The gap between rural and urban areas is one of the main reasons that also leads to an increase in the educational gap (Adedoyin & Soykan, 2020; Zhao & Watterston, 2021; Ziebell et al., 2020).

One of the unprecedented events during the Covid-19 outbreak was the interference between the living environment and education. Many teachers taught, practiced, evaluated, and provided feedbacks at home. This has created many problems for them (Joshi et al., 2020; Phillips et al., 2021). The same thing happened to students. Research conducted in 40 European countries showed that the home environment has increased learning inequality among students (Di Pietro et al., 2020). Our findings were similar to the studies in India (Jain et al., 2021), Australia (Ziebell et al., 2020), Slovakia (Mikušková & Verešová, 2020) and Spain (Portillo et al., 2020). In this study, we found that pressure on teachers' work has increased for a variety of reasons, including the rapid and sudden transfer of instruction from face-to-face to online (Adedoyin & Soykan, 2020; Phillips et al., 2021). In addition, increased stress, anxiety, negative emotions, feelings of inadequacy and inability have been reported among teachers, some of whom are thinking of changing jobs (Mikušková & Verešová, 2020; Miller & Harris, 2020; Phillips et al., 2021). It is feared that after the end of Covid-19 and the reopening of schools, the experiences and lessons learned at a great cost would be forgotten (Zhao & Watterston, 2021). The participants of the present study stated that many of them do not have a room or work space at home. There was an interference between their family roles

and their work roles. Many teachers, especially female teachers, refused to conduct online classes or record educational videos at home because they felt that their home environment was not suitable for that. They compared their home environment with others who had very beautiful homes, and they were ashamed of it. In addition to home conditions, some female teachers preferred not to record educational videos because of their appearance and clothes. In fact, teachers had lost their privacy.

Another key finding of the present study is that according to the experiences of high school teachers, the use of face-to-face teaching-learning methods in the context of virtual education is not efficient and effective, and shows the unpreparedness of teachers for virtual education. The results of the research are contradictory in this regard (For example: Bai et al., 2020; Di Pietro et al., 2020; Jain et al., 2021; Jaramillo, 2020; Mikušková & Verešová, 2020; Modica, 2020; Pokhrel & Chhetri, 2021; UNESCO & Mundial, 2020; Xiao & Li, 2020). Some research shows teachers demonstrated high ability and competencies when they were faced with quickly shifting their style of teaching because of Covid-19 (Ziebell et al., 2020).

Another finding of the current research is that with the continuation of Covid-19 and forcing teachers to use the E-learning environment, some teachers gained more skill in using technology over time. Their fear of new technologies has disappeared and they have found a positive attitude towards it. This finding is consistent with Jaramillo's (2020) study.

One of the unique findings of the current research is that during the Corona era, the interaction among the students and between the students and teachers have decreased. Due to this reduction in communication, the emotional relationship between them has also decreased. For this reason, the teachers could not teach the students the manners in the classroom at the beginning of the academic year, and some of them used inappropriate words for conversation. Teachers were also unable to provide timely feedback due to lack of communication with students.

During the Covid-19 era, some students were negligent in doing their homework so that their parents did their homework for them. With the reduction of interaction among students, participation in doing homework and achieving academic progress also decreased among some of them. Some students were engaged in other activities in cyberspace while the teacher was teaching. Due to the conditions of Iran and restrictions on internet access, students had to use VPN to communicate with the teacher, which increased the possibility of viewing inappropriate content by students and their academic failure. Due to lack of familiarity with cyberspace or lack of time, parents did not have enough supervision on how to use their children's mobile phones, which was one of the serious factors in the academic failure of some students. The findings of the current study are in line with various research indicating a decrease in the academic achievement of students in different countries during the Covid-19 outbreak (Cachón-Zagalaz et al., 2020; Di Pietro et al., 2020; Pokhrel & Chhetri, 2021; Thamtanajit, 2020; Ziebell et al., 2020).

Due to the special feature of the E-learning environment in the Iranian schools (SHAD, which is similar to Telegram messenger), different people including the principal, other teachers, parents and people from the Department of Education could attend the teacher's class. This has increased the possibility of monitoring the activities of teachers. In fact, the teacher had moved from the brick classroom to the glass classroom, where anyone could see the inside and the activities that took place there. This made the teachers pay attention to more considerations in their teaching and try to improve its quality, and to some extent, it caused an increase in their work pressure.

The teachers stated that due to the special nature of the E-learning environment, the focus was more on the cognitive domain and less attention was paid to the dimensions of the affective domain, including the social, emotional, spiritual, aesthetic, moral and motivational, and also the psychomotor domain. Other researchers, too, indicated that the quality of learning in practical courses has been more decline than in theoretical courses. Virtual labs may cover part of the learning, but they certainly cannot replace real labs (e.g., Adedoyin & Soykan, 2020).

Some teachers thought that their teaching has become more qualitative in the E-learning environment. Because they designed more detailed lesson plans for their courses, taught more simply, regularly and clearly, provided better and higher quality tasks to students, and delivered more and precise feedback to students. However, during the Covid-19 era, we encountered a general decline in academic achievement of student.

And finally, the last finding of the current research shows that teachers think they have gained more skill in producing electronic content in the era of Covid-19. In fact, they have been able to produce content that is according to the capabilities of the E-learning environment and on the other hand, also takes into account the needs of the students.

Based on the findings of the present study, if educational systems aim to increase the quality of teaching and learning in the E-learning environment, it is appropriate to try to remove technological barriers such as internet access, provide teachers with a suitable environment for producing electronic content in schools, instruct appropriate methods of E-learning environment to teachers, try to improve teachers' attitudes about technology,

provide proper context for interaction among students, teachers and parents, supply parents with proper training so that they can supervise the activities of students along with the teacher and provide a safe environment for the teachers so that they feels relaxed in the classroom while being monitored.

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Method of Multi-Agent Search System as a Component of Adaptive Distributed Learning Environment

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Abstract

Adaptive distributed learning environments increasingly rely on both cloud-based and local resources. However, existing e-learning platforms fragment metadata across web repositories and offline archives, leading to disjointed user experiences and suboptimal search accuracy. This study aims to address these shortcomings by developing a multi-agent search system that unifies online and offline content within a single adaptive framework. We propose an architecture composed of five specialized agents (crawler, local scanner, evaluator, indexer, and coordinator) interacting via a message bus to perform metadata harvesting, semantic evaluation, and indexing. A comparative identification method combines ontological similarity with TF-IDF relevance metrics, supported by a two-tier ontology model that includes both general information-retrieval concepts and subject-specific domain vocabularies. A prototype implementation using FastAPI for the web service and Electron for the desktop client was evaluated on a hybrid dataset of 10 000 online learning resources and 5 000 local PDF files. Experimental results indicate a 36% improvement in Precision@10 compared to purely descriptor-based search, at the expense of a 22% increase in average response time. These findings confirm the feasibility of the approach and its capacity to enhance thematic filtering and personalized learning trajectories in hybrid learning ecosystems. In conclusion, our multi-agent design effectively bridges the gap between online and offline search, improving both accuracy and adaptability. We recommend further reducing latency through distributed caching and parallelized processing, extending the ontology framework to support mobile offline synchronization, and integrating user-behavior analytics to enable dynamic adjustment of relevance weighting based on learner feedback.

Keywords: Adaptive distributed learning environments, hybrid search engine, multi-agent approach, component architecture, ontologies.

Introduction

With the rapid development of information and communication technologies, e-learning systems that combine web-based platforms with local resources are becoming increasingly important. E-learning as a form of knowledge acquisition is based on the use of both cloud services and offline applications and printed materials, which places increased demands on the flexibility of architectural solutions. Insufficient consistency of standards and poor formalization of metadata complicate automatic content processing and lead to the loss of relevant results. The lack of a unified search mechanism both in the web space and in local archives reduces the level of personalization of learning paths and limits the possibilities of an adaptive approach.

One of the key obstacles is heterogeneous metadata, which is formed according to the recommended LOM and SCORM standards, but can differ significantly from each other. The open nature of these standards gives developers the freedom to fill in the fields, which often leads to inaccurate resource descriptions and ambiguity during indexing. This gap between user expectations and the actual content of the descriptions exacerbates the problem of building an effective adaptive environment. In addition, modern learning ecosystems should provide seamless integration of online and offline components, combining streaming courses and cloud storage with local file collections. In the context of hybrid search, it is necessary to develop mechanisms that allow finding materials both on the Internet and in local archives, without losing a single personalization model.

Metadata heterogeneity arises because the LOM and SCORM recommendation standards provide only general guidelines without strict requirements for the format or content of description fields. As a result, there are both well-structured records and laconic or overly detailed descriptions, which makes it difficult to index them in a unified way. This situation is typical for both open access web resources and PDF materials in local repositories, which creates significant barriers for automated search and comparison algorithms. Simple descriptor and Boolean models that rely only on keywords and basic tags do not provide a deep contextual understanding of the content of resources. As a result, the learning environment loses its ability to accurately reflect the user's current needs and correctly generate personalized trajectories.

Modern e-learning platforms are mostly based on a component-oriented architecture that divides the system's functionality into modules for search, storage, content delivery, and analytics. Despite the flexibility of this approach, real-world implementations face a number of serious limitations. First, web search components usually use only descriptive methods (TF-IDF, Boolean queries), which leads to high speed but low accuracy, especially for complex topic queries. Secondly, built-in ontological mechanisms are mostly limited to single-level description of domain concepts, which does not allow to correctly process hybrid queries that combine semantic depth with response speed. Let's consider three main classes of existing solutions.

Component-oriented search modules. Typical LMS (Learning Management Systems) integrate third-party search engines or custom modules that focus only on online data. They use keyword indexing and standard LOM/SCORM metadata, but do not take into account the user's local repositories or offline materials. As a result, learning trajectories become fragmented: students receive separate results from the web and cannot simultaneously search local collections. Solving this problem by adding a separate offline scanner leads to duplication of functions and integration complexity, as there is no single standard for exchanging metadata between online and offline modules.

Single-level ontological approaches. To improve relevance accuracy, some systems use ontologies, but mostly only at the general level. Such solutions provide improved semantic search within a single domain, but do not detail the context of the discipline. They cannot work with general concepts and specialized terms at the same time, which reduces the accuracy of searching for disciplinary materials. In addition, these systems usually work exclusively online, and any attempts to adapt the ontological core to local resources face inconsistencies in RDF triplets formats and the lack of synchronization mechanisms.

Decentralized agent solutions. Some researchers have proposed the use of agents for distributed search, but their architectures are limited to two or three types of agents and do not take into account the hybrid nature of learning content. Such solutions can collect data in parallel, but do not offer a unified relevance assessment predicate for heterogeneous formats. The result is a high complexity of results integration: web page crawlers and local indexing agents return incompatible metadata sets, which requires additional conversion and often leads to loss of context.

All of these approaches demonstrate either flexibility but low accuracy or a high level of semantic processing but limited scalability and support for online mode only. That is why there is a need for an architecture that combines the advantages of component, ontological, and agent-based approaches, providing a single metadata standard and a combined relevance assessment model for a hybrid environment.

Methodology

We propose a holistic multi-agent architecture that combines the processes of online and offline search for learning resources in a single adaptive system. Our model responds to the main challenges of modern learning ecosystems: metadata fragmentation between web platforms and local repositories, lack of a unified mechanism for assessing the relevance of heterogeneous formats, and low accuracy of topic filtering in a hybrid context. Instead of treating online and offline data separately, we integrate them through five classes of agents, each of which performs a specific function in the overall search cycle, from initial collection to presentation to the user.

The proposed solution significantly improves the current state of affairs by unifying metadata and using a comparative identification method that combines semantic and descriptive relevance assessment. Compared to traditional systems that either quickly search by keywords (TF-IDF) or use long-tail ontological queries, our architecture allows for flexible adjustment of the balance between search speed and depth of semantic analysis. In addition, the implementation of a two-tiered ontological model provides a more precise narrowing of the search space, where a general ontology is responsible for unified concepts, and subject-oriented ontologies detail the context of specific disciplines.

Thus, our multi-agent system solves two main problems: first, it reduces the impact of metadata heterogeneity by unifying resource descriptions; second, it improves the accuracy of results through combined relevance assessment optimized for the hybrid environment. In the following, we will take a closer look at each of the five classes of agents, the comparator predicate formula, and the ontological integration framework.

In the proposed multi-agent system, each agent has a well-defined role in the common message bus. The crawler agent performs the initial collection of metadata from web pages in accordance with LOM and SCORM standards, and the local crawler indexes PDF and DOCX files in a local repository. Then the evaluator agent applies a comparative model of topical relevance, and the indexer agent generates the final RDF triplets for storage in the knowledge base. The coordinator synchronizes the work of all agents, sending requests depending on user settings and resource availability. The roles and functions of agents in the proposed hybrid search system are shown in Table 1.

Table 1. Roles and functions of agents in a hybrid search system.

Agent	Data sources	Key features
Crawler	Web repositories	HTML collection and preprocessing, LOM/SCORM metadata extraction
Local scanner	Local files	Indexing PDF, DOCX, PPT according to Dublin Core scheme
Evaluator	Metadata collected	Calculating relevance through ontological relationships and descriptors
Indexer	Output of the evaluator	Building reverse indexes, saving RDF triples
Coordinator	All agents	Managing request queues, balancing online and offline modes

In the context of heterogeneous formats, the basis for assessing thematic relevance is a comparative predicate that combines semantic and statistical components. The overall relevance coefficient of the document d to the query q is determined by the formula

$$R(d,q) = \alpha \, \mathrm{sim}_{\mathrm{ont}}(d,q) + \beta \, \mathrm{sim}_{\mathrm{tfidf}}(d,q), \quad (1)$$

where $\mathrm{sim}_{\mathrm{ont}}$ denotes semantic similarity based on ontology, and $\mathrm{sim}_{\mathrm{tfidf}}$ denotes cosine similarity of TF-IDF vectors of descriptors; α and β are weighting factors that determine the balance between deep contextual understanding and descriptor search speed. The use of the equivalence predicate allows the evaluator agent to filter out irrelevant documents at the initial stage, significantly narrowing the search space and increasing the overall efficiency of the system.

A two-level ontological model is used to unify the description of heterogeneous sources (online and offline resources). The first level contains a general ontology of information retrieval with the main classes "Resource", "Topic" and "Format", and the second level includes subject-oriented ontologies that detail the concepts of specific disciplines (for example, "Mathematics course" or "Literary genre"). In a generalized architecture, the step-by-step processing will look like this: the indexer first maps descriptors to classes of the general ontology, and then the evaluator refines the query context through the links of the subject-oriented ontologies. This approach allows achieving high accuracy of thematic filtering of both online and offline materials in a single adaptive environment.

Results

A microservice model was chosen to implement the prototype: a web server is responsible for processing crawler and evaluator requests, and a local application acts as a crawler and partially duplicates the functions of the indexer. This approach ensures scalability and the ability to deploy the system both in the cloud and on user workstations.

The technical implementation of the prototype relies on the FastAPI for receiving and routing requests between agents, RabbitMQ as a message bus, and PostgreSQL for storing unified RDF triples. The OWL API is used as the ontology engine, which allows to dynamically load two-level ontologies and perform semantic inference queries. The local scanner is built as a desktop application on Electron, which connects directly to the same database as the web service, providing a single point of access to user materials.

To evaluate the effectiveness of the system, a hybrid test environment was set up, consisting of an online repository of 10,000 articles and a local collection of 5,000 PDFs of methodological materials. Each query was processed in two modes: purely descriptive search (TF-IDF) and hybrid (combined ontological and descriptive analysis). Accuracy measurements were performed using the Precision@10 metric, and latency was recorded as the average response time in milliseconds. The measurement results are shown in Table 2.

Table 2. Comparison of search modes by accuracy and latency.

Search mode	Precision@10	Average response time (ms)
TF-IDF only	0.62	469
Hybrid (ontology + TF-IDF)	0.84	574

The experiment showed that the hybrid mode provides a 36% increase in accuracy despite a 22% increase in processing time. Such an increase in relevance is critical for adaptive learning environments where the quality of the content delivered takes precedence over the maximum response speed. Further optimizations can be aimed at parallelizing computations in the evaluator and caching ontological queries to reduce latency without losing accuracy.

Conclusions

The study proved that a multi-agent architecture with five types of agents effectively integrates online and offline resources into a single adaptive learning environment. The combination of ontological and descriptor analysis using the comparative identification method allows to achieve a significant increase in the relevance of search results, which is confirmed by the experimental evaluation of Precision@10: from 0.62 to 0.84 in hybrid mode. Thus, the proposed solution solves the problem of metadata heterogeneity and low search accuracy in a hybrid context by combining the advantages of semantic depth and descriptive performance. At the same time, a 22% increase in latency indicates the need for further optimizations in the evaluator components and ontological query caching to reduce response time.

At the next stage of system development, it is recommended to focus on several areas. First, it is advisable to explore the possibilities of distributed caching of ontological subqueries and optimization of message queues in RabbitMQ to reduce latency. Secondly, the introduction of interactive adaptation mechanisms based on user behavioral analytics will further personalize educational trajectories and automate the adjustment of weights in the $R(d, q)$ formula depending on satisfaction and learning outcomes. Finally, the extension of the two-level ontological model to mobile platforms and the introduction of offline synchronization will open the way to learning in conditions of unstable Internet connection, which is especially important for regions with weak infrastructure.

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Teaching in the Digital Age: Investigating TPACK-21 in the Context of 21st Century Skills

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Abstract

As education systems worldwide emphasize the importance of 21st-century competencies, teachers are expected to foster students' development of key thinking skills such as complex problem-solving, critical thinking, and creative thinking. In today's rapidly growing information age, it can be claimed that Technological Pedagogical and Content Knowledge (TPACK) is increasingly regarded as a crucial framework for effective teacher knowledge. Accordingly, the integration of technology into pedagogy is considered an essential component of meaningful and effective instruction. It has therefore been suggested that TPACK should not only encompass pedagogical and technological knowledge but also be updated to prioritize the enhancement of students' thinking skills in alignment with 21st-century learning goals. Given that teachers are central actors in implementing diverse methods and tools in the classroom, examining how competent they are in supporting students' acquisition of 21st-century skills can be seen as critical for improving educational practices and learning environments. Based on this premise, the present study aims to explore teachers' 21st-century skill competencies through the lens of the Technological Pedagogical Content Knowledge for the 21st Century (TPACK-21) framework. Adopting a descriptive research design, the study utilized the Turkish adaptation of the TPACK-21 scale, which includes 38 items measuring the integration of pedagogical, technological, and content knowledge in relation to 21st-century skills. Participants were selected through a convenience sampling method and consisted of teachers from various subject areas. Data were analyzed for each component using descriptive statistics such as mean. It is hoped that the findings will contribute to a better understanding of the relationship between teacher competence in TPACK-21 and their ability to support 21st-century skill development, potentially offering valuable implications for teacher training programs and educational policy.

Keywords: Educational technology, Technology integration, TPAB, TPACK, TPACK-21, 21st century skills

Introduction

Education systems across the globe are undergoing significant transformations in the face of rapid technological advancement and the evolving demands of the modern world. There is an increasing emphasis not only on the acquisition of knowledge but also on the cultivation of higher-order thinking skills that enable learners to navigate complexity, think critically, and generate creative solutions. In parallel, education significantly shapes individuals' lives and plays a crucial role in preparing students for the complexities and challenges of the twenty-first century, where a wide range of competencies is required to meet the demands of contemporary society (OECD, 2018a). Consequently, it has become more essential to revise and adapt educational systems to align with current global circumstances (Marope, 2017). Educators are pivotal to this transition, since they are anticipated to facilitate students' learning of new abilities by using their expertise and experience in inventive manners (OECD, 2018b).

In this context, with the rapid advancement of technology, the demands of the modern world have significantly evolved, prompting the identification of essential skills and competencies necessary for today's world. While many of these skills existed prior to the 21st century, they have gained increased prominence in recent decades due to the shifting requirements of personal life, academic pursuits, and professional environments (Voogt & Roblin, 2012). The capabilities needed in the 21st century differ notably from those emphasized in the 20th century, leading to the widespread adoption of the term 21st-century skills. In this context, it should be considered that teachers are unlikely to effectively assist their students in acquiring the competences necessary to succeed in the twenty-first century if they lack the necessary 21st-century knowledge and abilities (Shafie, Majid & Ismail, 2019; Valtonen, et al., 2017).

Accordingly, as the discussion on 21st-century competencies emphasizes the necessity for teachers to possess the knowledge and skills required to guide students effectively, it is significant to explore theoretical frameworks that explain how such competencies can be conceptualized and developed. In this sense, one of the most influential frameworks that acknowledges the complexity of effective technology integration is the Technological Pedagogical Content Knowledge (TPACK) framework developed by Koehler and Mishra (2006). The TPACK framework provides a theoretical lens to understand the dynamic interplay among technological, pedagogical, and

content knowledge, highlighting the integrated skills, competencies, and roles teachers must possess to effectively incorporate technology into the teaching and learning process (Koehler & Mishra, 2009). By integrating knowledge of pedagogy, subject matter, and technology, TPACK provides a comprehensive structure for examining teacher competence. Hence, there are a number of studies that investigated TPACK (Schmid, Brianza, Mok & Petko, 2024; Karataş & Ataç, 2024; Kocagül & Çoban, 2024). However, with the growing urgency to align teaching practices with 21st-century learning goals, researchers have argued that the TPACK framework should be expanded to adapt to the changing world's needs. Consequently, it can be claimed that educators need to develop 21st-century competences, especially technological pedagogical content knowledge (TPACK), to adequately prepare students with the skills and digital literacies required to succeed in a changing environment. Some definitions which include reflective thinking, problem solving, creative thinking, critical thinking and ICT are exemplified below.

Reflective Thinking: The capacity to consciously examine and evaluate one's own learning, education, and skill development.

Problem Solving: The ability to tackle new or unfamiliar challenges by drawing on prior knowledge and experiences and applying them in innovative ways.

Creative Thinking: The skill of combining personal abilities with diverse knowledge sources to generate novel ideas or products.

Critical Thinking: The capability to analyze extensive information, assess the credibility of knowledge and compare multiple sources critically.

Information and Communication Technology (ICT): Includes a range of devices such as computers, tablets, and smartphones, along with web-based applications, software, social media applications and digital learning environments (e.g., Moodle, Office365).

Examples of these 21st century skills self-evaluating TPACK statements can be illustrated through different domains of knowledge. For instance, within the scope of pedagogical knowledge (PK), a teacher may demonstrate competence by guiding students' discussions during small group work involving two to five students. Content knowledge (CK) is reflected in an understanding of the fundamental principles of collaborative learning, while technological knowledge (TK) encompasses familiarity with emerging technologies and their functionalities. Pedagogical content knowledge (PCK) is exemplified by the ability to guide students' content-related problem solving in natural sciences during small group activities. Technological pedagogical knowledge (TPK) highlights knowing how to use information and communication technologies (ICT) as a medium for sharing ideas and engaging in collaborative thinking. Finally, technological content knowledge (TCK) entails knowing specific technologies that can be used to illustrate complex concepts in natural sciences.

The TPACK for the 21st Century (TPACK-21) framework represents such an effort by emphasizing the integration of technology not simply as an instruction tool but as a means to enhance students' engagement in critical, creative, and collaborative thinking. Evaluating teachers' competencies through the lens of TPACK-21 thus can offer a promising avenue for understanding how well-prepared they are to meet the expectations of 21st-century education (Wardani, Drajati & Handayani, 2020; McRaven, 2024). Against this backdrop, the present study seeks to explore teachers' perceived competencies in supporting 21st-century skills using the TPACK-21 framework. By focusing on teachers from various disciplines and analyzing their responses, the study aims to contribute to the ongoing discourse on teacher effectiveness, professional development, and educational innovation in the 21st century.

Methodology

Research Design

This study used a descriptive research design to explore teachers' self-perceived competencies in integrating 21st-century skills through the TPACK-21 framework. The research aimed to determine the extent to which teachers consider themselves proficient in combining pedagogical, technological, and content knowledge to foster students' development of key 21st-century competencies, such as critical thinking, creative thinking, and complex problem-solving.

Participants were selected using a convenience sampling method, which enabled the inclusion of a diverse group of in-service teachers from different subject areas and school levels. The participants' average experience in teaching was 1-5 years (n = 22), 5-10 years (n = 15), over 10 years (n = 11) and the subjects of the participants varied from Turkish, Maths, Social studies, Science, English, Religious Studies, Visual Arts to Music. All participants were informed about the purpose of the study and voluntarily agreed to take part in the research. Data

were collected by using TPACK-21 scale which was originally developed by Valtonen et al., (2017) and adapted by Alpaslan, Ulubey & Ata (2021). TPACK-21 is a 38-item six-point Likert type designed to measure the integration of pedagogy, technology, and content knowledge in alignment with 21st-century learning goals. (1 = I need more knowledge about the subject; 6 = I have strong knowledge about the subject). The Cronbach alpha values for the reliability of the scale were as follows: PK21 (α = .93), CK (α = .92), TK (α = .88), PCK21 (α = .95), TPK21 (α = .95), TCK (α = .89) and TPACK-21 (α = .96). Descriptive statistical techniques, including means, frequencies and percentages, were used to analyze the data and provide a general overview of teachers' competency levels across the different components of the TPACK-21 framework.

Results

According to the results of the descriptive statistics overall mean is 3,264. The descriptive statistics indicate that teachers obtained the lowest mean score in TCK (M = 3.010, SD = 1.188) and the highest mean score in PK21 (M = 3.415, SD = 1.82). This suggests that teachers perceived themselves as relatively less competent in integrating technology with content knowledge, whereas they reported stronger competence in pedagogical knowledge related to 21st-century skills.

The scores for the other variables are also above the mean (CK = 3.278, SD = 1.312; TK = 3.280, SD = 1.190; PCK21 = 3.291, SD = 1.137; TPK21 = 3.297, SD = 1.132; TPACK21 = 3.282, SD = 1.121), which reflects a generally positive self-evaluation of their knowledge and skills. Nevertheless, the relatively lower score in TCK highlights a potential challenge for teachers in effectively integrating technology with subject content. In contrast, the higher results in pedagogical orientations and 21st-century-related practices suggest that teachers are more inclined and better prepared to address the contemporary learning needs of their students.

When the components of the framework were analyzed in detail, it was found that teachers perceived themselves as most competent in their ability to integrate pedagogical strategies that promote student engagement and cognitive development. The integration of technology into these domains, however, appeared to be an area where teachers reported more variability, with some expressing high confidence and others indicating limited proficiency or experience.

Overall, the findings show that teachers scored lowest in TCK (M = 3.010), indicating challenges in integrating technology with content, while the highest score was in PK21 (M = 3.415), reflecting stronger competence in pedagogy related to 21st-century skills. The other variables are also above the mean, suggesting generally positive self-perceptions; however, the relatively low TCK score points to a need for further support in combining technology with subject content. These findings point to the importance of continued efforts to enhance teacher competencies in the use of technology to support 21st-century learning goals, particularly in areas where confidence and perceived preparedness remain uneven.

Conclusion

This small-scale study aimed to examine teachers' self-perceived competencies in integrating 21st-century skills into their teaching practices through the lens of the TPACK-21 framework. The findings suggest that while teachers generally feel confident in applying pedagogical and content knowledge to support students' critical, creative, and problem-solving abilities, their technological integration skills remain an area with room for improvement. These findings are consistent with previous research, demonstrating similar patterns regarding teachers' confidence in pedagogical and content knowledge versus their comparatively lower proficiency in integrating technology effectively which highlights the importance of not only equipping teachers with general technological knowledge but also ensuring that they are prepared to use technology in ways that actively promote higher-order thinking and collaborative learning (Arreerad, 2022; Tsimba, Mugoniva & Mutembedza, 2020).

The findings are also consistent with the findings of Başaran (2020), who examined the TPACK-21 efficacies of 254 preservice teachers. This alignment may be attributed to the fact that the majority of participants in the present study had 1–5 years of teaching experience (n=22), which can be considered relatively new or novice. The findings further indicate that the ability to meaningfully integrate technology, pedagogy, and content with a focus on 21st-century competencies is not yet evenly distributed among teachers. These findings underscore the need for ongoing professional development initiatives that target specific aspects of TPACK-21, particularly those related to technology use for skill enhancement which reminds us of the roles of school principals. It should be emphasized that school principals play a crucial role as initiators of technology integration in schools, as their vision shapes the process, and they are expected to support teachers through continuous professional development programs (Wang, Tigelaar & Admiraal, 2022). Tailored training programs that emphasize practical strategies for designing

technology-rich learning experiences may help bridge this gap and better prepare teachers for the complex demands of 21st-century education (Mustafa, Nguyen& Gao, 2024).

Overall, the study contributes to a growing body of research that recognizes the critical role of teacher knowledge frameworks like TPACK-21 in shaping effective instructional practices. By drawing attention to the strengths and weaknesses in current teacher competencies, the findings offer valuable insights for teacher education programs, educational policymakers, and school administrators aiming to foster more innovative and future-ready learning environments.

Implications

The findings of this study carry several important implications for teacher education, professional development, and educational policy. First, the variability observed in teachers' competencies across the TPACK-21 dimensions suggests a need for more targeted and differentiated professional learning opportunities. Specifically, professional development programs should place greater emphasis on the pedagogically meaningful use of technology, with a clear focus on how digital tools can be leveraged to foster students' 21st-century skills, such as creativity, critical thinking, collaboration, and problem-solving.

Second, the results point to the importance of embedding the TPACK-21 framework into both pre-service and in-service teacher education curricula. By integrating theoretical and practical components of the framework, teacher training programs can better prepare future educators to design and implement instruction that aligns with 21st-century learning goals. This includes not only mastering technology but also developing the ability to make informed pedagogical decisions that are grounded in content expertise and responsive to student needs.

Furthermore, educational policymakers and school leaders should consider adopting systemic strategies that support teachers in bridging the gap between traditional instructional approaches and innovative, skill-based teaching practices. This may involve providing access to up-to-date technological infrastructure, creating collaborative professional learning communities, and encouraging reflective practice focused on TPACK-21 integration.

Finally, the study underscores the broader educational shift from content delivery toward the cultivation of student-centered, skills-based learning environments. As such, school systems should prioritize the development of assessment tools and teaching standards that recognize and reward the effective use of integrated knowledge frameworks like TPACK-21. Doing so can help ensure that teaching practices remain relevant and responsive in an increasingly complex, technology-driven educational landscape.

Although this study provides valuable insights, its limitations highlight the importance of exercising caution in interpreting the findings. Future research should address these concerns by involving larger sample sizes, examining diverse educational contexts, minimizing potential biases, and improving data collection methods to yield more comprehensive results.

Acknowledgements

I would like to thank all the participants in this study.

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A Phenomenological Analysis of Science Teachers' Perceptions of Artificial Intelligence

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Abstract

Artificial intelligence (AI) has emerged as a significant issue in education due to the rapid development of technology that can imitate human intelligence. Teachers' knowledge levels and attitudes toward these technologies play a crucial role in shaping future educational practices. This study aims to reveal science teachers' awareness of AI and their views on its potential use in science education. The study adopts a qualitative research approach, specifically the phenomenological design. The study group consists of 12 science teachers (nine female, three male) working in public schools in the Doğubayazıt district of Ağrı province, selected through maximum variation sampling. Data were collected using a semi-structured interview form and analysed through content analysis under eight themes: sources of information, definitions, comparison with human intelligence, AI technologies, areas of use, advantages, disadvantages, and use of AI in science classroom. According to the findings, teachers primarily became familiar with the concept of AI through digital media. Participants underlined that these technologies were built on coding procedures and characterized AI as a system that imitates human intelligence. The emotional dimension of human intelligence was viewed as a key point of distinction, with most teachers believing that AI cannot surpass human intelligence in this respect. The most used AI tools were found to be smart boards and mobile applications. Teachers indicated that AI technologies have a wide range of applications across various sectors, and in science education, they highlighted the usefulness of AI, particularly in experiment simulations, concretizing abstract concepts, and assessment processes. Participants did not perceive AI as a threat to the teaching profession; instead, they saw it as a supportive tool in the educational process. They also noted that AI facilitated learning, increased motivation, and contributed to equal opportunities in education. However, some potential negative effects were also mentioned, including concerns about job displacement, reduced social interaction, and risks related to personal data security.

Keywords: Artificial intelligence, AI in education, technology integration, science teachers, teacher education, science education.

Introduction

In the Information Age, artificial intelligence (AI) is increasingly shaping individuals' daily lives. Rapid improvements in AI technologies are leading to significant changes in education and instructional practices. Therefore, the utilization of AI in science education has been gaining increasing attention in recent years. As science learning aims to foster inquiry, problem-solving, and conceptual understanding, the integration of AI raises important questions about its potential role in teaching, learning, and assessment. In this context, both the advantages and disadvantages of AI have become central to ongoing discussions.

The concept of AI traces back to Turing's (1950) definition, suggesting that machines can think similarly to humans. Baker et al. (2019) define AI as "computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving" (p. 10). Similarly, Nabiyev (2012) describes AI as intelligent programs that assist in solving complex problems and generating responses not only to predefined issues but also to new situations. With the rapid advancements in technology over the past decades, AI has increasingly become integrated into various aspects of daily life, suggesting that it will play an even more significant role in education in the future.

In the educational context, several applications of AI have already emerged. For example, intelligent tutoring systems (Luckin et al., 2016; Montebello, 2018), automated grading (Wang & Zhao, 2020), and real-time learning analytics dashboards (Keuning & van Geel, 2021) are examples of applications through which artificial intelligence has been increasingly incorporated into education. These technologies provide meaningful opportunities to support personalized learning, formative and summative assessment, and lesson planning (Celik et al., 2022; Chen et al., 2022; Zawacki-Richter et al., 2019).

Particularly in science education, AI-supported tools have the potential to make the learning process more effective, efficient, and engaging. Applications such as intelligent tutoring systems, adaptive learning platforms, virtual laboratories, and AI-powered simulations can help students better understand abstract scientific concepts, conduct experiments in safe and controlled environments, and receive immediate personalized feedback (Holmes et al., 2019; Kim & Kim, 2022; Luckin et al., 2022; Topal et al., 2021, Zawacki-Richter et al., 2019; Zhai, et al., 2020).

However, the potential of AI in education has not yet been fully realized (Luckin et al., 2022). Teachers serve as the main users of these technologies and act as mediators in the application of AI within educational settings. Studies indicate that educators possessing a robust understanding of AI are better equipped to choose suitable AI applications for science education and effectively incorporate them into teaching methodologies (Celik, 2023; Luckin et al., 2022). However, the successful implementation of these technologies is significantly influenced by teachers' awareness, knowledge, and attitudes (Celik, 2023; Celik et al., 2022).

While most existing studies have concentrated on general educational contexts, research specifically examining science teachers' views on AI remains limited. Considering that science teachers play a central role in fostering scientific thinking, experimentation, and technological literacy, their perspectives are crucial for the effective use of AI in science education. Understanding their awareness, attitudes, and experiences provides valuable insights into how AI can be meaningfully integrated into classroom practices. Therefore, this study addresses a significant gap in the literature by exploring in-service science teachers' opinions through a phenomenological design, contributing to both theory and practice in the field of science education. As a result, the goal of this study was to determine science teachers' awareness of AI and their perspectives on its possible use in science education. The study was guided by the following questions:

1. From which sources do science teachers obtain their knowledge about AI?
2. How do science teachers define AI?
3. In what ways do science teachers compare human intelligence to AI?
4. Which AI technologies do science teachers use?
5. What are the views of science teachers regarding the applications of AI technologies?
6. What are the views of science teachers regarding the advantages of AI?
7. What are the views of science teachers regarding the disadvantages of AI?
8. What are the views of science teachers regarding the integration of AI technologies into the science classrooms?

Methodology

This study employed a qualitative research approach, specifically a phenomenological design, to explore the perceptions of science teachers regarding AI. Phenomenology was chosen as it allows for an in-depth examination of participants' subjective interpretations (Yıldırım & Şimşek, 2018; Yin, 2009).

Participants

In Türkiye, science classes are mandatory for elementary school students from grades 5 to 8. All elementary school classrooms are equipped with smart boards. The Ministry of National Education offers complimentary access to the Educational Information Network (EIN) for both students and educators. EIN offers various information sources, such as text, images, audio, and video. Teachers may also supply video, audio or visual materials.

A total of 12 in-service science teachers (nine females, three males) from the Doğubayazıt district of Ağrı province of Türkiye participated in the study. Their ages ranged from 26 to 40, with teaching experience between 1 and 15 years. Participants were selected using maximum variation sampling to capture diverse perspectives across different backgrounds and levels of experience (Yıldırım & Şimşek, 2018).

Data Collection Tools and Procedure

This study used a Semi-Structured Interview Form developed by the researchers after reviewing national and international literature on the topic. The form examined science teachers' sources of information, definitions, comparisons with human intelligence, and their personal experiences with AI technologies. Additionally, it explored teachers' perspectives regarding the applications, benefits, drawbacks, and possible impacts of AI in the domain of education. The finalized Semi-Structured Interview Form comprised nine questions. Sample items included, "What comes to your mind when you hear the term AI? Could you explain?", "What are the similarities and differences between AI and human intelligence?", and "What are the benefits of the widespread use of AI?"

The data collection procedure started with providing teachers with initial information regarding the purpose, scope, and ethical considerations of the study. Data was gathered through face-to-face interviews conducted at the school

after class hours with science teachers who consented to participate in the study voluntarily. The duration of each interview ranged from approximately 24 to 46 minutes. Science teachers participating in the study were coded as T1, T2, T3, ... T12.

Data Analysis

The interviews were audio-recorded during implementation, and the data were subsequently transcribed. The content analysis method that entails the identification and organization of trends and outcomes within a particular topic was utilized (Yıldırım & Şimşek, 2018). It comprises four stages: (1) data coding, (2) theme identification, (3) organization of codes and themes, and (4) description and interpretation of findings. The findings were reported by presenting the frequency of each code under eight themes: sources of information, definitions, comparison with human intelligence, AI technologies, areas of use, advantages, disadvantages, and use of AI in science classrooms.

Results

The interviews with 12 in-service science teachers yielded numerous major findings spanning eight themes: sources of information, definitions, comparison with human intelligence, AI technologies, areas of use, advantages, disadvantages, and use in education. Each theme represented a distinct aspect of teachers' perceptions and experiences with AI.

The theme of *sources of information* offered light on where and how participants first encountered the concept of AI. Table 1 presents codes, participants, and frequencies for the first theme, sources of information.

Table 1. Science teachers' sources of information regarding AI.

Codes	Participants	Frequency
Digital media	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12	12
Article	T3, T6, T9	3
Movie-video	T3, T8, T12	3
Traditional print media	T2, T11	2
Colleague	T4, T10	2

According to Table 1, teachers primarily became familiar with the concept of AI through digital media. A limited number of participants also referenced scientific articles, movies/videos, traditional print media, and their colleagues.

The theme of *definitions* illustrated how science teachers conceptualized and described AI. Table 2 presents codes, participants, and frequencies for the second theme, definitions.

Table 2. Science teachers' definitions of AI.

Codes	Participants	Frequency
A system based on codes	T1, T3, T4, T5, T6, T7, T10, T11, T12	9
Robots doing jobs that humans can do	T3, T6, T11	3
A system that imitates human intelligence	T5, T7, T8	3
A system based on human intelligence	T9, T12	2
Virtual events	T1	1
A complex structure that the human brain cannot comprehend	T2	1
Application of human intelligence on technological devices	T4	1

According to Table 2, AI was commonly defined as a system that imitates human intelligence and is built upon coding procedures. However, teachers emphasized that AI lacks the emotional dimension of human cognition.

The theme of *comparison with human intelligence* highlighted teachers' perspectives on the similarities and differences between AI and human cognitive abilities, particularly in relation to emotional intelligence. Table 3 presents codes, participants, and frequencies for the third theme, comparison with human intelligence.

Table 3. Science teachers' views on the comparison between AI and human intelligence.

Codes	Participants	Frequency
Inability to react emotionally	T1, T2, T3, T4, T6, T7, T8, T9, T10, T11, T12	11
Inferior, limited, and simpler than human intelligence	T1, T2, T4, T5, T7, T8, T10, T11, T12	9
Thinking/acting like a human being	T1, T3, T4, T5 T6, T10, T11, T12	8
Human superiority/ inability to replace humans	T2, T4, T5, T7, T9, T10, T12	7
Stronger info processing & learning capacity	T3, T4, T7, T8, T10, T11, T12	7
Being a human product/ dependence on humans	T3, T9, T10, T12	4

According to Table 3, most teachers believed that AI could think and act like humans to a certain extent, yet it cannot surpass human intelligence, particularly in emotional and social aspects.

The theme of *AI technologies* demonstrated the practical tools teachers employed. Table 4 presents codes, participants, and frequencies for the fourth theme, AI technologies.

Table 4. AI technologies reported by science teachers.

Codes	Participants	Frequency
Smartphones	T1, T3, T5, T11, T12	5
Smart Boards	T2, T3, T7, T12	4
Robot Vacuum Cleaners	T3, T7, T12	3
Internet Banking	T5, T11	2
Navigation	T4	1
Automatic Parking Sensor	T4	1
Health Monitoring App	T5	1
ChatGPT	T8	1
DALL-E	T8	1
Autonomous Car	T8	1
Hologram Apps	T9	1

According to Table 4, the most frequently mentioned tools were smart boards and mobile applications, followed by experiment simulations, virtual reality, and assessment technologies.

The theme *areas of use* described the fields in which they believed AI can be effectively applied. Table 5 presents codes, participants, and frequencies for the fifth theme, areas of use.

Table 5. Areas of AI use identified by science teachers.

Codes	Participants	Frequency
Education	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12	12
Medicine / Health	T3, T4, T5, T7, T9, T12	6
Industry	T4, T5, T7, T9, T10	5
Information Technologies	T2, T8, T10, T12	4
Military / Defence Industry	T3, T8, T9, T11	4
Space Technologies	T4, T8, T10, T12	4
Robotic Coding	T1, T10	2
Social Media	T3, T12	2
e-Commerce	T5, T11	2
Virtual Assistant	T5, T10	2
Home Appliances	T8, T11	2
Agriculture	T3	1
Wearable Technologies	T6	1
Photography	T6	1
Academic Research	T6	1
Information Storage	T7	1
Architecture	T9	1

According to Table 5, teachers stated that AI can be applied in education, health, defence, industry, and agriculture, with special emphasis on its role in science classrooms through simulations, visualization of abstract concepts, and assessment.

The themes of *advantages* captured the perceived opportunities of AI. Table 6 presents codes, participants, and frequencies for the sixth theme, advantages.

Table 6. Advantages of AI reported by science teachers.

Codes	Participants	Frequency
Creating new job opportunities	T1, T2, T4, T5, T6, T7, T8, T9, T10, T11, T12	11
Providing ease of work	T1, T3, T6, T7, T8, T10, T11, T12	8
Increasing work efficiency/productivity	T2, T4, T5, T6, T9, T10, T11, T12	8
Supporting the national economy	T1, T2, T3, T5, T6, T7, T9	7
Saving time	T4, T5, T9, T11, T12	5
Advancing science and technology	T2, T4, T10, T11	4
Facilitating data storage and access	T5, T7, T9, T12	4
Contributing to national development	T9, T11, T12	3
Simplifying data analysis	T8, T12	2
Operating in risky jobs	T10, T12	2
Facilitating lives of disabled people	T1	1

According to Table 6, teachers highlighted that AI facilitated learning and saved time, enhanced student motivation and interest, provided equal opportunities in education, improved efficiency, productivity, and scientific advancement.

The themes of *disadvantages* captured the perceived challenges of AI. Table 7 presents codes, participants, and frequencies for the seventh theme, disadvantages.

Table 7. Disadvantages of AI reported by science teachers.

Codes	Participants	Frequency
Narrowing job fields / increasing unemployment	T1, T2, T3, T4, T5, T6, T7, T8, T10, T11, T12	11
Encouraging laziness among people	T1, T9, T10, T11, T12	5
Reducing the need for human labour	T1, T4, T12	3
Decreasing social interactions	T1, T2, T10	3
Allowing unauthorized data usage	T5, T6, T9	3
Being misused for military purposes	T2, T11	2
Posing threats to humans	T3, T10	2
Causing professional incompetence	T4, T8	2
Enabling unethical applications	T6, T7	2
Negatively affecting family economy	T9, T12	2
Creating a non-thinking society	T10, T12	2

According to Table 7, teachers reported concerns included job displacement and reduced need for human labour, decreased social interaction and risk of screen dependency, threats to personal data security and potential unethical uses.

Finally, the theme of *use of AI in science classroom* captured areas in which science teachers used AI tools in science classroom (Table 8) and benefits of AI use in science classrooms (Table 9).

Table 8. Use of AI in science classrooms reported by science teachers.

Codes	Participants	Frequency
Conducting experiments	T2, T3, T4, T7, T11, T12	6
Concretizing abstract concepts	T3, T4, T6, T7, T9	5
Assessment and evaluation	T4, T5, T6, T10, T12	5
Dangerous experiments	T1, T6, T8, T10	4
Holograms	T3, T8, T9	3
Teaching process	T5, T10, T12	3
Material development	T2, T5	2
Distance education	T5, T11	2
Paperwork	T7	1
Virtual Reality	T9	1

Nine of the 12 science teachers surveyed said they had benefited from AI tools, while three did not. All participants agreed that AI had the potential to transform educational processes, and that curriculum updates were necessary to ensure effective AI implementation. All teachers viewed AI as an advantageous supportive tool, though 2 mentioned possible threats. According to Table 8, science teachers indicated that AI technologies have a wide range of applications in science classrooms, particularly in experiment simulations, concretizing abstract concepts, and assessment processes.

Table 9. Benefits of AI use in science classrooms reported by science teachers.

Codes	Participants	Frequency
Making lessons interesting/entertaining	T1, T2, T3, T4, T5, T7, T8, T9	8
Saving time	T1, T3, T4, T9	4
Ensuring permanent learning	T5, T7, T8, T12	4
Providing equality of opportunity	T2, T5, T11	3
Increasing attention	T5, T10, T12	3
Activating the students	T1, T10	2
Appealing to different types of intelligence	T3, T11	2
Facilitating teachers' work	T3, T10	2
Providing quick feedback	T3, T11	2
Providing learning material	T4, T6	2
Weakening teacher–student interaction	T2	1
Tracking attention span	T3	1
Enabling more examples	T4	1
Causing screen addiction	T5	1

Table 9 reveals that most scientific teachers saw AI as advantageous for making lessons more engaging, saving time, and promoting long-term learning, however a minority cited downsides such as screen addiction and less teacher-student interaction.

Conclusions

The findings of this study indicate that science teachers' understanding of AI primarily develop through their engagement with digital media, underlining the influential role of online platforms in shaping educators' awareness of emerging technologies (Baker et al., 2019; Celik, 2023; Holmes et al., 2019). Teachers acknowledge that AI is rooted in coding procedures and imitates human intelligence, yet they emphasize that the emotional dimension of human intelligence remains beyond the scope of AI. This perspective aligns with the broader literature, which recognizes emotional intelligence as a unique and irreplaceable aspect of human thought (Nabiyev, 2012; Turing, 1950).

Participants also express doubts regarding the capacity of AI to surpass human intelligence, particularly in areas requiring information processing and learning capacity. Similar to prior research, teachers view AI as powerful in computational tasks but insufficient in replicating complex human emotions (Luckin et al., 2016; Zhai et al., 2020). Concerns are further raised about the possible negative outcomes of AI integration, including job displacement, reduced social interaction, and risks to data security. These concerns mirror ethical and practical challenges identified in previous studies (Celik et al., 2022; Zawacki-Richter et al., 2019), emphasizing the need for responsible policies and design principles to ensure AI supports rather than disrupts education (Chen et al., 2022).

At the same time, the results reveal that teachers view AI as broadly applicable across sectors and as a complementary, not threatening, tool in education. In line with Luckin et al. (2016) and Montebello (2018), teachers envision AI as an assistant to instruction rather than a replacement, a perception that contrasts with widespread societal fears about AI-driven job loss (Celik, 2023). Teachers further highlight AI's potential to facilitate learning, increase motivation, and foster equity of opportunity (Kim & Kim, 2022; Topal et al., 2021). However, these perceived benefits are not guaranteed, as prior research also points to risks related to technological dependence, unequal access, and ethical concerns (Holmes et al., 2019; Luckin et al., 2022).

Finally, findings suggest that while teachers show motivation to integrate AI into their classrooms, they require support to effectively align these technologies with subject-specific pedagogy. This echoes the conclusions of earlier studies, which stress the importance of professional development to strengthen teachers' AI-related pedagogical knowledge (Celik, 2023; Keuning & van Geel, 2021; Zawacki-Richter et al., 2019). Future research should therefore design and evaluate training programs that empower teachers to responsibly and effectively use AI in science education.

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Artificial Intelligence in Education: interdisciplinary approaches to understanding energy efficiency at middle school level

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Abstract

This paper proposes a didactic project model designed for lower secondary students (8th grade) that harnesses the potential of AI in combination with content from physics, computer science, and civic/ethical education. The aim of the paper is to present an integrated project model involving Physics, Computer Science, and Civic/Ethical Education. The research hypothesis is that implementing interconnected instructional strategies — such as hands-on experiments, AI-based digital simulations, and ethics-focused debates — leads to a significant development of transdisciplinary competencies among middle school students, by stimulating critical thinking, collaboration, and the integration of knowledge from various domains. The research objectives are as follows: (1) to analyze how AI applications can be integrated into educational activities to support the understanding of energy efficiency concepts at the middle school level; (2) to investigate the impact of ethical reflection in the use of AI technologies, with an emphasis on developing responsibility and ecological awareness among students; (3) to explore the potential of interdisciplinary approaches in promoting systems thinking and integrated understanding of the relationship between science, technology, and society; (4) to evaluate the effectiveness of interconnected teaching strategies (experiments, digital simulations, ethical debates) in developing transdisciplinary competencies. The results confirm the value of integrating AI into educational projects and highlight the relevance of interdisciplinary strategies in preparing students for the challenges of contemporary society.

Keywords: Artificial Intelligence, education, Physics, interconnected instructional strategies, students, interdisciplinarity, transdisciplinary competencies.

Introduction

The profound transformations of the digital age demand a rethinking of education, oriented toward developing competencies relevant to the knowledge society. Artificial Intelligence (AI) is rapidly expanding in the field of education, becoming an increasingly profitable global market thanks to its ability to profoundly transform how students learn, interact, and are assessed. (Bostan, T.C., 2023) AI is increasingly present in educational environments—not merely as a tool for automation, but as a learning medium that fosters critical thinking, collaboration, and interdisciplinary understanding (Luckin et al., 2016). Integrating AI into school curricula is seen as an opportunity to connect fields such as science, computer science, and civic education, offering students a systemic perspective on the relationship between technology and society (Holmes et al., 2022).

International literature highlights that AI can support education in two major directions: optimizing teaching processes and personalizing learning, as well as redefining content in relation to new digital and ethical competencies (OECD, 2018). Recent studies emphasize AI's potential to facilitate interdisciplinary learning, especially in STEAM fields, through interactive simulations, data analysis, and ethical scenarios that stimulate reflection and social responsibility (Williams et al., 2023; Park et al., 2023).

At the same time, research warns of the risks associated with uncritical use of AI in education, such as deepening digital inequalities, superficial learning, or perpetuating algorithmic biases. Therefore, integrating AI into the curriculum must be accompanied by an ethical and reflective approach that cultivates ecological awareness, civic responsibility, and moral discernment (Ciochină & Zeru, 2024).

In lower secondary education, especially, teaching projects that combine scientific experiments, digital simulations, and ethical debates can foster deep and contextualized learning. AI should not be treated as a separate discipline, but rather as a transversal element integrated into science, computer science, and civic education lessons (MIT Media Lab, 2023). Students are encouraged to become not only users but also conscious designers of AI-based systems.

Within this conceptual framework, the present paper proposes an integrated teaching model for eighth-grade students that leverages AI in combination with content from physics, computer science, and civic/ethical education. By combining hands-on experiments, digital simulations, and ethical reflection, the aim is to develop transdisciplinary competencies essential for shaping active, responsible citizens prepared for the challenges of a technologized and interconnected society.

Through innovative applications, students can analyze building energy consumption, simulate savings scenarios, and understand the impact of ecological decisions using graphs, 3D models, and augmented reality. A growing number of companies are developing AI-powered solutions that enable these experiences, helping shape a generation that is more environmentally aware and better equipped to address sustainability challenges.

In today's landscape of accelerated digitalization and the shift toward competence-based education, integrating artificial intelligence into interdisciplinary learning approaches is becoming increasingly relevant and necessary.

Methodology

This research aims to develop and test an interdisciplinary didactic design model, intended for middle school students (grade 8) (Bostan, C.G.&All, 2025), that integrates artificial intelligence (AI) applications in educational activities in the fields of physics, computer science and civic/ethical education. The methodology adopted is of a qualitative-applicative type, with exploratory elements, focused on analyzing the learning process and evaluating the impact of interconnected didactic strategies on the development of transdisciplinary skills.

The aim of the paper is to present an integrated project model involving Physics, Computer Science, and Civic/Ethical Education. The research hypothesis is that implementing interconnected instructional strategies — such as hands-on experiments, AI-based digital simulations, and ethics-focused debates — leads to a significant development of transdisciplinary competencies among middle school students, by stimulating critical thinking, collaboration, and the integration of knowledge from various domains.

The research objectives are as follows:

(1) to analyze how AI applications can be integrated into educational activities to support the understanding of energy efficiency concepts at the middle school level;

(2) to investigate the impact of ethical reflection in the use of AI technologies, with an emphasis on developing responsibility and ecological awareness among students;

(3) to explore the potential of interdisciplinary approaches in promoting systems thinking and integrated understanding of the relationship between science, technology, and society;

(4) to evaluate the effectiveness of interconnected teaching strategies (experiments, digital simulations, ethical debates) in developing transdisciplinary competencies.

The guiding research questions are: (1) how can AI applications be leveraged for educational purposes, especially to facilitate the understanding of energy efficiency? (2) what role can ethics play in raising awareness of the sustainable use of advanced technologies? (3) how does interdisciplinary learning support the development of systems thinking at the middle school level? (4) to what extent do interconnect instructional strategies (practical experiments, AI simulations, ethical debates) contribute to the development of transdisciplinary competencies among middle school students?

Research design. The research is based on an educational case study, conducted within a pilot teaching project. The proposed model includes active learning activities, based on: practical experiments (physics – energy efficiency); digital simulations with AI (computer science – energy consumption modeling); ethical debate (civic education – responsibility and sustainability).

These components are integrated into a coherent teaching scenario, carried out over 1– 2 lessons.

Interdisciplinary lesson plan for the project "Future Energy - between science, technology and responsibility", with a focus on physics and the integration of artificial intelligence

The lesson aims to model energy consumption with the help of artificial intelligence, through an interdisciplinary project of Physics, Computer Science, Civic Education, addressed to 15-year-old students.

General skills aimed to be developed in students are: applying the laws of physics in real contexts (physics); using digital technologies for modeling and simulation (computer science, AI); developing critical thinking and civic responsibility (civic education)

Operational objectives. At the end of the lesson, students will be able to: explain the concepts of energy, efficiency and renewable sources; use a simple AI application to simulate the energy consumption of a home; analyze the impact of energy choices on the environment; formulate sustainable solutions for a "green city".

Resources needed: laptops/tablets with internet access; simulation applications; worksheets, flipchart, markers

Table 1 Lesson progress

Stage	**Teacher activity**	**Student activity**	**Methods**
1. Attention grabbing (10 min)	Present a short video about smart cities and AI	Discuss ideas and impressions	conversation, brainstorming
2. Exploration (20 min)	Explain key concepts: energy, efficiency, AI	Complete a worksheet with real-life examples	explanation, exemplification
3. Practical activity (30 min)	Guide students in using an AI application to simulate energy consumption	Work in teams, test scenarios (e.g. LED vs. incandescent bulbs)	learning by discovery
4. Interdisciplinary reflection (20 min)	Moderate a debate: "Is AI a sustainable solution?" Argue from different perspectives (physics, civics) debate, critical thinking	Argue from different perspectives (physics, civics) debate, critical thinking	debate, critical thinking
5. Conclusions and evaluation (10 min)	Review and feedback	Complete a mini-reflection journal	self-evaluation, discussion

AI component. For the theme "Future Energy – Between Science, Technology and Responsibility", an effective AI simulation should be: interactive, related to energy efficiency, have an ethical component and allow students to visualize, analyze and reflect on the impact of technology on the environment and society.

Recommended AI simulations: Simulation of a "Smart Home" with AI for energy efficiency. Students use an application or platform that simulates a smart home. With the help of AI, they can: analyze the energy consumption of different appliances (refrigerator, light bulbs, air conditioning, etc.); set scenarios (day/night, family at home/away); automatically optimize the operation of appliances to reduce consumption; receive recommendations generated by AI for energy saving.

To simulate the energy consumption of a room using artificial intelligence, students have access to several useful and accessible applications:

- *Smart Home Simulator by Energy3D* – 3D simulation of energy efficiency in buildings (Xie, C. & all, 2018);

- *PPC myEnergy Coach* - is a digital tool integrated into the PPC myEnergy Coach application, which allows you to estimate the energy consumption of your home based on a personalized questionnaire. You can enter data about the area of the room; the types of appliances used and get recommendations for optimization.

- The consumption calculator – Electrica Furnizare (*Electricity calculator* - EDS Electricity & Natural Gas Supplier) is a useful online tool for estimating monthly electricity costs, depending on your own consumption and the tariffs applicable in the residential area of interest.

Ethical component. After the simulation, students can discuss who should decide which appliances are prioritized; whether it is moral for AI to reduce consumption without the user's consent; what happens if AI favors comfort at the expense of the environment.

Results and Conclusions

The results obtained from the implementation of the didactic project confirm the value of integrating artificial intelligence (AI) into educational activities, highlighting its potential to facilitate interdisciplinary learning and to stimulate the development of transdisciplinary competencies among middle school students. The use of AI-based digital simulations, combined with practical experiments and ethical debates, led to a deeper understanding of energy efficiency concepts, as well as a visible increase in student engagement in the learning process.

Students demonstrated an enhanced ability to connect knowledge from physics, computer science, and civic education, developing systemic and reflective thinking in relation to the challenges of contemporary society. Ethical reflection on the use of intelligent technologies contributed to the formation of ecological awareness and a responsible attitude toward energy resources and technological impact.

Furthermore, the research emphasized the importance of collaboration between disciplines and among educators, as well as the need for continuous professional development in the field of AI and digital pedagogy. The proposed model can be adapted and extended to other educational contexts, offering a flexible framework for addressing complex themes through active methods connected to current technological realities.

In conclusion, integrating AI into interdisciplinary educational projects not only enhances the quality of learning but also contributes to shaping conscious, critical citizens who are prepared to respond responsibly to the challenges of the future.

Recommendations and Practical Implications

The research results highlight several concrete directions that can be leveraged in educational practice, particularly in the context of integrating artificial intelligence (AI) into interdisciplinary teaching projects:

Promoting transdisciplinary approaches in the curriculum. Integrating AI into lessons that combine physics, computer science, and civic education allows students to understand scientific concepts in a contextualized framework with social relevance. It is recommended to include flexible modules that enable collaboration between teachers from different disciplines.

Using AI simulations as active learning tools. AI-based digital simulations, such as those modeling energy consumption in a household, can be used to stimulate critical thinking and informed decision-making. It is advisable to select intuitive, accessible applications adapted to students' age level.

Introducing ethical reflection into technological activities. Moral debate regarding the use of AI contributes to the development of civic and ecological consciousness. Teachers should incorporate ethical questions into STEM projects to encourage students to analyze the social implications of technology.

Continuous professional development for educators. For AI to be effectively integrated into the educational process, it is essential to develop teachers' digital and pedagogical competencies. Organizing interdisciplinary workshops and exchanges of best practices among educators is recommended.

Encouraging student collaboration in real-world projects. Project-based activities carried out in teams help develop communication skills, responsibility, and systemic thinking. Students should be involved in solving real problems with community impact.

These recommendations can support educators, educational authorities, and digital resource developers in designing relevant, interactive, and responsible learning experiences adapted to the challenges of contemporary society.

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Integrating Browser-Based Metaverse Platforms in Middle School Physics: A Case Study on the Magnetic Effect of Electric Current

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Abstract

This paper explores a new pedagogical strategy for teaching the topic "The Magnetic Effect of Electric Current" to 8th grade students using a browser-based Metaverse platform. Designed for laptops and tablets, the approach eliminates the need for VR headsets, making immersive learning accessible to schools with limited technological resources. The study investigates how digital environments can enhance conceptual understanding in physics, particularly for abstract phenomena like magnetic fields. The intervention involved creating a virtual educational space, tailored to middle school learners. Activities alternated between physical and virtual formats to foster collaboration and critical thinking, supported by formative assessments through worksheets and real-time feedback. Key advantages include intuitive visualization of invisible concepts, increased student motivation through engaging digital environments, and broad accessibility via browser-based access. Limitations noted were occasional technical issues, the need for teacher training, and the absence of tactile feedback. The findings suggest that simplified Metaverse integration—without VR—can effectively support active learning and skill development. While not a full substitute for physical experiments, it serves as a valuable complement in digitally connected but resource-constrained educational settings.

Keywords: Metaverse, education, virtual environment, digital resources, teaching, creativity.

Introduction

In the light of recent years, the development of educational content has overcome the barriers of paper and print, being increasingly present in the virtual environment, thanks to the Internet and new technologies. Many education providers have made strides towards the digital environment and are implementing a range of distance teaching, learning and assessment approaches. Artificial intelligence should not be seen merely as a technological tool but as a catalyst for pedagogical transformation, enabling personalized learning experiences and fostering critical thinking, which aligns closely with the evolving needs of digital-native students. (Bostan T.C., 2023) This idea advocates integrating emerging technologies (such as AI and the Metaverse) not just for efficiency, but to reshape how students interact with content, teachers, and each other. Adaptive, interactive, and student-centered learning environments can be created, even in resource-constrained educational contexts.

The digital transformation of education has created significant opportunities for integrating emerging technologies into the teaching process, especially in STEM subjects. In this context, the use of immersive environments such as Metaverse platforms is increasingly relevant for facilitating the understanding of abstract physics phenomena—like magnetic fields—that cannot be directly observed in physical reality (Dede, 2009).

Research literature highlights that 3D simulations and digital collaboration in virtual environments can significantly contribute to the development of exploratory thinking and increase students' intrinsic motivation (Merchant et al., 2014). At the same time, challenges related to technological infrastructure in schools require flexible solutions that do not depend on advanced equipment such as VR headsets or high-performance digital labs (OECD, 2021). In this regard, browser-based Metaverse platforms like *Spatial* and *FrameVR* offer a viable alternative for institutions with limited resources but basic digital connectivity.

This study proposes an innovative pedagogical approach for teaching the topic "The Magnetic Effect of Electric Current" to 8th grade students, by designing a thematic educational virtual space adapted to the middle school level. Students were engaged in interactive exploration of the magnetic field through manipulation of 3D objects (coils, compasses, conductive wires), application of the right-hand rule, and investigation of how electric current variation affects the generated field. This approach aligns with recommendations for using virtual environments to promote active and collaborative learning (Mikropoulos & Natsis, 2011; Chittaro & Ranon, 2007).

The main objective of the research is to analyze the pedagogical impact of a simplified Metaverse space on students' understanding of electromagnetic concepts and their cognitive and emotional engagement in physics lessons. The paper contributes to the educational literature by highlighting the advantages and limitations of an immersive teaching approach without VR requirements, and offers practical directions for responsibly integrating such technologies into middle school physics education.

Theoretical Framework

The integration of immersive digital environments into the teaching process is grounded in solid foundations from constructivist learning theory, which posits that knowledge is actively built through interaction with the environment and reflection on personal experiences (Piaget, 1972; Vygotsky, 1978). Collaborative interactions in immersive environments mirror Vygotsky's emphasis on social learning, where knowledge is co-constructed through dialogue and shared exploration. In this context, 3D simulations and virtual spaces offer authentic opportunities for experiential learning, allowing students to explore, test, and visualize abstract concepts in a personalized and interactive manner. As Bostan (2023) emphasizes, the synergy between artificial intelligence and immersive platforms like the Metaverse enhances the adaptability of instruction and supports learner autonomy—key principles in constructivist education.

Recent studies emphasize the effectiveness of immersive environments in facilitating conceptual understanding, particularly in science education, where many phenomena—such as magnetic fields—cannot be directly observed (Dede, 2009; Mikropoulos, Natsis, 2011). These environments support the construction of mental representations through manipulation of virtual objects and provide a conducive framework for collaborative learning, enhancing affective engagement and the development of transversal skills (e.g., collaboration, digital literacy, problem-solving). (Merchant et al, 2014).

Moreover, Web3D and Metaverse-based approaches align with strategic directions promoted by international organizations, which advocate for the use of emerging technologies to personalize learning and increase digital inclusion (OECD, 2021). Browser-based platforms such as *Spatial* respond to these requirements by removing technological barriers and offering a flexible, scalable, and adaptable environment for diverse educational contexts.

Thus, the theoretical foundation of this study is supported by the convergence of active learning theories, empirical research on the effectiveness of immersive environments, and educational policies oriented toward digital transformation—justifying the choice of a Metaverse-based instructional intervention for teaching electromagnetic concepts at the middle school level.

Methodology

This paper presents a pedagogical approach to teaching the topic "The Magnetic Effect of Electric Current" to 8th grade students (50 students, 2 class), through the implementation of a browser-based Metaverse platform like Spacial.io. The instructional design is optimized for use on laptops and tablets, eliminating the need for VR headsets or advanced equipment, and allowing increased accessibility for schools with limited technological infrastructure.

The purpose of this study is to explore the pedagogical impact of immersive digital environments in promoting conceptual understanding in physics - especially regarding invisible phenomena, such as magnetic fields. Objectives of the work - highlighting how 3D simulations and digital collaboration in immersive environments can improve the understanding of electromagnetic concepts and motivate students to engage cognitively and affectively in physics lessons, even in educational contexts with moderate technological facilities.

The specific objectives of the didactic intervention included: designing a thematic educational virtual space in Metaverse (*Spatial*), adapted to the middle school level; interactive exploration of the magnetic field by manipulating 3D objects (coils, compasses, conductive wires); applying the right-hand rule and investigating the effects of electric current variation on the generated field; stimulating critical reflection and collaboration between students, through rotations between physical and virtual activities; formative assessment through worksheets, observations and real-time feedback.

Spatial.io as a Browser-Based Metaverse Platform for Physics Education

In the context of digital transformations in education, Metaverse platforms offer innovative opportunities for teaching abstract concepts, especially in subjects such as physics, chemistry, or biology. These environments allow students to interact with virtual objects, collaborate in real time, and explore invisible phenomena in an intuitive and engaging way (Dede, 2009; Lee et al., 2021).

Spatial.io is a 3D collaboration platform that works directly in the browser on desktop, tablet, or mobile phone, without requiring advanced VR equipment. Its user-friendly interface enables users to create customized virtual spaces, integrate various files including media (images, videos, 3D models), and interact via voice or text chat.

For teachers, Spatial.io offers the possibility to build interactive lessons, thematic exhibitions, or educational galleries tailored to students' learning levels. Spaces can be organized into thematic zones, facilitating gradual exploration of content.

Relevant features for teaching include:

- **Multi-platform accessibility:** Works on common devices, removing technological barriers.
- **3D object manipulation:** Students can interact with coils, wires, compasses, simulating magnetic fields.
- **Real-time collaboration:** Students can work in teams, communicate, and reflect together.
- **Integration of external resources:** Links to PhET simulations, educational videos, worksheets, and various documents.

Best Practice Example: Magnetic Field Lesson. In the lesson "The Magnetic Effect of Electric Current," Spatial.io was used to create a virtual space called *Magnetic Fields Lab*. Students explored three thematic zones: *Experimentation Zone*: manipulating coils and observing field direction; *Application Zone*: using the right-hand rule on 3D models; *Reflection Zone*: posting conclusions and questions on a virtual board. This approach enabled students to better understand the invisible phenomenon of magnetic fields, collaborate actively, and express their thinking in a safe and engaging digital environment.

Pedagogical Impact. Studies show that using immersive environments in teaching: increases student motivation and engagement (Makransky & Lilleholt, 2018); promotes deep conceptual learning (Lindgren et al., 2016); stimulates critical thinking and collaboration (Wu et al., 2020).

In the case of Spatial.io, the major advantage is accessibility—the platform can be used in schools with modest infrastructure without compromising the quality of the educational experience. In conclusion, Spatial.io proves to be an effective tool for integrating immersive education into the school curriculum. Through its technological flexibility and pedagogical potential, the platform can transform traditional lessons into memorable learning experiences tailored to the needs of the digital generation.

In conclusion, Spatial.io proves to be a pedagogically effective and technologically accessible tool for integrating immersive education into the school curriculum. By enabling real-time collaboration, interactive 3D exploration, and seamless integration of external resources, the platform supports the development of conceptual understanding and 21st-century skills. Its browser-based flexibility makes it particularly suitable for schools with limited infrastructure, offering a scalable solution for digital transformation in STEM education.

Creating a Space in Spatial.io. Go to the website www.spatial.io and create a free account. Click on "Create a Space" and choose a suitable template, such as "Classroom," "Gallery," or "Open Space." Name the space Magnetic Fields Lab, then set the access level to either "Unlisted" (for sharing via link) or "Public" (for open access).

To populate the space with various elements, use the "+" icon from the top-right menu in Figure 1.

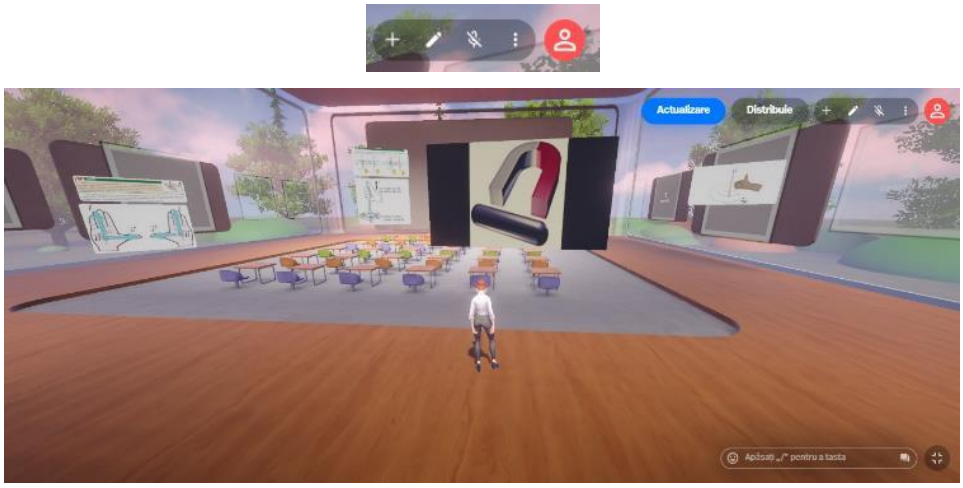

Figure 1 „The Magnetic Effect of Electric Current" lesson on Spatial.io

A window is opened (Figure 2) in which various items can be selected and imported, including 3D models from Sketchfab, templates, files from the local device, notes, or web-based resources.

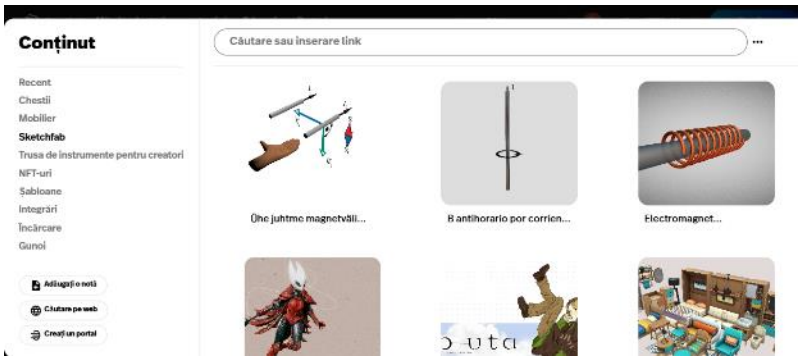

Figure 2

Lesson Plan – The Magnetic Effect of Electric Current

Grade Level: 8th Grade *Subject*: Physics

Topic: The Magnetic Effect of Electric Current.

Duration: 50 minutes

Lesson Type: Consolidation and Application.

Learning Environment: Virtual (Spatial.io) + Physical Classroom Activities

Learning Objectives. By the end of the lesson, students will be able to: identify the magnetic field generated by an electric current; apply the right-hand rule to determine the direction of the magnetic field; explore how varying the current intensity affects the magnetic field; collaborate and reflect critically in a digital immersive environment.

Required Resources: laptops or tablets with internet access; free accounts on Spatial.io; customized virtual space in Spatial.io; digital worksheets (Google Forms or editable pdfs); real-world materials: compasses, wires, batteries; timer and audio signal for activity transitions.

Table 1 Lesson Structure

Phase	Duration	Activity	Method
Introduction	5 min	Present objectives and access virtual space	Whole class
Virtual Exploration	15 min	Manipulate 3D objects, apply right-hand rule	Group work
Physical Activity	15 min	Recreate experiments with real materials	Group work
Reflection	10 min	Post conclusions in virtual space, discuss	Whole class
Formative Assessment	5 min	Complete digital quiz, receive feedback	Individual

Assessment methods: completion of digital worksheets during exploration; teacher observations in the virtual space; student reflections (written or oral); final mini-quiz with conceptual questions.

Results

The implementation of the immersive instructional approach using Spatial.io yielded encouraging results in terms of student engagement, conceptual understanding, and collaborative behavior. The lesson "The Magnetic Effect of Electric Current" was delivered to two 8th grade classes (n = 50), combining virtual exploration with physical experimentation and structured reflection.

Student Engagement and Interaction. Observations during the virtual session revealed a high level of student engagement. Most students navigated the virtual space with ease, showing curiosity and enthusiasm in manipulating 3D objects such as coils, compasses, and wires. The use of avatars and real-time voice chat facilitated spontaneous collaboration, with students discussing field directions and helping each other apply the right-hand rule.

In the Reflection Zone, students posted over 40 individual contributions, including questions, hypotheses, and conclusions. Examples of student reflections included: *"I didn't know the compass needle could change direction depending on the wire's position."; "The right-hand rule makes more sense when I can rotate the coil and see the field."*

Conceptual Understanding. Formative assessment through digital worksheets and a final mini-quiz indicated a notable improvement in students' grasp of electromagnetic concepts. Out of 50 students: **86%** correctly identified the direction of the magnetic field in at least two scenarios; **78%** successfully applied the right-hand rule in virtual and physical contexts; **92%** demonstrated understanding of the relationship between current intensity and field strength. These results suggest that the immersive environment supported the construction of mental models and facilitated the transfer of knowledge between virtual and real-world contexts.

Collaborative and Reflective Skills. Students worked in small groups during both virtual and physical phases of the lesson. Teacher observations noted increased peer-to-peer interaction, with students asking clarifying questions, debating interpretations, and jointly completing tasks. The structured rotation between virtual and physical activities encouraged reflection and comparison, reinforcing the learning process. In post-lesson feedback, students reported: feeling more confident in explaining the phenomenon; enjoying the freedom to explore and test ideas; appreciating the mix between digital and hands-on activities.

Technical and Logistical Observations. While most students accessed the virtual space without difficulty, a few encountered technical issues such as: delays due to older devices; some students did not have microphones, which limited voice-based collaboration. These challenges were mitigated through group support and chat-based interaction.

Conclusions

The integration of immersive environments into science teaching is supported by numerous studies that highlight the potential of these technologies in facilitating conceptual learning, especially in the case of invisible or difficult-to-intuitive phenomena (Dede, 2009; Mikropoulos & Natsis, 2011). Interactive simulations allow students to actively build mental representations of physical processes, and collaboration in virtual spaces stimulates affective involvement and the development of transversal skills (Merchant et al., 2014). In addition, Web3D and Metaverse-based approaches align with the strategic directions of digital education promoted by international bodies (OECD, 2021).

The advantages of the proposed approach include: – increased accessibility, with the platform operating directly in the browser and allowing the inclusion of all students, regardless of their personal VR device equipment; – intuitive visualization of the magnetic field, an abstract phenomenon that is difficult to faithfully reproduce in physical reality; – stimulating exploratory thinking and learning through discovery; – increasing motivation by integrating a familiar and captivating digital environment for the current generation.

Among the identified limitations are: – occasional technical difficulties (internet connection, older devices, lack of microphones for collaboration); – the need for initial training time for teachers in using the platform; – the lack of haptic or sensory feedback that would completely replace the real physical experiment.

The conclusions of the paper show that the responsible integration of a simplified Metaverse space, without VR requirements, offers students the opportunity to actively construct scientific concepts and practice transversal skills such as collaboration, reflection, and digital adaptation. Although it does not completely replace physical experimentation, this approach effectively complements it, especially in educational environments where material resources are limited but digital connectivity is present.

Suggestions for Future Research

To strengthen the findings of this study, future research is recommended in the following directions:

- Applying the methodology to other physics topics or STEM disciplines, in order to evaluate the transferability of the approach;
- Conducting longitudinal studies to analyze the long-term impact on students' motivation, academic performance, and development of digital competencies;
- Comparing the effectiveness of immersive environments versus traditional methods, across diverse educational contexts (urban/rural, with/without physical labs);
- Exploring the integration of additional sensory feedback, through emerging technologies such as haptics or augmented reality, to deepen the experimental experience.

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Gifted Students' Views on the Use of Artificial Intelligence in Mathematics Teaching

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Abstract

Recent developments in artificial intelligence have created new opportunities, especially for gifted students with high learning potential. However, how these students utilize artificial intelligence, the strategies they employ, and the impact of these technologies on their learning are not yet fully understood. This study aims to determine the views of gifted students on artificial intelligence and its use in mathematics teaching. This study, which uses the case study method from qualitative research approaches, involved 23 gifted students. The participants were selected using a convenience sampling method. Data were collected through a written opinion form consisting of questions related to topics such as artificial intelligence, intelligence tools/applications, mathematics, and their use in lessons. Before the interview, the interview questions were reviewed by two mathematics educators, one measurement and evaluation expert, and one Turkish language expert, and necessary corrections were made based on their feedback. All participants were asked the same questions, and they were required to write their responses. The data obtained from the research were evaluated using content analysis. Gifted students expressed that they viewed artificial intelligence as a source of information, did not trust it too much due to the possibility of errors, and used artificial intelligence for problem-solving and learning purposes in mathematics lessons. In addition, the study revealed that the gifted students were not familiar with artificial intelligence programs specifically designed for mathematics.

Keywords: gifted, artificial intelligence, mathematics, students, teaching, views

Introduction

Artificial intelligence (AI), which is used in many fields today, can be defined as the ability of a computer system or robot to imitate human-like cognitive functions such as learning and problem-solving and to perform tasks that require human intelligence (Bozkurt et al., 2021). The rapid developments in the field of artificial intelligence have led to the widespread use of AI-based applications in education, including teaching, projects, and managerial processes (Arslan, 2020; Zhang et al., 2025). The reasons for such prevalence include the capacity of AI to enable individualized learning, increase efficiency, provide enhanced student support, analyze student performance, and offer cost-effectiveness (Seyhan, 2024). On the other hand, there are certain concerns regarding the use of AI in educational settings. These include hindering students' creative thinking, fostering laziness, raising ethical issues, and potential inequalities in access to AI tools (Seyrek et al., 2024).

In fields such as mathematics, where analytical thinking skills are prioritized, AI-supported learning environments enable individualized and in-depth learning. Among the AI applications used in mathematics education are Khan Academy, Photomath, MathGPT, Wolfram Alpha, and ChatGPT. These applications can support students' learning according to their individual needs, provide data-based feedback to teachers, and make learning processes more interactive (Mohamed et al., 2022; Opesemowo & Ndlovu, 2024; Tapan Broutın, 2024). A recent review study claimed that research on the use of AI in mathematics education remained limited (Aladağ, 2024).

Although AI has become highly popular in the field of education, there is still a need for research on how and in what ways it can be used effectively, along with its advantages and disadvantages. Views concerning the use of AI have been gathered from university students (Benzer & Benzer, 2022) and from teachers in various branches (Küçükkara et al., 2024; Özer et al., 2023; Sontay et al., 2024). Developments in AI bring new opportunities, particularly for gifted students with high learning potential. However, how these students use AI, which strategies they adopt, and how these technologies affect their learning have not yet been sufficiently understood. In this context, the aim of this study was to identify the knowledge and views of gifted students regarding AI and its use in mathematics teaching. The main research question of the study was as follows: "What are the knowledge and views of gifted students concerning AI and its use in mathematics teaching?"

Methodology

This research, conducted to determine gifted students' knowledge and views regarding AI and its use in mathematics teaching, employed the case study method, one of the qualitative research approaches. A case study is a method applied to explain the purpose and evaluate conditions through in-depth analysis by observing events from the perspective of a social structure, group, institution, or organization (Yıldırım & Şimşek, 2021). This method is highly effective in understanding complex and multidimensional phenomena. Instead of aiming for theoretical generalizations, it seeks to examine and understand a particular situation within its real-life context. By focusing on specific research questions or hypotheses, it searches for answers. A case study is particularly useful when the boundaries between the phenomenon and the context are not clearly defined (Yin, 2017).

Participants

This study involved 23 gifted students (at primary and middle school levels) studying at Yozgat Fatma Temel Turhan Science and Art Center, where the researcher was employed, during the 2024–2025 academic year. Accordingly, the convenience sampling method was used. Convenience sampling is a method in which the sample is formed from individuals that the researcher can easily access and collect data from. This method is advantageous in terms of time and cost (Büyüköztürk et al., 2018). Table 1 presents information on the participants.

Table 1. Information about the participants

Variables		n
Gender	Female	7
	Male	16
Science and art center group	Support	18
	Awareness of individual talents	5
Grade level	3	9
	4	7
	5	6
	6	1

Data Collection Tool

The interview questions, prepared and used by the researcher within the framework of the relevant literature, consisted of 16 questions on topics such as AI, intelligence tools/applications, mathematics, and its use in lessons. Before implementation, two mathematics educators, one assessment and evaluation specialist, and one Turkish language specialist reviewed the interview questions, and necessary revisions were made according to their feedback. Through these questions, it was aimed to reach participants' views on AI applications and their purposes of use in general, as well as their views on AI applications specifically in mathematics education, the advantages and disadvantages of AI, and their use of AI in mathematics education.

Since the questions were predetermined, it can be stated that structured interviews were conducted. A structured interview consists of pre-prepared questions administered uniformly to all participants. The interviewer does not deviate from these questions and conducts the interview systematically (Yıldırım & Şimşek, 2021).

Data Collection

Before collecting the data, the necessary ethical approval was obtained from the Social and Human Sciences Ethics Committee of Yozgat Bozok University (date: June 18, 2025, decision number: 26/53). The data were collected at Yozgat Fatma Temel Turhan Science and Art Center through an interview form. The interview method is widely preferred in qualitative research conducted in social sciences (Yıldırım & Şimşek, 2021). The interview questions were revised according to expert opinions and finalized before the application. After the data collection tool was finalized, the students were asked to write their responses to the prepared questions.

Data Analysis

The data obtained in the study were analyzed using the content analysis method. Content analysis is the process of organizing and interpreting data by bringing together similar data within the framework of specific concepts and themes (Yıldırım & Şimşek, 2021). Content analysis is a widely used technique in the examination of written texts, and its main purpose is to identify the frequency of recurrence of specific words or concepts and to form

categories (Neuman, 2017). The primary reasons for preferring this method include increasing reliability and reducing bias. Reliability is associated with obtaining the same results in repeated studies after data analysis or ensuring consistency among different researchers. In addition, forming categories based on specific standards reinforces reliability. The aim of reducing bias is not to obtain entirely objective data but rather to ensure that interpretations are made more fairly. This method also aims to transform qualitative data into numerical values to allow for comparisons between categories. In this study, the data obtained through open-ended forms were subjected to a four-stage analysis process. These stages were (1) coding the data, (2) identifying themes, (3) organizing codes and themes, and (4) defining and interpreting the findings (Yıldırım & Şimşek, 2021). During the coding process, two researchers worked together and reached a consensus. Categories, codes, and frequencies were tabulated, and participant views were supported with direct quotations.

Results

The views of the gifted students participating in the study regarding AI and its use in mathematics teaching were categorized into the following: the definition of AI, artificial intelligence tools used, purposes of use, use in schools, level of trust in AI, its effect on career choice, its use in mathematics teaching, advantages in mathematics teaching, and disadvantages in mathematics teaching. The findings are presented in Table 2.

Table 2. Views of gifted students on AI and its use in mathematics teaching*

Category	Code
Definition	Robot (S4, S5, S19, S20, S21, and S23), application (S1, S17, S18, and S22), source of information (S3, S11, and S12), program (S2 and S13), helper (S6), friend (S7), tool (S10), era (S14), magic (S15), and human (S16)
AI tools used	ChatGPT (S1, S2, S6, S7, S11, S13, S15, S19, and S23), Google search engine (S2, S4, S11, S13, and S21), Gemini (S3, S7, S11, S15, S19, S20, and S23), Siri (S4, S7, S13, and S20), Canva (S6), DeepSeek (S7 and S13), Instagram (S8, S9, and S10), Facebook (S8, S9, and S10), Twitter (S8), and YouTube (S9 and S10)
Purposes of use	Research/learning (S2, S7, S10, S11, S12, S13, S15, S16, S17, S18, S19, S20, S21, and S22), homework (S3, S7, and S23), games/entertainment (S8, S10, S14, and S19), conversation (S7 and S19), and content creation (S6)
Use in school	Yes (S2, S3, S4, S5, S6, S14, S16, S17, S18, S19, S20, S22, and S23) and no (S1, S7, S8, S9, S10, S11, S12, S13, S15, and S21)
Trust in AI	Yes (S7, S10, S11, and S16) No (S1, S2, S3, S4, S5, S6, S8, S9, S12, S13, S14, S15, S17, S18, S19, S20, S21, and S22)
Effect on career choice	Yes (S2, S3, S5, S8, S9, S10, S15, S13, S19, S22, S23) No (S1, S4, S6, S7, S11, S14, S15, S17, S20, S21)
Use in mathematics teaching	Problem solving (S1, S2, S5, S6, S7, and S14), fractions (S2), graphs (S11), exponents (S13), and length measurement (S16)
Advantages in mathematics teaching	Facilitates better understanding (S4, S5, S6, S8, S9, S10, S11, S18, and S19), topic teaching (S3, S7, S11, S12, S21, and S22), helps solve questions (S2 and S7), and rapid computation (S15 and S23)
Disadvantages in mathematics teaching	Eye strain (S2, S8, S9, S10, and S18), back pain (S9), addiction (S11), misinformation (S12 and S19), and hinders understanding (S21)

**Some participants did not respond.* S: student

As seen in Table 2, the definitions of AI provided by the gifted students who participated in the study were coded as robot, application, source of information, program, helper, friend, tool, era, magic, and human. For example, S1 defined it as "Applications through which we can talk and generate pictures," S6 as "A helper that assists us," and S7 as "A friend with whom you can confide." S14 described AI as "The era in which technology has developed."

The participants reported that they used AI tools such as ChatGPT, Google search engine, Gemini, Siri, Canva, DeepSeek, Instagram, Facebook, Twitter, and YouTube for purposes including research/learning, completing homework, games/entertainment, and conversation. Most participants stated that they used ChatGPT and primarily for research/learning. Some students expressed their thoughts on this matter as follows: S2 stated, "ChatGPT and the Google search engine help with my research;" S23 explained, "I use ChatGPT and Gemini artificial intelligences for doing homework and obtaining information;" and S3 commented, "I ask Gemini questions about topics I do not know when doing homework and thus learn." S6 indicated that they used artificial intelligence for content creation by stating, "ChatGPT and Canva help me with my requests. I tell them to turn a picture into a cartoon and to assist me."

Some participants noted that AI was used in information technology and Turkish lessons at schools, while most expressed that they did not trust AI. The statements of some students who did not trust AI included "Not much. Sometimes it gives incorrect information." (S12) and "I do not trust it. Sometimes it says the wrong thing, sometimes the right thing." (S13). One student, however, stated that they trusted AI: "Yes, it approaches me like a friend." (S7). On the other hand, some students participating in the research noted that AI would affect their career choice, while others indicated it would not. Some of their views on this matter were as follows: "Artificial intelligence may affect fields such as medicine, housework, and engineering. Therefore, I may become a doctor and also a software developer." (S2), "Artificial intelligence may affect all professions. Artificial intelligence has developed so much that robots may replace me." (S8), "Artificial intelligence may affect all professions. But my opinion would not change because I would do the job I love." (S20).

The participants stated that they used AI in mathematics education for problem solving, fractions, graphs, exponents, and length measurement. They also indicated that the use of AI in mathematics education could provide advantages in facilitating better understanding, teaching topics, solving questions, and performing calculations quickly. On the other hand, they noted potential disadvantages such as eye strain, back pain, addiction, misinformation, and hindrance to understanding. Some students expressed their opinions on this matter as follows: "I benefited from artificial intelligence in fractions and problem solving. It helps us solve questions and with topic explanation. If we look at it for too long, our eyes could be damaged." (S2), "I benefited [from artificial intelligence] in graphs. It explains the topics we do not know and do not understand. But it can cause addiction." (S11), "I did not benefit in mathematics. It teaches the topics and operations we do not know. Sometimes it gives incorrect information and confuses us." (S12), "I ask questions. Artificial intelligence helps us learn mathematics lessons and understand them better. Artificial intelligence sometimes gives wrong answers, and it may also mislead us." (S19), "I do not use it in mathematics lessons. It ensures that we learn mathematics. If artificial intelligence solves the questions, I cannot understand how they are solved." (S21).

Discussion and Conclusions

As a result of the study, gifted students expressed that they viewed AI as a robot, an application, and a source of information. The definitions provided by gifted students regarding AI are consistent with existing definitions. The fact that some gifted students regarded social media applications as artificial intelligence tools indicates that they did not have sufficient knowledge of the subject. Although these social media applications are supported by AI in their operations, they are not AI tools themselves. This finding may be associated with the relatively young average age of the participant group. Indeed, some studies conducted at the university level have shown that students are aware of many AI tools (Benzer & Benzer, 2022; Köroğlu & Kana, 2025).

Most of the gifted students participating in the study expressed that they did not trust AI much due to the possibility of errors. This is a promising finding, as it is highly important to approach AI outputs critically rather than accepting them passively (Yoon et al., 2024). Another finding obtained from the research is related to the career choices of gifted students. Since some professions may emerge and others disappear with the advancement of AI (Benzer & Benzer, 2022), students indicated that this situation could affect their career choices. Moreover, although the gifted students stated that they used AI in mathematics lessons for problem-solving and learning purposes, it was revealed that they were not familiar with AI programs specifically designed for mathematics. Based on these findings, the following recommendations can be made:

- Various practices can be implemented to familiarize gifted students with AI -based programs that can be used specifically in mathematics.
- Based on the idea that AI may make mistakes, students' skills in evaluating the accuracy of AI outputs and comparing them with other sources can be developed.
- Teachers can use AI tools in problem-solving processes. This can increase students' motivation and improve their skills.

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A Review of Studies on the Use of Chatbots in Mathematics Learning

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Abstract

The integration of artificial intelligence-supported technologies into educational processes is rapidly increasing. In this context, there is a growing need for the systematic review of scientific studies on the use of chatbots in mathematics education. The main research problem of this study is to reveal how chatbot technologies are utilized in mathematics learning processes and to identify the emerging research trends in this field. The aim of the study is to systematically analyze the existing literature on the use of chatbots in mathematics education, evaluate the current state of research, and derive insights that can inform future studies. Accordingly, 22 international articles published between 2018 and 2024 were selected using the PRISMA flow diagram and analyzed through content analysis. The data were examined under various themes including publication year, country of origin, journal, research method, sample group and size, data collection tool, data analysis method, chatbot technology used, interface, pedagogical role, variables studied, and duration of implementation. The findings indicate a marked increase in publications in recent years, with most originating from the United States and South Korea. ChatGPT was identified as the most commonly used technology, and the majority of studies were conducted with pre-service teachers at the university level. Moreover, most implementations were short-term, with limited assessments of long-term impacts. In conclusion, while chatbot-supported mathematics education is emerging as a growing trend in the literature, there remains a need for further research in terms of sample diversity, pedagogical depth, and sustainability. Future studies are recommended to focus on long-term, inclusive, and mobile-compatible chatbot applications.

Keywords: Mathematics, artificial intelligence, chatbot, systematic review

Introduction

The integration of artificial intelligence (AI) technologies into educational processes has significantly accelerated in recent years, reshaping traditional pedagogical approaches and enabling more personalized and interactive learning experiences (Hwang & Tu, 2021; Awang et al., 2025). Among these technologies, AI-supported chatbots, also known as conversational agents, have emerged as innovative tools for facilitating real-time feedback, tutoring, and scaffolding within educational environments (Chen et al., 2025; Wollny et al., 2021). In the context of mathematics education, where learners often face challenges related to abstract reasoning and conceptual understanding, chatbots offer a promising avenue for individualized support, increased engagement, and cognitive assistance (Son, 2024; Niño-Rojas et al., 2024).

The growing academic interest in chatbot applications is evident in the expanding body of systematic reviews and bibliometric analyses focusing on their role in various educational domains, including mathematics (bin Mohamed et al., 2022; Panqueban & Huincahue, 2024). Recent studies highlight a shift in the focus of educational technology research — from tool-centric evaluations to investigations emphasizing pedagogical roles, cognitive outcomes, and learner experience (Monroy Andrade, 2024; Cotič et al., 2024). However, despite this trend, reviews dedicated solely to the use of AI-supported chatbots in mathematics learning remain limited in scope, often failing to provide a comprehensive synthesis of technologies, research designs, and pedagogical implications.

Furthermore, while technologies such as ChatGPT and Google Dialogflow have enabled more advanced natural language interactions, the literature reflects notable gaps related to sample diversity, implementation duration, mobile adaptability, and critical pedagogical functions (Voskoglou & Salem, 2020; Awang et al., 2025). Existing studies frequently center on higher education contexts, particularly involving pre-service teachers, and tend to employ short-term experimental designs that may not fully capture the longitudinal impact of chatbot use.

In light of these trends and challenges, this study aims to conduct a systematic review of international academic literature on the use of AI-supported chatbots in mathematics education between 2018 and 2024. By examining publication characteristics, research methodologies, technological features, and pedagogical roles, this review seeks to map the current landscape, identify prevailing research patterns, and highlight underexplored areas. The findings are intended to serve as a reference for future studies and support the development of more inclusive, sustainable, and pedagogically meaningful chatbot applications in mathematics learning.

The primary objective of this study is to systematically compile and analyze research on the use of artificial intelligence (AI)-supported chatbots in mathematics learning processes, in order to identify the prevailing trends in the use of chatbots within the field of mathematics education. Through this synthesis, the study aims to provide a comprehensive and inclusive perspective on the current body of literature, with the goal of offering guidance for future research and serving as a foundational reference point for new studies in the field.

Related Works

The integration of artificial intelligence (AI) technologies into education has advanced significantly in recent years, both conceptually and practically. Among these technologies, chatbots—also referred to as conversational agents—have gained attention for their ability to provide personalized support, engage learners in interactive dialogues, and offer immediate feedback (Chen et al., 2025; Wollny et al., 2021). Systematic reviews on educational chatbots have shown that these tools can act as tutors, enhance student motivation, and serve as guides throughout the learning process (Kuhail et al., 2022; Kumar, 2021).

Comprehensive studies on AI applications in education have discussed not only the instructional opportunities but also the ethical, pedagogical, and technical challenges posed by these technologies (Holmes et al., 2021; Castañeda & Selwyn, 2018). Hwang and Tu (2021), in their bibliometric mapping analysis, reported a growing trend in AI-related research in mathematics education, highlighting chatbots as a rising tool in this domain. However, they also emphasized the lack of in-depth investigations into the pedagogical roles of chatbots (Awang et al., 2025).

Systematic reviews specifically focused on mathematics education have identified several roles for chatbots, such as problem-solving, concept explanation, personalized guidance, and assessment. For instance, bin Mohamed et al. (2022) found that chatbots enhanced students' academic performance by effectively clarifying mathematical concepts. Similarly, Son (2024), using the SAMR model, pointed out that intelligent tutoring systems in mathematics education are primarily used at the "substitution" and "augmentation" levels, with transformative learning environments still underdeveloped.

Niño-Rojas et al. (2024) provided a historical overview of intelligent tutoring systems in mathematics and emphasized their strong potential in delivering adaptive support, real-time feedback, and problem-solving assistance. These findings suggest that chatbots should not be viewed merely as technological tools but as pedagogical actors capable of influencing the learning process.

Despite these advancements, certain limitations persist in the current literature. Most studies have been conducted with pre-service teachers at the university level, while learners at the elementary or secondary levels have been largely overlooked (Panqueban & Huincahue, 2024). In addition, the majority of implementations are short-term, making it difficult to assess the long-term educational impact of chatbot usage. Research on mobile-based chatbot platforms also remains limited (Voskoglou & Salem, 2020).

In summary, the related literature confirms the growing presence of AI-supported chatbots in mathematics education. However, critical research gaps remain in areas such as implementation duration, user diversity, pedagogical role variation, and sustainability. Addressing these gaps through a systematic review will help map current trends in the field and provide valuable guidance for future research efforts.

The aforementioned literature highlights the growing use of AI-supported chatbots in mathematics education, while also revealing that current implementations remain limited in scope and diversity. In this context, the present study aims to analyze prevailing trends in the field, identify methodological characteristics, and evaluate both the pedagogical strengths and shortcomings of existing research. Accordingly, the key research questions guiding this study are presented below.

1. What are the demographic characteristics of the studies on the use of AI-supported chatbots in mathematics learning processes? Specifically:

    1.1. What is the distribution of these studies by publication year?

    1.2. What is the distribution of the studies according to the countries of the corresponding authors?

    1.3. What is the distribution of the studies by the academic journals in which they were published?

    1.4. What are the most frequently used keywords in these studies?

2. What are the methodological trends of the studies on the use of AI-supported chatbots in mathematics learning processes? Within this scope:

    2.1. What types of research designs (qualitative, quantitative, or mixed methods) have been employed?

    2.2. What types of sample groups have been selected in these studies?

    2.3. What is the distribution of sample sizes?

2.4. What data collection instruments have been used in the studies?

2.5. What data analysis methods and techniques have been preferred?

3. What information is provided about the AI-supported chatbots used in the studies on mathematics learning processes? Specifically:

3.1. What technological infrastructures were used in the design of the chatbots?

3.2. How were the chatbot interfaces structured?

3.3. What roles did the chatbots assume during implementation?

3.4. What variables were used to assess the effectiveness of the chatbots?

3.5. What was the duration of chatbot use in the implementations?

Methodology

In this study, which examines research conducted on the use of AI-supported chatbots in mathematics learning processes from past to present, a qualitative research approach was adopted, and the systematic review method was employed. Systematic reviews aim to comprehensively synthesize the existing literature on a particular topic, providing in-depth insights that can guide future research (Petticrew & Roberts, 2008). For a systematic review to be effective, the rationale of the study, the procedures followed, and the conclusions reached must be clearly and thoroughly presented (Liberati et al., 2009). In this regard, the PRISMA-P framework, originally developed by Liberati et al. (2009) and updated by Moher et al. (2015), was used as a guiding structure to organize and report the conducted review. Accordingly, in the initial phase, the key points of focus were determined based on the content of the studies to be analyzed. Subsequently, studies addressing the use of AI-supported chatbots in mathematics learning processes were identified and included in the analysis. Finally, inclusion and exclusion criteria were established to determine which studies would be evaluated and which would be excluded from the review.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria used in this study were developed based on the framework proposed by Cevher and Yıldırım (2024). The studies selected for inclusion or exclusion in the literature review were determined according to the following criteria:

Inclusion Criteria:

- The study must make a direct reference to chatbots used specifically in the context of mathematics education.
- The study should address the roles, design processes, or technologies of the chatbots and provide information on their effects in terms of implementation outcomes.
- The study must be published in a peer-reviewed academic journal with full-text access available.

Exclusion Criteria:

- Studies focusing on chatbots used outside the field of mathematics education were excluded.
- Publications lacking sufficient explanation of how the chatbot was used, designed, or defined were excluded.
- Studies not published in English were not included in the review.
- Publications without accessible full texts were excluded from the analysis.
- Theses, conference papers, book chapters, or review articles were not considered within the scope of this study.
- Studies that did not provide methodological information or failed to clearly state a research methodology were excluded.

This selection process was designed to maintain the systematic nature of the review and to ensure the reliability of the findings.

Research Strategy and Study Identification

In this study, the Web of Science (WoS) scientific database was selected for the literature review. WoS is one of the most widely used and reliable sources in international literature reviews due to its broad range of subject categories and interdisciplinary coverage (Karasözen et al., 2011). Therefore, WoS was chosen to access literature relevant to the scope of this research. The database search was conducted on April 28, 2025, without applying any time restrictions. The search aimed to identify studies involving the use of "chatbots" or "conversational agents" in the context of mathematics education, using the following keywords: “mathematics edu*,” “mathematics teach*,” and “mathematics learn*.” The search query employed was as follows:

Search Query:

((TS= (mathematics edu) OR TS= (mathematics teach*) OR TS= (mathematics learn*)) AND (TS=(chatbot*) OR TS= (conversational agent)))*

This structure allowed for a systematic identification of literature focused on the use of chatbots in mathematics education. The initial search yielded a total of 54 studies. When the results were limited to publications classified as “articles,” the total number of studies was reduced to 32. Among these, only publications written in English were considered, resulting in 31 studies that were further evaluated based on the predetermined inclusion and exclusion criteria. Each article abstract was carefully reviewed, and in cases where the content was unclear or insufficient, the full texts were examined to ensure eligibility. Following this detailed screening process, 22 studies that met the criteria for inclusion in the analysis phase were selected for further examination. To illustrate the steps followed in the systematic review process, a flow diagram outlining the search and selection procedures is presented in Figure 1.

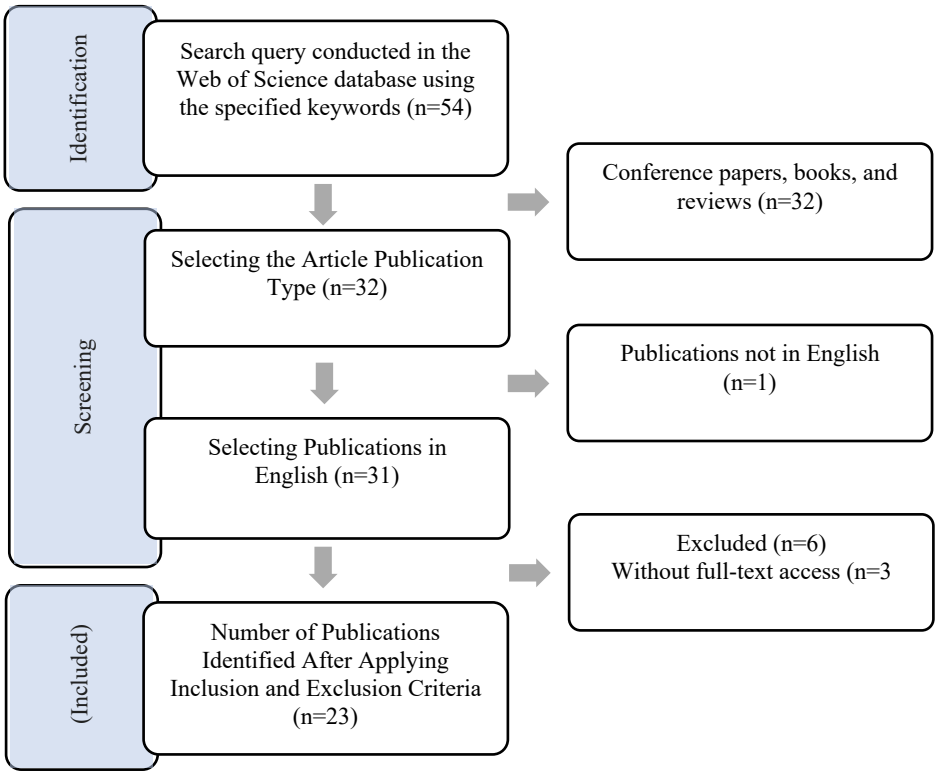

Figure 1. Flowchart illustrating the search and selection process

Data Collection

The data used in this study were obtained through the document analysis method. The data identified by the researchers through a comprehensive literature review were systematically evaluated and structured under the heading "Publication Screening Form" provided in Appendix 1. This form was adapted to fit the purpose of the study based on the classification developed by Cevher and Yıldırım (2020). The Publication Screening Form consists of three main sections: (i) demographic information, (ii) methodological information, and (iii) information related to chatbots.

(i) Demographic Information: This section includes the following basic information for each publication: publication ID, year of publication, title, keywords, name of the journal in which it was published, and the country of the corresponding author.

(ii) Methodological Information: Under this heading, the methodological characteristics of the studies were examined. The research type, sample level, sample size, data collection tools used, and data analysis methods applied in each study were identified.

(iii) Information Related to Chatbots: Details regarding chatbot usage were collected based on various classifications proposed in the literature (e.g., Hobert & Wolff, 2019; Hwang & Chang, 2021; Kuhail et al., 2022; Pérez et al., 2020; Kumar, 2021; Wollny et al., 2021). These details were categorized into the following subcategories: type of user interface used, platform on which the chatbot was developed, duration of implementation, its function/role in the educational process, and the variables used to measure its impact.

Data Analysis

The data derived from the publications examined within the scope of this study were systematically analyzed using the content analysis method. The primary goal of content analysis is to group data of similar nature under common themes in order to create a structured and meaningful whole (Yıldırım & Şimşek, 2006). In line with this objective, the data were independently reviewed by the researchers and categorized under relevant themes. During the analysis process, the data were classified and interpreted in accordance with the predefined research questions. The findings were visually presented through tables and figures to facilitate reader comprehension. Through this structured approach, the main trends and distributions of studies on chatbot-assisted mathematics learning were revealed in a clearer and more comprehensible manner.

Findings

The findings of this study have been structured and presented systematically in alignment with the predefined research questions. In the presentation of the findings, both the frequency of use of variables and their corresponding percentage (*%*) values have been reported. If a given variable appeared in multiple studies, it was indicated using the frequency symbol (*f*); if it appeared in only one study, it was denoted by the symbol (*n*).

1) Findings on the Demographic Characteristics of the Publications

a) Findings on the Distribution of Publications by Year

The distribution of the reviewed publications by year is presented in Figure 2.

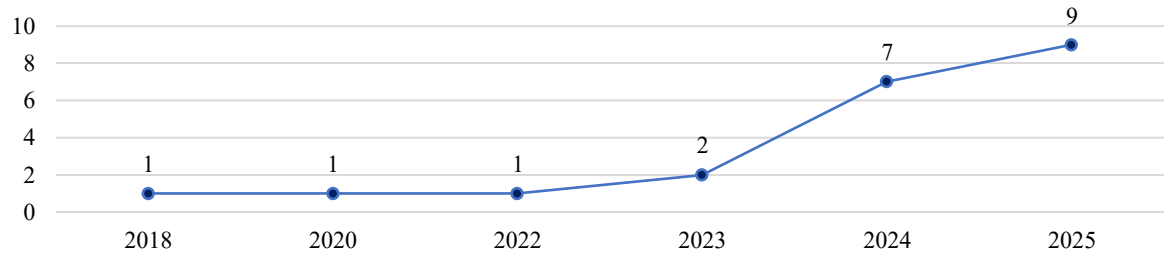

Figure 2. Distribution of publications by year

An examination of studies on the use of AI-supported chatbots in mathematics learning processes reveals that such publications began appearing in 2018 and have shown a steadily increasing trend over the years. However, there were certain years during which no relevant studies were identified. Notably, a significant rise in the number of publications has been observed in recent years. It should be noted that the current study was conducted as of April 2025; thus, the data for this year are not yet complete. In addition, one study currently in early access is listed in the system with a publication year of 2026. Since this affects the data distribution, it was excluded from the graph.

b) Findings on the Distribution of Publications by the Country of the Corresponding Author

The distribution of the reviewed publications based on the country of the corresponding author is presented in Figure 3.

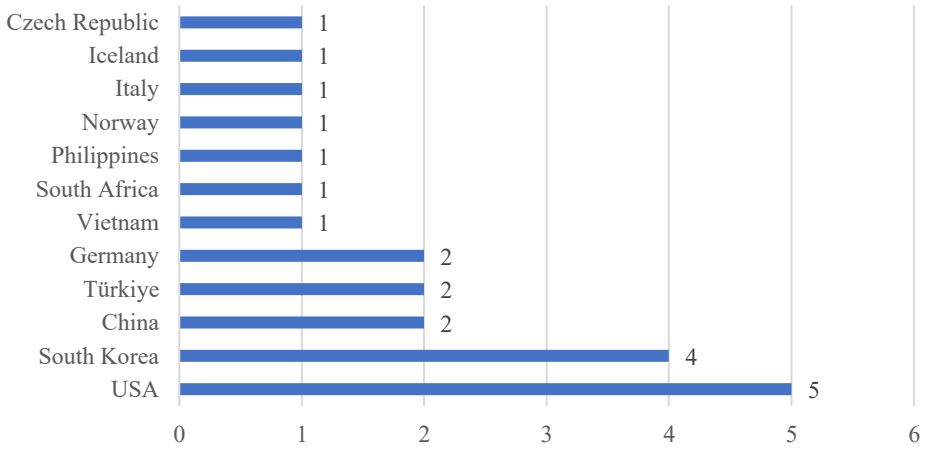

Figure 3. Distribution of publications by country

As shown in Figure 3, the country with the highest number of publications is the United States (*n*=5), followed by South Korea (*n*=4).

c) Findings on the Distribution of Journals in Which the Publications Were Published

The findings regarding the journals in which the reviewed publications were published are presented in Table 1.

Table 1. Journals in which the publications were published

Journal Title	Number of Publications *(n)*
1. Education and Information Technologies	3
2. International Journal of Education in Mathematics Science and Technology	2
3. AI	1
4. Computers & Education	1
5. Education Sciences	1
6. Frontiers in Artificial Intelligence	1
7. IEEE Transactions on Learning Technologies	1
8. International Electronic Journal of Mathematics Education	1
9. International Journal of Integrated Engineering	1
10. International Journal of Management Education	1
11. International Journal of Stem Education	1
12. Intervention in School and Clinic	1
13. Journal of Computer Assisted Learning	1
14. Journal of Education Culture and Society	1
15. Mathematics Enthusiast	1
16. Physical Review Physics Education Research	1
17. Science & Education	1
18. Teaching and Teacher Education	1
19. Theory Into Practice	1

As shown in Table 1, studies on the use of chatbots in mathematics learning have been published across 19 different journals. When ranked by the number of publications, Education and Information Technologies appears as the leading journal with three publications (*n*=3), followed by the International Journal of Education in Mathematics Science and Technology with two publications (*n*=2).

d) Findings on the Keywords Used in the Publications

The findings related to the keywords used in the reviewed studies are visualized in Figure 4. Within the scope of the analysis, only keywords that appeared in more than one publication were included; terms that were used only once were excluded from the word cloud. The word cloud was generated based on the frequency of keyword usage and was visually scaled to reflect the conceptual density present in the literature.

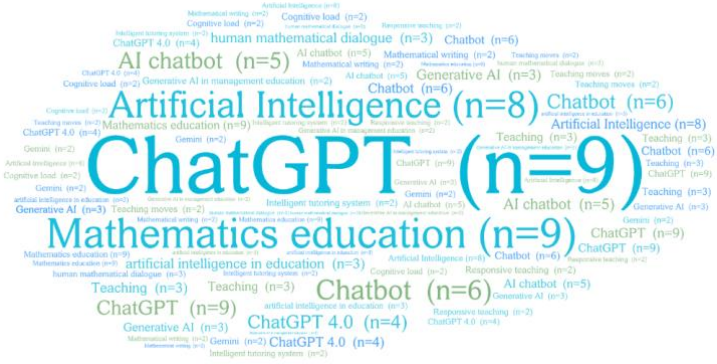

Figure 4. Frequently used keywords in the reviewed publications

An examination of Figure 4 reveals that the most frequently used keywords in the studies are "ChatGPT" (*n*=9) and "Mathematics Education" (*n*=9). These two keywords represent the primary concepts emphasized in the reviewed publications. The term "Artificial Intelligence" (*n*=8) ranks second, indicating that the majority of the studies are framed within an AI-based context. The keyword "Chatbot" (*n*=6) ranks third, reflecting the concentration of studies focused specifically on chatbot usage.

2) Findings on the Methodological Trends of the Publications

a) Findings on the Research Types of the Publications

The findings regarding the research types of the publications examined within the scope of this study are presented in Figure 5.

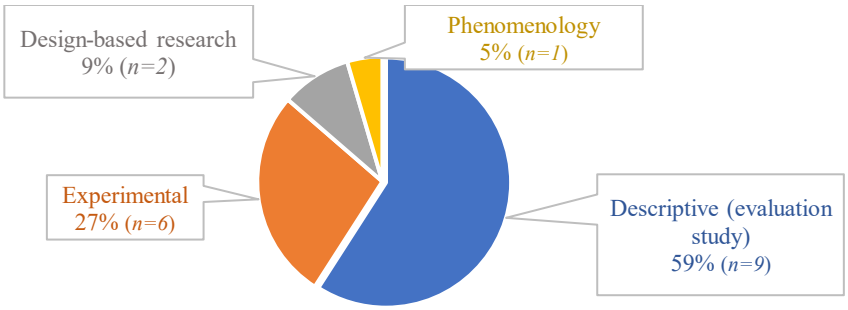

Figure 5. Distribution of the publications by research type

An analysis of Figure 5 shows that the majority of the reviewed studies adopted a descriptive research design aimed at explaining or evaluating the current state of affairs. The second most commonly used design was the experimental research design, involving experimental and control groups. In contrast, studies based on design-based research and phenomenology were among the least preferred research approaches.

b) Findings on the Research Methods of the Publications

The findings regarding the research methods employed in the reviewed publications are presented in Table 2.

Table 2. Distribution of the publications by research method

Yöntemi Research Method	***n***	***%***
Quantitative Research	7	32
Qualitative Research	7	32
Mixed Research	6	27
Design-Based Research	2	9
Total	22	100

According to the data presented in Table 2, 32% (*n*=7) of the reviewed studies employed a quantitative research method, 32% (*n*=7) used a qualitative research method, and 27% (*n*=6) adopted a mixed methods approach. In addition, two studies (9%) were conducted using a design-based research methodology.

c) Findings on the Sample Groups of the Publications

Figure 6 presents the findings regarding the sample groups of the studies included in the research.

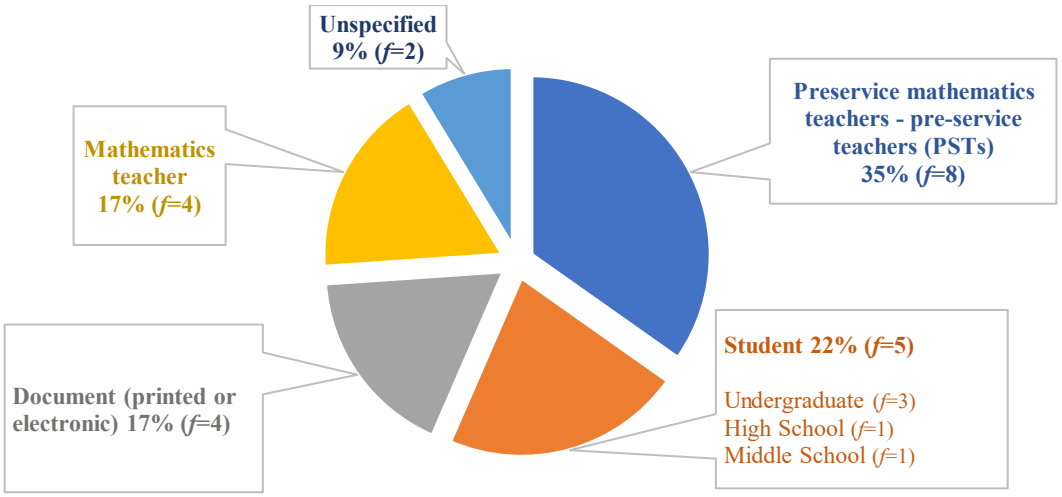

Figure 6. Distribution of publications by sample group

An examination of the data presented in Figure 6 reveals that the most frequently selected sample group was "pre-service mathematics teachers (PSTs)" at the undergraduate university level (*f*=8). This was followed by the "students" group (*f*=5), which included participants from various educational levels. Additionally, it was identified that two publications did not provide any information regarding their sample groups.

d) Findings on the Sample Sizes of the Publications

The findings related to the sample sizes of the studies analyzed within the scope of the research are presented in Figure 7.

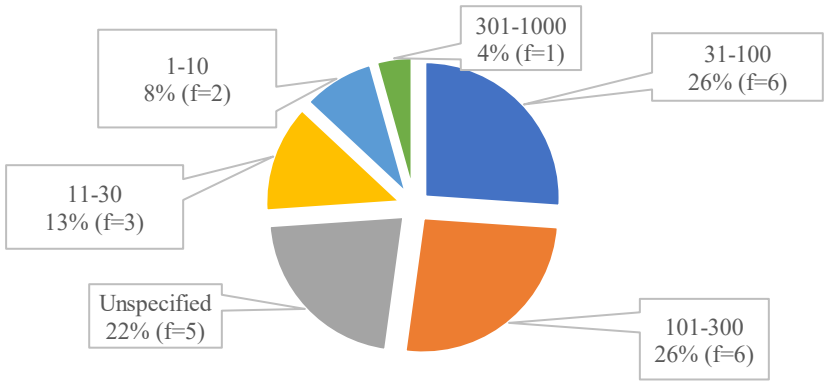

Figure 7. Distribution of publications by sample size

As shown in Figure 7, the most frequently preferred sample size ranges in the reviewed publications were "31–100" and "101–300" (*f*=6 for each). On the other hand, the least common sample size range was "301–1000," which appeared in only one study (*f*=1). Additionally, it was found that five publications did not provide any information regarding sample size.

e) Findings on the Data Collection Instruments Used in the Publications

The findings regarding the data collection instruments used in the publications analyzed within the scope of the study are presented in Table 3.

Table 3. Distribution of data collection instruments used in the publications

Veri Toplama aracı	***f***	***%***
System (Log) records	12	34
Likert survey	9	26
Interview form	5	14
Achievement test	3	8
Open-ended survey	2	6
Document	2	6
Rubric	1	3
Unspecified	1	3

According to the data presented in Table 3, system (log) records were used as the data collection instrument in 34% of the reviewed studies (*f*=34). This was followed by Likert-type questionnaires, which appeared in 26% of the studies (*f*=26). Interview forms ranked third, used in 14% of the publications (*f*=14). In addition, one study did not provide any information about the data collection instrument used.

f) Findings on the Data Analysis Methods Used in the Publications

The findings related to the data analysis methods employed in the studies analyzed within the scope of the research are presented in Table 4.

Table 4. Distribution of Data Analysis Methods Used in the Publications

Data Analysis Method				***f***	***%***
Quantitative	Quantitative			6	17
	Inferential	Parametric	ANOVA / ANCOVA	2	6
			Correlation Analysis	2	6
			Independent Samples t-Test	2	6
			Regression Analysis	1	3
		Non-parametrik	Mann-Whitney U-Test	3	7
			Kruskal-Wallis	1	3
			The Wilcoxon Test	1	3
	Advanced Statistical Methods	Latent Profile Analysis		2	6
		Structural Equation Modeling		1	3
Qualitative	Content Analysis			13	37
Unspecified				1	3

According to Table 4, the most frequently used data analysis method was qualitative content analysis, employed in 37% of the reviewed studies (*f*=13). Quantitative analysis methods were examined under different categories. The most common quantitative method was descriptive analysis, used in 17% of the studies (*f*=6). Among inferential statistics, parametric tests were distributed equally across ANOVA/ANCOVA (*f*=2, 6%), correlation analysis (*f*=2, 6%), and independent samples t-test (*f*=2, 6%). Regression analysis was less frequently used, appearing in only 3% of the studies (*f*=1). Among non-parametric tests, the most commonly used method was the Mann-Whitney U test (*f*=3, 7%). Other non-parametric methods included the Kruskal-Wallis test (*f*=1, 3%) and the Wilcoxon test (*f*=1, 3%). Regarding advanced statistical analysis, Latent Profile Analysis (*f*=2, 6%) and Structural Equation Modeling (*f*=1, 3%) were employed. Lastly, one publication did not specify which data analysis method was used.

3) Findings on Chatbot Characteristics in The Publications

a) Findings on the Technologies of Chatbots Used in the Publications

The findings related to the chatbot technologies employed in the studies analyzed within the scope of the research are presented in Table 5.

Table 5. Technologies employed in chatbots within academic publications

Technologies Employed in Chatbots	***f***	***%***
ChatGPT (OpenAI)	15	60
Developed by researchers		
- IBM Watson Assistant	2	8
- Google Dialogflow	2	8
- Facebook Messenger	1	4
- Unspecified	3	12
Google Gemini	1	4
MathGPT	1	4

According to the information provided in Table 5, the most commonly used chatbot technology in the reviewed publications was ChatGPT, developed by OpenAI (*f*=15). In addition, in some studies, researchers developed their own chatbots using various design platforms tailored to the specific needs of the study. Other chatbot technologies such as Gemini, developed by Google, and MathGPT, which focuses on solving mathematical problems, were used in only one study for comparative analysis purposes. Furthermore, some publications reported the use of multiple chatbot technologies within a single study.

b) Findings Related to the Operational Interfaces of Chatbots Used in the Publications

The findings regarding the chatbot technologies utilized in the publications examined within the scope of the study are presented in Table 6.

Table 6. Information on the operational interfaces of chatbots used in the publications

Operational Interface	***f***	***%***
Web-based	18	82
Mobile-based	1	4.5
Both mobile and web-based	1	4.5
Not specified	2	9

According to the information presented in Table 6, the vast majority of the studies reviewed (f=18, 82%) employed a web-based interface. One study preferred a mobile-based interface, while another utilized both mobile and web-based platforms. In two studies, no information was provided regarding the operational interface of the chatbot.

c) Findings Regarding the Roles of Chatbots in Practice in the Publications

The purposes and roles for which chatbots were utilized in the examined publications are presented in Table 7.

Table 7. Information on the roles of chatbots in practice in the publications

Role of the Chatbot	***f***	***%***
Solving Mathematical Problems and Explaining Concepts	7	32
Chatbot Acting as a Teacher	5	24
Interactive and Simulation-Based Use	4	18
Individual Guidance for Students	3	14
Assessment and Examination Process	1	4
Critical Thinking and Discussion Initiator	1	4
Game- and Interaction-Based Use	1	4

As shown in Table 7, the most common role of chatbot technology in the reviewed studies was “solving mathematical problems and explaining concepts” (f=7). This was followed by the use of chatbots acting in a “teacher” role (f=5). In third place were studies utilizing chatbots for “interactive and simulation-based” purposes (f=4).

d) Findings Regarding the Variables Examined in Relation to Chatbot Impact in the Publications

Table 8 presents the variable groups addressed in the publications and the sub-concepts included in these groups.

Table 8. Variable groups and their distribution in the publications

Variable Group	Included Sub-Concepts	*f*	%
Learning Achievement and Performance	Learning outcomes, academic achievement, knowledge retention, exam performance, learning experience	10	17
Chatbot Usage and Effectiveness	Chatbot performance, ChatGPT experience, awareness, satisfaction, usage, perception	10	17
Teacher Role and Training	Teacher support, guidance, mentorship, teacher training, instructional tools, familiarity, training needs	9	16
Problem Solving and Support	Problem solving, question solving, solution guidance, mathematical support, feedback, individualized guidance	9	16
Cognitive and Emotional Processes	Cognitive load, critical thinking, self-efficacy, interest, attitude, behavioral intention, performance expectancy	6	10
Mathematical Competency and Understanding	Mathematical thinking, concept explanation, mathematical writing, mathematical discussion, problem posing	6	10
Interactive and Simulation-Based Learning	Virtual student, simulation, interactive learning, classroom games, gamification	6	10
Sociopolitical Awareness	Sociopolitical problem posing, awareness, mathematics related to social issues	2	4

According to the data in Table 8, the most frequently examined variable groups were “Learning Achievement and Performance” (f=10) and “Chatbot Usage and Effectiveness” (f=10). These groups emphasized elements such as students' academic achievement levels, their experiences with chatbot use, and satisfaction levels. Pedagogical themes such as teacher roles, problem-solving support mechanisms, and cognitive-emotional processes were also notable. Variables associated with critical mathematics education, such as “Sociopolitical Awareness” (f=2), were addressed in a limited number of studies.

d) Findings on the Implementation Durations of Chatbots in the Publications

The durations of chatbot implementations in the studies reviewed are presented in Table 9.

Table 9. Distribution of chatbot implementation durations in the publications

Type of Implementation Duration	*n*
Scenario-Based Single Sessions	9
Medium-Term Trials (2–4 weeks)	6
Short-Term Trials (1–5 days)	1
Long-Term Applications (8+ weeks)	1
Users with Cumulative Experience within 1 year	1
Unspecified / Not Reported	4

According to the data in Table 9, the most frequently preferred implementation type involved short-term interactions based on scenario-based single sessions (n=9). Medium-term trials lasting between two and four weeks (n=6) were the second most common implementation type. In four studies, no information was provided regarding the duration of chatbot implementation.

Results and Conclusions

This study aimed to systematically examine academic research on the use of AI-supported chatbots in mathematics learning processes and to identify prevailing trends in the field. The discussion based on the findings from 22 selected studies is presented below:

Publications on chatbot use in mathematics education began to emerge around 2018 and have shown a notable increase in recent years. This trend reflects the rapid expansion of artificial intelligence technologies in education, particularly the widespread adoption of advanced language models such as ChatGPT. The digital transformation following the COVID-19 pandemic is also considered a key driver of this increase. The growing significance of educational technologies has prompted researchers to investigate the pedagogical implications of these tools (Awang et al., 2025; Chen et al., 2025; Holmes et al., 2019; Luckin et al., 2016). The increasing presence of AI in mathematics education is similarly highlighted in recent reviews (bin Mohamed et al., 2022; Panqueban & Huincahue, 2024).

The United States was found to be the country with the highest number of publications, indicating both a robust technological infrastructure and institutional openness to innovative educational practices. It also suggests strong research funding and organizational support for technology integration in education (OECD, 2021). In contrast, studies from developing countries remain limited, underscoring that digital inequalities extend beyond access to include disparities in knowledge production (Selwyn, 2010).

Most of the reviewed publications were published in high-ranking (Q1 and Q2) journals such as Education and Information Technologies, Sustainability, and Smart Learning Environments. This demonstrates that chatbot technologies are not only examined from a technical perspective but also from the standpoint of sustainable education, digital pedagogy, and learning technology. The publication of these studies in top-tier journals also reflects the growing global academic interest in this subject (Zawacki-Richter et al., 2019).

Keyword analysis revealed that the most frequently used terms were “chatbot,” “mathematics,” “education,” “learning,” “AI,” and “ChatGPT.” These keywords confirm that AI-assisted learning processes are central to the literature, with ChatGPT standing out as the dominant technology. However, the limited emphasis on advanced pedagogical concepts such as "feedback," "tutoring," and "adaptivity" suggests that the field is still developing.

In terms of methodology, a balanced distribution of qualitative, quantitative, and mixed-methods designs was observed, while design-based research remained limited. This indicates a diversity of research strategies, yet a relative scarcity of long-term and innovative approaches. Design-based research is particularly valuable in evaluating and refining the educational integration of technological tools (Design-Based Research Collective, 2003; Wang & Hannafin, 2005).

The most common sample group was pre-service mathematics teachers at the university level, implying that chatbots are positioned as supportive tools in teacher education. However, research involving primary and secondary students or individuals with special needs remains scarce, indicating a lack of inclusive and differentiated implementation (Holmes et al., 2021; Monroy Andrade, 2024; Voskoglou & Salem, 2020).

The most frequently used data collection methods were system logs and questionnaires. While these are effective for quantitative analysis, a deeper understanding of user experiences requires greater integration of qualitative methods (Chen et al., 2025). Combining ethnographic observation, interviews, and learning analytics can offer a more holistic perspective on learner behavior (Siemens & Long, 2011; Ifenthaler & Yau, 2020).

ChatGPT was the most commonly used chatbot technology, appearing in 60% of the reviewed studies. Its open access, strong language generation capacity, and widespread visibility explain this dominance. However, over-reliance on commercial technologies may limit diversity and suppress innovation (Awang et al., 2025; Castañeda & Selwyn, 2018).

Most chatbots were delivered through web-based interfaces, with mobile-based applications being relatively rare. Expanding mobile-compatible chatbot solutions may enhance accessibility and usability, particularly for younger users who are more comfortable with mobile platforms (Traxler, 2009).

Chatbots were primarily used to explain concepts, solve problems, and act in teacher-like roles. These applications show their effectiveness as instructional support tools. However, implementations involving critical thinking, gamification, or sociopolitical awareness were lacking (Son, 2024).

The most common variables used to assess chatbot effectiveness were learning achievement, user satisfaction, and problem-solving. While these are essential for instructional evaluation, indicators related to sustainability—such as long-term learning, behavioral intention, and user resistance—have received limited attention (Niño-Rojas et al., 2024; Voskoglou & Salem, 2020). Davis's (1989) Technology Acceptance Model (TAM) emphasizes that perceived usefulness is key to sustainable technology adoption.

Most implementations were short-term, either single-session or 2–4 week trials. Very few studies involved long-term, semester-length interventions. This finding suggests that the effects of chatbots are generally assessed through short-term outcomes. However, fully understanding their educational potential requires long-term, multi-session implementations embedded in natural learning flows. Short-term studies may fall short in capturing temporal changes in student engagement, retention, and attitudes (Panqueban & Huincahue, 2024; Monroy Andrade, 2024). Future studies should explore sustained pedagogical impacts, including habitual usage, motivational continuity, and cognitive development over time.

Based on the findings of this study, several multi-level recommendations are proposed:

In terms of research design, future studies should adopt long-term, multi-session experimental designs and increase the use of design-based and user-centered methodologies.

In terms of sample diversity, more comparative research from developing countries is needed. Future studies should include primary, secondary, and high school students, target learners with special educational needs, and involve active teachers and parents as users.

In terms of technological development, mobile-compatible chatbot solutions should be promoted, and alternative interaction modalities such as voice systems and augmented reality should be explored. Developing independent chatbot applications using open-source or locally developed software should also be encouraged.

In terms of pedagogy, chatbots should be designed not merely as information transmitters but as guides, mentors, discussion leaders, or simulation managers. More content should be developed focusing on sociopolitical mathematics problems and critical thinking skills.

In terms of sustainability and impact evaluation, chatbots should be assessed not only for short-term effectiveness but also for long-term outcomes such as habitual use, changes in learning behavior, and voluntary use intention. Attention should also be given to potential drawbacks such as user resistance, system fatigue, and digital burnout.

For practitioners and policymakers, national strategies should be developed for integrating chatbot technologies into instructional processes. In-service teacher training should be provided to enhance digital pedagogical competencies. Finally, chatbot applications should be aligned with curriculum goals and designed with sensitivity to the cultural context.

Acknowledgements

The authors gratefully acknowledge the support of generative artificial intelligence tools in the preparation of this manuscript. In particular, ChatGPT-4.0 was utilized for language refinement and clarity improvement, DeepL for translation verification, and Grammarly for grammar and style checks. These tools were employed solely to enhance the linguistic quality of the text; all intellectual content, data interpretation, and conclusions remain the sole responsibility of the authors.

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Modeling the Evolution of Student Academic Groups for Educational Process Management

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Abstract

The paper presents a model for the evolution of student academic groups during the educational process, based on multi-species Lotka-Volterra equations. It also includes experimental results focused on improving the efficiency of group formation, grounded in statistically estimated relationships between students. The model assumes that both the teacher's and each student's influence on the group's evolution is limited and external influence can be neglected.

To estimate student interactions, an interaction matrix has been built based on survey responses about group activity. Eigenvalue analysis of the matrix was used to understand the group's state and dynamics. The hidden roles of students within the group were explored by analyzing the matrix's eigenvectors, which helped identify the optimal way for students to participate in order to maximize overall group productivity.

The model confirmed that smaller group activities and the execution of educational projects are more effective in development of necessary skills. The role of the teacher is also discussed. In addition, extensive data on social behaviors, attitudes, and opinions within the academic group is presented to validate the reliability of the proposed model.

Keywords: educational process management, Lotka-Volterra equations, interaction matrix.

Introduction

The paper presents results of a fieldwork with an academic group of students while learning a "Telecontrol and Navigation" course in Belarusian State University in the spring of 2025. The aim of the work was improvement of educational process efficiency based on projects activity of students inside small groups. The next assumptions was used:

- The educational process becomes more effective when it is based on intrinsic activity of students and mutually beneficial collaboration. It should not be a performance of one person, but a kind of dialogue or discussion of the participants, including the teacher.
- The evolution of the student group can be simulated using a statistically estimated matrix of relationships between students. Matrix analysis also allows to improve the process of small groups formation and to offer the recommendations on each student optimal way of participation in order to maximize overall group productivity

The educational process can be simulated with the help of Lotka-Volterra equations. It is possible to present the academic group formally as a non-linear dynamic system in order to find processes that limit students' activities. The mathematical model to be presented is based on a set of interpretations, assumptions and agreements. It requires careful interpretation and should be additionally tested. The model assumes that both the teacher's and each student's influence on the group's evolution is limited and external influence can be neglected.

Math Basics

Let start with a matrix form of generalised multi-species Lotka-Volterra equations. Note that experimental data are for a real academic group of 21 students, while theory is explained using 4-dimensional symbolic equations (1).

$$\frac{d}{dt}\vec{U}=\begin{bmatrix} U_1 & 0 & 0 & 0 \\ 0 & U_2 & 0 & 0 \\ 0 & 0 & U_3 & 0 \\ 0 & 0 & 0 & U_4 \end{bmatrix}\left\{\begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix}+\begin{bmatrix} W_{11} & W_{12} & W_{13} & W_{14} \\ W_{21} & W_{22} & W_{23} & W_{24} \\ W_{31} & W_{32} & W_{33} & W_{34} \\ W_{41} & W_{42} & W_{43} & W_{44} \end{bmatrix}\vec{U}\right\}, \text{ where } \vec{U}=\begin{bmatrix} U_1 \\ U_2 \\ U_3 \\ U_4 \end{bmatrix}; \quad (1)$$

$\vec{U}$ – is the vector of the group state;

U_i - represents the current state of i-th item of the system under simulation (population density of i-th species in the wild nature for example or the skills size of i-th student during educational process) which is changed during evolution.

W_{ij} - is the interaction coefficient between peer i and peer j. A positive W_{ij} indicates a positive effect on peer health (e.g., collaboration), a negative W_{ij} indicates a negative effect (e.g., competition or predation), and an W_{ij} of zero indicates no direct interaction.

V_i - represents the intrinsic productivity (state growth rate) of item i.

Simulated collaborative activity such as presentation of course materials in class was used in order to estimate interaction matrix experimentally. It was built at the base of series of polls concerning other students' activity at the lessons and bets on the results of their work. The opinion of other students was also used to calculate each student final grade. Hence the interaction matrix was formed using classical sociological survey rules: anonymously, indirectly, taking into account the real risk and cost of student decisions. Experimentally estimated interaction matrix for the academic group of 21 students in shades of gray is shown in the fig.1.

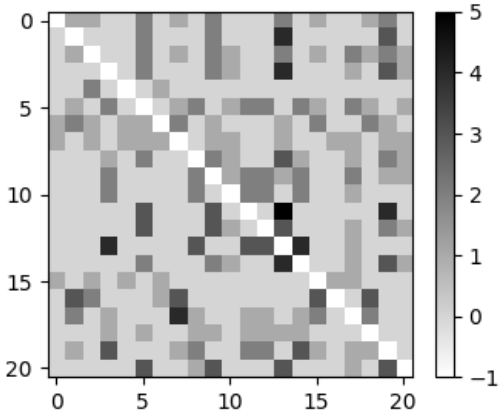


Figure 1. Experimentally estimated interaction matrix in shades of gray.

The matrix diagonal was not estimated. There should be some negative value which can limit species productivity.

One can calculate eigenvalues λ_i and eigenvectors $\vec{U}_i$ of interaction matrix. If the state of the system is represented by eigenvector $\vec{U}_i$ the next substitution can be used:

$$\begin{bmatrix} W_{11} & W_{12} & W_{13} & W_{14} \\ W_{21} & W_{22} & W_{23} & W_{24} \\ W_{31} & W_{32} & W_{33} & W_{34} \\ W_{41} & W_{42} & W_{43} & W_{44} \end{bmatrix} \vec{U}_i = \lambda_i \vec{U}_i \tag{2}$$

In this case system can be simplified and reduced to

$$\frac{d}{dt}\vec{U}_i = \begin{bmatrix} U_1 & 0 & 0 & 0 \\ 0 & U_2 & 0 & 0 \\ 0 & 0 & U_3 & 0 \\ 0 & 0 & 0 & U_4 \end{bmatrix} \left(\begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} + \lambda_i \vec{U}_i \right) \tag{3}$$

After substitution variables are separated and the system (3) can be solved analytically:

$$U_i(t) = \frac{V_i}{\lambda_i \left(C_{1i} \exp(-V_i t) - 1 \right)} \tag{4}$$

Simulation Results and Interpretation

Each eigenvector $\vec{U}_i$ represents a stable pattern of relations. Note that formally both negative and complex values are allowed for species states and it is not exactly clear what to do with negative ones. The imaginary component of the eigenvalues spectrum contains the most important information and is shown in figure 2.

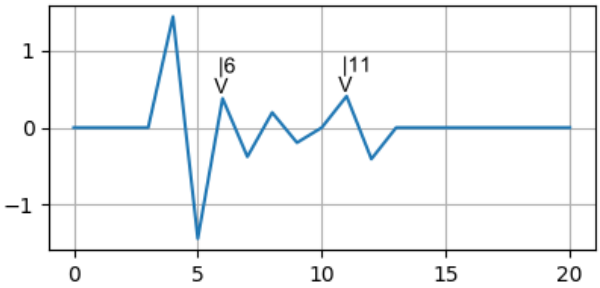


Figure 2. Imaginary part of eigenvalues spectrum of interaction matrix.

The non-zero imaginary component of eigenvalue tells about predator–prey relations or parasitism in the case of wild nature simulations. If human relations are under investigation then such eigenvalue indicates the unfair deal with someone in order to benefit from their work. It is the signal of injustice and inequity. Eigenvector analysis corresponding to eigenvalues with non-zero imaginary parts such as 6 and 11 can help to improve group relations. The eigenvector $\vec{U}_6$ as an example is presented at the fig. 3.

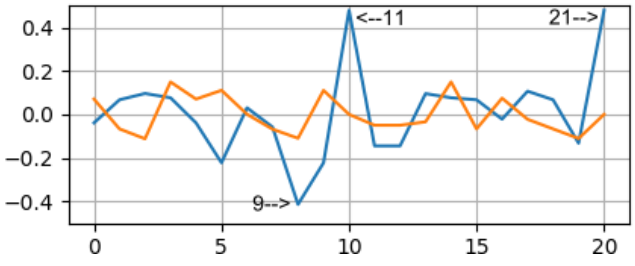


Figure 3. Stable scheme $\vec{U}_6$ of relations.

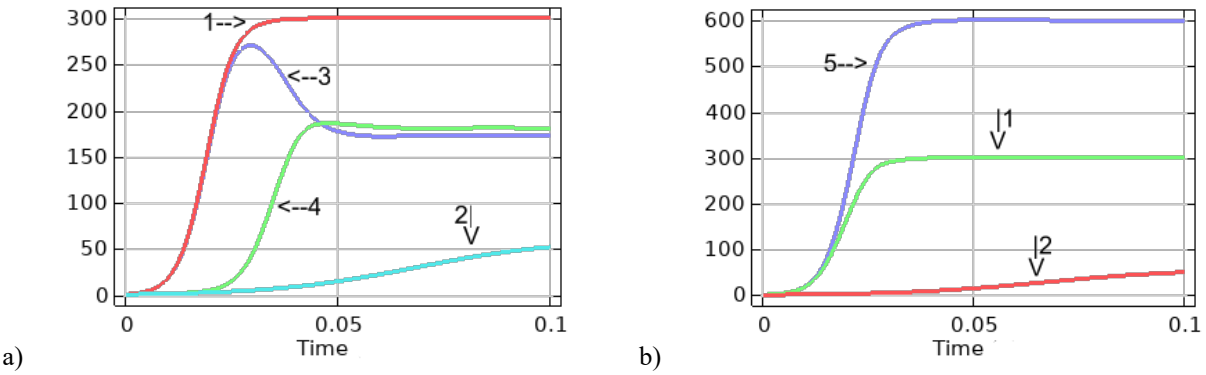
Let us illustrate this by a simple example of predator–prey equations.

$$\frac{d}{dt}\vec{U}=\begin{bmatrix}U_1 & 0\\ 0 & U_2\end{bmatrix}\left\{\begin{bmatrix}300\\ 60\end{bmatrix}+\begin{bmatrix}-1.0 & -0.7\\ 0.7 & -1.0\end{bmatrix}\vec{U}\right\} \tag{5}$$

Predator intrinsic productivity is assumed to be small. The predator exists mostly due to the interaction with the prey. Such a situation is more probable in human relations. The interaction matrix possess two possible stable patterns of relations:

$$\lambda_1=-1-0.7\,j,\begin{bmatrix}1\\ j\end{bmatrix};\quad \lambda_2=-1+0.7\,j,\begin{bmatrix}1\\ -j\end{bmatrix} \tag{6}$$

The solution (3-prey, 4-predator) of equations 5 is presented in the fig. 4a. An important detail in the evolution of the predator-prey system is the oscillations of population density and non-zero imaginary part of eigenvalues of the interaction matrix. All other possible relation patterns have real eigenvalues. Population density dynamics of separated prey (1) and predator (2) are provided as a reference. The collaboration of two preys (5) is reflected in fig. 4b and also worth attention because of high productivity.



a) b)

Figure 4. Simulation of evolution of predator-prey system (a) and prey-prey cooperation (b).
1,2 – separated prey and predator respectively; 4,3 – predator-prey system; 5 - prey-prey cooperation

Persons that achieve gain by misleading others can be detected from the eigenvector (see fig.3). Mostly the persons 11,21 from group list and likely 9 profit from such relations pattern. Eigenvalue of relation pattern 6 was noted earlier to be complex hence the scheme is unfair. It should be excluded somehow in order to improve relations and increase educational efficiency. This result correlates with other surveys and teacher opinion.

Analysis of group state is more complex with another example 11 of unfair relationships presented at the fig. 5, but it is obvious that separation of person 8 from students 3 and 14 will improve the situation.

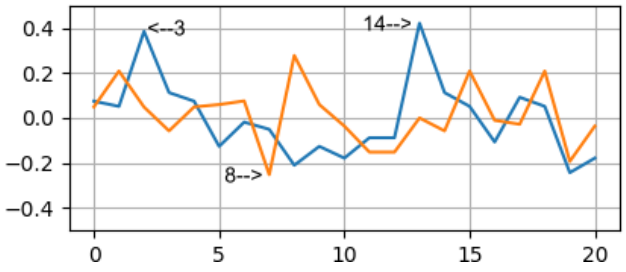


Figure 5. Stable pattern $\overrightarrow{U_{11}}$ of relations.

Reliability Estimation of Presented Results

It is also possible to find students, who are looking for unfair ways to benefit from others by analyzing student opinions on questions concerning education (fig. 6). Additional series of questions correlate with the results of eigenvalue analysis and can be used to confirm the results of search of individuals who engage in predatory behavior. Both analysis techniques lead to the same students. The example is responses of students 9,11,21 from the fig. 3:

- Q: “Which activity is preferred to enhance teamwork outcomes?” (fig. 6a). Most of the this students prefer “waiting”.
- Q: “Who can provide you the most objective final grade?” (fig. 6b). Selected students choose “any teacher that is loyal”.

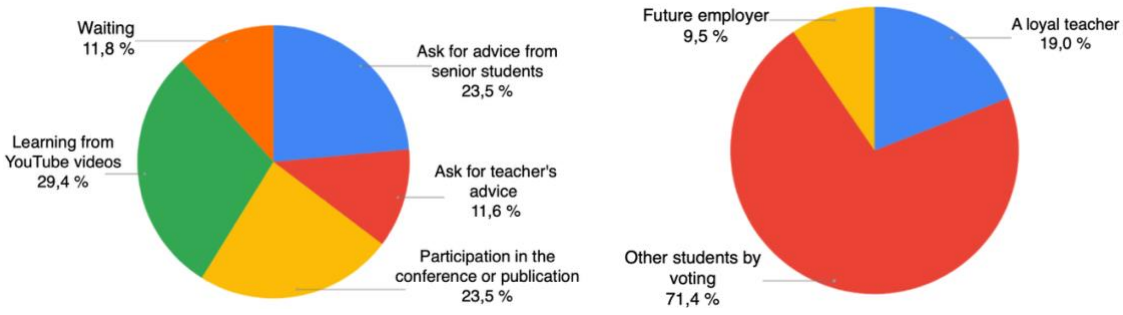


Figure 6. Results of additional surveys

Also presented ideas is indirectly confirmed by a number of recent researches:

Only a few of the modern approaches to education are really focused on enhancing the skills necessary for further practice. Passive perception of information is the norm in most educational courses, while experience-based skills are the most essential for future work. The use of new organization techniques of education and its advantages has been an active exploration for a considerable amount of time (Slavin, 1996; Freeman 2014), but getting to the point where educational practices can implement a learning approach that is capable of meeting the challenges of modern job markets requires a competent methodological approach and process management.

One of the possibilities for the educational process is courses that involve group project activities. This learning approach allows for not only the acquisition of necessary competencies through personal experience, but also the development of the ability to work in a group and organize collective activities. (Springer, 1999; Johnson 2013, 2014; Davidson 2014).

In the context of the transition to educational methods that involve active independent actions on the part of students, methods of managing the educational process and their anthropological prerequisites have been considered in a number of studies (Cohen, 1994; Millis, 2010; Jackson, 2019), but they are still a complex methodological task and require further development.

Conclusions

The educational process was simulated with the help of Lotka-Volterra equations. The academic group was formally presented as a non-linear dynamic system in order to find processes that limit students activities. Thr presented mathematical model requires a set of interpretations, assumptions and agreements and should be tested additionally. The model assumes that both the teacher's and each student's influence on the group's evolution is limited and external influence can be neglected.

Educational process efficiency based on projects activity of students inside small groups can be improved during the process of small groups formation. An optimal way of participation of each student can be defined at the base of a model of student academic groups evolution and analysis of statistically estimated matrix of relationships between students.

The educational process becomes more effective when it is based on intrinsic activity of students and mutually beneficial collaboration. It should not be a performance of one person, but a kind of dialogue or discussion of the participants, including the teacher. The model confirmed that smaller group activities and the execution of educational projects are effective in development of necessary skills.

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Okul Öncesi Dönem Çocukları için Üretken Yapay Zekâ Destekli Mahremiyet Eğitiminin Etkililiğinin Değerlendirilmesi

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Özet

Bu çalışma, okul öncesi dönem çocuklarına yönelik üretken yapay zekâ destekli mahremiyet eğitiminin tasarlanması ve uygulanabilirliğinin değerlendirilmesini amaçlamaktadır. Günümüzde dijitalleşmenin etkisiyle birlikte çocukların çevrimiçi ve fiziksel ortamlarda mahremiyet ihlallerine maruz kalma riski artmakta, bu durum erken yaşta verilecek mahremiyet eğitiminin önemini ortaya koymaktadır. Özellikle 3-6 yaş arası çocukların kişisel sınırlar, özel alan ve bedensel farkındalık gibi kavramları tanıması; onları olası istismar ve olumsuz deneyimlerden koruma noktasında temel bir beceri olarak değerlendirilmektedir.

Araştırma kapsamında, üretken yapay zekâ aracı olarak ChatGPT destekli hikâye tabanlı dijital materyaller ve çoklu ortam araçları geliştirilecektir. Bu materyallerin okul öncesi dönemde mahremiyet eğitimi açısından işlevselliği ve pedagojik katkıları değerlendirilecektir. Çalışma, Tasarım Tabanlı Araştırma (Design-Based Research) yöntemi çerçevesinde yürütülecek olup; materyal geliştirme, pilot uygulama, değerlendirme ve yeniden düzenleme süreçlerini içerecektir. Uygulama süreci sonrasında öğretmen ve ebeveynlerle yapılacak görüşmelerin yanı sıra gözlem formları ve araştırmacı günlükleri aracılığıyla veriler toplanacaktır.

Henüz uygulama aşamasına geçilmemiş olan bu araştırma, yapay zekâ destekli dijital eğitim materyallerinin okul öncesi dönemdeki çocukların mahremiyet eğitimi süreçlerine nasıl entegre edilebileceğine dair teorik bir çerçeve oluşturmayı hedeflemektedir. Bu bağlamda çalışma, hem alanyazına katkı sağlamayı hem de gelecekteki uygulamalara yön verecek bilimsel bulguların elde edilmesini amaçlamaktadır.

Anahtar Kelimeler: Mahremiyet eğitimi, okul öncesi, yapay zekâ, dijital hikâye, çoklu ortam

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Abstract

This study aims to design and evaluate the feasibility of generative artificial intelligence-supported privacy education for preschool children. In the context of increasing digitalization, the risk of children being exposed to privacy violations in both online and physical environments has grown significantly. This highlights the critical importance of providing structured privacy education at an early age. Especially for children aged 3 to 6, understanding concepts such as personal boundaries, private space, and bodily awareness is considered a foundational skill for protection against potential abuse and negative experiences.

Within the scope of the study, digital, story-based educational materials supported by generative artificial intelligence tools like ChatGPT will be developed. These materials will be enriched with multimedia elements and designed to support the privacy education process for preschool-aged children. The study will be conducted using a Design-Based Research (DBR) approach and will include stages such as material design, pilot implementation, evaluation, and revision. Data will be collected through observations, interviews with teachers and parents, and researcher journals during the implementation process.

As the project has not yet been implemented, this study primarily aims to offer a theoretical framework on how AI-supported digital materials can be integrated into early childhood privacy education. In this context, the research intends to contribute to the literature and generate scientific insights that will guide future applications in this field.

Keywords: Privacy education, preschool, artificial intelligence, digital story, multimedia

Giriş

Gelişimsel açıdan en hızlı öğrenme ve davranış edinimlerinin gerçekleştiği okul öncesi dönem, bireyin sosyal, duygusal ve bilişsel gelişimi açısından kritik bir süreçtir. Bu dönemde çocukların kişisel sınırlarını tanıması, özel

alan bilinci geliştirmesi ve bedensel farkındalık kazanması, sağlıklı bir kimlik gelişiminin yanı sıra onları olası ihmal ve istismar durumlarına karşı koruyabilmek için temel bir gerekliliktir (Köksal Akyol, 2015).

Günümüzde dijitalleşmenin hız kazanması, sosyal medya ve internetin yaşamın ayrılmaz bir parçası haline gelmesi, çocukların hem çevrimiçi hem de fiziksel ortamlarda mahremiyet ihlallerine daha açık hale gelmesine yol açmaktadır (Koçoğlu ve Avcı, 2021). Bu durum, erken yaşlarda kazandırılması gereken mahremiyet eğitiminin, yalnızca geleneksel yöntemlerle değil, teknolojik araçlarla da desteklenmesini zorunlu kılmaktadır. Araştırmalar, ebeveynlerin ve öğretmenlerin mahremiyet eğitimi konusunda bilgi eksiklikleri yaşadığını ve materyal desteğine ihtiyaç duyduklarını ortaya koymaktadır (Çakır, 2015; Çalışkan, 2019).

Mahremiyet eğitimi yalnızca cinsel gelişimle sınırlı olmayıp, çocukların kendi bedenlerini tanıma, başkalarının sınırlarına saygı gösterme, uygun sosyal ilişkiler kurma ve güvenli davranış geliştirme gibi çok yönlü bir yapıya sahiptir (Çelik, 2020; İpek, 2020). Bu bağlamda eğitimin sadece aile ortamında değil, okul öncesi öğretmenleri rehberliğinde ve çoklu ortam destekli öğrenme materyalleri aracılığıyla pekiştirilmesi önemlidir (Türkyılmaz, 2019).

Bu çalışma, yapay zekâ destekli dijital hikâyeler ve çoklu ortam materyalleri aracılığıyla çocuklara mahremiyet kavramının kazandırılmasına yönelik bir model geliştirmeyi amaçlamaktadır. Üretken yapay zekâ araçları, özellikle ChatGPT, çocuk edebiyatına uygun içeriklerin oluşturulmasında yenilikçi bir yaklaşım sunmaktadır (Kutlucan ve Seferoğlu, 2024; Zileli, 2023). Eğitimde teknolojinin pedagojik süreçlere entegrasyonu, öğrenmeyi destekleyici, etkileşimli ve kişiselleştirilmiş bir deneyim sağlamada önemli bir potansiyel taşımaktadır (Arık ve Seferoğlu, 2020; Tabier and Bakanay, 2023).

Bu çerçevede, çalışmanın temel motivasyonu okul öncesi dönemde çocukların mahremiyet bilinci geliştirmelerine katkı sağlayacak yapay zekâ destekli dijital materyallerin tasarlanması ve bu materyallerin öğretmen ve ebeveyn desteğiyle uygulanabilirliğinin değerlendirilmesidir.

Yöntem

Bu araştırma, okul öncesi dönem çocuklarına yönelik üretken yapay zekâ destekli mahremiyet eğitimi materyallerinin geliştirilmesi ve değerlendirilmesine odaklanan bir Tasarım Tabanlı Araştırma (Design-Based Research; DBR) çerçevesinde yürütülecektir. DBR yaklaşımı, eğitim uygulamalarını iyileştirmeyi hedefleyen, kuram ve uygulama arasında köprü kuran, sistematik ve yinelemeli bir araştırma süreci sunmaktadır (Wang and Hannafin, 2005). Bu yöntem, araştırmacının gerçek yaşam ortamlarında doğrudan uygulamaya dayalı müdahaleler tasarlamasına ve bu müdahalelerin etkililiğini sürekli veri toplayarak değerlendirmesine olanak sağlar (Sari and Lim, 2012; Kuzu, Çankaya ve Mısırlı, 2011).

Araştırma süreci üç temel aşamadan oluşacaktır:

1.1. Tasarım Aşaması

İlk aşamada, konuya ilişkin kapsamlı bir literatür taraması yapılarak mahremiyet eğitiminin temel bileşenleri ve okul öncesi döneme özgü gereksinimler belirlenecektir. Bu bilgiler doğrultusunda, üretken yapay zekâ aracı olarak ChatGPT kullanılarak çocukların gelişim düzeyine uygun, senaryo temelli dijital hikâyeler üretilecektir. Hikâyeler; "bedenim bana aittir", "özel alan", "izin verme", "iyi dokunuş-kötü dokunuş" ve "sır–sürpriz" gibi kavramlara odaklanacaktır. Üretilen içerikler görsel ve sesli ögelerle desteklenerek çoklu ortam materyallerine dönüştürülecektir. Tasarım sürecinde, ChatGPT'nin eğitilmesi için uzmanlar tarafından hazırlanmış yönlendirici veri setlerinden (promptlar ve örnek metinler) yararlanılacaktır.

1.2. Pilot Uygulama ve Veri Toplama

Geliştirilen materyaller, sınırlı sayıda öğretmen ve ebeveynin katılımıyla pilot olarak uygulanacaktır. Bu süreçte veri toplama araçları olarak nitel yöntemlerden faydalanılacaktır. Öğretmen ve ebeveynlerle yapılacak yarı yapılandırılmış görüşmeler, uygulama sırasında kullanılacak gözlem formları, kontrol listeleri ve araştırmacı günlükleri aracılığıyla veriler toplanacaktır. Gözlem formları çocukların kavramlara yönelik tepkilerini, öğrenme süreçlerini ve katılımlarını değerlendirmek amacıyla uzman görüşleri doğrultusunda geliştirilecektir. Veriler içerik analizi yöntemiyle çözümlenecektir.

1.3. Geliştirme ve Yeniden Uygulama

Pilot uygulama bulguları doğrultusunda dijital materyallerde gerekli iyileştirmeler yapılacak ve yeniden yapılandırılan materyaller daha geniş bir örneklem grubuna uygulanacaktır. Bu aşamada da benzer veri toplama araçları kullanılacak ve önceki bulgularla karşılaştırmalı analizler yapılacaktır. Süreç boyunca katılımcıların geri

bildirimleri, materyalin erişilebilirliği, pedagojik işlevselliği ve çocukların gelişimsel kazanımları açısından değerlendirilecektir.

Bu bütüncül yaklaşım doğrultusunda, çalışmanın çıktılarının hem eğitim bilimleri literatürüne hem de uygulamalı öğretim materyalleri tasarımına katkı sağlaması hedeflenmektedir. Ayrıca, üretken yapay zekânın okul öncesi döneme entegre edilmesine yönelik sistematik bir model önerisi sunulması amaçlanmaktadır.

Beklenen Bulgular

Bu araştırmanın sonucunda, üretken yapay zekâ destekli dijital materyallerin okul öncesi dönemde mahremiyet eğitiminin etkinliğini artırabileceği öngörülmektedir. Literatürde, çocukların özellikle 3–6 yaş aralığında kişisel sınırlar, özel alan, dokunma izinleri gibi kavramlara karşı duyarlılığının arttırılmasının, çocukları istismar ve ihmal risklerine karşı daha dirençli hale getirdiği vurgulanmaktadır (Çelik, 2020; İpek, 2020). Bu doğrultuda geliştirilecek dijital hikâye temelli ve çoklu ortam destekli eğitim materyallerinin, çocukların mahremiyet kavramlarını anlamalarını kolaylaştıracağı ve bu kavramların günlük yaşam bağlamında içselleştirilmesini destekleyeceği beklenmektedir (Sezgin, 2009; Nalçacı ve Ercoşkun, 2005).

Çalışma kapsamında kullanılacak olan ChatGPT gibi üretken yapay zekâ araçları sayesinde, çocuklara özgü dil kullanımı ve gelişim düzeylerine uygun içeriklerin üretileceği öngörülmektedir. Bu içeriklerin, çocukların bilişsel ve duyuşsal katılımını artırarak öğrenme sürecini daha etkileşimli ve kalıcı hâle getireceği düşünülmektedir. Ayrıca, öğretmen ve ebeveynlerin bu materyallere yönelik görüşleri aracılığıyla, materyallerin uygulanabilirliği, anlaşılırlığı ve pedagojik etkililiği hakkında kapsamlı veriler elde edilmesi beklenmektedir.

Pilot uygulama sürecinde toplanacak gözlem verileri ve görüşmeler ışığında; çocukların mahremiyetle ilgili temel kavramlara dair bilgi düzeylerinde artış olacağı, bu kavramları tanıma ve ifade etme becerilerinde gelişim gözlemleneceği tahmin edilmektedir. Aynı zamanda, eğitim materyallerinin etkileşimli yapısının çocukların dikkat süresi ve öğrenmeye katılım oranı üzerinde olumlu etkiler yaratması da beklenen sonuçlar arasındadır.

Sonuç olarak, bu araştırmadan elde edilecek bulguların; okul öncesi eğitimde yapay zekâ temelli içeriklerin pedagojik olarak nasıl yapılandırılması gerektiğine dair bilimsel ve uygulamalı çıktılar sunması öngörülmektedir. Bu çıktılar, eğitim politikaları ve materyal geliştirme süreçleri açısından da yol gösterici olacaktır.

Sonuçlar

Bu çalışmada, okul öncesi dönem çocuklarına yönelik üretken yapay zekâ destekli dijital materyaller aracılığıyla mahremiyet eğitiminin desteklenmesi amaçlanmaktadır. Geliştirilmesi planlanan hikâye tabanlı içeriklerin, çocukların gelişim özellikleri dikkate alınarak hazırlanması ve çoklu ortam unsurlarıyla zenginleştirilmesi, öğrenme sürecini daha etkili ve kalıcı hâle getirecek bir potansiyel taşımaktadır.

Araştırma süreci sonunda elde edilmesi beklenen sonuçlar doğrultusunda, üretken yapay zekâ destekli dijital materyallerin çocukların mahremiyet farkındalığını artırmada işlevsel olacağı öngörülmektedir. Bu materyallerin, çocukların kişisel sınırlarını tanıma, özel alan kavramını anlama ve güvenli sosyal ilişkiler kurabilme becerilerini desteklemesi beklenmektedir. Ayrıca, dijital hikâyelerin senaryolar yoluyla günlük yaşamla ilişkilendirilmesinin, çocukların deneyimledikleri durumları anlamlandırma süreçlerine katkı sağlayacağı düşünülmektedir.

Bu bağlamda, öğretmenlerin ve ebeveynlerin söz konusu dijital materyallerin uygulanabilirliği, anlaşılırlığı ve çocuk gelişimine katkısı konusundaki görüşleri, materyal tasarımı ve uygulanması açısından değerli geri bildirimler sunacaktır. Uygulama süreci sonunda, mahremiyet eğitiminin çocuklar üzerindeki kısa vadeli etkilerinin yanı sıra, uzun vadede davranışsal kazanımlar açısından da olumlu etkiler göstermesi öngörülmektedir.

Sonuç olarak, bu çalışmanın eğitim teknolojileri ve erken çocukluk eğitimi alanında yenilikçi bir uygulama modeli sunması, yapay zekâ destekli öğrenme materyallerinin okul öncesi eğitimde kullanılabilirliğine dair bilimsel temelli çıkarımlar sağlaması ve gelecekteki araştırmalara yön verici bir temel oluşturması beklenmektedir.

Teşekkür

Bu çalışma, Anadolu Üniversitesi Bilimsel Araştırma Projeleri Koordinasyon Birimi (BAP) tarafından desteklenmektedir. Araştırmanın planlanması ve geliştirilmesi sürecinde sağlanan mali ve kurumsal katkılardan dolayı Anadolu Üniversitesi'ne teşekkür ederiz.

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Case study of the WEIWER® Grey Literature: A Systematic Review inspired by the MAECC® method

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Abstract

By definition, and briefly, grey literature refers to texts that are not formally or commercially published, to which, therefore, may be difficult to get access to. Among the various types of documents encompassed by grey literature are academic works such as research projects, master's dissertations, doctoral theses, and postdoctoral reports. It is these works, particularly those carried out within the framework of the WEIWER® International Academic Network, that we aim to analyze, with the purpose of mapping their contributions and impact. To this end, and by employing the MAECC® method, a systematic review was conducted of a defined corpus, corresponding to the case study presented in this paper. The results indicate that the temporal scope of the 10 identified resources spans from 2012 to 2025, with most of the referenced studies meeting an operational dimension within the analysis of the Wikimedia ecosystem in education. It is also noteworthy that they pertain to diverse contexts (Portugal, Brazil, and Mozambique) and various levels of education (primary, vocational, and higher education). Thus, it can be concluded that there is a growing interest among researchers in themes related to the Wikimedia ecosystem, further highlighting the potential for its integration across different educational levels.

Keywords: WEIWER® International Academic Network, Wikimedia ecosystem, Educational research, Academic contributions, MAECC® method.

Introduction

The WEIWER® International Academic Network (*Wikis, Educação & Investigação* | Wikis Education & Research), hereinafter referred to as WEIWER® or the WEIWER® Network, was officially created in 2018 and unofficially in 2012 when the first research project began, which is covered in this meta-analysis. WEIWER® is located at the Distance Education and eLearning Laboratory (LE@D) of the *Universidade Aberta* (UAb), the Open University Portugal, and has the macro-objective of implementing and analyzing the use of Wikipedia in learning scenarios at different levels of education, exploring and studying that vast potential (Cardoso et al, 2024). This text is an excerpt of a broader investigation, in which we focus the context of grey literature (GL), a concept with a broad-spectrum status.

As Botelho & Oliveira (2017, p. 511) point out, GL is associated to "unconventional and non-commercial, semi-published publications, difficult to find through traditional distribution channels, with ineffective bibliographic control [...] and often not included in bibliographies and catalogs. They are produced in limited numbers and have variable production and publishing standards [...] They present highly updated and more detailed information and knowledge, reach a smaller audience and are not determined solely by commercial interests". Hence, it is this literature that we meta-analyze and present in a subsequent section. But, first, we briefly dedicate our attention to the conceptual framework that support WEIWER®, specifically the aspects inherent to open education and the operational aspects of the WEIWER® pedagogy. Then, in addition to presenting the problem and objectives, we also discuss the methodological design, specifically the case study and the Meta-model for Analysis and Exploration of Scientific Knowledge® (MAECC®). Finally, we present both the collected data and their discussion, guiding the conclusions and future research.

As mentioned above, WEIWER® is an international academic network based at UAb's LE@D. Fig. 1 presents its characterization data. All WEIWER® publications (white literature and grey literature) featured in the project's website are made available in the *Repositório Aberto*, the UAb Open Repository, which is indexed by the Open Access Scientific Repositories of Portugal (RCAAP). It is important to emphasize that the UAb, both the aforementioned repositories, and the LE@D laboratory itself are closely involved with issues associated with openness, and, within this dimension of openness, we highlight Open Education. Likewise, the Wikimedia Ecosystem is closely associated with that dimension, e.g. Wikipedia articles constitute Open Educational Resources (OER) and, when integrated into teaching practices, Open Educational Practices (OEP).

Project title:	Rede Académica Internacional WEIWER® - *Wikis, Educação & Investigação* | Wikis Education & Research
Coordination:	Teresa Cardoso
R&D Axis:	1. Theories and Practices in Open and Distance Education
R&D Unit Registration:	PTIN/UID4372-LEaD/012018
Project website:	https://lead.uab.pt/weiwer/

Figure 1. Characterization of the WEIWER® International Academic Network (Cardoso et al., 2024)

In this context, WEIWER® has operated, for more than a decade, at various educational levels (primary education, secondary education, vocational education, higher education, and adult education) and in several countries: Portugal, Brazil, and Mozambique. It has even partnered with one of the departments of the Portuguese Ministry of Education – the School Library Network – since the 2019/2020 academic year. Through this Wikipedia implementation at various educational levels, it was possible to consider the aspects associated with openness and their relationship at the curricular and/or pedagogical level. The WEIWER® Pedagogy, which we call WikiPedagogy, emphasizes the aspects associated with the openness, previously identified. Wikiliteracy emerges from these dimensions, which, according to Cardoso and Pestana (2004), presents itself as a broader dimension than the concept incorporated when it was introduced by Ball (2019). That is, it is not limited solely to wiki editing but integrates also a set of literacies allocated to digital literacy, namely Information Literacy, TransMedia Literacy and Critical Literacy. In other words, the curricular and/or pedagogical integration of the Wikimedia ecosystem, in general, and Wikipedia in particular, has the potential to promote a wide range of literacies, depending on the intended achievement. Finally, we note the "Digital Capital" that encompasses the entire framework. Addeo et al. (2023, p. 2) define it as "a set of internalized abilities and aptitudes [...] as well as externalized resources [...] that can be historically accumulated and transferred from one arena to another." Therefore, it is a capital that "contributes to life opportunities enhancement by creating a bridge between online and offline realms." Currently, as the authors explain, it comprises three levels (1st - "Access" ICT; 2nd - "Use" ICT; 3rd - "Tangible Outcomes"), the latter being associated with the effective contribution of the opportunities generated by that capital itself. More broadly, and according to Benoliel & Schechter (2023, p. 239), working with digital capital strengthens and influences social capital, economic capital, and cultural capital, allowing for the cultivation of "educational capacity and resilience in the school ecosystem, with a particular focus on the role of digital capital in reinforcing the school ecosystem capitals," thus representing the sixth capital. DuBose (2023, p. 50) also highlights the system of communicating vessels between the six capitals, stating that "[c]ommunities that are underrepresented in digital spaces are often also low in the traditional 5Cs". The relationship between Digital Capital and the editing of Wikipedia articles is also mentioned by the author, evidencing the breadth of literacies that digital literacy encompasses.

Methodology

We now address the questions and objectives that support this research. To the general research question, *How can we characterize the grey literature produced within the WEIWER® Network based on the MAECC® method?*, corresponds the general research objective, to characterize the grey literature produced within the WEIWER® Network based on the MAECC® method. This research objective is divided into four specific objectives:

1. To identify the contexts in which WEIWER® grey literature was created;
2. To describe the objectives that have motivated the development of WEIWER® grey literature;
3. To explain the methodologies used in the production of WEIWER® grey literature;
4. To highlight the implications of WEIWER® grey literature.

In turn, the specific research questions are the following:

- What are the contexts in which WEIWER® grey literature is created?
- What objectives have WEIWER® grey literature been developed for?
- What methodologies have been used in the production of WEIWER® grey literature?
- What implications do WEIWER® grey literature reveal?

Research Design

Regarding the research methodology of the study "WEIWER® Grey Literature Case Study: A Systematic Review Inspired by the MAECC® Method," which we developed, and as the name suggests, it focus on the meta-analysis of data, using a mixed-methods approach. The data emerges from the WEIWER®, specifically that which is listed in the project's website. So, as mentioned, this text is a fraction of a broader investigation, which includes, in addition to the 10 publications meta-analyzed here, all the resources published, including in proceedings books at scientific events.

Meta-analysis, a term coined in 1976 by Gene Glass, is one of the best-known processes of systematic literature reviews (Cardoso et al., 2010). It is a statistical method used to combine results from different studies to weigh, compare, and identify patterns, disagreements, or relationships that emerge across multiple studies on the same topic (Snyder, 2019). Chueke & Amatucci's (2022) corroborate this perspective, as they consider meta-analysis to be a methodological approach that, using statistical techniques, synthesizes empirical results from multiple studies. Moreover, it is an approach that presents several possibilities in the field of scientific research, namely: i) obtaining new results from the formulation of previously unconsidered conclusions; ii) comparing and contrasting seemingly contradictory results, analyzed with superior statistical power; iii) expanding existing theories or formulating new research hypotheses, based on a significant volume of studies. According to Kim (2023, p. 161), "systematic review and meta-analysis is a research methodology that involves the selection, review, critical evaluation, data collection, and analysis of all available literature using a predetermined, systematic, and explicit method to answer specific research questions". Kim (2023) also notes that, although meta-analysis consists of a statistical method that synthesizes and quantitatively analyzes the results of multiple studies on the same topic, the data analysis process can take the form of qualitative and quantitative syntheses. In this research, meta-analysis will be supported by the MAECC®, an analytical-methodological tool created by Cardoso (2007), comprising a computer-supported relational database, which, in our case, we created using an Excel spreadsheet.

Corpus of (meta) analysis

The publications considered in this study are research projects, master's dissertations, doctoral theses, and postdoctoral reports published on the WEIWER® website (https://lead.uab.pt/weiwer/). As can be seen in Fig. 2, there are 10 publications.

Codification	Title	Year of Publication
GL1	Open and Networked Learning in Educational Design: Meta-Analysis of References from TEDE/UNIFESP and Wikipedia	2020
GL2	The "Wikipedia Club" as a Digital Development Ecosystem with the School Library: A Case Study in Elementary Education in the District of Setúbal	2025
GL3	Wikipedia at the University Program: Meta-Analysis of Courses in the Lusophone Community Between 2011 and 2018	2020
GL4	Wikipedia as a Teaching and Learning Resource in Higher Education in Mozambique: A Case Study in a Library Science and Documentation Course	2024
GL5	Wikipedia as an Open Educational Resource: Conceptions and Practices of Students and Teachers in Online Higher Education	2014
GL6	Wikipedia as an Open Educational Resource: Training and Pedagogical Practices in Portuguese Elementary Education	2015
GL7	Wikipedia as an Open Educational Resource: A Contribution to the Program Wikipedia at the University	2018
GL8	Wikipedia as an open educational resource: curricular integration in vocational education	2024
GL9	Wikipedia in higher education: student and teacher conceptions and practices	2012
GL10	The "Wikipedia Club" as a digital development ecosystem with the school library: a case study in elementary education in the district of Viana do Castelo	2025

Figure 2. Meta-analysis corpus

Analysis instrument

Fig. 3 presents the analytical-methodological instrument, drawing on Cardoso (2007); it was initially constructed based on a first reading of the GL available on the WEIWER® website, followed by a more detailed analysis. As the author describes, the process is "interactive, because the aforementioned transformations were suggested by the theoretical (conceptual) framework that was being constructed and by the 'echoes of analogy' that emerged from the corpus analysis" (p. 50).

Meta-categories	Macro-categories
1. IDENTIFICATION:	1.1. Title 1.2. Author(s) 1.3. Year of publication 1.4. Framework 1.5. Type of academic exam 1.6. Instituição of test 1.7. Disciplinary area 1.8. Scientific orientation 1.9. Access
2. OBJECTIVES:	—
3. METHODOLOGIES:	3.1. Research methodologies 3.2. Study participants
4. IMPLICATIONS:	4.1. Conclusions 4.2. Suggestions for futures research

Figure 3. Meta-analysis grid supporting the study

Results

According to the Meta-analysis Grid supporting the study (Fig. 3), we can see that we are dealing with four MAECC® Meta-categories. The first refers to the Meta-category "Identification," which comprises 9 Macro-categories, starting with the "Titles," all of them are pointing to the Wikipedia phenomenon. It is important to note, however, that Wikipedia appears in different dimensions. Also, within the context of openness, other elements can be identified, such as OER (4 occurrences), OEP (1 occurrence), and Open and Networked Learning (1 occurrence). Let us reiterate that Wikipedia, as one of the projects within the Wikimedia ecosystem, assumes a dimension associated with openness, given that it is an OER, and its integration into teaching practices is an OEP. Regarding the "Authors" Macro-Category, we identify one researcher who authors four resources (Filomena Pestana), while the remaining researchers are the author of one resource each (Ana Batista, Emília Rodrigues, Luciano Gamez, Marcelino Muandichalira, and Natércia Santos). Regarding the "Year of Publication" Macro-Category, there are publications that began in 2012 and ended in 2025. The years 2012, 2014, 2015, and 2018 all had one publication, while the years 2020, 2024, and 2025 had two publications. The trend line identifies an upward and therefore positive trend in project participation. Regarding the Macro-Category "Framework," we can see that five publications correspond to Higher Education, these being carried out in the context of the Open University Portugal (3 occurrences), the Federal University of São Paulo (UNIFESP), Brazil (1 occurrence), and 1 occurrence at the School of Journalism - Manica Delegation in Mozambique. Another research assumes a meta-analytical nature, of a program aimed at Portuguese-speaking universities (Wikipedia at the University Program), and, therefore, it integrates 22 higher education institutions, 1 Portuguese and 21 Brazilian. Regarding Basic Education, we are in the presence of 3 publications, one that took place in the district of Lisbon, another in the district of Setúbal, and another in the district of Viana do Castelo, all in Portugal. The classes involved were the 6th grade (1 occurrence), the 7th grade (1 occurrence), and the 8th grade (2 occurrences). Finally, we identified the framework that developed in an 11th-grade class of the Professional Course in Tourist Information and Entertainment at a school in the municipality of Torres Vedras, also in Portugal. We can see that, although Higher Education – GL1, GL3, GL4, GL5, GL7, GL9 – predominates (5 occurrences), Basic Education has a significant presence – GL2, GL6, GL10 – (3 occurrences), and, lastly, Vocational Education (GL8) has one occurrence, demonstrating the versatility of curricular and pedagogical integration with Wikipedia in teaching practices. Regarding the Macro-category "Type of Academic Examination," there is a high number of master's degrees (7 occurrences) – GL2, GL4, GL5, GL6, GL8, GL9, GL10 –, followed by Postdoctoral programs (2 occurrences) – GL1 and GL3 –, and finally, Doctorates, with one occurrence (GL7). In the macro-category "Delivering Institution," it is important to note that the entire corpus corresponds to degrees awarded at the UAb. The data for the macro-category "Disciplinary Area" are all from the field of Education. In this area, there is consistency in Distance Education and E-learning (GL1, GL3, GL7), Information Management and School Libraries (GL2, GL4, GL10) and E-learning Pedagogy, with 3 occurrences each. In contrast, Pedagogical Supervision has 1 occurrence only (GL6). Regarding the macro-category "Scientific Supervision," it is important to highlight that two

supervisors were identified: Teresa Cardoso as supervisor (10 occurrences) – GL1 to GL10 –and Filomena Pestana as co-supervisor (4 occurrences) – GL2, GL4, GL8, GL10. Finally, in the macro-category "Access", all publications are open access (10 occurrences).

Regarding the Meta-category "Objectives," it shows two major segments: objectives corresponding to operational and non-operational research. The former are associated with, for example, the verbs "Implement," "Integrate," and "Contribute" (GL2, GL6, GL7, GL8, GL10), and the latter are associated with the verbs "Map," "Characterize," and "Know." Both segments have 5 occurrences. It is important to note that in the non-operative segment, we can identify meta-analytic research – GL1, GL3 – (2 occurrences) and exploratory research – GL4, GL5, GL9 – (3 occurrences).

Regarding the Meta-category "Methodologies" and within this the Macro-category "Research Methodologies", 7 investigations used the case study – GL2, GL4, GL5, GL7, GL8, GL9, GL10 – and 4 of them also used the project methodology (GL2, GL7, GL8, GL10). In addition, there is 1 occurrence (GL6) regarding the project methodology, and 2 occurrences related to Meta-analysis, specifically MAECC® – GL1 and GL3.

Regarding study participants, we provide partial data for each level of education. Higher Education, which includes publications GL1, GL3, GL4, GL5, GL7, and GL9, involved 135 faculty members, 4,118 students, 62 Wikipedia ambassadors, and 80 technicians in the field of Educational Design at UNIFESP. Regarding Basic Education, publications GL2, GL6, and GL10 involved two faculty members and 87 students. Finally, publication GL8, related to Professional Education, involved 36 students. As for the total data, the meta-analysed corpus integrated 4,250 students, 137 teachers, 62 Wikipedia Ambassadors and 80 technicians.

Regarding the Meta-category "Implications," we present the data inherent to the Macro-category "Conclusions." Therefore, taking GL6 as a starting point, we are faced with a Not Applicable (NA) situation, given that it is a research project. Regarding the non-operational, meta-analytic investigations (GL1 and GL3), they achieved their objectives; however, the former still requires further strengthening. In the dimension associated with exploratory (non-operational) investigations – GL4, GL5, GL9 – the proposed objectives were achieved too, meaning that an appropriate operational framework in each context was attained. Finally, the operational investigations – GL2, GL7, GL8, GL10, also like the previous dimensions, achieved their proposed objectives, and, therefore, translate learning contexts through the curricular and pedagogical integration of Wikipedia.

Regarding the data identified as "Suggestions for Future Research," which are substantiated as a Macro-Category integrated into the Meta-Category "Implications," it is possible to highlight, within the scope of non-operative and meta-analytic research, the consolidation of the meta-analysis (GL1) and its expansion to other platforms (GL3). Regarding the remaining non-operative research, two dimensions must be distinguished: GL9, which presents itself as a research project and therefore is NA; GL4 and GL5, in which the focus is static, descriptive, and measurable. That is, the survey was conducted with both students and teachers, and these participants acted as sources of data or opinions, without engaging in activities that promote the active construction of knowledge. Specifically, they surveyed the existing openness to integrating Wikipedia curricularly and pedagogically into their teaching practices. Both studies considered promoting the expansion of data collection to other situations, namely classes and courses (GL4, GL5, GL9). Finally, with regard to operational investigations (GL2, GL6, GL7, GL8, GL10), all future investigations will result in an increase in the number of participants (classes and courses) at each level of education they embody (Higher Education, Basic Education, Professional Education).

Conclusions

As mentioned, this text is an excerpt from a broader investigation, namely, the mapping of GL published on the WEIWER®, as listed in the project's website. In this case cohort, we map publications that are considered research projects, master's dissertations, doctoral theses, and postdoctoral reports. All 10 publications are open access (Access). It is possible to verify that the topics in the context of Wikipedia assume different dimensions (Title), whether by the educational level in which they are addressed (Framework) (Higher Education with 5 occurrences, Basic Education with 3 occurrences, and Vocational Education with 1 occurrence), or by their operational or non-operative nature (Objectives) (Operational with 5 occurrences and non-operative with 5 occurrences). These data, combined with the WEIWER® pedagogical framework, emphasize its validity. Its publication occurred between 2012 and 2025 (Year of Publication), corresponding to 7 occurrences for master's degrees, 1 occurrence for doctorates, and 2 occurrences for postdoctoral degrees (Type of Academic Examination). We can also highlight the case study as the most visible element, as it appears both alone and associated with the project methodology (7 occurrences), followed by the project methodology, which also appears both alone and associated with the case study (5 occurrences), and the MAECC® meta-analysis, with two occurrences (Research Methodologies). Moreover, those 10 research works involved 4,250 students, 137 teachers, 62 Wikipedia ambassadors, and 80 technicians (Study Participants). In "Implications," we note too that the "Conclusions" are positive regarding the

results achieved. Finally, both in-depth study and expansion to other contexts are anticipated as "Suggestions for Future Research". It is also noteworthy that they pertain to diverse contexts (Portugal, Brazil, and Mozambique) and various levels of education (primary, vocational, and higher education). Thus, it can be concluded that there is a growing interest among researchers in themes related to the Wikimedia ecosystem, further highlighting the potential for its integration across different educational levels.

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An Analysis of AI Trends in Instructional Technology from a Bibliometric Perspective

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Abstract

The growth and integration of artificial intelligence technologies into online learning environments have revolutionized educational practices. This research aims to comprehensively explore, which includes a bibliometric analysis and social network analysis (SNA) of scholarly publications indexed in one of the major databases, Web of Science (WoS), providing a deep understanding of the growth and structure of AI research in online learning. The systematic bibliometric studies illuminate publication trends, highly cited profile authors, and thematic clusters (Durak et al., 2024; Li & Wong, 2023), while the SNA provides a comprehensive collaboration analysis (Borgatti et al., 2018) of how AI increasingly shapes teaching and learning in open and distance education. These comprehensive findings approach reassures the validity and reliability, providing a solid foundation for future research and practice on how AI increasingly shapes teaching and learning in open and distance education (Alzahrani et al., 2024; Durak et al., 2024). Research strives to analyzes the collaborative networks within a substantial corpus of 620 seminal articles at the intersection of artificial intelligence and educational technology. Using social network analysis and a co-citation analysis of referenced articles, the author uncovers a distinct "network-of-networks" architecture. The results characterize a research ecosystem defined by decentralized global ties, intensely collaborative local teams, and a knowledge base anchored in interdisciplinary sources. Therefore, the global research ecosystem in AI and EdTech emerges as a complex, multi-layered structure, a finding clarified through our analysis of both collaboration and co-citation networks.

Keywords: Social network analysis, artificial intelligence, online education, bibliometrics

Introduction

Bibliometrics quantifies the attributes of documents or entities (Chen & Xu, 2024; Li & Wong, 2023), while SNA focuses on the relationship structure between nodes that connect them within a system. Social network analysis (SNA) uses a strong framework methodological and theoretical for studying the relationships among social entities, which are often represented as 'nodes' (individuals or entities) and 'ties' (relationships or interactions) in a graph structure. The perspective enables researchers to understand how social structures emerge and how they influence individual and group behaviour (Wasserman & Faust, 1994). SNA, as a concept, imitates social life as networks; SNA provides insights into collaboration patterns, information flow, influence, and collective action. SNA has been increasingly applied to a broad scientific spectrum from the social sciences, information science, and computational fields, emphasizing its interdisciplinary nature. The SNA method goes beyond simple two-person interactions to explore the larger connections network that influences social processes (Borgatti, Everett, & Johnson, 2018); therefore, it applies to individuals and organizations, institutions, and even countries, making it a flexible tool for interdisciplinary research. The relational orientation has made SNA central in studies ranging from online communities to global trade networks, fostering a sense of inclusion and belonging in a larger academic community. Artificial intelligence technologies' growth and integration into online learning environments have revolutionized educational practices. Consequently, it has opened new options to adaptive learning, personalized feedback, and data-driven pedagogy, manifesting hope for the future of education. A systematic review of literature by Dogan et al. (2023) and Mustafa et al. (2024) shows that AI applications in online education significantly influence learner outcomes, especially in engagement, personalization, intelligent tutoring, and analytics. These developments are described in the literature as promising and inspiring for the future of education. Contemporary studies reveal that AI in online learning research is organized around distinct clusters, including language learning applications, personalized learning systems, and performance-focused analytics

Although the bibliometric indicators reveal insights in the scientific field, SNA uncovers the diffusion of knowledge in any field through mapping co-citation and co-authorship patterns that reveal the cohesiveness of scientific research.

Moreover, social network analysis (SNA) highlights the role of bridging scholars and institutions that connect fragmented research areas, fostering a sense of community and facilitating interdisciplinary collaboration. By combining bibliometric indicators with network perspectives, this study not only quantifies the impact of AI in online learning but also illuminates the intellectual and collaborative dynamics driving the field's development, making you feel part of a larger community.

Social Network Analysis

Key metrics in SNA describe nodes' relative position and influence within a network. Freeman's (1979) seminal work from sociology into social network analysis as a groundbreaking framework. SNA measures centrality, such as degree, betweenness, closeness, and eigenvector centrality, which capture the different dimensions of importance and influence in the system. A node with high degree centrality is usually located at the center of the graph. A node with high betweenness centrality often acts as a connector between groups, controlling the flow of information. Similarly, closeness centrality highlights how efficiently a node can reach others, while eigenvector centrality emphasizes influence through well-connected neighbors.

In other words, key measures in social network analysis (SNA) are commonly defined in the literature and include centrality, density, and community detection metrics (Borgatti, Everett, & Johnson, 2018; Wasserman & Faust, 1994). Applying these metrics is crucial in understanding the structure and dynamics of social networks, as they provide insights into the roles of individual nodes, the overall connectedness of the network, and the presence of substructures (AI Central, 2024).

> Degree centrality, which counts the number of direct connections a node has, is a powerful tool for understanding the immediate activity level of a node. It can help you identify key players in a network and predict how information or influence might flow.
>
> Betweenness centrality measures how often a node connects two nodes in the shortest path between them, and it is a fascinating concept. It reveals the flow of information and resources in the networks as a transitivity.
>
> Closeness centrality shows the closeness of a node to all others based on shortest paths, indicating accessibility within the network.
>
> Eigenvector centrality indicates how a node is in relation to its influential neighbors.
>
> Density shows the relativity of connections of all the nodes to the overall possibility of connections, reflecting overall network cohesion.
>
> Communities (clusters) groups of similar internally structured nodes within the whole system.

Looking beyond individual-level metrics, SNA also underscores network-level characteristics such as density, reciprocity, and clustering. High-density networks may facilitate trust and collaboration but foster redundancy and groupthink (Granovetter, 1973). Zakimi et al. (2023) state that "*community detection methods play a crucial role in unveiling subgroups within larger systems, providing insights into homophily, cohesion, and the diffusion of ideas*" (p. 3). SNA's core concepts form the foundation for analyzing how social structures shape outcomes in various domains, including education, health, and organizational studies.

Social network analysis has evolved from two conceptual theories —sociological and graph theory —into a cross-disciplinary toolkit, driven by advancements in computational power and methodological innovation. Table 1 presents recent publications that highlight its expanding applications, ranging from technical deep learning methods to solving practical problems in public health and addressing policy issues. Since its inception, Social Network Analysis (SNA) has been widely used in academia to study collaboration and mapping intellectual structures. Its interdisciplinary nature, evident in the study of co-authorship and citation networks, helps reveal disciplinary boundaries and the diffusion of ideas across fields (Chen, 2006). However, bibliometric studies remain important for identifying citation counts and productive scholars and institutions. Early studies by scientists demonstrate that such relational analyses offer a vital perspective on scientific communication that is more comprehensive than citation counts alone (Katz & Lazarsfeld, 1955), indicating the existence of communities among researchers and professionals.

Recent work highlights the evolution of SNA, expanding its applications into new and diverse contexts. For example, SNA has been successfully applied to public administration, as well as the organizational, public, and private sectors, leading to methodological innovations (Xiao, Si, & Guo, 2024). In the field of social media and behavioral health, researchers have studied he interconnections among problematic usage components, presenting a network-based view of digital well-being (Chen et al., 2025). Additionally, advancements in community detection have presented a new technique for uncovering and interpreting, particularly in large networks and

dynamic systems (El-Moussaoui et al., 2025). It shows that SAN studies not only portray the adaptation of SNA within various scientific domains but also its elaboration, keeping the audience informed and up-to-date with the latest developments in the field.

By applying bibliometric analysis and social network analysis, the aim is to address and answer the following research questions:

Table 1. Recent publication using social network analysis method

Topics	Citation	Key Contribution
Deep Learning & Community Detection	El-Moussaoui et al. (2025)	Provides a systematic review of deep learning architectures (e.g., graph neural networks) for community detection, synthesizing challenges such as scalability and interpretability in dynamic networks.
Behavioral & Psychological Modeling	Chen et al. (2025)	Models the network structure of problematic social media use components, demonstrating the interconnections between negative emotional outcomes and addiction-like behaviors rather than treating them as isolated symptoms.
Tools & Evaluation	Amure and Agarwal (2025)	Offers a comparative evaluation of popular SNA software (e.g., NetworkX, iGraph) based on performance and usability, providing practical guidance for tool selection, especially for large-scale networks.
Public Administration & Policy	Xiao et al. (2024)	Reviews 144 empirical papers to identify a methodological shift in the field toward inferential techniques like exponential random graph models and a stronger integration of theory.
Bibliometrics & Literature Review	Cowhitt et al. (2024)	Introduces a novel longitudinal mixed-methods SNA approach to map the evolution of ambiguous ideas within scientific literature, enhancing the methodology for systematic reviews.
Combining Network Analysis and Topic Detection	Rizzoli, da Silveira, De Falco, Sarrica (2024)	Connects relationship patterns with shared ideas and meanings
Networks revisited: Social media, inequality in TV production	David Lee (2024)	How social media affects career opportunities and inequality
Sampling Methods	Alizadeh et al. (2024)	Empirically compares methods for generating a national random sample of Twitter users, addressing a critical challenge in the generalizability of social media-based research.

- What are the most cited Articles (references) in the in AI, and online learning?
- What is the author collaboration network characteristics?
- What is the educational collaboration network characteristics?
- What is the country collaboration network characteristics?

Methodology

WoS is the most reliable reference database, with high ethics and standards. Two terms used in the query were "artificial intelligence" and "educational technology" as topics in the Web of Science, with no time restrictions, including the core database. Six hundred twenty articles, including their bibliographic data, were retrieved with no time restrictions, ensuring the study's inclusivity. A comprehensive analysis was conducted, with 620 records extracted using Bibliometrix, a powerful tool for bibliometric analysis, within RStudio version 2025.05.0. The bibliometrics analysis was created and mapped at the command line using the reference manual available at this address (www.bibliometrix.com). Bibliometrix (Aria, M., & Cuccurullo, C., 2017) was used to calculate the network characteristics. Vosviewer (Van Eck, N. J., & Waltman, L., 2010) was used to map a paranomic view of the networks. The following sections present the results and discussion, which are then discussed.

Results

Co-citation network Structure

Figure 1 illustrates the most frequently co-cited documents, mapped into two separate clusters, and their intellectual structure in terms of their relationships. Two clusters represent a cohesive body of literature. The classic works, such as those by Hair et al. (1998), Zawacki-Richter (2019), and Chen (2016), are in the red cluster.

Authors' seminal works set a solid framework, with new perspectives including methodological guidance in the scientific realm. The almost large node sizes within this cluster indicate that these studies are frequently cited together, highlighting their ongoing influence and higher centrality in the research domain.

Conversely, reflecting the current research, the blue cluster is dominated by contemporary publications, presenting the new research facade. One can say that group of studies demonstrates how new applications, empirical findings, and methodological innovations are emerging, often in response to evolving scholarly and practical challenges. The presence of bridging connections between the red and blue clusters illustrates how contemporary research is grounded in established theory, while simultaneously expanding the field in new directions.

The dynamic interplay between the foundational works and the emerging studies suggests both continuity and innovation, highlighting the field's ability to adapt to new contexts while maintaining strong theoretical roots.

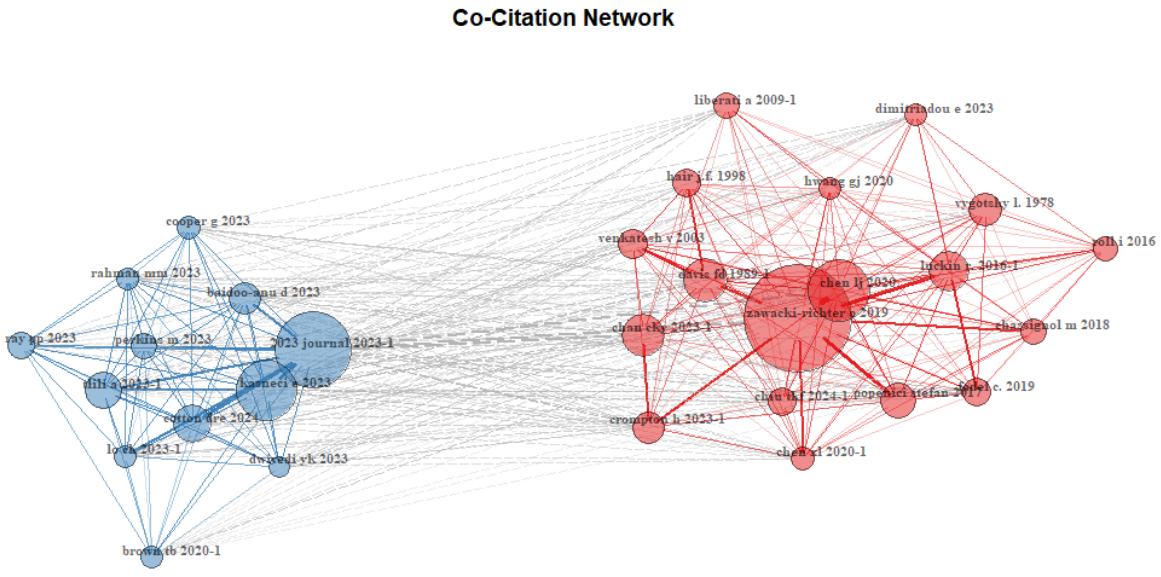

Figure 1. Co-citation network of the analyzed publications (References). The network shows two major clusters: (a) a red cluster of seminal works (e.g., Hair et al., 1998; Zawacki-Richter, 2019; Chen, 2016) that form the theoretical backbone of the field, and (b) a blue cluster of recent studies (mostly 2023) that represent the current research front. Node size reflects co-citation frequency, and edges represent co-citation links.

Table 2 depicts network attributes comprises a total of 25,745 nodes, indicating a vast number of interconnected nodes. Despite its large size, the low density value of 0.004 indicates that only a small number of nodes are connected, which is typical of large-scale scholarly networks. The transitivity coefficient (0.577) suggests a moderate tendency for connected nodes to create a cluster that eventually connects to other neighboring clusters

as well. The diameter of 7 and an average path length of 2.985 suggest that, although the network is vast, most nodes can be reached through relatively short paths, reflecting a "small-world" structure. Furthermore, the degree of centralization value (0.19) indicates a fair engagement of ties around a limited number of highly connected nodes, suggesting that while some actors serve as central hubs, influence is not overly dominated by a single source (Wasserman & Faust, 1994).

Table 2. Descriptive statistics about the co-citation (References) network were calculated in bibliometrix

Size	25745
Density	0.004
Transitivity	0.577
Diameter	7
Degree Centralization	0.19
Average path length	2.985

Co-universities network structure

Figure 2 depicts a panaromic VOSviewer network map visualizing research collaborations between universities, with Arizon a State University appearing as a central or key player. The graph is made of four distinct clusters, and each clsuter represent s a group of closely collaborating institutions: one cluster links Beijing Normal University with Nanyang Technological Univ ersity; another connects East China Normal University with Zhejiang University of Technology; a third pairs Universiti Sains Malaysia with The Education University of Hong Kong; and a final cluster consists of Lingnan University. Overall, the visual ization highlights a collaborative network spanning major academic institutions in the United States, mainland China, Hong K ong, and Southeast Asia.

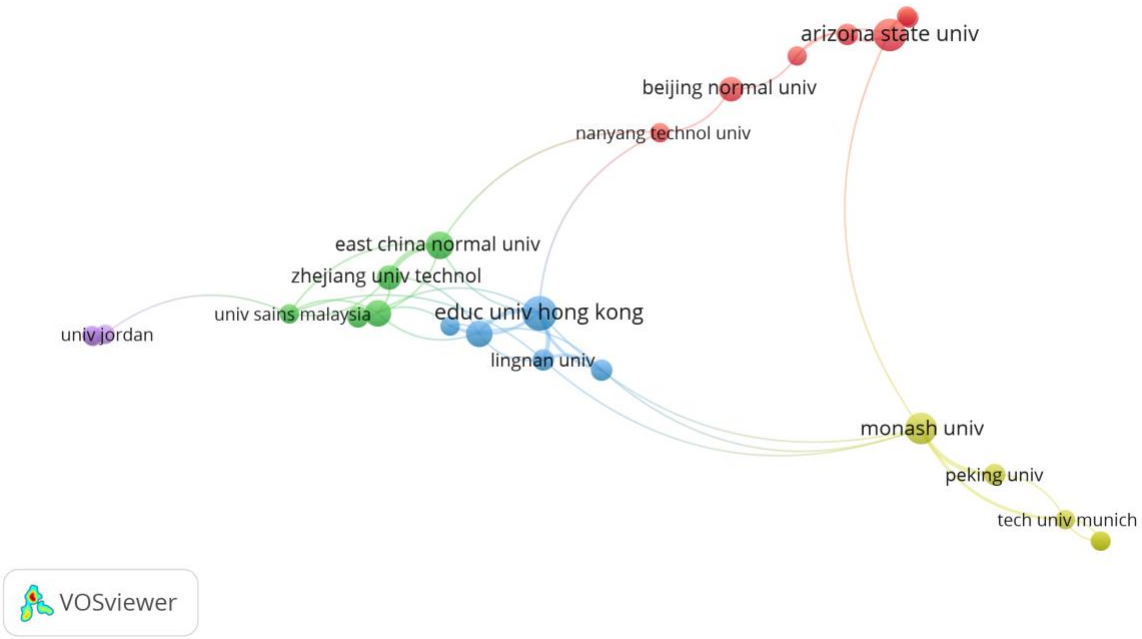

Figure 2. Universities collaborations in AI and Educational technology

Table 3. Descriptive statistics about the co-education collaboration network were calculated in bibliometrix

Size	87
Density	0.087
Transitivity	0.54

Diameter	5
Degree Centralization	0.355
Average path length	2.308

A total of 87 nodes, characterized by a compact system with a moderate density of 0.087, indicating a meaningful level of connectivity without being overly dense. A strong local clustering indicates a transitivity of 0.54, showing that connections often form tight triangles. The network is highly efficient for information flow, as its average path length of 2.308 and diameter of 5 mean that any two nodes are only a few steps apart. Moreover, the moderate degree of centralization, at 0.355, suggests a structure that is not entirely decentralized but has some influential hubs that play a key role in holding the network together (see table 3).

Co-countries network structure

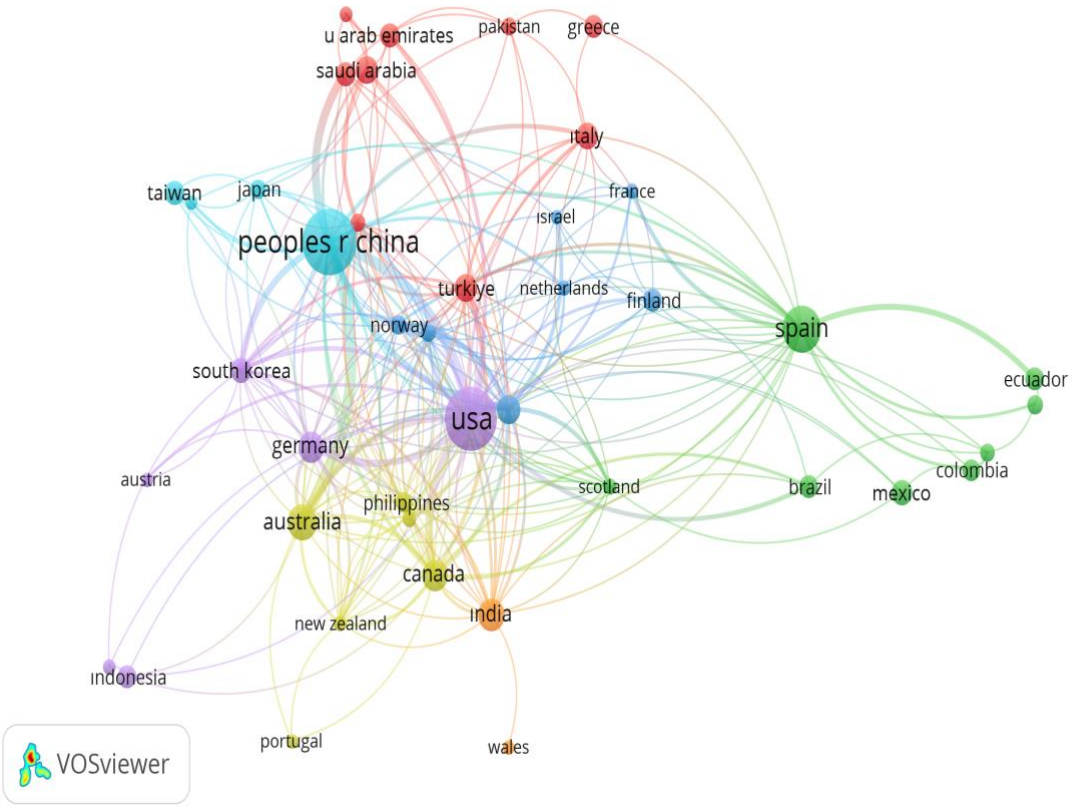

Figure 3. Co-countries collaboration network of AI and Educational technology

VOSviewer maps and visualizes the global landscape of international research collaboration between countries. The presence of nations from every inhabited continent—including the USA, Germany, and France, representing North America and Europe; Saudi Arabia and the UAE, representing the Middle East; Japan, India, and China, representing Asia; and Australia and New Zealand, representing Oceania—indicates a truly worldwide scope of scientific cooperation. The visual clustering of certain countries, such as Norway, the Netherlands, Finland, France, and Spain, likely reveals powerful regional partnerships or shared research priorities within Europe. Similarly, the proximity of the USA to Canada, Germany, and Australia suggests these nations act as major central hubs in the global research network. The overall structure illustrates how scientific collaboration forms a complex web that connects established research powerhouses with rapidly developing scientific communities worldwide.

Co-authorship network structure

The authors, such as Greiff Gamuel, Yan Liwang, and Shen Weijie, lead the collaboration in their cluster, which is a Prominent node central to the network's dense interconnections. Therefore, it suggests that these researchers

frequently collaborate on publishing papers, forming the intellectual core of the network. Other authors, such as Gasevic Dragan and Martinez Maldonado Roberto, may appear as separate but linked nodes, representing distinct sub-groups or interdisciplinary collaborators who bridge this central cluster with other specialties.

The current network in the figure reveals a well-connected structure, likely that of a multidisciplinary research team focused on AI and its implications for education, with a few key statistics acting as primary hubs for collaboration and knowledge exchange (See Fig 4 and Table).

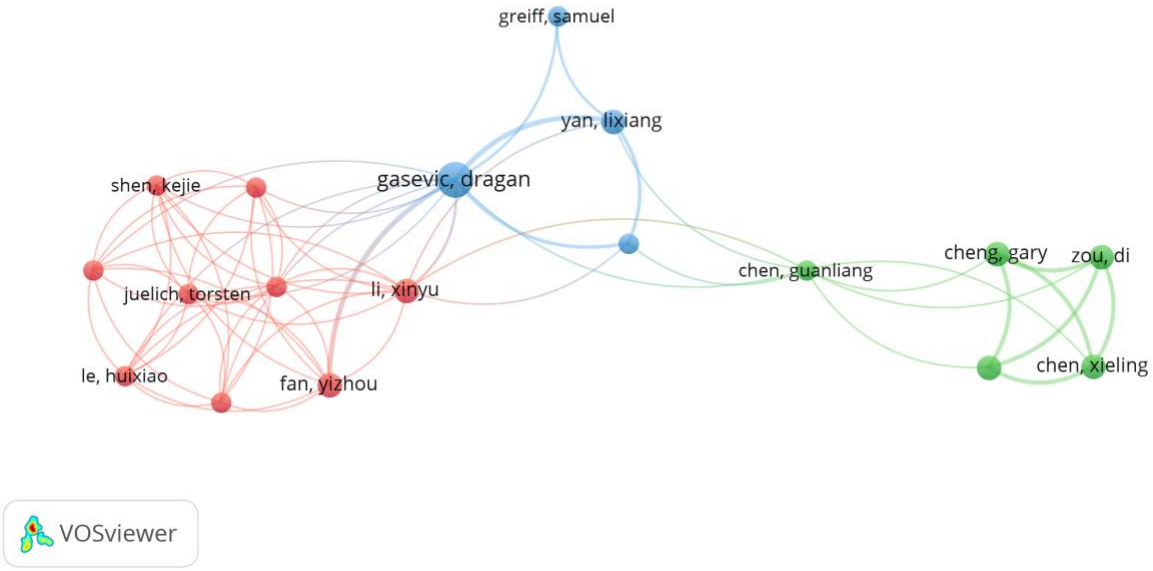

Figure 4. Co-authors collaboration network of AI and Educational technology

Network maps the collaborative relationships among 2,017 authors within a specific scientific domain, specifically AI and online Technology. The large size of the network indicates a substantial and active scholarly community. Its extremely low density (0.003) reveals that while the community is extensive, direct collaboration between any two authors is rare; the network is sparse. However, the near-perfect transitivity (0.946) is the defining feature, indicating that authors overwhelmingly publish in tightly knit, closed teams. If Author A works with B, and B works with C, then A and C are very likely to have also collaborated. In other words, transivity creates a structure of dense, isolated clusters. The combination of a long diameter (13) and a moderately high average path length (4.8) confirms that the network is not a single, well-mixed group but is instead a "long chain" of interconnected clusters, where it takes many steps to connect authors from distant parts of the network. The very low degree of centralization (0.03) finalizes this picture, indicating a decentralized community with no single, dominant author acting as a central hub, but rather one governed by numerous, tightly knit collaborative groups.

Figure 5. Descriptive statistics about the co-author collaboration network were calculated in bibliometrix

Size	2017
Density	0.003
Transitivity	0.946
Diameter	13
Degree Centralization	0.03
Average path length	4.797

Summary of Research Findings

1. What are the most cited Articles (references) in AI and online learning?
Our co-citation analysis reveals that the intellectual foundation of this field is built upon a core set of highly cited references. The most prominent are systematic reviews (e.g., Zawacki-Richter et al., 2019), which provide essential mapping of the nascent field; These articles form the essential "core curriculum" cited by researchers to establish context and legitimacy

2. What are the characteristics of the author collaboration network?
The author collaboration network is extensive (2,017 authors) but highly fragmented. It is characterized by an extraordinary level of local clustering (Transitivity: 0.946), indicating that researchers tend to work in small, tight-knit teams. However, the network is sparse (Density: 0.003) and decentralized (Degree Centralization: 0.03), meaning there are no single dominant authors. This structure creates a "network of networks" where innovation occurs within specialized, closed clusters, with long paths (Average Path Length: 4.8) connecting disparate groups.

3. What are the characteristics of the educational collaboration network?
The institutional collaboration network, inferred from country and author data, reveals a structure where a few key universities, such as Arizona State University, Beijing Normal University, and East China Normal University, serve as central hubs within their respective clusters. These institutions form the backbone of distinct collaborative groups, linking regional researchers and serving as bridges to the global network. The educational collaboration is therefore characterized by strong, hub-and-spoke systems centered around major research-intensive universities.

4. What are the characteristics of the country collaboration network?
The country collaboration network is a global "small-world" system. Major research-producing nations, such as the USA, China, Germany, Australia, and Saudi Arabia, serve as central hubs with extensive international connections. Despite this global connectivity, strong regional clustering is evident, with distinct collaborative blocks in Europe, Asia, and the Middle East. Results demonstrate a pattern in which geographic and cultural proximity fuel regional partnerships, which are, in turn, integrated into the wider global network through these major hubs.

Limitations of the study

While this study provides a comprehensive overview, its findings are subject to several limitations:

1. **Database Scope:** The analysis relied solely on the Web of Science (WoS) core collection. While WoS is renowned for its quality control, it excludes other databases that include other journals, which
2. **Search Query Specificity:** The study's scope is defined by the specific query of the two terms "artificial intelligence" and "educational technology." To distinguish between the broad and strict meanings of terms, a more complex query is needed.
3. **Methodological Focus:** The bibliometric approach excels at revealing the structural "what" and "who" of a research field but cannot explain the "why" behind the observed collaborations. The reasons for cluster formation, the nature of the knowledge exchanged, and the success factors of partnerships remain inferential without qualitative data.

Conclusions

In summary, according to the literature, social network analysis reveals the collaborative anatomy of the rapidly evolving field of AI in Educational Technology research. For the sake of clarity in network visualizations, specific strengths, such as graph threshold and the number of authors based on their link strength in the network, are considered. The USA, China, and Germany emerged as global hubs, functioning as central nodes. The macro-level "small-world" structure of this network facilitates the rapid global dissemination of pivotal findings in areas such as machine learning and adaptive learning systems. However, this broad connectivity is underpinned by distinct regional clusters, suggesting that local innovation ecosystems, funding priorities, and educational policies significantly shape collaborative efforts in AI-driven education.

At the meso-level, the author collaboration network reveals a highly specialized social fabric. Although the high clustering coefficient suggests yields in interdisciplinary clusters, where computer scientists, educators, and psychologists collaborate closely on specific challenges, such as automated assessment or AI ethics, are often formed. The very low degree of centralization indicates that a few individuals do not dominate the field; instead, it is propelled by numerous, decentralized cluster groups.

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Analysing Lecturer Engagement in Online Learning Environments: Trends and Implications

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Abstract

The Learning Management System (LMS) has become a cornerstone of interaction between lecturers and students at modern universities, supporting not only online teaching, but also enhancing traditional, face-to-face learning. For students to succeed in increasingly digital academic environments, it is essential that lecturers are both confident and competent in using such platforms. However, widespread adoption remains difficult to achieve in the absence of clear incentives or institutional pressure. The COVID-19 pandemic triggered a period of Emergency Remote Teaching (ERT), during which lecturers were compelled to engage extensively with digital technologies. This sudden shift may have exposed previously sceptical users to the pedagogical value of the LMS. As such, the question arises: Did COVID-19 act as a catalyst for LMS adoption in higher education? This study investigates LMS usage at the Central University of Technology, Free State (CUT), by comparing platform engagement data from 2019 and 2023, years that directly precede and follow the ERT period. The dataset includes three key metrics captured from the LMS: total logins, total hours spent, and total clicks, analysed for both lecturers and students. Descriptive statistics were used to explore engagement trends, followed by a one-way Analysis of Variance (ANOVA) and Tukey's Honest Significant Difference (HSD) post-hoc test to determine statistically significant differences between user groups and time periods. Findings reveal a significant overall increase in LMS engagement from 2019 to 2023, with students demonstrating statistically significant growth across all three metrics. Lecturer engagement also increased, particularly in terms of time spent and clicks. These results suggest that the ERT period may have served as a behavioural tipping point for technology adoption. Insights from this study can inform the design of more effective institutional strategies to encourage sustained LMS use beyond periods of crisis.

Keywords: Learning Management System (LMS), Emergency Remote Teaching (ERT), Technology Adoption, Higher Education, Lecturer Engagement.

Introduction

Emergency Remote Teaching (ERT) during COVID-19 lockdowns changed the trajectory of online learning rhetoric and research. One can only imagine what journal article titles would have looked like if there were no pandemic. It is rare for a global community, in this case instructional designers, to be so absorbed by a single topic. Even now that the pandemic has ended there is still a lot of data to be studied on its effects in the online learning environment. One question that many instructional designers are pondering is the effect ERT had on their university. Numerous global reviews have documented the transformative impact of COVID-19 on digital learning strategies in higher education (Aristovnik et al., 2023), providing context for the institutional focus of this paper.

However, one persistent challenge in digital education is understanding what prompts lecturers to meaningfully adopt and sustain use of Learning Management Systems (LMS). The value of collaborative tools in online environments has been emphasised for over two decades (Bernard & Rubalcava, 2000), yet lecturer confidence in using them remains a barrier.

At the Central University of Technology (CUT), Free State, all classes were conducted remotely from March 2020 to October 2022. Classes during the two adjacent years, 2019 and 2023 were facilitated with a blended, student-centred approach as is the university's standard practice. The question driving this paper is "Did COVID-19, unintentionally, serve as a catalyst for LMS adoption?" Comparative data from the two years could enlighten the way in which the LMS is understood and adopted.

The aim is to determine whether there is a significant difference in LMS engagement metrics – total logins, time spent, and number of clicks – across these two years for both students and lecturers. Understanding what drives LMS adoption can help institutions design more effective support strategies and training interventions. If the data shows that ERT led to a sustained increase in LMS usage, it may offer valuable insight into how behavioural change in digital learning can be initiated and sustained, even beyond the urgency of a global crisis.

The paper will start off with a summary of the current literature on LMS usage and the impact of COVID-19 thereon. Thereafter, the methodology will be outlined and results captured and discussed. The paper will conclude with the impact extrapolated and what this could mean for the future of online learning.

Literature Review

An LMS is a web-based software that allows an instructor to facilitate, manage and assess learning outcomes in an online environment. Turnbull, Chugh and Luck (2021) defines an LMS as "online learning technologies for the creation, management and delivery of course material." The definition may seem vague, but for a good reason. These systems come in different shapes and sizes, and some can even be customised to the institution. On top of the different types of LMSs, instructors often design their own learning environment within these open architecture spaces based on their subject needs and the learning outcomes that underpin the instructional design plan. Because of the multitude of ways in which these systems can be implemented, it is often difficult for instructional designers to know how the system is engaged and what factors influence lecturers to use it.

LMS Engagement

For an institution to mandate a blended learning approach using its LMS as the central point for the online learning environment, the management must be sure that the system is being engaged by both instructors and students and understand any reasons behind non- or low adoption. Bradley (2021) notes that despite broad institutional adoption of LMS platforms, many lecturers still underutilise their full functionality, pointing to a need for deeper support and training structures. This data is also important for instructional designers who support and train the user of the LMS. Not to be confused with engagement in a learning context which is made up of behavioural, cognitive and emotional engagement (Pedler & Hudson, 2020), LMS engagement refers to the relationship users have with the LMS used by their institution.

Factors that could prevent users from engaging the LMS include, but are not limited to, digital literacy, technological competence, previous experience, the complexity of the system and ease of navigation. In a South African context, access to technology can be included. Some studies also include hedonic factors which could affect users' intrinsic motivation for engaging (Rasheed, Kamsin, & Abdullah, 2020).

The variability in adoption levels can also be understood through the lens of Diffusion of Innovations theory (Rogers, 2003), which describes how new technologies spread through stages, from initial awareness to sustained use, and categorises adopters from early adopters to laggards. Botha, Smuts, and de Villiers (2021) applied this framework in the South African higher education context, illustrating how LMS feature implementation often follows predictable adoption curves. Their findings highlight the importance of institutional support and timely interventions to accelerate uptake, particularly among late adopters.

Measuring LMS Engagement

LMS engagement can be measured through platform analytics, which provide data on time spent in the system, number of logins, clicks, content views, and communication activity. Among these, time spent and frequency of interaction (e.g., clicks) are often used as practical proxies for engagement. Kittur, Bekki, and Brunhaver (2022) note that time-on-platform alone can offer valuable insights into learner or instructor behaviour and areas needing support. Metrics like clicks can also reflect interactive elements, such as collaborative discussions or peer assessments, which have been shown to improve learning outcomes (Oyarzun & Martin, 2023).

Enhancing LMS Engagement

Encouraging the adoption of the LMS can be difficult without an incentive that appeals to both lecturers and students. Collaborative tools within LMSs, such as group assignments and discussion forums, are shown to increase student engagement when effectively integrated (Demosthenous, Panaoura, & Eteokleous, 2020). One reason for poor adoption can simply be not being confident in using the software. Instructional designers employ multiple strategies to improve competence in the LMS by providing support and training to all users, but few interventions are as impactful as necessity. The shift to ERT during the pandemic created exactly such a necessity. Not only did the forced social distancing during the pandemic force competence but also showed universities' management how important adoption of the LMS is (Ziraba, Akwene, Mariana Nkea, & Lwanga, 2020). Some studies also note that flow and intrinsic motivation contribute to the likelihood of continued LMS use, especially when students experience positive engagement during their interactions with the system (Goh & Yang, 2021).

Methodology

LMS usage metrics data was extracted from Blackboard Data for the Central University of Technology production instance. Two full academic years were selected: 2019 (pre-ERT) and 2023 (post-ERT), each representing a time when blended learning delivery was campus-based. These years were selected as they directly abutting the university's ERT period, allowing for a focused comparison of LMS engagement before and after the pandemic-driven digital shift.

The data set includes records for both students and instructors defined as follows:

- Instructors: Lecturers enrolled with full administrative access to their course sites.
- Students: Registered participants enrolled via the institutional Student Information System (SIS) integration.

The LMS engagement metrics that were analysed are as follows:

- Total logins: The number of times the user accessed the LMS. This is a proxy for habitual use and system reliance (Song & Zheng, 2024).
- Total hours spent: The cumulative time spent within the LMS environment, a depth-of-engagement indicator (Kittur, Bekki & Brunhaver, 2022).
- Total clicks: The number of interactions registered by the LMS interface. A user will click more often in active engagement as with a discussion forum than they would during passive reading of a long article.

These metrics were selected based on their availability through LMS analytics and their established use in studies of platform-based learning behaviour (Heil & Ifenthaler, 2023).

Table 1. Description of the dataset

Measure→ User↓	Total Logins	Total Hours Spent	Total Clicks
Instructor	Number of times the lecturer logged into the LMS module	Time (in hours) the lecturer spent actively logged into the LMS module	Number of mouse clicks per recorded session
Student	Number of times the student logged into the LMS module	Time (in hours) the student spent actively logged into the LMS module	Number of mouse clicks per recorded session

Descriptive statistics (mean, median, standard deviation) were used to summarise LMS engagement patterns. To test for differences across user-year groups (2019 instructors, 2023 instructors, 2019 students, 2023 students), a one-way Analysis of Variance (ANOVA) was conducted. Where the ANOVA indicated significant results, Tukey's Honest Significant Difference (HSD) post-hoc test was used to identify specific group differences (Abdi & Williams, 2010; Chmiel, Wallan & Haberland, 2022).

Results

The analysis focused on three LMS engagement metrics: total logins, total hours spent in the system, and total clicks. Descriptive statistics for these metrics across two user roles (instructors and students) and two academic years (2019 and 2023) are presented in Table 2.

Table 2. Descriptive statistics for LMS engagement by year and user type

		Total Logins			Total Hours Spent			Total Clicks		
		mean	std	median	mean	std	median	mean	std	median
Year	User Type									
2019	Instructor	14.32	21.06	5.0	5.13	13.49	0.69	165.37	353.85	41.0
2019	Instructor	12.89	17.53	6.0	1.75	4.58	0.2	76.93	133.95	26.0
2023	Student	13.82	24.13	4.0	7.74	21.37	0.55	196.41	583.03	21.0
2023	Student	17.68	22.65	9.0	5.48	11.46	0.9	104.55	235.96	40.0

Total Logins: $F = 1836.38$, $p < 0.001$

Total Hours Spent: $F = 5575.25$. $p < 0.001$

Total Clicks: $F = 1200.08$, $p < 0.001$

These results indicated that user engagement with the LMS varied significantly by year and user type. Consequently, Tukey's Honest Significant Difference (HSD) test was conducted to determine where these differences occurred.

Table 3. Tukey HSD Post-hoc comparisons for total logins

Metric	Group 1	Group 2	Mean Difference	p-value	Lower	Upper	Significant
Total Logins	2019_Instructor	2019_Student	-1.44	<.001	-2.3909	-0.4806	TRUE
	2019_Instructor	2023_Instructor	-0.5	0.681	-1.6589	0.6553	FALSE
	2019_Instructor	2023_Student	3.36	<.001	2.4071	4.3133	TRUE
	2019_Student	2023_Instructor	0.93	0.002	0.257	1.6109	TRUE
	2019_Student	2023_Student	4.8	<.001	4.6291	4.9629	TRUE
	2023_Instructor	2023_Student	3.86	<.001	3.1879	4.5361	TRUE

Table 3 shows that student logins increased significantly from 2019 to 2023 (mean difference = 4.80, $p < .001$), suggesting a stronger habit of regular LMS access post-ERT. Instructor logins, however, showed no statistically significant change between 2019 and 2023 ($p = .681$). Comparisons between students and instructors in both years also revealed significant differences, indicating overall higher login variability by role and year.

Table 4. Tukey HSD Post-hoc comparisons for total hours spent

Metric	Group 1	Group 2	Mean Difference	p-value	Lower	Upper	Significant
Total Hours Spent	2019_Instructor	2019_Student	-3.38	<.001	-3.8192	-2.9412	TRUE
	2019_Instructor	2023_Instructor	2.61	<.001	2.0766	3.1402	TRUE
	2019_Instructor	2023_Student	0.35	0.161	-0.0842	0.7919	FALSE
	2019_Student	2023_Instructor	5.99	<.001	5.6774	6.2997	TRUE
	2019_Student	2023_Student	3.73	<.001	3.6573	3.8108	TRUE
	2023_Instructor	2023_Student	-2.25	<.001	-2.5643	-1.9447	TRUE

As shown in Table 4, both instructors and students spent significantly more time on the LMS in 2023 than in 2019. The increase for instructors was notable (mean difference = 2.61 hours, $p < .001$), while the student increase was even larger (mean difference = 3.73 hours, $p < .001$). These results suggest a post-ERT shift toward deeper engagement with the platform across both user groups.

Table 5. Tukey HSD Post-hoc comparisons for total clicks

Metric	Group 1	Group 2	Mean Difference	p-value	Lower	Upper	Significant
Total Clicks	2019_Instructor	2019_Student	-88.45	<.001	-98.2088	-78.6876	TRUE
	2019_Instructor	2023_Instructor	31.04	<.001	19.2171	42.8659	TRUE
	2019_Instructor	2023_Student	-60.82	<.001	-70.5591	-51.0794	TRUE
	2019_Student	2023_Instructor	119.49	<.001	112.5715	126.4079	TRUE
	2019_Student	2023_Student	27.63	<.001	25.9234	29.3346	TRUE
	2023_Instructor	2023_Student	-91.86	<.001	-98.7495	-84.9719	TRUE

Table 5 highlights significant increases in LMS click activity across all groups. Instructors in 2023 clicked significantly more than in 2019 (+31.04 clicks, $p < .001$), while students also showed a substantial rise (+27.63 clicks, $p < .001$). These results align with the interpretation that users were not only logging in more but also interacting more actively with content and tools.

For clarity, the most relevant comparisons—2019 vs. 2023 for instructors and 2019 vs. 2023 for students should be highlighted:

- Instructors: From 2019 to 2023, logins increased slightly but not significantly ($p = .681$), while time spent (mean difference = 2.61 hours, $p < .001$) and clicks (mean difference = 31.04, $p < .001$) increased significantly.
- Students: From 2019 to 2023, logins (+4.80, $p < .001$), time spent (+3.73 hours, $p < .001$), and clicks (+27.63, $p < .001$) all increased significantly.

Discussion

The results indicate that the LMS usage within the CUT increased significantly between 2019 and 2023. This increase holds for both lectures and students, but students showed a statistically significant growth in all three metrics – total logins, total hours spent, and total clicks – suggesting their relationship with the LMS changed markedly post-ERT. Lecturers' LMS usage increased with total hours spent, and total clicks, but remained the same with total logins. This may show that lecturers made more focused use of the LMS, using it more purposefully than merely using it as a learning material storage space.

These findings mean a positive response to the question driving this paper; "Did COVID-19, unintentionally, serve as a catalyst for meaningful (Learning Management System) LMS adoption?" The increase in post-ERT engagement suggests that forced engagement with the LMS made lecturers aware of the benefits which brought on a behavioural change that, hopefully, will form long-lasting habits. As Song and Zheng (2024) propose, the combination of intrinsic motivation and pressure from a high-stakes period may be habit-forming and increase the likelihood of lecturers and students continuing to use the LMS.

The increase in student activity being more pronounced than that of the lecturers could also be insightful. This aligns with findings by Botha, Smuts, and de Villiers (2021), who applied Rogers' (2003) Diffusion of Innovations theory to LMS feature adoption and found that students often adopt LMS features faster once institutional structures support consistent exposure. Instructors, particularly those in the late majority or laggard categories, may require more time and ongoing support to move from compliance to confidence. Wright et al. (2023) found that student satisfaction with online learning increased post-pandemic, particularly when systems were well-integrated into course delivery—a trend that may explain the sharper rise in student engagement metrics in this study.

For learning designers and institutional planners, the findings underscore the importance of identifying what triggers meaningful technology adoption. If increased LMS engagement can be sustained beyond crisis conditions, it may suggest that immersive exposure, targeted training, and timely support are key to successful digital adoption strategies.

Conclusion

This paper explored LMS engagement by examining how it is measured, what influences its adoption, and how it can be enhanced. Drawing on the Diffusion of Innovations theory (Rogers, 2003), which explains how new technologies move from initial awareness to widespread and sustained use, this study used frequency of logins, time spent, and click activity as proxies for user engagement. Confidence in LMS use remains one of the most critical factors in encouraging adoption, and building this confidence is a key role for instructional designers.

By comparing LMS analytics from 2019 and 2023—the years immediately preceding and following the Emergency Remote Teaching (ERT) period—this study found statistically significant increases in engagement among both lecturers and students. The findings suggest that the COVID-19 pandemic acted as a catalyst, prompting users to explore the LMS in greater depth. Exposure to the system under pressure may have revealed its pedagogical value, encouraging sustained use even after the crisis passed.

Understanding why and how users adopt educational technology is vital for those tasked with promoting its integration. Findings such as these can help instructional design teams design more targeted interventions and justify ongoing investment in LMS platforms and support services. While login frequency, session time, and click counts provide useful insights, they remain surface-level indicators. Future research should extend this work by analysing datasets from other institutions and incorporating metrics that offer a deeper view of user engagement, such as the types of tools used or the pedagogical context of interactions.

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Assessing Moodle Usability and Influencing Factors in Higher Education: A Case Study

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Abstract

Although distance education has a history of nearly two centuries, it still encounters difficulties in choosing suitable platforms and creating user-friendly interfaces. Learning Management Systems (LMS) used in distance education facilitate automated delivery of course content and monitoring of student progress, with Moodle being one of the most widely adopted open-source platforms. Despite offering a broad array of instructional functionalities, Moodle's adoption and effective use may be constrained. The system's usability is influenced by contextual factors specific to the case as well as by the attributes of its users. This study seeks to examine students' perceptions of Moodle usability, the impact of their perceived effectiveness of distance education on this usability, and the factors influencing their use of Moodle. Employing a case study approach, the research utilized both quantitative and qualitative data collection methods. A data collection instrument with three sections was used, including demographic and open-ended perception questions, items on Moodle usage and related challenges, and a 20-item scale measuring Moodle LMS usability. The sample comprised 110 volunteer higher education students from a public university in Türkiye, aged 18 to 23, who represented various academic departments. Descriptive statistics indicated that students rated the overall usability of the Moodle LMS at a moderate level, with system quality, perceived satisfaction, and individual performance receiving moderate scores, whereas system interaction and usage intention were rated lower. MANOVA results demonstrated that students' perceived effectiveness of distance education had a significant impact on their perceptions of Moodle usability, with those perceiving low effectiveness reporting significantly lower scores in system quality, perceived satisfaction, and system interaction compared to those with high perceived effectiveness. Additionally, content analysis revealed that students identified multiple factors influencing their Moodle use, with interface complexity and login/access difficulties being the most frequently reported challenges, alongside technical issues, concerns about content quality, and notification problems. However, more than half of the participants indicated no problems. These findings underscore the importance of addressing both technological and contextual factors to enhance Moodle's usability and support more effective distance education experiences for students. These findings imply that improving Moodle's usability requires addressing technical issues and students' perceptions of distance education to enhance engagement and satisfaction.

Keywords: Distance Education, Usability, Moodle Learning Management System (LMS), Higher Education

Introduction

Despite its history spanning nearly two centuries (Moore et al., 2011; Spector et al., 2008), distance education continues to face challenges in selecting appropriate systems and designing user-friendly interfaces (Ahmed et al., 2024). LMS offers numerous advantages by allowing learners to learn according to their own schedule, speed, and from any location, resulting in significant savings of time and resources (Nafidi & El-Batri, 2023). Modular Object-Oriented Dynamic Learning Environment (Moodle), among the most commonly adopted open-source LMS platforms (Kakasevski et al., 2008), was founded by Martin Dougiamas, whose childhood experience with distance education in remote Western Australia inspired him to create an online learning system that is flexible, accessible, and globally available (Moodle, 2025).

Moodle offers a wide range of instructional features, including scheduling, content access, performance tracking, and reporting, while also facilitating interaction among teachers, students, and peers, as well as supporting exams, registration, and study planning (Alomari, 2024). In their systematic review, Ziraba et al. (2020) highlighted that Moodle adoption and use are influenced by technological factors (skills, accessibility, readiness, infrastructure), social factors (cultural acceptance, environmental influences, peer support), human factors (attitudes, self-efficacy, satisfaction, perceived usefulness and ease of use), and reinforcement factors (communication, content quality, time management, course nature). As exemplary studies, Hanif et al. (2018) showed that, regarding human and reinforcement factors, subjective norms, perceived external control, system accessibility, enjoyment, and the ability to demonstrate results significantly enhance both perceived usefulness and ease of use of e-learning systems. Regarding technological and social factors, Abdullah and Toycan (2018)

reported that technological readiness is a key predictor of e-learning implementation, while content, educational, leadership, and cultural readiness also contribute, albeit to a lesser extent. Similarly, attitudes toward using Moodle are shaped by both its perceived usefulness and ease of use, with usefulness playing the most dominant role (Šumak et al., 2011). In a very recent study, drawing on the Technology Acceptance Model and the Information Systems Success Model, Eren (2024) explored the determinants of students' performance and intention to adopt systems in distance education. The research showed that information quality and system quality on their own did not lead to better individual performance; factors such as system interaction, perceived enjoyment, satisfaction, and usage intentions had a positive impact. Overall, the evidence suggests that the educational context and Moodle's system features together play a decisive role in influencing students' perceptions, engagement, and effective use of the platform. At the same time, despite Moodle's widespread adoption, research specifically examining the factors that affect its utilization in universities remains limited (Al-Fraihat et al., 2025).The present study investigates, in a specific university context, students' perceived Moodle usability levels, the influence of perceived distance education effectiveness on these perceptions, and the factors affecting their use of Moodle. To achieve this aim, the following research questions will be addressed:

1. What are the students' perceived levels of Moodle usability?
2. How does the students' perceived effectiveness of distance education levels influence their perceived Moodle usability levels?
3. Which factors do students identify as influencing their use of Moodle?

Methodology

Research Design

Given its focus on exploring students' use of the Moodle LMS within the context of a single university, this study adopts a case study design. In the context of this case, the university initially adopted emergency remote teaching as a response to the Covid-19 pandemic crisis, employing one platform for synchronous instruction and subsequently transitioning to another platform for asynchronous learning. Approximately two years ago, the institution migrated to the Moodle system, which has since been made available to all faculty members and students. Despite its accessibility, challenges remain in promoting widespread use of Moodle, largely due to negative attitudes toward distance education. In practice, students using Moodle for mandatory asynchronous courses are required to complete weekly content delivered as 14-week SCORM packages for four courses, while also following announcements and checking their grades on the system. With respect to the role of the researchers, they were actively engaged in administering the Moodle system, coordinating the asynchronous courses, and providing technical support.

Sampling

The sample consisted of 110 volunteers who were selected using the convenience sampling method (Fraenkel et al., 2012). Participants fell within the 18 to 23 age range (M = 20.58, SD = 1.34). Participants in the study were enrolled in various academic units. The highest number of students was from the Faculty of Arts and Science (n = 31, 28.2%) and the Faculty of Economics and Administrative Science (n = 31, 28.2%), followed closely by the Faculty of Engineering and Technology (n = 30, 27.3%). Students from the Faculty of Law accounted for 8.2% (n = 9), while those from the Faculty of Communication represented 7.3% (n = 8). Only one participant (0.9%) was from the Maritime Vocational School. Participants reported a high level of digital competence (e.g., skills related to computer and internet use). The mean score was 4.16 (SD = 0.97) on a scale ranging from 1 (very low) to 5 (very high), indicating generally strong self-perceived digital skills.

Data Collection

Before commencing the study, ethical approval was secured from the ethics committee of the authors' affiliated university (Approval number: E-65364513-650-89032), and informed consent was subsequently obtained from all participants. The electronic survey was distributed via email through Google Forms without requesting any information that could identify the students.

A data collection instrument comprising three sections was utilized for data gathering. The first section included questions on age, faculty affiliation, perceived digital competency level, and perceived effectiveness of distance education. The second section included four questions related to Moodle usage, covering knowledge/skills related to Moodle use, need for any support while using Moodle, and any difficulties or problems that affected your use of Moodle. In the third section, the scale items measuring the usability of the Moodle LMS were presented, containing 20 items measured with a 5-point Likert scale. This scale was used with permission. The

original 27-item scale, consisting of 7 factors (Information Quality (IQ), System Quality (SQ), System Interaction (SI), Perceived Enjoyment (PE), Perceived Satisfaction (PS), Usage Intentions (UI), and Individual Performance (IP), developed to measure the success of a distance education system, has been reported as a valid and reliable scale. CFA indicated an acceptable model fit: χ^2 (301) = 476.000, $p < .001$; $\chi^2/df = 1.581$ (≤ 3), RMSEA = 0.041 (< 0.08), GFI = 0.911 (≥ 0.90), AGFI = 0.888 (slightly below 0.90), CFI = 0.975, NFI = 0.934, and TLI = 0.970, all suggesting good fit (≥ 0.90). Reliability analyses showed strong internal consistency across all factors, with reliability coefficients (Cronbach's alpha) surpassing the 0.70 cut-off (Eren, 2024). Due to the incompatibility of the IQ and PE factors with the specific context of the system examined in this study, these factors were omitted. Accordingly, the research was carried out utilizing a modified version of the scale comprising five factors and 20 items. After data collection, the reliability of the scale was reassessed, yielding a Cronbach's alpha coefficient of 0.93, which indicates excellent internal consistency.

Data Analysis

The survey received responses from 115 students, with 5 opting out, resulting in a final voluntary sample of 110 participants. Descriptive analyses and MANOVA were conducted using IBM SPSS Statistics software. All assumptions required to conduct a MANOVA were evaluated and found to be sufficiently met. The five dependent variables (SQ, IP, PS, SI, and UI) were treated as continuous, and the independent variable (perceived effectiveness of distance education) consisted of three mutually exclusive categorical groups (Low, Moderate, High). The data met the requirements for observation independence and sample size adequacy. No univariate or multivariate outliers were detected, and multivariate normality was largely supported, with some moderate deviations deemed acceptable due to the robustness of MANOVA. The assumption of linear relationships among dependent variables was supported through visual inspection of scatterplots. Box's M test indicated homogeneity of variance–covariance matrices. Finally, Pearson correlations among dependent variables revealed no multicollinearity concerns, as all coefficients remained below the .90 threshold.

Regarding the qualitative analysis, out of 110 students, 81 reported no problems. 29 responses to the open-ended question were analysed using Braun and Clarke's (2006) six-phase thematic analysis (TA) approach. Initially, the data were thoroughly reviewed to gain familiarity, with preliminary ideas noted. Subsequently, systematic coding was conducted to identify salient features across the dataset, which were then collated into potential themes. These themes were rigorously reviewed for coherence with both the coded extracts and the dataset as a whole. Each theme was further refined and clearly defined. A second researcher independently conducted coding to assess interrater reliability. The agreement between the two sets of codes was calculated to be .92 (McHugh, 2012).

Findings

RQ1: What are the students' perceived levels of Moodle usability?

Descriptive statistics were computed to examine students' perceived usability of the Moodle LMS across five factors. The results indicated that students reported a moderate level of SQ (M = 3.09, SD = 0.94) and PS (M = 3.02, SD = 1.13). IP was also rated moderately (M = 2.93, SD = 1.10). In contrast, lower mean scores were observed for SI (M = 2.42, SD = 0.99) and UI (M = 2.40, SD = 1.18). The overall score showed a moderate level of perceived usability (M = 2.85, SD = 0.96), measured on a 5-point scale.

Table 1. Perceived Moodle Usability Levels.

Factors	Min.	Max.	M	SD
SQ	1.0	5.0	3.09	.94
IP	1.0	5.0	2.93	1.10
PS	1.0	5.0	3.02	1.13
SI	1.0	5.0	2.42	.99
UI	1.0	5.0	2.40	1.18
Total	1.0	5.0	2.85	.96

RQ2: How does the students' perceived effectiveness of distance education levels influence their perceived Moodle usability levels?

A MANOVA was performed to investigate the effect of perceived effectiveness of distance education (Low, Moderate, High) on five dependent variables: SQ, IP, PS, SI, and UI. The multivariate result was statistically significant, indicating that the combined dependent variables were affected by perceived effectiveness levels, Wilks' $\Lambda = .787$, $F(10, 166) = 2.11$, $p = .027$, partial $\eta^2 = .113$. Follow-up univariate ANOVAs revealed significant group differences for all five dependent variables: SQ: $F(2, 87) = 11.31$, $p < .001$, partial $\eta^2 = .21$, IP: $F(2, 87) = 6.33$, $p = .003$, partial $\eta^2 = .13$, PS: $F(2, 87) = 8.33$, $p < .001$, partial $\eta^2 = .16$, SI: $F(2, 87) = 6.33$, $p = .003$, partial $\eta^2 = .13$, UI: $F(2, 87) = 4.78$, $p = .011$, partial $\eta^2 = .10$. These results indicate that perceived effectiveness of distance education significantly influenced each outcome. Tukey HSD tests were conducted to examine pairwise differences between group means. Due to multiple comparisons, a Bonferroni correction was applied, adjusting the alpha level to .0033 across 15 post-hoc comparisons (5 dependent variables × 3 pairwise group comparisons). Bonferroni-adjusted post-hoc analysis showed that significant differences between Low and High groups were observed for SQ (MD = -1.03, $p < .001$), PS (MD = -1.08, $p < .001$), and SI (MD = -0.86, $p = .003$). For all three variables, differences between Low and Moderate and between Moderate and High groups were not significant at the adjusted alpha level. For UI, no significant differences were found after alpha correction, and although the Low versus High difference (MD = -0.90, $p = .012$) was notable, it did not reach significance. Similarly, for IP, no pairwise comparisons were significant at the corrected alpha level, with the Low versus High difference (MD = -0.93, $p = .004$) approaching but not meeting the threshold.

RQ3: What factors do students report as affecting their use of Moodle?

The TA revealed several challenges affecting Moodle usage. Login and access issues were most frequently reported (n = 10), including problems with passwords, internet connectivity, system availability, and the need for a mobile application. Interface-related difficulties (n = 9) encompassed accessing grades, controlling notifications, navigating course lists, and interacting with past courses and assignments. Content and material quality issues (n = 7) included lack of audio, content repetition, poor slide quality, text-audio synchronization problems, and misalignment between content and assessments. Offline access limitations were noted by three participants, primarily due to non-downloadable videos and restrictive slide formats. Additional concerns (n = 3) involved assignment upload failures and system freezes. See Table 2 below for an overview of the categories, corresponding codes, and representative quotations.

Table 2. Factors Affecting Moodle Use

Themes	Codes	Quotations
Login and access issues (n =10)	Internet connection problem Password problem Need for a mobile app System unavailability	"*I experienced difficulties logging into the Moodle system ....*" "*There is no dedicated app (mobile or desktop), which means I have to log into Moodle through the browser every time, repeatedly entering my password.*" "*...occasionally the system fails to log me in despite entering the correct password.*"
Interface quality (n =9)	Need for receiving notifications Controlling notification settings Difficulty in accessing grades Irrelevant list of courses on the homepage Difficulty accessing past courses Difficulty accessing assignments	"*I remember having difficulty finding where to access the course assignments aside from the notifications. Overall, I don't find the interface very user-friendly.*" "*I think the interface is very complicated…*" "*I have to navigate through 3-4 pages to access certain things. It would be much easier if I could find everything on the same page.*"
Content and material quality (n =7)	Lack of audio Issues with the sequencing of content Repeated content	"*Some of the presentations lacked audio, and there were issues with their sequencing. Additionally, a topic that had already been covered was repeated*."

	Duplicate content Long course content Unnecessary information Poor slide quality Text-audio synchronization problem Content–assessment misalignment	"*The slides tend to be overly long and include a lot of unnecessary information, making it hard to focus on the main ideas. It would be much more helpful if the slides were concise and highlighted only the essential points, preferably in bullet-point format…*" "*There were shortcomings in the courses, such as text-audio synchronization issues and incorrect answers in quizzes.*"
Offline access to materials (n =3)	Copy restrictions on slides Non-downloadable video-format slides Need for alternative material formats (.pptx, pdf)	"*It is not possible to copy content from the slides.*" "*The uploaded slides cannot be downloaded. Their video format also poses challenges. It would be more helpful if they were uploaded as PDFs.*" "*...the uploaded videos are difficult to use. It would be much more convenient if there were PPTX presentations instead of videos*."
Other (n =3)	Assignment upload issues System freeze	"*...the system frequently froze during use.*" "*Due to frequent problems such as being unable to upload our assignments, we often had to resort to using Teams.*"

Conclusions

The study found that students perceive the usability of Moodle at a moderate level, with higher ratings for SQ, IP, and PS compared to SI and UI. Given the influence of students' perceived effectiveness of distance education on their perceptions of Moodle, it is evident that planning should include the implementation of pedagogical approaches aimed at positively enhancing students' perceptions of distance education. Qualitative analyses highlighted several practical barriers to Moodle use, including login and access issues, interface difficulties, content quality concerns, and limited offline accessibility. Overall, the main conclusion is that students mainly perceive Moodle as moderately usable, with key barriers in system interaction, access, interface, and content quality, indicating the need for targeted improvements and pedagogical strategies to enhance platform use and students' perceptions of distance education. Supporting these, Al-Fraihat et al. (2025) emphasize that usability challenges, particularly related to system features and content design quality, substantially impede students' learning experiences. Similarly, Leo et al. (2019) highlight that factors such as perceived usefulness and ease of use particularly influence students' attitudes toward using Moodle. Regarding factors influencing engagement, Karishma and Raghuwaiya (2023) highlight several elements on Moodle, including peer competition, completion of assessments, participation in forum discussions, allocation of grades for online interaction, the need for clarification, and collaborative peer interactions, the impact of which can be further examined in our context. In line with the emphasis of this study on the importance of maintaining a positive attitude toward distance education, Teo et al. (2019) argue that instructional designers and educational practitioners should provide experiences that foster positive attitudes before implementing a new platform in classroom settings. While obtaining results parallel to the literature, our case study revealed the need to examine teachers' pedagogical practices regarding Moodle usage and interaction as well, and ways to enhance these practices. Additionally, interventions aimed at positively influencing students' attitudes toward distance education, as well as improvements in access and interface of Moodle, were identified as necessary. Furthermore, in addition to SCORM-based interactive content packages, there is significant demand for offline learning materials, particularly those that can operate independently of the system. Moreover, technical difficulties encountered in the initial stages, such as login problems, have a substantial impact on users' perceptions and overall system use. The findings suggest that sustaining effective learning experiences requires not only a reliable technical infrastructure but also the application of pedagogical interventions designed to enhance learner interaction. This study can serve as a reference for embarking on similar distance education processes.

Acknowledgement: This study is supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK) with 2224-B - Grant Program for Participation in Scientific Meetings within the Country. We would like to thank TÜBİTAK for their support of the study.

Disclaimer: The views and opinions expressed in this study are solely those of the authors and do not necessarily reflect the official policies, positions, or views of any affiliated institutions or organizations.

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Artificial Intelligence in traditional teaching: A literature review

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Abstract

Education remains a fundamental pillar in today's economy, making it possible for people to use their skills acquired through education. The use of artificial intelligence in the teaching process has risen in recent years, offering new perspectives on how technology can personalise educational content. This paper showcases a narrative review that focuses on how to integrate artificial intelligence in educational technology to make traditional teaching easier and more student oriented. All the literature selected was published between 2018 and 2025 and the reviewed papers are used to outline a general image on concepts such as: natural language processing, learning, personalisation, and adaptive learning platforms, which further can prove to be the base of how we will perceive the pedagogical support in the future. It discusses the advantages and disadvantages of using and integrating certain technologies into the teaching process. In addition, the study will point out concerns regarding data privacy, security and equity, aiming to serve as a solid foundation for future studies that seek to observe and discuss how to properly use artificial intelligence in the educational sphere.

Keywords: artificial intelligence, educational technology, adaptive learning, generative AI, literature review.

Introduction

Over the years education proved to be one of the pillars of economy, having a well-deserved place in the calculation of the Gross Domestic Product (GDP) of a country. The idea of educating young minds implies that by using a structured system of teaching methods, individual talents can be sharpened to make a country's economy prosper. The problem with this approach is that it targets individuals with different needs and talents by integrating them in a general system that cannot be a good fit for everyone. This approach proved to be rigid, making it difficult to change teaching methods without technical advancement. Things begin to change when Artificial Intelligence (AI) started to be used by regular people, especially Large Language Models (LLMs) like ChatGPT or Gemini AI.

LLMs represent a piece of software that serves the purpose of simulating conversations in natural language (NP) with humans by leveraging the usage of complex machine learning techniques and algorithms (Plebani, 2023). LLMs are capable of learning language patterns, facilitating the completion of linguistics tasks that prioritizes conversation and summarization (Yan et al., 2024).

The scope of this study is to identify key elements in all areas impacted by the usage and integration of AI. This paper addresses different concerns regarding ethics, academic integrity, data protection, privacy and content personalization. To be able to achieve this, a variety of different research questions needed to be formulated.

RQ1. What are the primary ethical issues when it comes to the usage of AI by students?

RQ2. When are LLMs more detrimental than beneficial?

RQ3. Does AI speed up the time needed by teachers to prepare for classes?

RQ4. Is AI-generated content suitable for being used as a teaching material?

Figure 1. Research Axes of AI in Education

Methodology

The methodology used in this research uses a mix of analysis techniques, focusing on a narrative approach of a literature review. The materials that were reviewed have been selected from a variety of online academic databases such as Google Scholar, IEEE Xplore and SpringerLink.

All the scientific papers were selected based on a specific set of criteria as follows:

- Publish dates of the articles had to be between 2018 and 2025.
- Keywords like artificial intelligence, adaptive learning and content personalization.
- English was the language used for publication.
- Strong correlation to the studied topic.

The narrative approach of a literature review was chosen because it offers the possibility of connecting and synthesizing information between different areas covered by the research topic of this paper. These areas cover topics that may include ethical principles, academic integrity, the study of proper integration and usage of LLMs in Education, aspects regarding cybersecurity, the creation of an adaptive learning environment etc.

Figure 1. Research Axes guiding the review

Results

Importance and impact of LLMs in preserving Critical Thinking

Learning experience and environment started to change in recent years, thanks to the technological advancement in the field of Information Technology, especially when it comes to the exponential evolution of AI. Teaching personnel can now shift their focus to a more personalized learning experience by using generative AI, enhancing skills such as writing, speaking and reading (Liu et al., 2025). While generative AI might seem like a good solution to the problem of content adaptation, we must keep in mind that these tools must be properly used to preserve critical thinking (CT).

The importance of preserving CT remains an important topic that can still be expanded. A common solution to this was to implement certain chatbots in educational context with different approaches such procedural learning (Yuxian, 2025). Favero et al. (2024) explored how CT may be fostered with the help of LLMs. They showcased that by implementing a proper educational chatbot, that "encourages students to explore various perspectives" CT may be preserved, even increased.

To preserve and enhance CT, multiple methods have been proposed, making it difficult to properly choose one while educators are typically trying to have AI literacy with LLMs. One of the most common solutions in this scenario was to use a specific framework, whose purpose is to enhance cognitive abilities among students. One of such frameworks is "AI-CRITIQUE" (AI-based Critical Reflection and Insightful Thought Unleashed for Education). The analyzed students in the study showed an increase in their cognitive levels when it comes to using reflection and other such cognitive skills, marking the validity of the proposed framework (Shanto et al., 2024).

In a recent study, Bleda Bejar, Dorca Josa and Oliveras Prat (2024) studied how Computer Science and Education students used tools like LLMs to learn complex topics. They concluded that 98% of the observed students used tools like Chat GPT and 40% of them trusted the validity of the LLMs responses. They showcased an interesting perspective among students. While some of them said that the information received from ChatGPT or similar sources was reliable, other students started to question the validity of the cited sources. This difference among the students highlighted the idea that without having literacy in how LLMs work might harm the CT of the students, making them trust information given by the AI tools, without checking its validity.

When it comes to understanding of complex subjects, LLMs "have shown promise in developing critical thinking" (de la Puente et al., 2024). This might be a key aspect, making it possible for students to receive targeted feedback that highlights their weaknesses in learning content that might be hard to comprehend at first. De la Puente et al. have offered a comprehensive overview on how the usage of AI in learning might be beneficial or detrimental. They have discussed the difference between short-term and long-term results of the integration of AI in students learning process. They analyzed the impact on 95 students and observed that AI tools have the potential to facilitate personalized learning experiences, aligning with existing literature findings, keeping in mind that their sample size was small and the research should be continued with a bigger sample size of students.

Data privacy, security concerns and ethical integrity of using AI in education

While preserving CT may be one of the most important aspects of using AI in education, we must discuss how ethics and security are being implemented in this given context. There are some studies that discuss how we can ensure that this type of software can be used in education. Miguel Morales Chan et al. (2025) proposes a framework, called INTEGRITY AI Model, a framework that guides the ethical adoption of AI in education. Their model addresses three topics: guiding principles, training actions and impact and Empowerment. Sakib Hasan et al. (2024) also stated in their study that clear policies should be established to ensure the proper utilization of AI in education.

One of the problems that the educational system might face while integrating AI tools into education is how to properly adapt the usage of this type of technology to all possible users. Students with disabilities might have difficulties when it comes to the usage of LLMs encountering "barriers" because "AI technologies are not designed with their needs in mind" (Eden et al., 2024). The chosen LLM should also be trained on data that covers the needs of students with disabilities, if that is not the case then this category of pupils can be viewed as outliers by the model.

Another risk that should be answered is that students should not rely on ChatGPT or similar tools to do their work. By doing so, students are becoming more likely to be questioned for concerns regarding academic dishonesty and plagiarism, since LLMs can generate text on any topic (Ahmed, 2024).

Regarding security concerns, people who use ChatGPT or similar software should be aware of the lack of transparency and privacy that these tools provide (Hashakimana & Habyarimana, 2020). This can be an important aspect, especially when LLMs are used for academic research. Sobaih (2024) explores in his work different ethical concerns for using AI, especially chatbots in academic research and publication. He concluded that "ethical concerns are overlapped" and using chatbots and their generated content may lead to the "spread of pseudoscience", striking a dilemma in the academic community. If we expand this and project this dilemma in education, how can we make sure that when teachers use LLMs to generate academic content, that content is properly verified to prevent the spread of pseudoscience?

Conclusions

The study showcased the possibilities of how educational systems can be improved by the usage of AI, especially tools like LLMs that can generate adaptive content.

Students have been facing difficulties in the learning environment, especially when it comes to learning subjects that might pose a difficulty for them. This has come to the attention of the teaching personnel more in recent years, mainly because the student's attention span has shifted thanks to the usage of technology.

AI tools, such as LLMs are extremely powerful and they can make the learning process smoother, more adaptable and personalized. With this grade of personalization, schools and universities should understand that a minimum literacy is needed to ensure that these tools are properly used. Without teaching students how to use AI, their CT might be affected in the long run.

AI in education should follow regulations and norms, which can be imposed by school, universities or even governmental institutions. These ensures a good regulatory framework for usage, making it both safe and ethic for students and teaching personnel to use AI tools. These regulations should be available at any given moment for users because people should be aware of how their personal data and information is being used.

AI tools, especially LLMs are powerful in the context of personalization and adaption of education content, helping students understand difficult concepts, making it a tool that does not substitute the need of human intervention, making teacher's input more valuable and necessary to ensure a good learning experience for students.

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Adoption of Technology-Enhanced Assessment Strategies for Inclusive Engineering Education: Evaluation of Students' Performance in an Undergraduate Module

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Abstract

Ensuring inclusive, high-quality engineering education remains a pressing challenge, especially for students who face barriers related to geography, socio-economic status, or limited access to campus-based resources. Although Open Distance e-Learning (ODeL) offers a promising solution to improve access, particularly for students unable to attend traditional, campus-based programs. Conversely, it still remains a challenge for engineering students to harness the optimal benefits, as the most commonly practised traditional assessment methods reinforce barriers faced by marginalised or remote students. Addressing these challenges requires careful integration of assessment strategies that would support the intended outcomes and improve student performance. Therefore, this study seeks to provide an evidence-based evaluation of the implementation of technology-enhanced assessment strategies to promote inclusive learning in engineering higher education. The study was conducted in an ODeL institution. Traditionally, the institution's engineering students were assessed using the traditional venue-based summative assessments. With the urgent need to conquer the learning limits posed by economic inequality and remote geographical challenges, the institution shifted to online assessments. Consequently, accelerated by the rapidly evolving technology innovations, the institution adopted the Online Continuous Assessments (OCA) technology-enhanced assessment strategy post the COVID-19 pandemic. Therefore, the study evaluates the impacts of this adoption compared to the traditional Venue-Based Summative Assessments (VBSA) strategies on students' performance in the engineering module. Descriptive analysis was used to examine data from the theory module for the period from 2018 to 2023. A comparative analysis between the two assessment strategies (OCA and VBSA) in relation to students' performance was performed. The findings indicated that the OCA approach had a more positive impact on student performance. Additionally, in 2020, when the summative assessments were conducted online, the highest failure rate, greater than two consecutive years average in OCA, was recorded. Therefore, adoption of the technology-enhanced strategy (OCA) promoted more opportunities for a variety of assessments, which support learning for engineering modules. Additionally, it is an evidence-based study that can help other institutions develop a technology-enhanced strategy to support students' learning in higher engineering education.

Keywords: engineering education, ODeL, technology-enhanced strategies, online continuous assessment, venue-based summative assessment.

Introduction

Providing equitable and high-quality engineering education continues to be a significant concern, particularly for students who encounter obstacles such as geographical isolation, financial constraints, or limited availability of campus-based facilities. Open Distance e-Learning (ODeL) has emerged as a valuable approach to widening participation by enabling access for those unable to engage in traditional on-campus learning. Moreover, the rapid change of innovations in technology has reshaped teaching and learning in ODeL settings, shifting towards online education, which fosters more inclusion of diverse students. Tested by Meldrum (2013), the study conducted on using online-open-book testing in engineering modules resulted in improved pass rates and was particularly beneficial for part-time students (inclusion). Driven by the same need to foster more flexibility and inclusion using technology, is the study by Sembey et al. (2024), which highlights the propagation of emerging technologies such as Artificial Intelligence and Learning Analytics in higher education assessment practices, emphasising their potential to enhance feedback and student engagement. Similarly, the Special Olympics Global Centre (2024) discusses the potential of inclusive AI technologies to transform education for students with intellectual disabilities. Though primarily focused on special education, their advocacy for real-time adaptability and personalised support offers important lessons for ODeL environments.

In an ODeL setup, student diversity spans a wide range of age groups, socio-economic backgrounds, cultural identities, languages, and geographical locations, both nationally and internationally (Tait, 2019). The model attracts non-traditional students, including working adults, first-generation university students, students from rural and urban areas, and individuals with different learning abilities who may not have access to traditional contact-based learning universities (Mbatha et al., 2009). Therefore, it can be noted that in an ODeL setting, inclusion is invaluable- it is seen as a deliberate design and delivery of educational experiences that ensure equitable access. However, despite its potential, it still remains a challenge for engineering students to harness the optimal benefits due to the most commonly practised traditional assessment methods (e.g., summative assessments), which often perpetuate the very barriers that disadvantaged remote students seek to overcome. In engineering, particularly, students learn best through active engagement, problem-solving, and collaborative learning environments that reflect real-world engineering challenges (Felder, 2004). These students benefit significantly from peer interaction, feedback, and scaffolded tasks that promote higher-order thinking and a sense of belonging in the learning. According to Alamri (2021), many engineering students favour experiential and iterative learning strategies, supporting the ideas of Boud & Soler (2016), who stated that authentic assessments such as digital portfolios and projects enhance student belonging. However, as advocated by earlier scholars such as Seale (2014), technology-enhanced platforms offer opportunities for diverse students to engage with context in flexible ways, but their effectiveness often depends on the design of the assessment strategies. For example, challenges such as increased workload and unequal access to digital resources brought by the rapid shift to online assessments, particularly during the COVID-19 pandemic, were identified (Fynn & Mashile, 2022). Additionally, while online assessments offer flexibility, they also presume access to appropriate devices at the time of the assessment and digital literacy, which cannot be assumed in the South African context. Therefore, with these presumptions, equity in online assessment remains a significant challenge for ODeL institutions, requiring effective and inclusive technology-enhanced mitigating strategies. The above reviews suggest that it should be about just moving online for inclusivity, but rather adapting to technology-enhanced strategies that enhance both student support and performance. To evaluate the validity of this suggestion, we carried out this study to measure the impact of adopting effective technology-enhanced assessment strategies in addition to shifting to online.

Focusing our study on a South African ODeL institution, traditionally, the institution's engineering students were assessed using Venue-Based Summative Assessment (VBSA). Accelerated by the rapid change of technology in ODeL spaces, the institution shifted to Online Summative Assessment (OSA). Consequently, guided by the institution's policies and the regulating bodies, the institution adopted the Online Continuous Assessments (OCA) technology-enhanced assessment strategy post the COVID-19 pandemic. In contrast, **Online Continuous Assessment (OCA)** refers to an ongoing process of evaluating students' learning through digital platforms, enabling the provision of frequent feedback, flexible learning pace, and fostering a more student-centred approach (Gikandi et al., 2011). It comprises assessments such as quizzes, projects, assignments, blogs, and other formative assessments. OCA allows students to interact with content and feedback continuously, fosters meta-cognition, and enhances learning retention, particularly for non-traditional and remote students (Wanner et al., 2015). **Venue-Based Summative Assessment (VBSA),** on the other hand, is a traditional assessment model where students are evaluated at the end of the instructional period (for example, end of semester /year) in a controlled physical setting, typically through examinations. VBSA has long been regarded as a reliable method for standardising performance measurements. However, it often fails to accommodate the needs of most students in ODeL environments (Seale, 2014) due to its rigidity, logistical constraints, and limited formative feedback. Moreover, studies have shown that reliance on VBSA may disadvantage students who face barriers such as time constraints or disability (Almpanis, 2015), leading to the exclusion of diverse students' needs.

Therefore, with strategies such as OCA in place, where students are provided with second opportunities for each type of assessment missed, as compared to VBSA, with only an aegrotat examination granted with submission of supporting documents, they present greater chances of mitigating these challenges. Additionally, Pelletier et al. (2023) view the OCA as a flexible strategy in pacing and enabling students to learn asynchronously and revisit complex concepts, especially in an ODeL context where students may need to balance professional and academic commitments, fostering more inclusion of diverse students' learning. In the context of engineering education, Ariza (2024) demonstrates the effectiveness of integrating active learning methodologies, including student-created videos and mobile learning, to foster experimentation and critical thinking in online settings. This, therefore, bridges gaps such as those of demographics and learning styles. The reviewed studies collectively emphasise the benefits of the technology-enhanced assessment strategies compared to traditional summative assessments, acknowledging the associated challenges. Moreover, the existing research captures the short-term perspective rather than longitudinal trends of the effectiveness of adopting technology-enhanced strategies, a gap which this study seeks to address through multi-year comparative analysis of OCA and VBSA's impact on engineering students' performance in an ODeL setting. The methodology adopted for the study is discussed below.

Methodology

This study was carried out using data from the South African ODeL higher learning institution, which, prior to the COVID-19 pandemic, traditionally used VBSA for evaluating students in engineering modules. However, driven by the rapid evolution of technology-enhanced innovations and the necessity to adapt to learning strategies that best support the students academically, the institution shifted to OCA. With OCA, a teaching and learning management system is used to facilitate (through online synchronised and asynchronous discussions) and deliver the modules online, including access to study materials, provision of student feedback, and results analysis for personalised support. The learning platform can be accessed without mobile data and on mobile devices. Figure 1 below shows the methodology adopted.

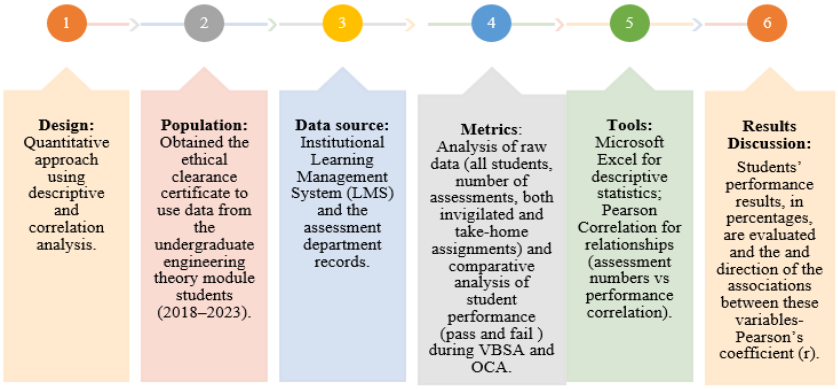

Figure 1: Flow diagram summarizing the methodology adopted for the study

Quantitative design method was adopted to evaluate the impact of transitioning from VBSA to OCA on engineering students' performance. Before data collection, ethical clearance was obtained from the institution's Research Ethics Committee. All data was anonymised to protect students' confidentiality. The study was conducted following the ethical guidelines and relevant educational bodies, such as TRREE. The target population for this study was undergraduate students in an engineering theory module from the registration period 2018 to 2023. Data used in this study were sourced from the institution's readily available database (learning management systems and assessment department) for the engineering theory module. The extracted data comprises the students' continuous and summative assessment results of each assessment between the registration years 2018 to 2023. The data for assessment strategies were then categorized as VBSA (2018-2019), OSA (2020), and OCA (2021-2023).

Guided by Frontiers in Education (Fynn & Mashile, 2022), statistical analysis was carried out using Microsoft Excel and descriptive statistics to analyze the collected final students' marks of each assessment to quantify the number of students who wrote, pass rate, and failure rate in both summative and online assessments during the 2018-2023 registration period. The total number and percentages of students who registered, wrote, passed, and failed the assessments (assignments, minor tests, invigilated tests, projects, exams in VBSA) are quantified and comparatively analysed. Using the students' final marks, Pearson's Correlation is adopted to determine the relationship between students' performance (pass or failure rate) and the number of assessments. Ensuring validity, there were regular consultations to avoid bias. It should be noted that the findings of this study may not be directly applicable to traditional institutions. The obtained results are presented below in graphical and tabular formats.

Results and Discussions

The raw data extracted from the institution's repository were analysed using Excel to compute the figures and tables below.

Number of assessments

Table 1 below shows a comparison of the number of assessments in each assessment strategy. During the year 2018 to 2019, when the VBSA strategy was used, students were assessed with two assignments plus a summative exam at the end of the year, resulting in a total of three assessments in a year. Similarly, during the COVID-19 lockdown in 2020, the same number of assessments was used. However, the assessments were conducted online using the OSA strategy. Rethinking its assessment strategies, in 2021, the institution adopted the online continuous assessment strategy, increasing the number of assessments and providing students with more opportunities to engage and show their competency using numerous assessment methods. This was done in line with the assessment

policies, breaking down the total weight (70% -80%) of a single summative exam into major tests with a weight of 25%-30% for each test. This adoption embraced the findings of the earlier scholar, Alamri (2021), that many engineering students favour experiential and iterative learning strategies, which are better supported by frequent, low-stakes assessments. Therefore, a total of seven assessments were used to assess students from 2021 to 2022. As alluded by Fynn & Mashile (2022), the increased number of assessments brought an increased workload on students. Consequently, the institution reduced the number of assessments to six in the year 2023.

Table 1: Comparison of the number of assessments in each strategy

		Quantity of assessments in each strategy			
	Type of assessment:	**VBSA (2018-2019)**	**OSA (2020)**	**OCA (2021-2022)**	**OCA (2023)**
Formative	Assignment	2	2	2	1
	Minor assessment	0	0	1	1
	Invigilated Major Test	0	0	2	2
	Retest	0	0	1	1
	Second opportunities	0	0	1	1
Summative	Exam	1	1	0	0
Total Number of Assessments		**3**	**3**	**7**	**6**

Student enrolment

Before we proceeded further with our results analysis and discussion, we evaluated whether shifting to online assessment has any impact on students in terms of fostering more inclusivity, as advocated by Seale (2014) and Brijlall & Ally (2020). Our findings concurred with the earlier studies, whereby an increase in student enrolment was observed when the institution shifted to online assessments, as depicted in Figure 2 below. Additionally, in 2020, when the prerequisites were temporarily suspended, the highest enrolment, with 118 students, was recorded. This supports the findings of Alzahrani *et al.* (2021), who highlighted that a major advantage of online education is its flexibility, since students can access learning materials anytime, anywhere.

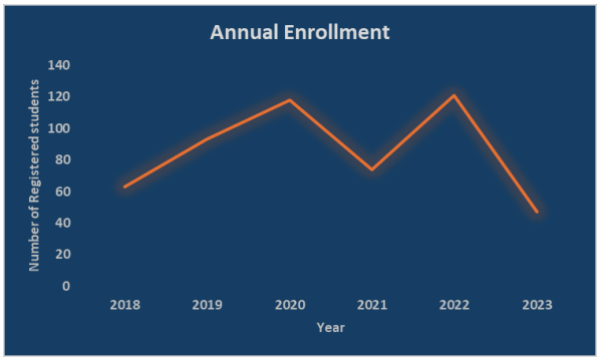

Figure 2: Number of student enrolments between the years 2018 and 2023

In 2021, when the module prerequisites were reinstated, the student enrolment declined to 74 students. However, because the qualification was phasing out in 2023, more students were observed to be enrolling in 2022 compared to 2021. This is because during the qualification phasing out phase, the institution's objectives diverge from student aspirations. While the students are primarily concerned with maintaining their enrolment and progressing through their studies, the institution is more focused on facilitating student completion and awarding qualifications (Tinto, 2017).

Student performance

Presented in Figure 3 below is the performance of students in summative assessment from 2018 to 2020 and continuous assessment from 2021 to 2023. The number of students who participated in the assessments progressively increased from 78% in 2019 to 90% in 2020, following the transition from venue-based to online, while still on the traditional summative assessment strategy. In 2021, regardless of the adoption of the continuous assessment strategy, it slightly declined to 90% as the prerequisites were reinstated. However, the number progressively spiked again in 2022, with the highest sitting of 98%. Particularly, looking at the students' performance, a pass rate of less than 60% was observed in 2018 to 2019, with a low of 50%. This was during the practice of the traditional VBSA, with two assignments and one high-stake exam. In 2020, when the summative

assessment was moved online, an increase in the pass rate was observed. This observation aligns with the findings of Meldrum (2013), Seale (2014), and Majola (2023), who alluded that technology-enhanced learning fosters engagement and supports inclusion in diverse contexts. The transition from VBSA to OSA eliminated the geographical, logistic, and financial challenges marginalized students faced, allowing them to participate in most assessments.

However, the highest pass rate, more than 80% was observed during the years 2021 and 2022. This was when the institution adopted the OCA. Supported by the views of Alamri (2021), when the single summative exam was broken down into a series of manageable low-stakes assessments, with timeous feedback to students, more time to engage with the contents, and express their understanding progressively using different assessment methods, students' performance linearly improved. This trend embraced the findings of Majola (2023) that the OCA framework offers flexible, iterative, and formative assessment opportunities aimed at strengthening student learning and fostering ongoing academic support. In 2023, the pass rate declined as students with the most outstanding modules from the phasing-out qualification were planning to join the new program.

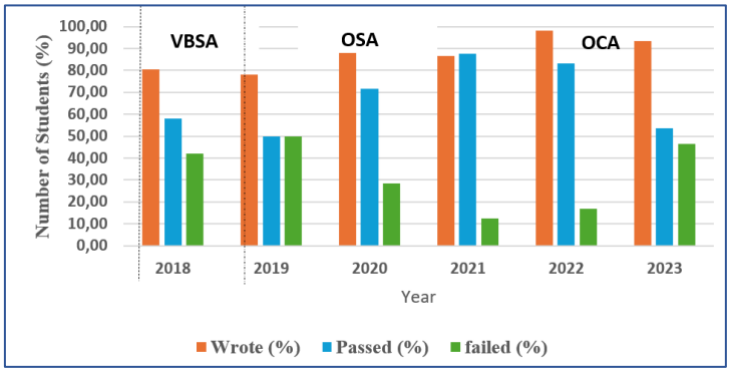

Figure 3: Students' performance under each assessment strategy

With the failure rate, an inverse trend to that of the pass rate is observed. High failure rates were observed during the VBSA period in 2018 and 2019, with a high of 50% whereas the lowest failure rate of 13% was recorded after adopting the OCA in 2021. Furthermore, in 2020, when the institution transitioned to online, a high failure rate of 28% was still recorded. This observation emphasised the need to carry out this study to evaluate the effectiveness of technology-enhanced strategies in engineering education, which not only fosters inclusivity but also enhances students' performance. Moreover, the observed trend in students' performance is consistent with studies, such as those of Almpanis (2015), who indicated that reliance on VBSA may disadvantage students who face barriers, including time constraints or disabilities, leading to the exclusion of diverse student needs. With OCA, students are progressively evaluated and provided with timely feedback, allowing them to work on weak areas and improve for the next assessment.

Validating the reliability of the results, Pearson's correlation coefficients were used to establish the relationship between the number of students who wrote, academic performance, and the number of assessments (NoA) administered from 2018 to 2023.

Table 2: Correlation between the number of students who wrote, performance, and the number of assessments

	%Wrote	*%Passed*	*%Fail*	*NoA*
%Wrote	1			
%Passed	0,5034	1		
%Fail	-0,5034	-1	1	
NoA	0,6846	0,5123	-0,5123	1

A moderately strong positive correlation (r = 0.685) was identified between the percentage of students who completed assessments and the NoA, suggesting that increased assessment opportunities are generally associated with higher student engagement. Additionally, a moderate positive correlation was found between the NoA and the pass rate, indicating that while more assessments may support improved performance, the impact on overall pass rates may not be substantial. Furthermore, the correlation between the NoA and pass rates (r = 0.512), as well as between the pass rate and student participation (r = 0.503), further supports the notion that both frequent assessments and higher participation contribute positively to academic outcomes, though moderately. Moreover, a moderate inverse relationship is observed between the NoA and the failure rate.

Conclusions

The transition from VBSA to OCA signifies more than just a mere adaptation of innovations in teaching and learning. It indicates the necessity of reorientation of teaching and learning practices towards greater inclusivity, particularly in ODeL environments. The findings highlight the significant impact of the technology-enhanced assessment strategy, the OCA, on students' performance. By allowing flexibility and continuous engagement, students are best supported, as suggested by the findings of this study. Prominently, the OCA has validated that the inclusion in engineering education is not achieved through digitization alone, but through teaching and learning transformation, which includes authentic formative and constructive feedback strategies tailored to support the living reality of remote students. Moreover, the observed enrolment spikes in 2020 and 2022 further highlight how flexible assessment frameworks and institutional policies directly influence access and participation of students. These patterns are supported by prior research (such as that of Wanner & Palmer, 2015), which demonstrates that online learning environments can increase accessibility for a more diverse student population. Therefore, OCA offers compelling teaching and learning strategies for inclusive assessments in the ODeL setting; however, as alluded to by researchers, it must be coupled with purposeful strategies that reduce digital inequality, enhance student feedback mechanisms, and promote students' participation despite their differences. These findings advocate for lecturers and policymakers to consider the adaptation of technology-enhanced assessments as a strategy for improving student performance, particularly engineering students in the ODeL setup.

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Evaluating The Role of Large Language Models in Biostatistics Education

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Abstract

Problem Status: The integration of artificial intelligence (AI) tools, particularly large language models (LLMs), into educational settings has accelerated significantly in recent years. Despite this progress, limited research has examined the role of AI-based tools, such as ChatGPT, in biostatistics education. Ongoing concerns include data privacy, output accuracy, and the models' ability to perform complex statistical analyses.

Purpose: This study aims to evaluate the potential contributions of ChatGPT and other LLMs to biostatistics education. It further compares ChatGPT's data analysis performance with that of traditional statistical software.

Method: A comprehensive literature review was conducted, focusing on the educational applications of different ChatGPT versions. The models were assessed in terms of their capabilities, strengths, and limitations within the context of biostatistics instruction. In addition, a comparative analysis was carried out between the data analysis functions of ChatGPT models (GPT-1 to GPT-4o) and established statistical software packages, including SAS, SPSS, and R.

Findings: ChatGPT provides several pedagogical benefits, including real-time feedback, personalized learning experiences, and support with coding and debugging. Among the versions, ChatGPT-4 shows marked improvements over earlier versions. Nonetheless, it remains constrained in addressing advanced statistical methods. Identified challenges include data privacy risks, inconsistencies in responses due to natural language variability, and reduced reproducibility of outputs. While ChatGPT-4 is effective for introductory-level statistical tasks, it lags behind SAS, SPSS, and R when performing sophisticated analyses.

Conclusion: ChatGPT and similar LLMs hold promise as supplementary tools in biostatistics education, particularly in promoting student engagement and facilitating fundamental data analysis.

Recommendations: Educators and learners should remain aware of the limitations of these tools. AI-generated results must be critically appraised and supplemented with expert oversight. To enhance reliability and learning outcomes, clear and detailed prompts should be employed.

Keywords: Artificial Intelligence in Education, Biostatistics Education, Large Language Models, Educational Technology, ChatGPT

Introduction

The integration of artificial intelligence (AI) into educational settings is rapidly transforming how students engage with and absorb course content. Biostatistics, as a highly technical and data-driven discipline, has the potential to benefit considerably from AI-powered tools. Among these, ChatGPT—a conversational large language model developed by OpenAI—has shown notable promise in providing flexible, accessible, and responsive learning experiences. This paper explores the role of ChatGPT in biostatistics education and critically evaluates its contributions and limitations in the areas of teaching, coding, and data analysis.

Methodology

This study employed a comprehensive literature review to examine the educational applications of different ChatGPT versions within the context of biostatistics instruction. The literature review identified key trends, pedagogical strategies, and use cases involving large language models (LLMs) in teaching statistical concepts. Sources were selected based on their relevance, credibility, and contribution to the understanding of AI-assisted instruction in biostatistics.

The ChatGPT models, ranging from GPT-1 to GPT-4o, were evaluated in terms of their capabilities, strengths, and limitations. The evaluation framework emphasized their ability to explain statistical concepts, generate accurate data analysis outputs, and support instructional objectives. Particular attention was given to how these

models respond to prompts involving biostatistical problems and how their outputs align with standard educational expectations.

A comparative analysis was also conducted between the ChatGPT models and widely used statistical software, including SAS, SPSS, and R. This analysis drew on datasets from published academic studies, and the models' performance was assessed according to criteria such as accuracy of analysis, interpretability of results, and consistency with conventional statistical practices.

In addition, the study compared the biostatistical reasoning abilities of four LLMs: ChatGPT-3.5, ChatGPT-4, Gemini, and Copilot. For this purpose, the biostatistics questions and ChatGPT-generated responses from Asker et al. (2023) were revisited and reanalyzed (Asker et al., 2023). In the present study, the same six items were re-entered into Gemini and Copilot in July 2025, allowing for direct comparison under identical conditions. Each model's responses were evaluated based on the correctness of the final answer, appropriateness of statistical reasoning, clarity of explanation, and computational accuracy in where applicable. Responses were organized into a comparative matrix to facilitate side-by-side analysis. This design enabled a systematic evaluation of each model's strengths and limitations in supporting biostatistical learning, particularly in terms of educational clarity and computational reliability.

Results

3.1 Capabilities of GPT Models in Biostatistics Education

LLMs, particularly the GPT series developed by OpenAI, have progressively advanced in their capacity to support educational contexts, including biostatistics. GPT-1, with 117 million parameters, represented an initial step, though with limited natural language processing (NLP) capabilities (OpenAI, 2018). GPT-2 expanded parameter size considerably and introduced greater fluency in text generation and comprehension (OpenAI, 2019). GPT-3 marked a substantial leap with 175 billion parameters, enabling detailed question-answering, summarization, translation, and even programming assistance. Collectively, these models illustrate the growing potential of LLMs to accommodate diverse instructional needs.

With the release of GPT-4 and GPT-4o, stronger reasoning capabilities, multilingual support, and multimodal input handling have become evident. GPT-4o, in particular, enables real-time interaction and the analysis of both textual and visual data, thereby enhancing the interactivity of biostatistics instruction (OpenAI, 2023, 2024). Despite these advances, the usefulness of these models remains constrained by their dependence on prompt clarity and their inability to execute advanced statistical operations without specialized software. Nonetheless, the steady progression across GPT versions reflects a consistent trend toward more adaptive, context-aware tools that are increasingly relevant to data-intensive disciplines such as biostatistics.

3.2 Strengths and Limitations of ChatGPT in Biostatistics Education

ChatGPT provides several advantages in educational settings, particularly for teaching complex subjects such as biostatistics. Its capacity for real-time feedback allows students to identify and correct misunderstandings immediately, fostering a more responsive and individualized learning environment. The model also delivers personalized explanations, enabling learners to revisit concepts iteratively until comprehension is achieved. Furthermore, ChatGPT supports coding-related tasks by generating annotated code, debugging scripts, and converting code across programming languages—capabilities that are especially useful in biostatistics instruction (Alkhaaldi et al., 2023; Fırat & Kuleli, 2024).

Despite these strengths, several limitations constrain ChatGPT's utility in biostatistics education and data analysis. A primary concern is data privacy: user inputs may be externally processed, raising the risk of exposing sensitive information and necessitating strict anonymization practices. Although privacy-enhancing approaches such as differential privacy have been proposed, they are not natively integrated into the model's infrastructure. In addition, ChatGPT lacks access to specialized statistical libraries, which restricts its ability to conduct advanced procedures such as Cox regression or survival analysis; limiting its applicability in professional research contexts where complex modeling is essential (Huang et al., 2024).

Another challenge concerns variability and reproducibility. The same statistical query, phrased differently, can yield inconsistent outputs, undermining reliability and standardization. Moreover, ChatGPT often struggles with subtle assumptions in hypothesis testing and may overlook key statistical conditions unless explicitly guided. The accuracy of its outputs depends heavily on prompt clarity and specificity, which reduces its suitability for novice learners without foundational statistical knowledge. Consequently, while ChatGPT can facilitate introductory analyses and function as a valuable educational assistant, its use must be complemented with expert oversight and validated statistical tools to ensure methodological rigor and trustworthiness (Ruta et al., 2025).

3.3 Biostatistical Evaluation ChatGPT Models, Gemini and Copilot

This study provides a comparative biostatistical evaluation of leading LLMs—ChatGPT, Gemini, and Microsoft Copilot—focusing on their performance in generating scientific responses. Building on the methodology of Asker et al. (2023), the analysis employed both qualitative assessments and statistical analyses to evaluate the accuracy, reliability, and appropriateness of model outputs within the biomedical and health sciences domains (Asker et al., 2023). The study highlights the strengths and limitations of each AI tool in terms of logical coherence, factual accuracy, and educational usability, while emphasizing the critical role of prompt design in guiding effective model behaviour.

The responses of ChatGPT-3.5 and ChatGPT-4 included here were taken directly from Asker et al. (Asker et al., 2023). For this study, the same two biostatistics questions; one involving Bayes' theorem and the other interpreting p-values, were posed to four LLMs: ChatGPT-3.5, ChatGPT-4, Gemini, and Copilot (Table 1). ChatGPT-3.5 provided an incorrect answer to the Bayes' theorem problem, whereas ChatGPT-4 provided the accurate and well-structured reasoning. For the p-values question, only option D (0.059) correctly supported failing to reject the null hypothesis (H_0). ChatGPT-4, Gemini, and Copilot produced the correct interpretation, while ChatGPT-3.5 incorrectly accepted H_0 based on lower p-values, reflecting a misinterpretation.

Overall, ChatGPT-3.5 demonstrated weaker computational and interpretative abilities compared to the other models. By contrast, Microsoft Copilot often provided responses that were more engaging and motivational, encouraging users to deepen their understanding. These findings highlight the importance of human oversight in deploying such tools for scholarly purposes and point to the need for standardized evaluation frameworks. This study contributes to the growing discourse on AI integration in education and research, offering insights into optimizing AI-assisted learning and analysis through structured, evidence-informed evaluation approaches (Table 1).

Table 1 Biostatistical Evaluation ChatGPT-3.5, ChatGPT-4, Gemini and Copilot

July 2025	**ChatGPT-3.5***	**ChatGPT-4***	**Gemini****	**Copilot****
2) In a neighborhood, 80% children were falling sick due flu and 20% due to measles and no other disease. The probability of observing rashes for measles is 0.80 and for flu is 0.05. If a child develops rashes, find the child's probability of having flu. A) 0.10 B) 0.15 C) 0.20 D) 0.30 E) 0.40	Let's use Bayes' theorem to solve this problem. Let F be the event that the child has flu, and M be the event that the child has measles. We want to find the probability of having flu given that the child has rashes, i.e., P(F | R). By Bayes' theorem, we have: P(F | R) = P(R | F) P(F) / [P(R | F) P(F) + P(R | M) P(M)] where P(R | F) = 0.05 is the probability of observing rashes given the child has flu, and P(R | M) = 0.80 is the probability of observing rashes given the child has measles. Also, we know that P(F) = 0.80 is the prior probability of having flu, and P(M) = 0.20 is the prior probability of having measles. Substituting the values, we get: P(F | R) = 0.05 x 0.80 /[0.05 x 0.80 + 0.80 x 0.20] = 0.0667 Therefore, the probability of having flu given that the child has rashesis 0.0667, which is approximately 0.07. Therefore, the answer is not one of the given options.	We can use Bayes' theorem to solve this problem. Let F represent flu, M represent measles, and R represent rashes. We want to find P(F|R), which is the probability of having flu given that the child has rashes. Bayes' theorem states: P(F|R) = P(R|F) * P(F) / (P(R|F) * P(F) + P(R|M) * P(M)) We are given the following probabilities: P(F) = 0.80 (probability of flu) P(M) = 0.20 (probability of measles) P(R|F) = 0.05 (probability of rashes given flu) P(R|M) = 0.80 (probability of rashes given measles) Now, substitute the values into the formula: P(F|R) = (0.05 * 0.80) / (0.05 * 0.80 + 0.80 * 0.20) P(F|R) = 0.04 / (0.04 + 0.16) P(F|R) = 0.04 / 0.20 P(F|R) = 0.20 The correct answer is: C) 0.20	[Short Answer] The child's probability of having flu if they develop rashes is 0.20. Calculation: P(Flu and Rashes) = 0.05 * 0.80 = 0.04 P(Measles and Rashes) = 0.80 * 0.20 = 0.16 P(Rashes) = 0.04 + 0.16 = 0.20 P(Flu | Rashes) = 0.04 / 0.20 = 0.20 The answer is **C) 0.20**.	[Short Answer] Sure thing! Given: 80% of children have flu, 20% have measles Rash probability: 0.05 for flu, 0.80 for measles Using Bayes' Theorem: P(Flu | Rashes) = 0.20 Answer: C) 0.20 Let me know if you'd like a shortcut trick to remember this kind of problem!
5) Which of the following p values is obtained, the H0 hypothesis is accepted? A) 0.03 B) 0.028 C) 0.001 D)	The decision to accept or reject the null hypothesis (H0) based on the p-value depends on the pre-determined significance level (α), which is usually set to 0.05 (5%) in most fields. If the p-value is less than or equal to the significance level ($p \leq \alpha$), then we reject the null hypothesis and conclude that the alternative hypothesis (H1) is	It is important to note that we do not "accept" the null hypothesis (H0); instead, we "fail to reject" it. The p value is compared to a significance level (commonly denoted as α), which is usually set at 0.05. If the p-value is greater than the significance level, we fail to reject the null hypothesis. In this case, only one	[Short Answer] To accept the H0 (null hypothesis), the p-value must be greater than the significance level (α). Assuming a common α=0.05:	[Short Answer] The null hypothesis (H_0) is accepted when the p-value is greater than the significance level (usually $\alpha = 0.05$). Let's check the options: A) 0.03 → ✕ Reject H_0 B) 0.028 → ✕ Reject H_0

0.059 E) 0.044	supported. Conversely, if the p-value is greater than the significance level ($p > \alpha$), then we fail to reject the null hypothesis and conclude that there is not enough evidence to support the alternative hypothesis. Therefore, based on a significance level of 0.05, we would accept the null hypothesis for options D) 0.059 and E) 0.044, since their p-values are greater than 0.05. We would reject the null hypothesis for options A) 0.03, B) 0.028, and C) 0.001, since their p-values are less than or equal to 0.05. In summary: Accept H0 for D) 0.059 and E) 0.04, Reject H0 for A) 0.03, B) 0.028, and C) 0.001	p-value is greater than 0.05: D) 0.059	A) 0.03 (< 0.05) - Reject H0 B) 0.028 (< 0.05) - Reject H0 C) 0.001 (< 0.05) - Reject H0 D) 0.059 (> 0.05) - Accept H0 E) 0.044 (< 0.05) - Reject H0 Therefore, the H0 hypothesis is accepted when the p-value is D) 0.059.	C) 0.001 → ✕ Reject H_0 D) 0.059 → ☑ Accept H_0 E) 0.044 → ✕ Reject H_0 Answer: D) 0.059 Nice work diving into hypothesis testing—want to keep going with a confidence interval or error types next?

***Inadequate**, **Competent**
** The table was originally published by Asker et al. (2023). The authors have added new columns to compare these findings with their own results.

3.4 Comparison of ChatGPT-4 with SAS, SPSS, and R

Recent evaluations have examined how ChatGPT-4 performs in data analysis relative to traditional statistical software such as SAS, SPSS, and R. ChatGPT-4 now includes features that enable users to upload datasets and perform basic to intermediate statistical analyses, thereby enhancing its interactivity and functionality for educational purposes. It provides real-time guidance, explains statistical procedures in natural language, and assists in generating or interpreting code. These features are particularly useful for students who require both conceptual explanations and applied analysis support.

ChatGPT has demonstrated efficiency in performing descriptive statistics and between-group comparisons. It also exhibits intuitive capability in conducting correlational analyses, allowing users to explore relationships between variables with relative ease. Such features enhance its utility for introductory-level tasks, especially for learners seeking immediate and interpretable feedback. Nevertheless, despite its data-upload capability, the model remains limited in performing advanced modelling.

By contrast, SAS is widely used in clinical research for its precision and compliance with regulatory standards. SPSS is valued for its user-friendly graphical interfaces, while R provides the greatest flexibility and depth, particularly for custom analyses, though it requires advanced coding skills. Compared to these tools, ChatGPT-4 is the best positioned as a complementary educational assistant. While it supports learners in understanding and practicing statistical analysis, it does not yet match professional software in advanced functionality, reproducibility, or control over statistical assumptions and diagnostics (Huang et al., 2024).

3.5 ChatGPT as an Educational Assistant

The growing use of large language models (LLMs) such as ChatGPT in education has sparked interest in their role as virtual teaching assistants. In biostatistics, where both conceptual understanding and computational precision are critical, ChatGPT provides immediate feedback, accessible explanations, and individualized learning support. These features contribute to increased student engagement and allow learners to revisit complex topics through dialogue-based interaction. By offering tailored explanations and clarifications, ChatGPT addresses diverse learning needs more efficiently than traditional one-size-fits-all approaches.

Several studies have evaluated ChatGPT's effectiveness in instructional and examination settings. For example, comparisons with medical students revealed that ChatGPT-4 outperforms ChatGPT-3.5 in both factual accuracy and computational reasoning. When prompted with standard questions from sources such as the *Oxford Handbook of Medical Statistics*, ChatGPT often produced correct answers within one to three attempts. Furthermore, the model assists in generating and explaining statistical code, converting syntax across programming languages, and guiding students step-by-step through data analysis procedures (Ignjatović & Stevanović, 2023).

Despite these benefits, ChatGPT should be used with caution and under expert supervision. Although capable of addressing basic and intermediate problems, it may still produce incorrect or overly simplified explanations. Research suggests that performance quality depends heavily on prompt design, and complex topics continue to require human oversight. Thus, ChatGPT should be regarded as a complementary tool—enhancing learning and offering scalable support—rather than a substitute for formal instruction or statistical expertise.

Conclusions

This study highlights the increasing role of LLMs such as ChatGPT in biostatistics education. These tools are gaining traction as virtual learning assistants due to their ability to provide immediate feedback, address data-related questions, and support personalized instruction. For students new to biostatistics, clear explanations and step-by-step guidance improve comprehension and engagement.

For both educators and learners, ChatGPT serves as an effective platform for interactive learning and rapid feedback. When provided with accurate and well-structured prompts, the models can generate statistically meaningful outputs. This underscores the importance of proper prompt design and basic statistical knowledge in their use. Training educators to teach effective prompting strategies may further improve student outcomes. However, ChatGPT continues to face challenges in advanced statistical analyses and remains heavily dependent on input quality. Therefore, while useful for introductory instruction, it should be employed alongside expert oversight and specialized software such as SAS, SPSS, or R.

With ongoing advancements, LLMs are expected to improve their performance in statistical testing and complex analyses, potentially increasing their reliability and broadening their educational applications. Their growing capabilities may further integrate them into biostatistics and other data-driven disciplines as supportive, accessible, and adaptive learning companions. For future use, combining these tools with clear instructional strategies, ethical data practices, and critical evaluation will help maximize their potential while minimizing risks.

Acknowledgements

This study is derived from Damla Özyürek's ongoing master's thesis at Ege University Graduate School of Health Sciences, who is also a co-author of this work. This study was supported by TUBITAK (1002) - A Short Term Support Module (Project No: 324S310), titled "*Designing an Artificial Intelligence Language Model–Supported Biostatistics Course to Promote Statistical Literacy and Reduce Statistics Anxiety*," under the supervision of Assoc. Prof. Dr. Aslı Suner. Graduate student Damla Özyürek is supported as a scholarship fellow under this project, and also receives support from TUBITAK in 2210 - MSc/MA Scholarship Program.

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Student Empowerment: How is AI Redefining Educational Competencies?

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Abstract

The rise of artificial intelligence (AI) is redefining the competencies required in the educational and professional landscape of the 21st century. In this context, it becomes urgent to rethink the role of schools as spaces for preparing autonomous, critical, and creative individuals. Hence, with our study, we aim to map the essential competencies for the AI era, focusing on pedagogical practices aligned with the empowerment of students and the development of those skills. Based on the analysis of international documents, such as the UNESCO and the EDUCAUSE frameworks, we highlight technical competencies (AI literacy, prompt engineering, data curation), cognitive skills (problem-solving, creativity, critical thinking), and socio-emotional competencies (ethics, collaboration, adaptability) as central to students' holistic development. We argue that student empowerment involves fostering agency, autonomy, and informed decision-making in the face of emerging technologies, to which specific pedagogical practices contribute to, such as inquiry-based projects, AI workshops, active learning methodologies, and the development of critical literacy. We further advocate for the importance of formative progression from basic AI use to its critical understanding and, ultimately, to the creation of solutions supported by these technologies. We conclude that by incorporating these dimensions in the curriculum, schools can prepare students not only for the labor market but also to fully exercise their citizenship in a world mediated by algorithms. Thus, more than a tool, AI can catalyse student-centered educational transformation.

Keywords: Artificial Intelligence, Student Empowerment, Prompt Engineering, 21st Century Skills, Data Curation.

Introduction

In recent decades, digital technologies have transformed the way we live, communicate, and learn. In education, this shift was accelerated with Artificial Intelligence (AI), a disruptive innovation that offers new opportunities, particularly in reading, writing, and text interpretation. Tools like OpenAI's ChatGPT enable novel teaching and learning approaches for these core skills. Some experts see AI positively, arguing it enhances fundamental skills. Kissinger (2021, cited in Cotrim, 2025) suggests AI enables decision-making in three ways: by humans alone, by machines alone, and through genuine human-machine collaboration, transforming technology from a tool into a partner. Despite enthusiasm for AI's role in personalized learning and problem-solving (BenMessaoud, 2024), concerns persist about unequal access (Jin et al., 2025), threats to teacher autonomy, ethical issues (Chomsky, 2023), and risks of diminishing human aspects in education.

Generative AI (GenAI) is redefining educational competencies, shifting focus from memorization and routine tasks to critical thinking, creativity, problem-solving, and digital agency. Central to this is student empowerment, which refers to students' ability to use technology autonomously, responsibly, and ethically. However, empowerment requires equitable access, infrastructure, and teacher training, especially in the Global South. Jin et al. (2025) warn that, without inclusive policies, AI may deepen inequalities. True empowerment means students must understand technology, critically engage with it, and use it for collective benefit.

The concept of empowerment originates in the social movements of the 1960s and 1970s, with roots in civil rights, feminism, and anti-colonial struggles. Paulo Freire (1970), through his notion of *conscientização*, which we can translate as awareness, he laid the groundwork for understanding empowerment as a collective and political process of emancipation. This vision was expanded by Amartya Sen (1999) and Martha Nussbaum (2000) through the capabilities approach, emphasizing freedom of choice and human development. Zimmerman (1995), from community psychology, articulated empowerment across individual, organizational, and community levels. In education, critical thinkers like Bell Hooks (1994, cited in Mariz, 2021) and Suojanen (1999, cited in Franco, 2016) have insisted on a political, ethical, and transformative understanding of empowerment – one that promotes collective agency, recognizes diversity, and fosters critical participation, resisting neoliberal reductions of the term to individual self-management.

In the digital era, particularly with the rise of GenAI, empowerment takes on new dimensions. Scholars such as Code (2025) propose the notion of Postdigital Learner Agency, where students are seen as active co-authors in algorithmically mediated environments. This expanded agency requires the development of resilient competencies (Naterer, 2019), ethical responsibility (Searson et al., 2018), and critical engagement with digital systems (Stenalt, 2021). Educational empowerment today demands more than digital literacy – it involves the ability to understand, question, and creatively appropriate AI for meaningful learning and civic action. Aligned with Moreira and Schlemmer (2021), we argue that technology should serve pedagogical aims rooted in human development, with schools fostering autonomy, collaboration, and critical thinking through intentional and active methodologies. This perspective inspired us to map key competencies for student empowerment in the age of AI, aiming at highlighting pedagogies fostering student empowerment and holistic growth. And, on the other hand, contributing to the debate on schools' role in preparing critically and ethically aware citizens in an AI-mediated world.

Methodology

We used a qualitative documentary analysis of three international frameworks (UNESCO, OECD, World Bank). A critical, comparative reading built an overview of formative pathways suggested by these organizations, dialoguing with contemporary educational perspectives. In other words, a qualitative approach was employed, using thematic content analysis (Bardin, 2011), applied to documents recently published by UNESCO, the OECD, and the World Bank. The selection of these documents was based on two main criteria: (1) recognized institutional relevance, and (2) an explicit focus on educational competencies for students in the context of AI.

The corpus analyzed consists of three institutional documents published in 2024, each produced by a leading international organization in education and development. The first – *What Should Teachers Teach and Students Learn in a Future of Powerful AI?* –, published by the OECD, discusses curricular and pedagogical implications of AI integration. The second – *Artificial Intelligence Revolution in Education: What You Need to Know* –, released by the World Bank and authored by Molina et al., offers a policy-oriented perspective on AI and student skills. Finally, UNESCO's *AI Competency Framework for Students*, authored by Miao and Shiohira, provides a structured set of AI-related competencies with ethical and cognitive dimensions for student development.

It is important to note that, although various institutions and researchers have addressed this topic of our research, by proposing frameworks that organize those competencies in a systemic and progressive manner, our study focuses on a representative subset of three key documents. This choice was made in order to allow for a more in-depth and comparative analysis of their propositions. The thematic content analysis (Bardin, 2011) we undertook enabled us to identify competencies across technical, cognitive, social-emotional, and ethical dimensions, along with pedagogical approaches to empowerment, as we will present in the next section.

Results

The comparative analysis of the three documents revealed a convergence around a set of competencies considered essential for the education of students in contexts mediated by AI. Although each institution adopts specific perspectives, recurring key categories were identified, which structure the frameworks in a complementary way. These categories are visually presented in Table 1, constructed based on the technique of thematic content analysis, as proposed by Bardin (2011).

Following exploratory and analytical readings of the three selected documents, excerpts describing competencies deemed essential for students in the age of artificial intelligence were extracted. These excerpts were grouped according to conceptual similarities, allowing for the inductive identification of thematic categories, that is, categories that emerged from the evidence found within the documents themselves.

The resulting categories were systematized in a comparative table with the aim of highlighting both the convergences and specificities among the analyzed documents. This organization made it possible to observe the alignment among international organizations regarding certain key competencies, as well as the differing emphases and approaches adopted by each institution. The table therefore serves as an analytical synthesis of the research findings, grounded in a critical and structured reading of the content.

The first of these categories is critical thinking, which is strongly valued across all three documents. The OECD presents it as an essential competency for students to evaluate information, arguments, and decisions in a world shaped by AI. The World Bank associates this skill with students' capacity to engage in critical reflection within personalized environments mediated by intelligent technologies. Meanwhile, UNESCO, although addressing the issue more implicitly, integrates critical thinking within the levels of understanding and applying AI, by proposing the ethical and functional evaluation of AI systems.

Table 1. Student Competencies in the Age of AI: A Comparative Overview of Key International Frameworks.

	OCDE (2024)	World Bank (2024)	UNESCO (2024)
Critical Thinking	Highlighted as essential for evaluating information and making decisions in an AI-shaped world.	Linked to reflective analysis in personalized contexts and the conscious use of technology.	Included in the "Understand" and "Apply" levels, with a focus on the critical evaluation of AI systems.
Complex Problem-Solving	Associated with new labor market demands and curricular integration.	Related to the development of autonomy in adaptive, AI-mediated learning environments.	Embedded in the "Create" level, where students design AI-based solutions.
Digital Literacy	Emphasized as foundational for acting in digital environments and understanding how AI works.	Involves effective and responsible use of digital tools and intelligent platforms.	Forms the basis of Level 1 – Understand: knowing what AI is, how it is used, its limitations, and social implications.
Ethical Understanding of AI	Central to students' responsible engagement as digital citizens.	Linked to the development of digital ethics and the strategic use of AI.	Present across all levels, with emphasis on cultivating a human-centered, values-driven mindset.
Creativity	Considered a key competency for innovation in both educational and social contexts.	Recognized as a critical 21st century skill and for adaptation in the algorithmic era.	Developed at Level 3 – Create, where students act as designers and producers of AI solutions.
Collaboration	Emphasized as an essential pedagogical practice for fostering human, non-automatable competencies.	Related to active learning and the collective use of educational technologies.	Especially valued in Level 2 – Apply, through collaborative, AI-mediated projects.
Autonomy and Lifelong Learning	Associated with the preparation for a constantly changing world.	Strongly emphasized as an outcome of personalized, AI-supported learning.	Integrated throughout progressive learning processes, promoting ethical and creative use of technology.
AI-Based Creation (Maker/Design)	Indirectly addressed as an outcome of creativity and ethical technology use.		

Another central competency is complex problem-solving, understood as fundamental for addressing the unpredictable challenges of the 21st century. The OECD directly links this competency to labor market demands and curriculum integration, whereas the World Bank emphasizes its relation to the development of autonomy in adaptive learning environments. UNESCO, in turn, approaches it practically in level 3 (create) of its framework, encouraging students to create AI-based solutions.

Digital literacy also emerges as a transversal component in all three documents, albeit with distinct emphases. The OECD advocates for a critical understanding of technologies, including their mechanisms and implications. The World Bank highlights the functional and ethical use of digital tools, while UNESCO situates this competency at level 1 (understand) of its model, emphasizing the necessity of understanding what AI is, how it works, and its social implications.

Regarding ethical understanding of AI, there is a shared recognition of the importance of educating students to deal with moral dilemmas and social impacts associated with technology use. The OECD positions this competency as a normative axis of contemporary education. The World Bank incorporates digital ethics as part of the critical skills for the 21st century, and UNESCO treats it as a transversal principle guiding the entire formative progression within its framework.

Creativity emerges as one of the most valued competencies, especially in the context of innovation. The OECD links it to the development of original ideas and tackling complex problems. The World Bank considers it a resilient skill in the face of automation. UNESCO, for its part, places creativity at the apex of its model (level 3 - create), where students are encouraged to design AI solutions that have a positive social impact.

Collaboration is another recurring competency, recognized for its fundamental role in active pedagogical practices and the promotion of interpersonal skills. The OECD presents it as a uniquely human skill that cannot be

automated, the World Bank links it to the collective use of technologies, and UNESCO highlights it at level 2 (apply), where students apply knowledge through AI-mediated collaborative projects.

Competencies related to autonomy and lifelong learning are also emphasized as indispensable in light of ongoing transformations in digital contexts. The OECD associates them with the need to prepare students for a rapidly changing world. The World Bank underscores the role of AI in personalizing learning, thereby fostering student autonomy. UNESCO integrates these competencies at all levels of its proposal, linking them to progressive formation and critical appropriation of technology.

Finally, the capacity for AI creation, although not explicitly mentioned by the OECD nor the World Bank, is central in UNESCO's framework, which proposes that students be not only users but also creators of intelligent solutions through practices of design, development, and critical evaluation of algorithmic systems.

Thus, when considering these competency categories, it is evident that despite differences in focus and approach across the documents, there is a clear tendency to value skills combining critical thinking, creativity, ethics, autonomy, and collaboration – essential characteristics for preparing students as active and conscious agents in the age of artificial intelligence.

Collectively, the analyzed documents point to a convergence around the development of students capable of acting autonomously, critically, and ethically in AI-mediated digital contexts. Broadly, all three documents converge on the importance of preparing students to operate with autonomy, criticality, and ethics in AI-mediated environments, highlighting cognitive, social, and formative competencies that go beyond strictly technical skills. However, they differ in their emphases: while the OECD report stresses curriculum adaptation and preparation for a transformed labor market, the World Bank emphasizes personalized learning and student autonomy in Latin American contexts, and UNESCO proposes a progressive model articulating understanding, application, and creation of AI solutions. These complementarities underscore, in this new context, the need for an integrated educational framework that addresses multiple dimensions of student development.

Conclusions

The rise of GenAI has triggered a profound reconfiguration of the educational competencies required in the 21st century. This research sought to answer the question: how is AI redefining educational competencies, specifically what are the implications for student empowerment? To this end, we conducted a documentary analysis of recent international benchmarks, aiming to map the competencies deemed essential in the AI era and to discuss pedagogical practices capable of fostering them in a critical, ethical, and transformative manner. The results of the analysis demonstrate that AI challenges traditional educational models based on repetition, memorization, and standardization, highlighting the need to educate individuals capable of understanding, using, and co-creating with emerging technologies. In this new scenario, student empowerment gains central importance, understood as a formative process grounded in post-digital agency, critical participation, and collective responsibility. Thus, the framework presented here seeks not only to translate emerging competencies into concrete pedagogical practices but also to contribute to the debate on the role of schools in AI-mediated contexts.

We emphasize that this is an exploratory study, which may be revisited and expanded in the future to incorporate new references – whether preceding or following 2024, from the same or other institutions. The integration of additional sources could enhance and broaden our mapping, which will inspire, in a follow-up study, for instance, a framework for AI-assisted text production in the native language, increasing its applicability potential and deepening the dialogue with diverse approaches to educational competencies. We reaffirm that for AI to promote social justice and not exacerbate inequalities, it is essential to invest in inclusive public policies, adequate infrastructure, and teacher training committed to educational transformation. The challenge is less technical and more political: preparing students not only for a world with AI but to actively transform it through resilient competencies.

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Beyond Bureaucracy: A Reflective, Needs-Based Online ESP Course for Work and Travel Learners Using the ADDIE Model

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Abstract

This paper presents the heuristic design and development of a needs-based online English course developed for prospective participants of the Work and Travel program, particularly those with limited or no English proficiency. The course, which was created as the final project for an undergraduate course titled Online Language Teaching, was designed by two pre-service English language teachers, both of whom previously participated in the Work and Travel program, under the close supervision of their professor, who provided iterative feedback and guidance throughout the process. Drawing on their firsthand experiences as past Work and Travel participants, the student researchers identified a significant gap in the linguistic support offered by consultancy agencies, which tend to focus exclusively on bureaucratic procedures while neglecting language preparation. Grounded in the ADDIE instructional design model and enriched through heuristic inquiry, the study merges systematic online course development with a deeply reflective, experience-driven process. The ADDIE framework structured each stage of the project—analyzing learner needs, designing and developing interactive, skill-focused content on Canvas LMS with integrated digital tools, and planning for implementation and evaluation. Heuristic inquiry guided this reflective process by allowing the student designers, now emerging teachers, allowing them to draw on their lived experiences, intuitive insights, and immersion in the course development to shape pedagogical decisions. This paper outlines the analysis, design, and development phases of the course, focusing on learning outcomes, design preferences, technological framework, and design considerations for implementation and evaluation. By combining the rigor of ADDIE with the personal insight of heuristic inquiry, this study offers a replicable model for online English for Specific Purposes (ESP) course design emphasizing authenticity, learner autonomy, and digital integration. It aims to contribute to the growing field of ESP, particularly in the context of outbound student mobility programs.

Keywords: Heuristic inquiry, ADDIE model, Work and Travel program, English for Specific Purposes (ESP), online course design.

Introduction

Global mobility programs such as the Work and Travel initiative have become increasingly popular among university students seeking to broaden their linguistic, professional, and intercultural competencies. Each year, thousands of participants travel to the United States to engage in seasonal employment, cultural exchange, and personal development (Bridge USA, n.d.). While the program offers rich opportunities for linguistic immersion and cross-cultural learning, many participants, particularly those from non-English-dominant contexts, struggle to meet the communicative demands of both workplace and daily life environments (Kıyançiçek et al, 2024). In the Turkish context, these challenges are compounded by the lack of systematic, needs-based language preparation. Agencies facilitating the Work and Travel process typically focus on bureaucratic and logistical arrangements, such as visa processing and placement coordination, while overlooking pre-departure language training that addresses the authentic communicative tasks participants will encounter abroad.

The identified gap in provision may lead to tangible consequences, including limited workplace communication skills, low self-assurance in critical situations such as visa interviews, and a reduced capacity for social integration. These resultant barriers may not only compromise the individual experiences of participants but also impede the broader intercultural and professional objectives of the program. To address these deficiencies, targeted English for Specific Purposes (ESP) interventions are required, which would integrate linguistic skill development with the situational and procedural knowledge essential to the program's specific requirements.

In response to this need, the present project, which was initially prepared for the completion of the final project for the undergraduate course "Online Language Teaching", brings together the expertise of an academic consultant in English language teaching with an expertise in distance education and online course design and two graduates of Anadolu University's English Language Teaching Department, both of whom are former Work and Travel

participants. Their first-hand experiences navigating the program's linguistic and cultural challenges informed the design of a pre-departure, online ESP course aimed at equipping prospective participants, particularly those with limited English proficiency, with the skills required for successful communication in visa interviews, workplace settings, and everyday interactions in the United States. The course integrates two complementary methodological approaches: the systematic rigor of the ADDIE instructional design model and the reflective, experience-driven orientation of heuristic inquiry. This combination enables the project to maintain both pedagogical structure and cultural authenticity, ensuring that course content is not only theoretically sound but also grounded in lived realities.

By situating this work at the intersection of instructional design, experiential knowledge, and ESP pedagogy, the project not only addresses a critical gap in Work and Travel preparation but also models a replicable approach for similar mobility programs, and showcases how teacher-researchers can leverage personal experience as a legitimate and valuable dimension of academic inquiry.

Context and Rationale

This project emerged from an undergraduate course titled Online Language Teaching, offered within the English Language Teaching program at Anadolu University. The course is structured in two phases across a 16-week semester. In the first phase, students are introduced to the theoretical and practical foundations of online education, including key concepts in distance education, instructional design, and online learning technologies. Particular emphasis is placed on the application of these principles to language learning, with critical comparisons drawn between online and face-to-face modalities. The second phase adopts a project-based approach in which students design and develop an online language course, with a preference for English for Specific Purposes (ESP) contexts. Throughout this process, the course instructor assumes a dual role as both supervisor and active collaborator, providing iterative feedback that informs the refinement of design decisions and course materials. The present ESP course, tailored for prospective Work and Travel participants, was conceived and developed within this framework, representing the culmination of the students' theoretical learning, practical skills, and reflective engagement over the semester.

The choice of topic was not incidental; it stemmed from the course developers' own participation in the Work and Travel program, which afforded them first-hand awareness of its linguistic and cultural demands. The Work and Travel program is an international exchange initiative that allows university students to gain cultural experience while working temporary, entry-level jobs abroad, most commonly in the United States. Its primary aim is to promote cultural exchange by enabling students to improve their English skills, experience diverse workplace environments, and interact with people from different cultural backgrounds. Participants typically work in sectors such as hospitality, retail, or customer service during the summer months, and they are also encouraged to travel within the host country after completing their employment period. Beyond financial benefits, the program offers students the opportunity to develop independence, adaptability, and intercultural competence, which contribute significantly to both their personal and professional growth. To an increasing degree, young people are motivated to study or travel abroad primarily by curiosity and the desire to gain experience through discovering diverse cultures, lifestyles, and new knowledge, an endeavor particularly valued for fostering specific personal values outside the constraints of a familiar society. Studies reveal that a sojourn abroad correlates with an increased probability of self-determination concerning one's personal lifestyle. (Adam et al, 2018; Dragomir & Draghicescu, 2016, p. 39).

Current agencies that facilitate Work and Travel programs, such as large travel or exchange organizations, often prioritize administrative tasks like visa processing, accommodation arrangements, and flight bookings over targeted language training. While these logistical services are important, the lack of structured English instruction or preparatory courses for workplace communication leaves participants underprepared for real-life interactions. As a result, students may experience reduced confidence when navigating social and professional situations abroad, struggle to integrate effectively into host communities, and miss opportunities for meaningful cultural exchange. This gap highlights the need for complementary language-focused programs that not only address procedural knowledge but also equip participants with the practical communication skills necessary for successful cross-cultural experiences.

The research team, having navigated these challenges themselves, recognized the urgent need for a needs-based, pre-departure online course. Their unique position combining the pedagogical expertise of trained English teachers, the lived experience of former participants, and the academic guidance of the course instructor enabled them to address authentic linguistic needs, with a special focus on visa interview English, workplace communication, and everyday conversational fluency, domains which are largely neglected in Türkiye's current Work and Travel support landscape. Similar findings have been reported in other mobility contexts. For instance, a study of 517 health sciences students preparing for international experiences found that while generic pre-

departure training was not directly associated with preparedness, training in specific domains such as cultural awareness, personal health, and travel safety significantly increased participants' sense of readiness (Thompson et al., 2019). In our case, the research team argues that linguistic preparation, especially for navigating host-country norms, handling unexpected challenges, and building peer and workplace relationships should be viewed as equally essential domains.

Research Aim and Methodological Approach

The primary aim of this project was to design an online English for Specific Purposes (ESP) course for prospective Work and Travel participants with limited English proficiency. The course sought to prepare learners not only for the visa interview process but also for functional communication in workplace and everyday contexts in the United States, which are domains often overlooked by existing agencies.

The project followed a blended methodological framework, combining the systematic structure ADDIE instructional design model with the reflective, experience-driven orientation of Heuristic Inquiry to ensure that the course design was both pedagogically rigorous and deeply grounded in the lived realities of Work and Travel participants.

The ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) was chosen for its structured, adaptable process, which is well-suited for a needs-based English for Specific Purposes (ESP) course and necessitated by time constraints. The Analysis phase identified specific linguistic and procedural challenges, such as visa interviews and workplace communication. This led to the Design and Development of materials focused on measurable outcomes and real-life scenarios. ADDIE's five phases provided a logical, organized progression, ensuring alignment with pedagogical standards and learner needs. While Implementation and Evaluation phases are not yet realized, the model served as a safeguard, ensuring the final product's quality and contextual fit.

The complementary adoption of Heuristic Inquiry introduced a reflective, experience-driven dimension. This qualitative approach values the self-as-researcher, treating lived experience and intuition as critical sources of insight into essential meanings connected with everyday human experiences (Douglass & Moustakas, 1985). The designers' personal experience as former Work and Travel participants was crucial, enabling them to identify authentic communication challenges often invisible to outsiders. Reflection was integrated throughout the process, validating design choices and ensuring materials were practical, culturally authentic, and emotionally relevant for learners by continuously testing ideas against personal memory and academic feedback.

Adopting the ADDIE Instructional Design Model for "Step Out Work & Travel"

Analysis

In the analysis step both learner and teachers were analysed. First, learner profiles were examined, revealing a target audience of Turkish university students preparing for Work and Travel, many of whom we observed lacked confidence in spoken English. Despite limited research on the language proficiency of prospective Work and Travel participants, existing literature shows that pre-program proficiency conditions the extent of language development attainable during mobility programs (Köylü, 2021). Moreover, the program explicitly states that "Sufficiently proficient in English to successfully interact in an English speaking environment" (US Department of State, n.d.). Improving students' proficiency beforehand is thus crucial, potentially easing their program experience and fostering greater language gain. Furthermore, research demonstrates a link between perceived oral proficiency and speaking anxiety (Okyar, 2023). Even with high self-efficacy, the audience factor significantly influences confidence (Demirel et al, 2020). Given that participants must communicate in the target language abroad, and that speaking proficiency can be problematic even within ELT departments (Dağtan & Cabaroğlu, 2021), targeting speaking skills before the Work and Travel program was considered essential due to the potential for audience-induced anxiety. Based on our experiential insights and guided by heuristic inquiry, the needs analysis revealed two primary areas of focus: language development for interviews, workplace, and daily life, and procedural knowledge for U.S. work and residency requirements.

In addition to the needs of the learners, resources of the course designers were mapped, including Canvas LMS as the primary platform, and integrated tools such as Canva, Edpuzzle, Quizlet, YouTube, and Padlet for interactive learning. The analysis also involved reflection on the instructors' dual roles and competencies as course designers and former Work and Travel participants.

Design

Within the design phase of the ADDIE model, instructional goals, content structure, and delivery strategies were systematically planned to ensure effective learning outcomes. In the context of a Work & Travel preparation course for learners at the A1–A2 levels, the design process emphasizes practical communication skills, gradual progression, and learner-centered activities. Learning objectives were defined based on the proficiency levels of the target group. At the A1 level, objectives include introducing oneself, applying basic everyday expressions, and managing simple interactions such as shopping or using public transportation. At the A2 level, learners are expected to handle more complex situations, such as workplace communication, ordering food, understanding short instructions, and engaging in basic social exchanges. Emotional and cultural authenticity served as key design criteria.

Content organization was initially designed as three modules. The first two modules focus on real-life contexts directly relevant to Work & Travel experiences, such as travel, accommodation, workplace communication, and social interactions. A third module, focusing on maps and giving directions, was planned but later excluded. The decision was based on current practices. Since most travellers rely on Google Maps and digital navigation tools, it was considered traditional direction-giving less essential to the learners' needs. This adjustment allowed the course to remain practical, up-to-date, and focused on skills with higher real-world applicability.

Considering the nature of the Work & Travel program, it was made sure that the instructional strategies prioritize communicative competence over extensive grammar instruction. Techniques including role-plays, scenario-based practice, and the use of visual materials such as images and flashcards were adopted to ensure learners have real-life simulations based on real life scenarios. Scaffolding is applied to guide learners step by step, moving from short sentences to simple dialogues as their proficiency develops.

Development

Canvas LMS was used to structure weekly content, deadlines, and interactive assessments, while Web 2.0 tools such as Kahoot!, Quizlet, EdPuzzle, Padlet, Canva, Youtube, Instagram, Google Forms supported engagement and multimodality. Web 2.0 tools were integrated since they transform learners into active participants by fostering interaction and collaboration. In language education, they are mainly used to increase engagement through interactive activities, promote collaboration with shared documents and boards, encourage creativity by producing posters or videos, provide instant feedback that supports self-assessment, and enhance learner autonomy by enabling practice beyond the classroom. To enable learners to remain in the same learning environment to avoid distractions, these platforms were embedded in the Canvas course where possible.

The design incorporates the content delivery in static pages, discussion boardsto increase learner participation and social presence, and assessment tools in Canvas LMS. Figure 1 exemplifies the design of the first module that prepares the prospective learners for the visa interview:

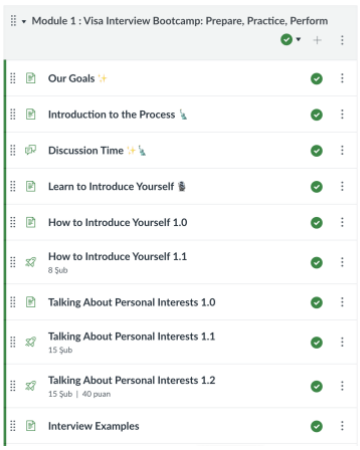

Figure 1. Design of Module 1 – Preparing the learners for the Visa Interview.

In line with the same principles, content creation focused on interactive, skill-oriented materials grounded in authentic Work and Travel experiences. Real-life stories were embedded into tasks, prioritizing functional communication over purely grammatical accuracy. Figure 2 demonstrates one activity where the teacher assists the learners in a scaffolded role-play activity:

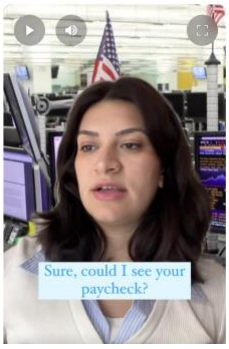

Figure 2. An example of a scaffolded role-play activity.

Implementation (Planned):

While the course has not yet been implemented, plans involve piloting with a small group of prospective participants, collecting both qualitative and quantitative data via learner feedback and LMS analytics. To attract prospective learners for the implementation phase, an Instagram account (@stepoutglobal) was created (Figure 3):

Figure 3. Logo of Step Out Global Language Course

Evaluation (Planned):

Once the course is launched, continuous evaluation will be carried out after each module. The effectiveness of this course will be assessed using the well-established Kirkpatrick Evaluation Model. This framework measures a program's impact on four levels: participants' immediate reactions, the knowledge and skills they gain (learning), how they apply those new skills in practice (behavior) and the extent to which targeted organizational outcomes occur as a direct consequence of the learning intervention and subsequent support (results) (Kirkpatrick and Kirkpatrick, 2022). We will gather this information through a combination of methods, including student feedback, pre- and post-course surveys, and analysis of learning analytics and interaction data and reflective redesign after each module.

Limitations

The study currently lacks empirical data collection from students, which limits the ability to measure learner outcomes directly. Without systematic feedback or assessment results from actual participants, it is difficult to evaluate the effectiveness of the course in achieving its stated objectives or to identify areas that may require improvement. The research relies heavily on personal insights and lived experiences of the course designers and instructors. While these perspectives are valuable for contextual understanding and initial course planning, they may introduce subjective bias, potentially affecting the neutrality and generalizability of the findings. Furthermore, as the course has not yet been implemented, the iterative cycles inherent to the ADDIE model such as continuous evaluation and refinement based on learner feedback are confined primarily to supervisor input and internal reflection. This restriction means that adjustments are not informed by the actual experiences, needs, or difficulties of the target learners. Consequently, while the design phase may be well-structured theoretically, the practical validation and iterative improvement that would normally enhance both pedagogy and content remain limited until the course is piloted and learner-driven data can be collected.

Conclusions

This project demonstrates the potential of experience-informed instructional design in ESP contexts, particularly for specialized mobility programs such as Work and Travel. Developed as a university-level course within an Online Language Teaching curriculum, it applies the ADDIE model to systematically plan, design, and organize instructional content while integrating authentic practitioner insights. By combining theoretical frameworks with

practical experience, the course addresses a critical gap in pre-departure language and procedural preparation for students.

Overall, the course exemplifies how academic preparation can be effectively linked with practical application, developing both subject-matter expertise and pedagogical digital competence among future teachers. For teacher education, the project highlights the value of reflective, project-based learning approaches that empower instructors as both designers and researchers, enhancing professional development. Being one of the first examples that integrates language development with legal consultancy within the context of Work and Travel preparation, it offers a replicable model for English for Specific Purposes (ESP) courses tailored to outbound mobility programs, addressing both linguistic and procedural needs. From an instructional design perspective, it demonstrates the effective merging of the ADDIE model's systematic rigor with the flexibility and depth of heuristic inquiry, providing a balanced framework for course creation. While empirical data from learners is not yet available, future implementation and systematic evaluation will be crucial to refine, validate, and optimize the model, ensuring that it effectively supports learners in authentic Work and Travel contexts.

Acknowledgements

We wish to thank Aylin Köseoğlu for her crucial and active role during the undergraduate Online Language Teaching course with her contributions to the design and development of the Work & Travel course.

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Can AI Teach Empathy? Algorithmic Interpretation vs. Human Response: A Reader-Response and Neuroscientific Perspective on AI in Literature Education

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Abstract

As artificial intelligence (AI) tools become increasingly integrated into education across disciplines, including the teaching of literature, a profound question emerges: Can AI meaningfully support the development of the humanistic goals of literary study, including empathy, one of its core aims? This study explores the tension between the humanistic goals of literary study and the rise of AI-driven tools that simulate dialogue, generate interpretations, and scaffold textual analysis. Anchored in Reader-Response Criticism, it highlights how literature's meaning is not fixed within the text alone but co-created through the reader's unique emotional and intellectual engagement. To deepen this perspective, the study draws on insights from Social Neuroscience, which shows that empathy and critical thinking rely on the interaction of distinct yet integrated brain networks. Meaning-making in literature activates both cognitive processes and affective processes. These are underpinned by complex neural systems that AI, despite advances in NLP-based sentiment analysis, cannot genuinely replicate. While AI models may offer textual interpretations or instant sentiment feedback, they run the risk of reducing this rich, subjective experience to mechanical outputs that bypass the brain's deeply social and emotional circuits. This raises pedagogical concerns about students over-relying on AI-generated readings by delegating the task of interpretation of literary texts and losing trust in their own interpretive and empathic capacities. The study suggests that AI, when used thoughtfully, can serve as a catalyst for deeper human dialogue rather than a substitute for authentic discussion. Practical strategies will be shared for designing activities that align with both Reader-Response principles and the understanding that literature uniquely activates the brain's social and emotional networks. By engaging students in activities where they can question what the algorithmic lens overlooks, educators can foreground the irreplaceable, subjective ways readers make meaning and develop empathy through literature, a process no AI can truly simulate, yet.

Keywords: Artificial Intelligence, Literature Education, Reader-Response Criticism, Empathy and Social Neuroscience

Introduction

Although artificial intelligence (AI) has become a central topic in educational technology research, its implications for the study and teaching of literature remain underexplored. While existing studies highlight AI's potential for supporting language learning and textual analysis (Asdar et al., 2026; Daghamin and Daghamin, 2025; Prestoza et al., 2026; Rani et al., 2026; Rosmayanti et al., 2026; Saddhono et al., 2024; Safii et al., 2025; Xu et al., 2025), few examine and discuss its potential impact through the dual lenses of literary criticism and neuroscience. This study intervenes in an underexplored area by bringing together insights from Reader-Response Criticism and Social Neuroscience to assess how AI may shape the empathic and interpretive aims of literary education. It ultimately aims to provide a balanced framework that positions AI as a supportive scaffold while preserving the distinctly human dimensions that make reading a uniquely transformative act.

Reader-Response Criticism and the Place of Reader in Literary Interpretation

Originating in the mid-twentieth century as a counterpoint to strictly text-centered approaches to literary interpretation and literary criticism, Reader-Response theory contends that literary meaning is not embedded solely within the text but is created through the reader's active engagement, interpretation, and imagination. Different theorists within reader-response criticism assign varying degrees of authority to text and the reader in the meaning-making process. Yet, each of these theories assign reader a role in the creation of literary meaning. Louise Rosenblatt's transactional theory (1978/1994) emphasizes co-creation of meaning with transactions between the reader and the text, distinguishing between efferent reading, which aims to extract information, and aesthetic reading, which centers around the lived-through experience. Similarly, Wolfgang Iser's (1978, 1980) phenomenological theory highlights the "blanks" and "gaps" that readers must fill based on their imagination and personal background, creating meaning through their own reading experience. Hans Robert Jauss (1982) adds a historical dimension, arguing that readers approach texts with horizons of expectation shaped by cultural norms

and prior literary experience. Stanley Fish (1980a, 1980b), in turn, situates meaning in the temporal unfolding of the reading act and in the interpretive communities that negotiate shared conventions.

Other theorists move further toward subjectivity. Norman Holland (1968, 1975) situates interpretation in the reader's psychological identity, suggesting that texts serve as frameworks for negotiating unconscious desires and anxieties. David Bleich (1978) emphasizes the pedagogical power of collective interpretation in "interpretive communities", where meaning arises through negotiated classroom responses. More recently, Marco Caracciolo (2014) extends reader-response into experiential narratology, distinguishing between consciousness enactment, immersive simulation of a character's perspective and consciousness attribution, the cognitive inference of mental states. Across these models, the reader is consistently foregrounded as the co-creator of meaning, making this body of theory particularly relevant for examining empathy in literature. The empirical studies confirm that teaching literature using reader-response principles contribute to the personal enrichment of students (Garzón and Castañeda-Peña, 2015; Inan and Boldan, 2018; Scherer, 2020; Spirovska, 2019; Süzer, 2006). One of the outcomes of this enrichment can be in the form of enhanced empathic capabilities since reader interaction with the literary text positions learners in various perspective taking activities.

Neuroscience and Empathy in Reading

Insights from social neuroscience complement and deepen these literary theories by providing empirical accounts of how reading engages the brain. Empathy, a core outcome of literary study, is now understood as a multifaceted construct with both affective and cognitive components. Affective empathy involves the vicarious sharing of emotions and is associated with neural activity in the anterior insula and anterior cingulate cortex (Decety and Jackson, 2004; Singer and Lamm, 2009). Cognitive empathy, often overlapping with Theory of Mind, entails inferring others' beliefs, intentions, and emotions and is supported by the medial prefrontal cortex and temporoparietal junction (Premack and Woodruff, 1978; Saxe and Kanwisher, 2003).

Reading fiction activates both systems. Narrative transportation immerses readers in story worlds (Green & Brock, 2000), while identification with characters can blur the boundaries between self and other (Broom et al., 2021). Robust empirical evidence supports a significant link between reading fiction and enhanced empathic abilities. A consistent finding in psychological research is that readers of fiction tend to exhibit better abilities in empathy and Theory of Mind (ToM) compared to non-readers (Best, 2020; Djikic et al., 2013; Mar, Oatley, and Peterson, 2009; Tamir et al., 2016; Stansfield and Bunce, 2014; Wimmer et al. 2024). Research using neuroimaging confirms that the cognitive processes elicited by literature engage the same neural networks activated during real-world social interaction, which supports the view of literature as a form of social simulation (Broom et al., 2016; Saxe and Kanwisher, 2003; Singer and Lamm, 2009; Stansfield and Bunce, 2014; Tamier et al., 2016). This interdisciplinary convergence highlights that the empathic dimensions of literary study are not accidental by-products but are deeply rooted in neurocognitive processes that develop and strengthen through sustained interaction with fictional narratives.

Advantages and Risks of Delegating Literary Interpretation to AI

It is neither realistic nor practical to avoid or ban the use of AI in literary study. Nevertheless, use of especially generative AI in literary study poses challenges and potential hazards in addition to the practicality it offers. On the one hand, it supports students with rapid access to background information, assists their perspective taking offering multiple interpretive frameworks, and scaffolds their learning by providing support in the analysis of themes, motifs, symbols and characterization. Current models like OpenAI ChatGPT, Microsoft Copilot, and Google Gemini already display capabilities that mimic the interpretive steps that literary critics take in the lexical and stylistic analyses of literary texts. They can further provide interpretations based on theories of literary criticism. While these algorithmic interpretations may assist widening the interpretive capacities of the learners, excessive dependence on AI interpretations might hinder interpretive practices that Reader-Response Criticism and neuroscience have long emphasized as essential to meaningful literary engagement that can foster empathy.

AI can supply immediate contextual information such as the historical context, authorial background or the literary canon that shapes the literary work. This can help students to situate themselves within the realm of the literary work rapidly. Nonetheless, outsourcing this foundational work might deprive the students of the experiential process through the experience of transportation into the fictional world. Studies show that such transportation activates emotional empathy through embodied simulation within neural regions such as the insula and somatosensory cortex (Broom et al., 2021). Missing this essential opportunity, students might acquire the "facts" of a text but miss its affective depth as they have no direct interaction with the fictional world created within a larger context.

In addition to smoothening the entry into the cultural, historical and literary background to the literary works, AI also has a practical role in simplifying linguistic challenges that students may face especially when tackling with complex or archaic texts. By paraphrasing or simplifying passages, AI can assist overcoming linguistic barriers. Though partially useful, this short-cut to analysis minimizes the cognitive effort central to empathy building. The sole effort of uncovering the hidden meanings in deliberate lexical and syntactical structures, readers are compelled to infer motives, beliefs, and intentions of fictional characters. This intensive intellectual practice is closely linked to Theory of Mind and supported by neural systems in the medial prefrontal cortex, temporoparietal junction, and superior temporal sulcus (Balgova et al., 2024; Premack & Woodruff, 1978; Saxe & Kanwisher, 2003; Tabullo et al., 2018). If this task is consistently delegated to AI, students may lose opportunities to cultivate interpretive resilience and the capacity for independent interpretation.

Like many online literary study guides such as Sparknotes, LitCharts, Gradesaver, AI can be consulted as a source to detect motifs, symbols, and structural patterns. However, over relying on AI may result in missing chances for dealing with ambiguity, connecting the themes to one's lived experiences and making personal inferences along with interpretations. This possible pitfall conflicts with Reader-Response principles, which place strong emphasis on reader's cultural and personal background, emotions, psychological make-up, the interpretive communities they belong and the historical context they interpret the literary works in (Rosenblatt, 1978; Iser, 1978; Holland, 1968). For this reason, it is of utmost importance that students maintain interpretive agency, articulating their own readings rather than leaning too heavily on AI-generated insights.

Even though delegating the task of interpretation to AI is unavoidable, it is quite natural in the age of AI that especially novice readers with limited literary background will resort to AI to lower their initial cognitive barriers in wrestling with literary texts, especially when they encounter unfamiliar genres. Yet, tolerance for ambiguity which is essential not only in the cultivation of empathy but also an essential outcome of literary study might be lost. One of the central tasks of literary study is to weigh a literary work from multiple perspectives, interpreting texts from sometimes conflicting theoretical lenses. When the task of interpretation is delegated to AI, students will most probably miss the opportunity of the mental training they may have from such practice. Besides, as suggested by Iser's (1978) concepts of textual "gaps" and the "implied reader", the gaps in the text will be filled with algorithmic probabilities instead of the lived experiences of the student. Further, the student can potentially miss the enriching experience from the "interpretive communities" as proposed by Bleich (1978). Therefore, the dialogical engagement and mental training which may foster empathy can be lost.

In addition to lowering initial cognitive barriers, AI can provide multiple perspectives on a single text, offering students interpretations they may never have considered. When prompted to provide multiple interpretations from different theoretical, psychological and sociological perspectives, AI-generated interpretations can certainly broaden horizons, sharpening the analytical understanding of complex characterization or thematic structure. However, this convenience can unintentionally displace the essential, first-hand emotional experience of encountering the literature. Research repeatedly highlights that directly experiencing a character's emotions is significantly more effective for fostering empathy than merely receiving interpretations second-hand (Bal and Veltkamp, 2013; Mar et al, 2009). Concepts like character identification and emotional empathy show that the reader's affective involvement is indispensable; this involvement simply cannot be outsourced without ultimately weakening literature's transformative potential.

Finally, reading summaries of a literary text is one of the first steps that many students take before analysing the work systematically. AI can generate concise summaries that are helpful for review or exam preparation, saving valuable study time. Still, these summaries may displace the slow, embodied engagement with the text that cultivates imagination and introspection. Embodied cognition theories emphasize that active, sensory engagement, such as reading slowly, imagining vividly, and identifying with characters, activates neural processes linked to empathy and "narrative transportation" (Green and Brock, 2000). Overuse of AI shortcuts risks turning reading into a passive reception rather than an active, meaning-making event, which eventually lead to skipping the steps essential in empathy building.

Considering the above concerns, outsourcing meaning-making to AI risks reducing literature to data, bypassing emotional immersion, and weakening students' practice of cognitive empathy. The vicarious experience of emotions, the imaginative bridging of textual gaps, and the negotiation of meaning within interpretive communities cannot be authentically replicated by algorithms. Overuse of AI may thus lead to diminished engagement, shallower reflection, and a loss of ownership in interpretation.

Pedagogical Implications: AI as Scaffold, Not Substitute

The challenge, then, is not whether AI should be present in literature classrooms but how it should be framed pedagogically. When integrated critically, AI can serve as a stimulus for reflection rather than an authority on

meaning. For instance, students might use AI to generate role-play dialogues with literary characters, but only after conducting close textual analysis with teacher guidence. Alternatively, AI can provide multiple viewpoints of a scene, which students then compare with their own interpretations, sharpening their Theory of Mind capacities. Other applications might include reflective journaling prompts to foster emotional empathy. Alongside emotional empathy, cognitive empathy might be cultivated with activities promoting both AI and students to generate hypothetical "what if" scenarios, engaging students in ToM practices. Besides, collaborative annotations of the texts and using AI to assist in the process as the digital partner of an interpretive community can be yet another activity to cultivate empathy in line with Reader-Response principles.

Each of these uses positions AI as a tool that diversifies perspectives and fosters dialogue without replacing the interpretive labor of the reader. By foregrounding human engagement, these strategies align with the transactional insights of Rosenblatt (1978), the communal focus of Fish (1980b), and the experiential emphasis of Caracciolo (2014). Neuroscience further validates these practices by showing that empathy emerges when readers themselves engage affectively and cognitively with texts.

Conclusions

AI's integration into education is inevitable, but its role in literature classrooms must be carefully negotiated. Reader-Response Criticism and social neuroscience together remind us that literature's humanistic value lies in the reader's active, embodied, and socially situated experience of texts. While AI can enrich this process through scaffolding and provocation, it cannot replicate the emotional resonance and interpretive depth that arise from genuine human engagement.

The task for educators, therefore, is not to resist AI but to position it thoughtfully as a catalyst for reflection, a medium for dialogue, and a complement to not a replacement for the human reader. In doing so, literature education can continue to cultivate empathy, moral imagination, and intercultural understanding, ensuring that the transformative power of reading remains intact in the age of AI.

Acknowledgements

The author declares that, in the interest of enhancing linguistic clarity and adherence to academic writing standards, the manuscript underwent AI-assisted language proofreading using [ChatGPT-5]. The author remains fully responsible for the content, analysis, and conclusions presented in this paper.

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Immersive Simulations in Social Sciences: A Meta-Analysis

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Abstract

This study critically examines the pedagogical efficacy and integration of immersive simulations within social science education. As digital technologies increasingly spread throughout educational environments, immersive simulation platforms offer promising avenues for enhancing experiential learning and developing essential skills such as language skills development, critical thinking, communication, collaboration, decision-making, engagement, motivation and problem-solving. Despite extensive research on immersive technologies in STEM fields, their application within social sciences remains underexplored and fragmented. This systematic literature review synthesises findings from over 35 studies sourced from Scopus, Web of Science, and Kazakhstani research outlets during the time interval from 2014 to 2025, employing a qualitative approach to categorise the types of immersive simulations, platforms and tools, their application in social sciences, benefits and challenges and pedagogical outcomes. The review defines key simulation typologies—virtual (game-based and case-based) and traditional (role-plays, scenario-based discussions, case studies, problem-solving tasks and experimental activities)—highlighting their respective contributions to fostering authentic, engaging, and risk-free learning environments. Results indicate that immersive simulations significantly enhance cognitive, communicative, and social skills, and positively influence motivation and learner engagement. However, challenges such as high technological demands, insufficient theoretical grounding, methodological limitations, and teacher preparedness hinder widespread adoption. The findings underscore the necessity for carefully designed curriculum-integrated approaches supported by robust methodological frameworks and teacher training. This review contributes to the emerging discourse by proposing a comprehensive definition of 'immersive simulation' tailored for social sciences, categorising existing tools, and identifying best practices and future research directions. Ultimately, the study supports the strategic implementation of immersive technologies to optimise pedagogical outcomes and equip learners with skills vital for navigating complex social realities.

Keywords: immersion, simulations, traditional and virtual simulations, social sciences, systematic analysis.

Introduction

Digital technologies have been actively integrated in higher education across different courses. Early and current studies explore the nature, types, and use of simulations for blended education. Latest educational technology achievements, such as immersive simulations (IS) being extensively explored across various fields such as medicine, STEM and business, still lack adequate or equal coverage within the social science domain. There is no in-depth analysis of their effectiveness in this area in terms of a comprehensive definition that covers all its aspects. The research on the use of simulation in social sciences is limited and fragmented.

The novelty of this systematic literature review is to investigate immersive simulations for the social sciences. This is also an attempt to elaborate on a definition of 'immersive simulation' (IS) that could be used regarding social science studies. The paper seeks to disclose the existing approaches to the IS concept, categorise its types, analyse their respective educational benefits, and identify typical implementation challenges. Furthermore, it explores the tools and platforms used, identifies good practices, and finally outlines future research directions.

To our knowledge, this is one of the studies to systematise and evaluate the full spectrum of IS and applications in the social science domain. A nuanced overview of the IS landscape intends to serve as a valuable resource for educators, researchers, and policymakers committed to advancing experiential, engaging, and authentic learning experiences. Ultimately, this is a contribution of immersive technologies to social science practices to improve learning outcomes.

Methodology

The methodology of research combines a qualitative approach to ensure a comprehensive understanding of IS use in the field of social sciences. The research design employs a systematic approach, adhering to established protocols for literature synthesis - including clear inclusion and exclusion criteria and analytical frameworks - to comprehensively analyse the types, platforms and tools, benefits, and challenges, pedagogical outcomes associated with immersive simulations in social sciences. Data sources and search strategy involve systematically exploring primary databases such as Scopus, Web of Science and reputable domestic journals to identify relevant literature and key conceptual papers, using keywords like 'immersion', 'simulations', 'immersive simulations', 'immersive simulations in social sciences', 'virtual reality simulations', 'game-based simulations', 'interactive simulations' and others.

Inclusion criteria:

- Articles published in English and Russian;
- Empirical, conceptual, or review articles focusing specifically on immersive simulations;
- Publications from 2014-2025 with relevant key conceptual papers;
- Studies employing qualitative and mixed methodologies;
- Research sourced from Scopus, Web of Science and reputable domestic journals.

Exclusion criteria:

- Articles in languages other than English and Russian;
- Studies outside the scope of pedagogical or educational applications of immersive simulations;
- Paywalled articles;
- Studies employing exclusively quantitative methods without qualitative insights;
- Theoretical papers without empirical or practical investigations.

A total of 35 articles is chosen for in-depth analysis to explore their detailed findings, methodologies, and pedagogical implications.

Literature review

The concept of simulation

Simulations in social science education are a multifaceted concept with diverse definitions. These diversities demonstrate the versatility and significance of simulation as a pedagogical tool, not only for language learning as noted by Kismetova and Tastemirova (2021), but also for training in various professional fields and strategic decision-making contexts. Devos et al. (2021) describe it as creating environments where students assume roles, collaborate, and solve problems in realistic scenarios. Jääskä and Aaltonen (2022) highlight simulation as a safe, controlled environment for applying knowledge and practising management skills, fostering experiential learning within a secure setting. Vlachopoulos and Makri (2017) explain simulations as goal-oriented games modelling natural or man-made systems that foster active, experiential learning. Yoon (2014) defines simulation as a model of a real-world system to understand complex phenomena.

The effectiveness of the simulations is largely ensured by the immersion effect, i.e. by immersing oneself in the simulated situation (Devos et al., 2021). Simulations in social contexts are used to analyse opinion dynamics, influence strategies, and decision-making, demonstrating their versatility beyond traditional education.

Building on this foundational understanding, the next section will explore different types of simulations, examining how their specific characteristics and formats further enhance learning experiences and skill development.

Types of simulations

There are various types of simulations, each designed to replicate real-world scenarios for diverse educational and research purposes. The integration of various simulation types in education is well-explored in pedagogical literature.

The terminology of simulation types varies, for example, Yoon (2014) classifies simulations into two primary categories: *traditional* (non-digital classroom activities) and *computer-based simulations,* which were later classified as "digital" or "virtual" by other scholars. There is also a possibility to classify simulations into digital and non-digital. Digital simulations engage students in the interactive, authentic, and self-driven acquisition of knowledge (Vlachopoulos & Makri, 2017). Interactive computer simulations, which examine dynamic interactions among variables, further enhance understanding of real-world concepts (Batamuliza, Habinshuti, & Nkurunziza, 2024). Moreover, Gaudron, Tamayo, and de La Fortelle (2020) highlight interactive simulations in collective decision-making processes. Kefalis, Skordoulis, and Drigas (2025) expand on this by describing digital simulations

as tools that facilitate inquiry-based, experiential learning through virtual labs and AR applications that mimic real-world scientific processes.

Nowadays, two main types of simulations are distinguished: 1) *virtual simulations* using VR, AR, and digital platforms; and 2) *traditional simulations* involving practical group scenarios, role-playing and dialogues (Yussupova et al., 2023; Makhmadieva, 2023). Traditional simulations are usually described as practical activities that mimic real-world scenarios, for example, "exercises such as building a bridge from Legos or throwing a die to mimic uncertainty," which help students understand complex concepts through hands-on engagement (Jääskä & Aaltonen, 2022). Similarly, Kismetova and Tastemirova (2021) include in-class role-plays, pair-work and problem-solving exercises, while virtual simulations, often part of serious games, foster active participation and reflection through feedback systems (Krath et al., 2021; Sim et al., 2022).

Virtual simulations are subdivided into game-based and case simulations. *Game-based simulations,* as defined by Sheffield, Koul, and Sims (2020), are structured, rule-based digital environments that incorporate game elements such as challenges, rewards, and interactivity to support learning. *Case simulations,* on the other hand, focus on presenting learners with detailed, real-world scenarios or cases that require analysis, critical thinking, and strategic decision-making. Based on the Medel et al. (2025) research, an interactive virtual simulation case is a digitally driven, scenario-based learning environment that actively engages students in decision-making processes within realistic contexts, enabling them to interpret data and make critical judgments through a series of decision points, with immediate feedback and outcome consequences. Some authors (Su et al., 2022; Sugiki et al., 2021) consider simulations as case-based models of complex urban and environmental systems, providing insights into policy and sustainable development.

These examples demonstrate the broad spectrum of simulation modalities from low-tech hands-on activities to high-fidelity digital experiences that cater to diverse learning objectives.

Benefits and challenges of simulations

Evidently, the integration of simulations within educational contexts has garnered significant attention for its potential to enhance learning experiences across disciplines. Along with this, numerous studies underscore both the benefits and challenges associated with applying such technologies.

When it comes to the benefits of simulations in the classroom environment, scholars emphasize such multifaceted impact on students as engagement, motivation, immediate feedback, skills development, and improve academic performance (Coban et al., 2022; Jääskä &Aaltonen, 2022; Thurairasu, 2022; Artyukhov et al., 2023, Haj-Bolouri & Katende, 2024), personalized learning paths (Song et al., 2023; Weng et al., 2024), the development of speech competence and communicative abilities (Devos et al., 2021; Kismetova & Tastemirova, 2021), enhance speaking skills, enrich vocabulary, reduce language barriers and improve memory (Yussupova et al., 2023), reproduce real-life contexts (Zvarych et al., 2023), create engaging, realistic, experiential and interactive learning environments for language learning (Weng et.al., 2024), provide a secure environment for studies (Yilmaz & Hebebci, 2022; Velez et al., 2025) and others.

Despite these benefits, scholars observe some challenges such as high technical requirements (Song et al., 2023), the teacher readiness and training to work with immersive technologies (Yussupova et al., 2023; Odaryuk et al., 2024), limited theoretical grounding (Weng et al., 2024), specifically a deficiency in methodological materials on integrating immersive technologies into the educational process (Makhmadieva, 2023), students' personal perception of simulation benefits (Jääskä & Aaltonen, 2022) and others. Further obstacles are that simulations create potential misunderstandings, reliance on more skilled peers, significant time investment, and the necessity for a foundational level of language proficiency and professional expertise (Devos et al., 2021; Makhmadieva, 2023).

The fundamental benefit that contributes to the present research is that students learn a new language, as Brawn (2024) emphasises, through immersion-based language programs for non-language-related subjects like mathematics, science, and social studies.

Immersive simulations in social sciences

Immersive simulations have become increasingly valuable in social science education due to their capacity to provide interactive, experiential environments that mirror real-world complexity. Recent research on immersive learning environments (Mystakidis & Lympouridis, 2023; Motley et al., 2024; Brawn, 2024; Odaryuk et al., 2024) and approaches (Thurairasu, 2022; Artyukhov et al., 2023; Szabó & Kopinska, 2023; Song et al., 2023; Yussupova et al., 2023; Tene et al., 2024) has highlighted the concept of immersion – derived from immergĕre (to dip or plunge) – which refers to the feeling of being fully 'inside' a virtual or physical environment (Rogers, 2019). Zvarych et al. (2023) emphasise immersive simulations that place learners in realistic scenarios for training and assessment. Immersion involves a convincing sense of presence, where learners feel genuinely embedded in the

environment, fostering deep involvement and active participation (Yussupova et al., 2023; Tene et al., 2024). Szabó and Kopinska (2023) note that immersion can be achieved through deep engagement, often supported by gamified approaches that increase motivation. Stracke et al. (2025) differentiate the level of immersion into non-immersive, semi-immersive, and immersive VR. According to Song et al. (2023), deep immersion transports learners into realistic settings – like urban squares or cafes – allowing practice in contexts closely mirroring real life. Brawn (2024) suggests key components for effective immersive environments, including learner autonomy, exposure to diverse experiences, authentic situated contexts, reflection, and skilled facilitation.

Thus, immersive simulations aim to replicate authentic situations in which learners examine complex problems, develop solutions, and reflect on outcomes, thereby deepening their understanding of specific phenomena or processes. Immersive simulation fosters critical thinking, empathy, and intercultural understanding.

Results and Discussion

The authors of this paper define immersive simulation as a technologically advanced pedagogical tool that creates a highly engaging, realistic, and participatory learning environment to support experiential learning, skill development, and critical thinking. This definition is followed by IS typology (Figure 1) through the authors' analysis of pedagogical and linguistic literature, where immersive simulations are divided into two types: virtual and traditional. Virtual simulations include game-based and case simulations, whereas traditional simulations include role-playing exercises, scenario-based discussions, case studies, problem-solving tasks, and experimental activities.

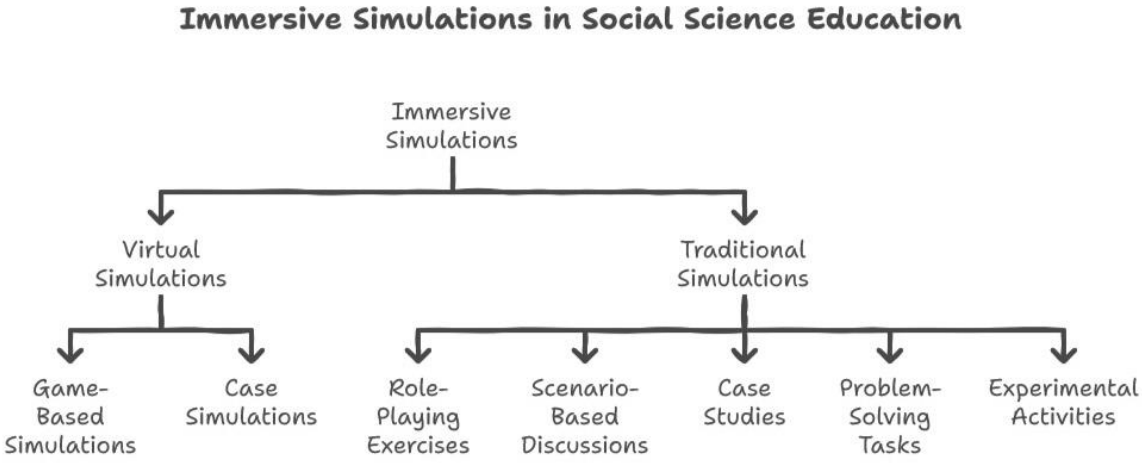

Figure 1. Types of immersive simulations in social science education.

The most widely mentioned and used immersive simulation programs have been selected and split by their thematic focus and primary learning outcomes, as follows: case simulations, game-based simulations, role-plays and scenario-based simulation (Figure 2).

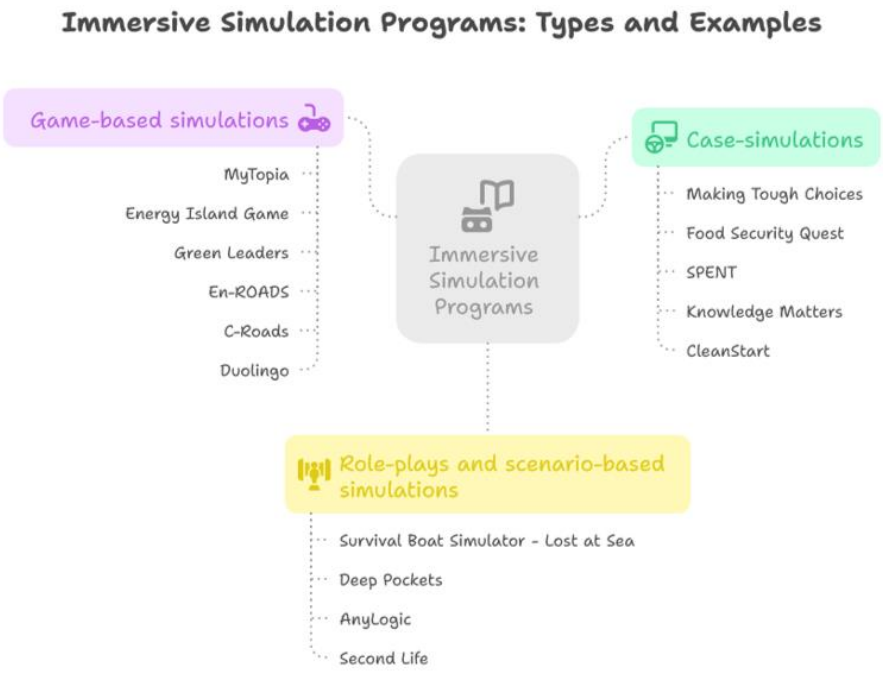

Figure 2. Immersive simulation programs.

The list of most frequently mentioned IS platforms and tools in the sources under review is replenished by those used nowadays in education. Table 1 illustrates the compatibility of immersive simulation platforms and tools with certain simulation types according to their key learning outcomes.

Table 1. Immersive simulation programs in social sciences.

Programs + link	**Simulation type**	**Social science domain**	**Key learning outcomes**
A. Policy and governance			
C-Roads https://www.climateinteractive.org/c-roads/	Game-based	Environmental policy	Engagement, motivation, practical understanding of project management skills
Making Tough Choices https://makingtoughchoices.org/	Case-based	Poverty studies, social welfare, community development, social work	Problem-solving, decision-making skills, interpersonal communication
The Deep Pockets	Role-play/ Scenario-based	Economics, Sociology	Decision-making, collaboration, communication
B. Sustainability and environment			
MyTopia https://mytopiagame.web.app/	Game-based	Political science, sociology, psychology, behavioral economics	Critical thinking & decision making, collaboration and interpersonal communication, problem-solving, experimental learning
En-Roads https://www.climateinteractive.org/en-roads/	Game-based	Environmental Policy	Decision-making, critical thinking, problem solving,
Energy Island Game https://energyislandgame.co.uk/	Game-based	Environmental Studies	Critical thinking, problem-solving, decision-making
Green Leaders https://greenleadersgame.co.uk/	Game-based	Environmental Governance, Sociology	Critical thinking, collaboration, problem-solving
CleanStart	Case-based	Sustainable Business, Economics	Decision-making, motivation

https://mitsloan.mit.edu/teaching-resources-library/cleanstart-simulating-a-clean-energy-startup			
C. Social inequality and empathy			
SPENT https://playspent.org/	Case-based	Sociology, Social Policy	Critical thinking. decision-making
Food Security Quest https://www.torontomu.ca/open-learning/modules/food-security-quest/	Case-based	Development Studies, Public Policy	Critical thinking, communication
D. Business and Economics			
Knowledge Matters	Case-based	Business, Management	Critical thinking, decision-making, problem-solving
AnyLogic	Scenario-based	Economics, Logistics	Communication, problem-solving
E. Language, culture and communication			
Duolingo https://www.duolingo.com/	Game-based	Linguistics, Communication	Motivation
Second Life https://secondlife.com/	Game-based/ Scenario-based	Anthropology, Sociology	Communication, collaboration, problem-solving
F. Leadership, teamwork, and problem-solving			
Survival Boat Simulator - Lost at Sea	Role-play/ Scenario-based	Psychology, Leadership	Critical thinking, decision-making

Summarising the benefits and challenges of IS as presented in the 35 articles, the authors consolidate them in Table 2 for a better comparative overview of simulations in the field of social sciences. This gives further research potential in terms of their implementation practices.

Table 2. Consolidated benefits and challenges of immersive simulations in social sciences education.

Benefits	**Challenges**
– Enhancement of motivation, retention, and experiential understanding – Immediate feedback – Language skills development – Learning skills development: decision-making, teamwork, problem-solving – Positive influence on pedagogical effectiveness – Promotion of life skills: critical thinking, communication, collaboration – Supports experiential and active learning – Fosters deeper understanding of complex social phenomena	– Technical issues: internet stability, equipment malfunctions, software errors – Lack of theoretical grounding: limited foundational theories guiding design and interpretation – Scarcity of methodological materials: insufficient resources for curriculum integration – Extra workload for teachers: training and mastering complex software/tools – Difficulty in fair assessment: challenges in measuring learning outcomes accurately – Health concerns: potential stress, anxiety, or disengagement from immersive environments – Over-reliance on technology: risks related to privacy, data security, and technical dependence – Accessibility issues: not all students or educators may find environments equally beneficial or comfortable

Overall, the research highlights that immersive simulations are vital for social sciences, as they facilitate diverse social skills, learning skills, and foreign language acquisition. Nevertheless, their successful introduction depends on overcoming technical, methodological, and pedagogical challenges; thus, future research should focus on developing guidelines, strengthening theories, and creating accessible simulation platforms to enhance their educational impact.

Simulations applicable in social science education have been divided by their types proposed by the researchers, up to the skills developed and their key findings identified (Table 3).

Table 3. Effect of simulation types on learning outcomes.

Types of simulations	**Researchers**	**Skills developed**	**Key Findings**
Traditional simulations	Yoon (2014)	Engagement and motivation, language skills development	Students reported high levels of engagement, motivation, and perceived improvement in language skills through the use of virtual simulation.
Game-based simulations	Jääskä & Aaltonen (2022)	Critical thinking & decision-making, collaboration and Interpersonal communication, problem-solving, experimental learning	Game-based learning (GBL) methods are effective in increasing student engagement, motivation, and practical understanding of project management skills.
Traditional simulations	Kismetova & Tastemirova (2021)	Communication skills	Moderate improvements in communication competencies among learners.
Virtual simulations & traditional simulations	Yussupova et al. (2023)	Critical thinking & decision-making	Virtual simulations indicated greater enhancement in decision-making skills than traditional ones.
Virtual simulations	Makhmadieva (2023)	Engagement and motivation, language skills development, critical thinking and decision-making	The use of immersive technologies in teaching Russian as a foreign language significantly enhances students' thinking abilities and leads to positive improvements in their oral speech skills, thereby increasing the overall effectiveness of language learning.
Augmented reality (AR) and Virtual reality (VR) simulations, case-based and contextual simulations	Krath, Schürmann, & von Korflesch (2021)	Critical thinking & decision-making, collaboration and interpersonal communication, engagement and motivation, experimental learning, problem-solving	Gamification, serious games, and game-based learning are primarily associated with improved motivation, engagement, problem-solving, and cognitive outcomes like critical thinking and content understanding, all explained through various interconnected theories.
Social simulations	Su et al. (2022)	Critical thinking & decision-making	Improved capacity to model and analyze complex social interactions.
Social dynamic simulations	Sugiki et al. (2022)	Critical thinking & decision-making, problem solving	Demonstrated significant improvements in understanding urban social dynamics.
Virtual reality scenario-based simulations	Ewais et al. (2024)	Critical thinking & decision-making, collaboration and interpersonal communication, engagement and motivation, problem-solving, experimental learning	High engagement levels result in substantial learning gains.
Digital computer-based business simulation games	Velez & Alonso (2025)	Critical thinking & decision-making, collaboration and interpersonal communication, engagement and motivation, problem-solving	Business simulation games (BSGs) effectively enhance students' decision-making skills in higher education by promoting critical thinking, collaboration, and problem-solving, provided that certain key elements—such as clear learning objectives, realistic scenarios, effective instructor guidance, and interactive activities—are

			incorporated into the BSG learning experience.
Virtual science laboratories	Sheffield, Koul & Sims (2020)	Critical thinking & decision-making, collaboration and interpersonal communication, engagement and motivation, problem-solving	Labster Simulations platform has potential to boost engagement, motivation, and critical thinking, but technical issues and limited interactivity hinder their effectiveness in deepening content understanding and pedagogical skills.
Interactive virtual simulation case	Medel et al. (2025)	Critical thinking & decision-making, engagement and motivation, problem-solving, experimental learning	Notable improvements in decision-making processes and confidence.
Immersive & non-immersive simulators	Dewan et al. (2023)	Critical thinking & decision-making, collaboration and interpersonal communication, engagement and motivation, problem-solving, experimental learning	Immersive and non-immersive simulators are valuable complementary tools that can improve maritime training, especially when traditional methods face limitations.

The results demonstrate that simulations positively impact various learning skills development in social sciences, observed as engagement and motivation, critical thinking, problem-solving, and experimental learning.

Additionally, improvements in collaboration, interpersonal communication and language skills suggest that immersive simulations effectively enhance both cognitive and social skills, supporting their integration into pedagogical practices. Further research is needed to confirm and refine these results.

Conclusion

This meta-analysis is a synthesis of reviewed sources from international and local research databases. This investigation demonstrates that simulation technologies markedly improve learners' skills of the XXI century. Diverse types of traditional and virtual simulations support authentic and flexible classroom experiences for experiential learning. Immersive simulation is one of the advanced pedagogical tools for an engaging and interactive learning environment in social sciences.

Results indicate that immersive simulations significantly enhance cognitive, communicative, and social skills, positively influencing motivation and learner engagement.

However, the successful integration of immersive simulations encounters limited theoretical grounding, technical capacities, and the need for teacher training and curriculum alignment. Further research is needed for employing immersive technologies in social sciences through accessible platforms, comprehensive user guidelines, and methodological support. This study suggests the potential to enhance educational outcomes and better equip educators, university policymakers, and learners to navigate the complexities of society.

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Innovative Solutions in Special Education : Applications and Effects of Augmented Reality (AR) and Virtual Reality (VR) Technologies

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Abstract

Today, the rapid advancement of technological developments has reshaped education and rehabilitation processes, making the learning experiences of individuals with special needs more accessible, motivating and interactive. Augmented Reality (AR) and Virtual Reality (VR) technologies are emerging as an innovative approach that combines the real and virtual world, increasing the user experience. AR and VR applications have an important potential in educational applications in terms of providing visual, auditory and even tactile feedback for students with learning difficulties, allowing students to have a more comprehensive learning experience. They have shown positive results in improving the academic and functional life skills of individuals with special needs. AR's opportunity to provide interactive experiences by enriching the real-world environment with digital content and VR's ability to provide users with enriched learning experiences through fully immersive, simulated environments are revolutionary in special education. These technologies have significant potential in developing individuals' academic and life skills by going beyond traditional methods and increasing student participation and motivation. In this context, 164 research articles have been accessed from the Ebscohost, Wos, Science Direct and Google Academic databases at national and international level to examine the role of Augmented Reality (AR) and Virtual Reality (VR) applications in educational technologies for individuals with Intellectual Disabilities. Dec.164 research articles have been accessed from the Ebscohost, Wos, Science Direct and Google Academic databases. This study aims to present a systematic review of 26 studies by addressing the applications and effects of VR and AR technologies in Special Education. In conclusion, it is seen that VR and AR technologies transform the learning processes of individuals in special education.

Keywords: "virtual reality", "mentally disabled", "augmented reality", "special education"

Introduction

The fact that individuals with intellectual disabilities face various difficulties in their educational processes necessitates the need for new technologies. Augmented Reality (AR) and Virtual Reality (VR) technologies have been effective in a wide range of areas, from individuals' academic, social and independent life skills Dec. In particular, the effects of these technologies on developing academic and social skills have been examined in different disability categories such as Autism Spectrum Disorder, Intellectual Disability, Learning Disability, Visual Impairment and Hearing Impairment. This study conducted a comprehensive literature review in order to understand the applications of both AR and VR technologies in special education and to compare the opportunities and challenges that these technologies present. The study evaluated the research findings conducted nationally and internationally and examined the studies conducted with quantitative, qualitative and mixed methods to understand the role of these technologies in education. In this context, the answers to the following questions have been sought :

1. What is the proportional distribution of research according to the study methods(quantitative, qualitative, mixed)?

2. What is the distribution of research by year?

3. What is the distribution of research by country?

4. What are the technologies used in the research (VR, AR)?

5. How is the distribution of the research conducted according to the disability category (autism, intellectual disability, learning disability, physical disability, etc.)?

6. What is the percentage distribution of national and international published research?

Individuals with special needs are individuals who differ significantly from their peers in learning, communication, social interaction, or behavior due to various developmental disabilities, learning disabilities, emotional or behavioral disorders, or other health problems (Kaimara et al., 2021). Individuals with special needs may face some difficulties in learning and applying daily living skills(Standen ve diğerleri, 2021). AR technologies refer to the creation and addition of computer-aided images to a real-world environment, providing an interactive learning experience(Morris et al., 2021). AR applications for children with special needs can create interactive and engaging learning experiences by adding digital information to the real world(Asatryan et al., 2023). The main goals of AR/VR technologies are to optimize communication skills and improve the quality of life for individuals with special needs(Borna, 2024). With these technologies, when traditional methods are ineffective, special needs individuals can be taught daily life skills and cooperative learning can be encouraged through a shared gaming experience(Kaimara et al., 2021). AR technologies make abstract concepts more concrete and interactive for students with intellectual disabilities(Terzioğlu et al., 2023).

Methodology

The aim of this study is to examine the impact of augmented reality and virtual reality technology in the field of special education and to evaluate their applications. 164 research articles were accessed from national and international databases such as Ebscohost, Wos, Science Direct and Google Academic. In this study, the applications and effects of VR and AR technologies in Special Education were discussed and 26 studies were examined using descriptive content analysis method. When these studies were categorized according to their methods, it was seen that 5 of them were examined with quantitative methods, 12 with qualitative methods and 9 with mixed methods.

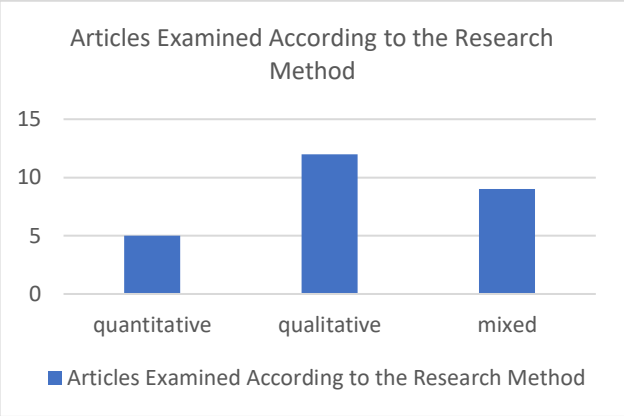

Table 1: Articles Examined According to the Research Method

Findings

AR and VR technologies have made significant progress in various fields worldwide and have had a versatile impact. AR/VR technologies, which are used with increasing interest in the field of special education, have been met with positive feedback in the education process of individuals with special needs. Technologies designed specifically for individuals with autism and mental disabilities have been observed to have positive contributions to the learning processes of individuals. Special education teachers generally stated that AG technologies increase the motivation of students with mental disabilities, help them understand abstract concepts and make learning more effective, and also stated that they face difficulties such as technical problems, lack of teacher education and cost with these technologies (Terzioğlu et al., 2023). It has been observed that in language learning environments developed for special education students, individuals apply what they have learned in real life and that virtual environments increase students' motivation, participation and self-confidence(Lan et al., 2018). Haptic technologies have been shown to provide feedback, improve fine motor skills, and provide therapeutic interventions in real-world scenarios and for individuals with sensory impairments(Irigoyen et al., 2024). Interactive virtual reality applications have been shown to allow for observation of how boys with social behavior problems react to realistic social situations(Verhoef et al., 2021). It is necessary to evaluate the

potential benefits of these technologies in special education and teachers' perceptions of these technologies(Terzioğlu et al., 2023).Other results obtained from the research findings are as follows;

1. Technology Usage (VR, AR, Both) : When examined according to the technologies used in these studies, it was seen that VR technologies were used in 7 studies, AR technologies were used in 10 studies, and both VR and AR technologies were used in 9 studies.

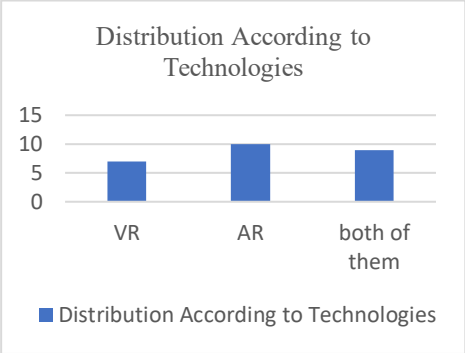

Table 2 : Distribution According to Technologies

2. Number of Articles by Year : When the articles are examined by year, the distribution of the articles that are appropriate to the subject scope by year is as follows. When the article distributions are examined by year, it is seen that there was a momentum after 2020 and the use of VR and AR technologies increased compared to previous years.

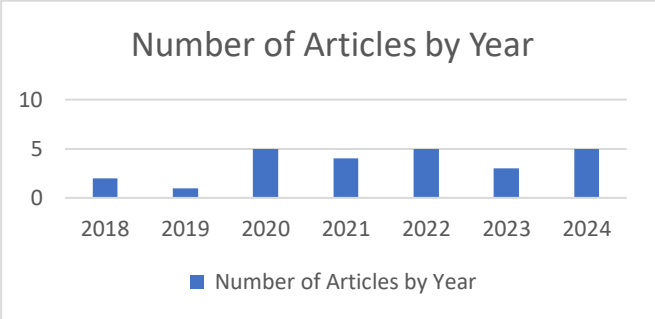

Table 3 : Number of Articles by Year

When the percentage distributions are examined, it can be seen that technological developments have accelerated in recent years, advanced hardware solutions have increased and the use of these technologies in education, health and business world has increased.

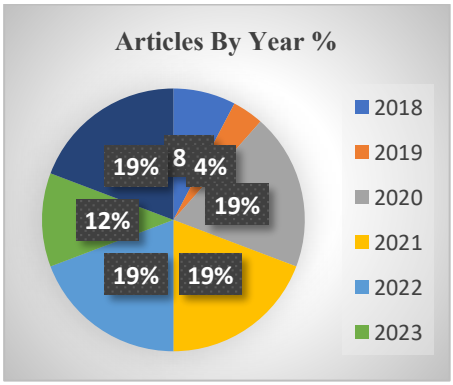

Table 4 : Percentage Distribution of Articles by Year

3. National and International Article Percentile Slice: When the studies examined at national and international levels are evaluated, it is seen that there is a great interest in these technologies on a global scale at the international level.

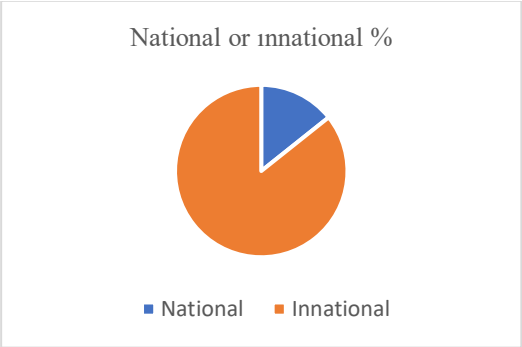

Table 5 : National and International Percentage Distribution of Articles

4.Article Distribution by Country: When studies are examined by country, the reason why the most is done in the USA is that technology giant companies are here, with advanced R & D and University Ecosystems, and large investments and funds, while the second place is followed by Turkey, the reason why there are more studies in the field of Dec Dec, academic interest and university studies in these areas have increased in recent years, defense industry and technological investments have been shown .

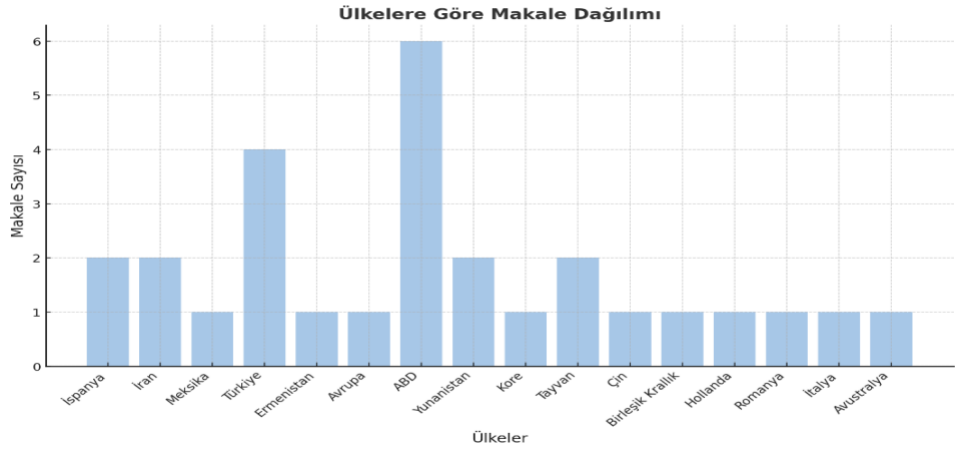

Table 6 : Number of Articles Published by Country

Discussion

In this research study, the use of VR (Virtual Reality) and AR (Augmented Reality) tools in special education was analyzed and the results of the research were discussed. The results of the research show that these technologies have a great impact in advancing the mental and social abilities of people with disabilities, especially those with autism spectrum disorders (ASD) and intellectual disabilities. These technologies empower individuals to be more involved in mutual interactions, increase their ability to cope with challenges and their individual life skills. VR technologies provide impressive experiences that enable people to concretize abstract concepts, while AR technologies have made learning interactive and inspiring. However, more research is needed to better understand the potential of combining both technologies.

Limitations

Although VR and AR technologies have a great potential in education, the lack of educational tools and infrastructure causes students not to use these technologies at an adequate level, teachers do not acquire sufficient knowledge about the use of VR and AR to enable instructors to use these technologies efficiently, teachers do not have sufficient knowledge about the use of VR and AR, or have difficulties adapting to these technologies, cultural and socioeconomic factors, psychological factors, a large part of the studies focus on groups such as autism

spectrum disorder (ASD) and intellectual disability, and data on different disability groups such as visual disability, motor ability deficiencies or sensory Dec Decencies are limited, technical infrastructure and problems such as cost limit the wide-scale applicability of these technologies.

Recommendations

For future studies, it is recommended to increase technological access, teacher training and support programs, application to different disability groups, research the long-term effects of these studies by taking into account accessibility and cost support, and cultural and social, economic differences.

Conclusion

This review study reveals important results about the applications of VR and AR technologies in special education. Technologies have the potential to further develop students' knowledge and skills by making learning processes more interactive and motivating. Positive feedback has been obtained, especially on issues such as autism spectrum disorder and intellectual disability. However, in order to reduce the limitations and bring a wider coverage, more comprehensive, long-term and inclusive research is needed in the future. With the advancement of technological developments, the role of VR and AR in special education will become even more important and these technologies will continue to be used as powerful methods to improve the quality of life of individuals.

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The Effect of Learning Environments Created with Digital Storytelling on Student Participation

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Abstract

Digital stories are powerful educational materials that enrich learning processes by bringing together visual, auditory and textual elements and enable active participation of students. They are effective tools in terms of providing an interactive and personalized learning experience. Digital stories provide an opportunity for technology to be integrated into learning environments in an effective way. The integration of technological developments into educational processes enables learning experiences to be student-centered. It is important in terms of helping students develop different perspectives, reflect their own experiences and gain authentic learning experiences. Digital stories, which offer a more interactive learning experience compared to traditional teaching methods, develop critical and creative thinking and problem-solving skills and positively affect students' motivation. In this study, it is aimed to contribute to innovative educational practices and student-centered approaches by examining the impact of learning environments created using the digital story method on students. Digital stories have enabled students to interact with technology, manage their own learning processes and increase their self-confidence. The use of digital stories has been shown to have positive effects on students' academic success, self-efficacy perceptions and problem solving skills.

Keywords: “digital storytelling”, “education”, “interaction”, “student participation”

Introduction

Digital storytelling refers to applications created by combining digital software and multimedia tools in video format (Pala, 2023). It is also referred to as enriched storytelling created using digital technologies such as computers, voice recorders, and video cameras (Rahiem, 2021). Today, digital storytelling is seen as an effective tool that enhances educational stages across different disciplines. Creating and narrating digital stories provides learners with opportunities to practice speaking in the target language and offers unique opportunities (Yang et al., 2020). In special education, the use of digital stories in early mathematics education is also very important in terms of providing personalized learning experiences that can be adapted to individual student needs and learning styles (Kumaş, 2024). The use of digital storytelling in early mathematics education in special education is also very important in terms of offering personalized learning experiences that can be adapted to individual student needs and learning styles (Kumaş, 2024). Due to new technologies becoming more affordable and accessible to more people, digital storytelling methods are spreading rapidly and widely (Raheim, 2021). Digital stories, which are widely used in educational settings, help teachers create a constructivist learning environment (Chujitarom & Panichrutiwong, 2024). They encourage student motivation and help them develop critical inquiry, reflection, and insight (Chujitarom & Panichrutiwong, 2024). Digital storytelling platforms are used at all levels of education, from early childhood to higher education (Raheim, 2021). Content and Language Integrated Learning (CLIL) considers the digital storytelling method to be an effective approach (Rutta et al., 2021). In online English education, research on digital storytelling has shown that digital stories help students actively participate in the learning process and improve their digital literacy by enhancing their vocabulary and cognitive load (Tatlı et al., 2020). It has been emphasized that digital stories have a positive impact on the identity development and cultural awareness of Native American youth and are seen as an important tool for preserving their cultural heritage (Wicker & Ruan, 2023). It is argued that digital stories are an effective method for developing students' interaction skills with families in family-centered nursing practices (Beierwaltes et al., 2020).

Methodology

To examine the effect of learning environments created through digital storytelling on student participation, research articles written in English between 2020 and 2024 were reviewed using the keywords 'digital storytelling', 'student participation', 'education', and 'interaction'. EBSCOhost and Web of Science databases were used for the literature review. A total of 344 articles were retrieved from the EBSCOhost database and 79 articles from the Web of Science database. The 423 articles retrieved were collected in the Mendeley database, and articles with duplicate URLs and those requiring payment were excluded, resulting in 289 articles. Forty-eight articles deemed relevant to the scope of the study were examined using descriptive content analysis. The graph below shows the studies examined according to the research method:

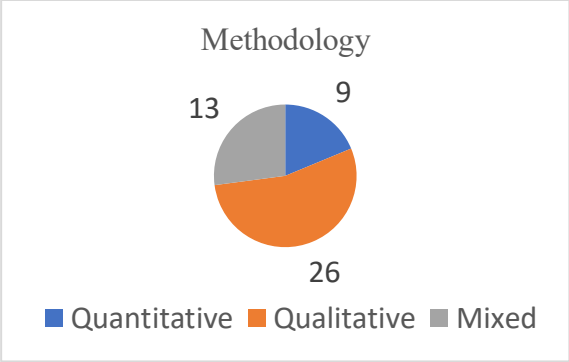

Table 1 : Distribution of Studies by Research Method

In addition to traditional learning methods, technology-supported learning environments are becoming increasingly important. In this context, digital storytelling stands out as an effective method that enriches learning experiences by ensuring active student participation. Considering all these circumstances, answers were sought to the following questions:

- What is the distribution of the articles examined according to their methods?
- What is the distribution of the reviewed articles by year?
- What is the distribution of the reviewed articles by country of publication?
- What are the professional fields covered by the articles?
- What is the percentage distribution at the national and international levels?

Findings

It has been observed that digital stories enhance preschool children's understanding of teaching materials more than traditional methods and also facilitate their understanding of a new language (Raheim, 2021). Digital story-based teaching is seen as an effective pedagogical approach in both developing English speaking skills and creative thinking (Yang et al., 2020). In mathematics education for special education students using digital stories, it has been observed that this method creates a positive attitude in students, makes learning enjoyable, and increases interest and motivation in students with special needs (Kumaş, 2024). In a study consisting of two experimental groups and one control group, the first group was asked to create their own digital stories, the second experimental group was shown digital stories prepared by the researchers, while the control group was asked to follow along with textbooks. The findings revealed that the experimental groups demonstrated more lasting learning compared to the control group; in the first and second experimental groups, lasting learning through experience was more pronounced in the first group (Kırıkçı et al., 2020). A case study conducted on Native American youth showed that they enjoyed the digital storytelling project, developed their personal identities, and that it enabled them to understand the world around them (Wicker & Ruan, 2023). When the studies were analyzed according to the research problems, the findings were as follows:

1) When Studies Are Examined by Year; The high number of articles published in 2020 and 2021 is directly proportional to the pandemic, as the shift to remote education during the COVID-19 pandemic led to a focus on digital storytelling.

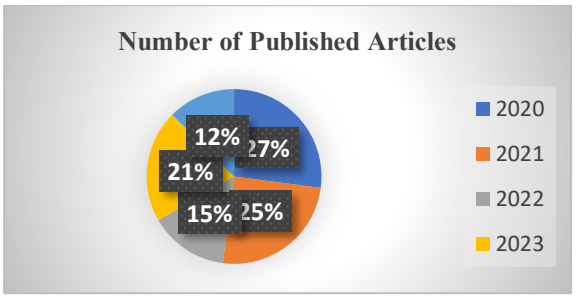

Table 2 : Distribution of Studies by Year

2) When examined by country of study;

Looking at the number of articles published, it is seen that more articles are published in Turkey compared to other countries.

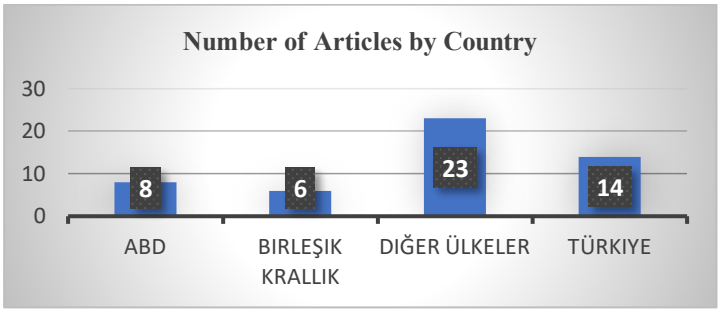

Table 3 : Number of Studies Published by Country

3) Distribution of Articles by Field of Study;

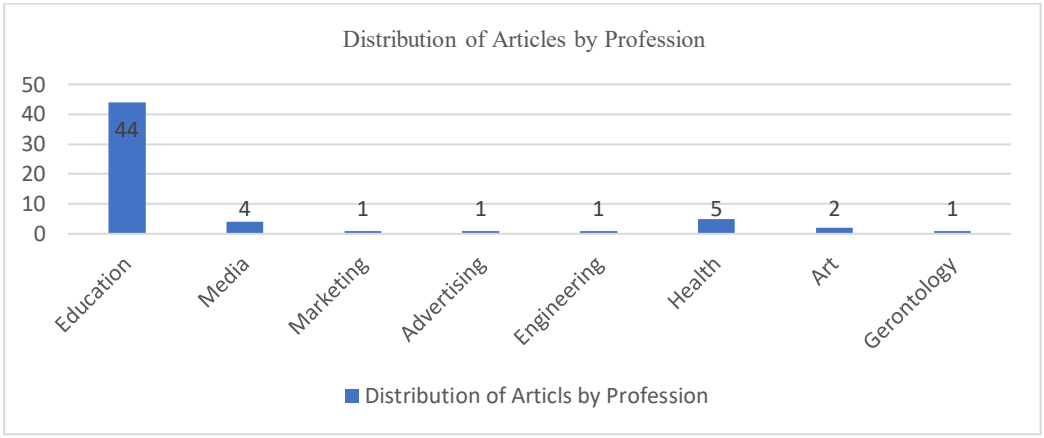

Table 4 : Distribution of Work by Occupation

When the studies are examined, the vast majority of articles on digital storytelling have focused on the field of education. This situation can be explained by the increasing potential and impact of digital storytelling in education and processes such as the integration of technology into education.

4) Percentage Distribution of Studies in National and International Context; This percentage distribution indicates that 14 articles were published in Turkey, representing 29% of national articles, while 34 articles (71%) were published internationally.

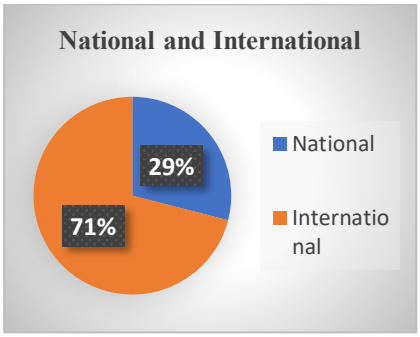

Table 5 : Percentage Distribution at the National and International Levels

Recommendations

The use of digital storytelling in education should be made more widespread. To enable teachers and academics to use digital storytelling more effectively, their pedagogical knowledge and skills should be developed, their technological literacy should be increased, and effective assessment strategies should be developed using student-centered learning approaches. Educators should make the story creation stages more interactive, providing students with more motivating support. Digital storytelling should be promoted to make abstract concepts concrete in science, technology, engineering, and mathematics (STEM) fields. Course content should be filled with digital stories to develop students' logical thinking skills.

Discussion

The positive effects of digital storytelling on students' academic achievement, self-efficacy perceptions, and problem-solving skills have been supported by numerous studies. The articles examined show that this method has been found to increase students' educational success in other educational areas, make the time spent in class more efficient for teachers, personalize learning, and encourage active participation. However, certain limitations in the technological foundation, teachers' theoretical or practical shortcomings in using digital tools more effectively, and the time-consuming nature of content creation restrict the effective use and widespread adoption of this method.

Conclusion

Digital storytelling is seen as an effective method that increases student motivation and supports student learning in different learning areas. Compared to traditional teaching methods, this method provides visual and auditory processes, enabling students to be more active in the learning process and developing their multifaceted thinking skills, such as problem solving, critical thinking, and creative expression skills. Given that digital storytelling is a powerful technological tool for creating personal and social awareness, its potential should be evaluated. For this method to be used more widely and effectively in the future, educators, technology developers, and producers need to work together and take joint action.

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The Relationship Between Mathematical Thinking Skills and Generative Artificial Intelligence Acceptance

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Abstract

Mathematical thinking is a multidimensional construct that encompasses a set of interrelated cognitive processes such as problem-solving strategies, metacognitive regulation, sense-making activities, and individuals' beliefs about mathematics. In recent years, generative artificial intelligence (AI) has been used at various educational levels to enhance skills in many areas of education, including mathematics. Technology acceptance is a critical factor for the effective integration into education. Therefore, it is important to examine the cognitive factors that influence individuals' acceptance of these new technologies including AI. This study aims to investigate the relationship between university students' mathematical thinking skills and their acceptance of generative artificial intelligence. Using a correlational research design, the Mathematical Thinking Skills Scale and the Generative Artificial Intelligence Acceptance Scale were administered to 115 students. The results revealed a strong positive correlation between mathematical thinking and generative AI acceptance ($r = .73$, $p = .000$). These findings suggest that cognitive skills may play a significant role in the adoption of AI technologies. It is recommended that individual differences affecting technology acceptance be taken into account in the design and implementation of AI-supported instruction.

Keywords: mathematical thinking skills, generative artificial intelligence, artificial intelligence acceptance

Introduction

Acceptance towards many AI tools used for educational purposes have been investigated using Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (Setala et al., 2025). AI Acceptance is important for effective AI integration in education (Ali et al., 2024). The relationship between individual differences and students' acceptance of generative AI needs to be examined (Karaoglan-Yılmaz et al., 2024). Differences in cognitive skills can also be related to how individuals adopt and accept Generative AI tools.

Learning to think mathematically means developing a) a mathematical point of view (b) developing competence with the tools of the trade—mathematical sense-making (Schoenfeld, 2017). It "entails learning how to generate those ideas, how to express them using words and symbols, and how to justify to oneself and to others that those ideas are true." (Carpenter et al., 2003). Rather than just finding the right answer, this requires deeper understanding of mathematical ideas, constructing and expressing new mathematical ideas, justifying and confirming by reasoning and applying problem solving strategies flexibly. Generative AI performs some of these tasks such as generating mathematical ideas and expressing them in different formats. Furthermore, it can explain its problem solving strategies to humans. In this respect, human-AI can involve co-performing mathematical thinking processes and making decisions about the reasoning processes that AI used on the human part.

Individuals with high-level mathematical thinking skills can experiment with Gen AI tools and refine their problem-solving capabilities (Egara & Mosimege, 2024). On the other hand, overreliance on Gen AI tools may hinder the cultivation of problem-solving abilities and higher level thinking skills, which are two sub-dimensions of mathematical thinking skills.

This research is driven by the following questions:

- To what extent university students accept generative artificial intelligence?
- Is there a relationship between students' generative artificial intelligence acceptance and mathematical thinking skills?

Literature Review

UTAUT model (Venkatesh et al., 2003) explains technology acceptance in four factors. *Performance Expectancy* is defined as the degree to which an individual believes that using the system will help him or her to attain gains in job performance. *Effort Expectancy* is the extent of easiness during using a system. *Social Influence* is defined

as the degree to which an individual perceives that important others believe he or she should use the new system. *Facilitating Conditions* is the extent of one's belief about the existence of organizational and technical setup in support of using the system. AI Acceptance refers to the intention of stakeholders in the education sector (students, teachers, policymakers, or administrators) to adopt and use AI technologies and AI-based applications.

AI is being used for cultivating mathematical thinking processes. Li et al. (2024) developed a conversational AI to facilitate math learning. Participants appreciated their experience with the conversational AI application, particularly valuing the ICE support features.

Induction: This strategy facilitates students' activation of their prior procedural and conceptual knowledge in order to be prepared for problem solving. It helps them recognize correlations and gaps between their existing knowledge and new mathematical concepts. In the context of mathematical thinking, induction enables students to engage in complex processes such as formulating hypotheses, making generalizations, and subsequently verifying them. AI identifies and links maths concepts with student questions, real-world applications and other learning material.

Concretization Concretization is the process of turning abstract math problems into easy-to-understand, real-world problems. Examples of concretization include breaking problems down into steps or relating mathematical ideas to familiar teaching content. AI provides incremental steps rather than revealing answers directly. AI searches instructional videos to answer questions.

Exemplification Exemplification is a strategy that uses illustrative examples to explain problem-solving objectives, reduce cognitive load, increase procedural fluency, and encourage the application of learned examples in new problem-solving contexts. AI suggests examples tailored to students' inquiries. AI presents alternative methods to solve a problem. All of these features are related to mathematical thinking and potentially can be related to AI acceptance.

Methodology

This study adopted the correlational method to explore the relationship between mathematical thinking skills and Generative AI acceptance. 115 university students from departments of Computer Engineering and Mathematics (60 F, 55 M) participated in the study.

We employed Generative Artificial Intelligence Acceptance Scale (Karaoglan– Yılmaz et al., 2024) to measure Generative AI acceptance levels of the students. The scale has the same factors with UTAUT and consists of 20 items. Mathematical Thinking Skills Scale (Ersoy and Başer, 2013) was used for measuring mathematical thinking levels and consists of 25 items and 4 factors (high-level thinking tendency, reasoning, mathematical thinking skill, and problem solving).

Results

GAI Acceptance & Gender

We used a Mann-Whitney U test for comparing GAI Acceptance scores of males and females. There was no significant difference between GAI acceptance scores of females (Mdn = 80.50) and males (Mdn = 82.00) (U = 1531.50, z = - .664, p < .05)

Tablo 1: GAI Acceptance and Gender

	Females (n = 60)	Males (n = 55)			
GAI Acceptance	**Mean Rank**	**Mean Rank**	***z***	***U***	***p***
	59.98	55.85	-.664	1531.50	.507
***p* < .05**					

GAI Acceptance & Department

We used a Mann-Whitney U test for comparing GAI Acceptance scores of Mathematics and Computer Engineering students. There was no significant difference between GAI acceptance scores between the students of two departments (U = 1186.50, z = - 1.422, p < .05)

Tablo 2 GAI Acceptance and Department

	Mathematics (n = 36)	Computer Engineering (n = 79)			
GAI Acceptance	**Mean Rank**	**Mean Rank**	***z***	***U***	***p***
	64.54	55.02	-1.422	1186.50	.155
***p* < .05**					

Mathematical Thinking & Gender

We used a Mann-Whitney U test for comparing mathematical thinking skills of males and females. There was no significant difference between mathematical thinking skills of females (Mdn = 97.00) and males (Mdn = 93.00) (U = 1403.50, z = - 1.383, p < .05)

Tablo 3 Mathematical Thinking Skills and Gender

	Females (n = 60)	Males (n = 55)			
Mathematical Thinking	**Mean Rank**	**Mean Rank**	***z***	***U***	***p***
	62.11	53.52	-1.383	1403.50	.167
***p* < .05**					

Mathematical Thinking & Department

We used a Mann-Whitney U test for comparing mathematical thinking skills of Mathematics and Computer Engineering students. Mathematical thinking skills of Mathematics students (Mdn = 103.50) is significantly higher than that of Computer Engineering Students (Mdn = 93.00) (U = 933.50, z = - 2.951, p < .05)

Tablo 4 Mathematical Thinking Skills and Department

	Mathematics (n = 36)	Computer Engineering (n = 79)			
Mathematical Thinking	**Mean Rank**	**Mean Rank**	***z***	***U***	***p***
	71.57	51.82	-2.951	933.50	.003*
***p* < .05**					

Mathematical Thinking & GAI Acceptance

We conducted a Spearman's correlation test to see whether mathematical thinking skills and GAI acceptance are related which indicated a strong positive correlation (r = .735, p <.05)

Tablo 5 GAI Acceptance and Mathematical Thinking

	Mathematical Thinking (M = 94.45)	
	r	***p***
GAI Acceptance (M = 80.20)	.735	.000**

Correlation tests of mathematical thinking and GAI Acceptance sub-factors all demonstrated positive relationships.

Tablo 6 Mathematical Thinking & GAI Acceptance Sub-factors

	GAIA1:Performance Expectancy		GAIA2: Effort Expectancy		GAIA3: Facilitating Conditions		GAIA4: Social Influence	
	r	***p***	***r***	***p***	***r***	***p***	***r***	***p***
Mathematical Thinking Skills	.634**	.000	.703**	.000	.669**	.000	.639**	.000

Correlation tests of GAI Acceptance and mathematical thinking sub-factors all demonstrated positive relationships.

Tablo 7 GAI Acceptance & Mathematical Thinking Sub-factors

	MD1: High-Level Thinking Tendency		MD2: Reasoning		MD3: Mathematical Thinking Skill		MD4: Problem Solving	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
GAI Acceptance	.725**	.000	.643**	.000	.443**	.000	.750**	.000

Discussion and Conclusion

Results of this study indicated that GAI Acceptance of university students is high (M=80.20). In a recent study, female teachers were found less sympathetic towards AI applications than males (Brandhofer and Tegler, 2024). However, our study did not find difference in AI Acceptance levels of female and male students. This may result from the the fact that our sample is younger and more likely to be competent users of technology.

AI acceptance showed a strong positive correlation with mathematical thinking skills. Specifically, correlations with High-Level Thinking Tendency and Problem Solving dimensions are high. This demonstrates the relationship between cognitive skills and AI acceptance. For AI integration, mathematical thinking skills can work both ways: high skills may improve AI acceptance and increased AI acceptance and adoption can help improving these skills. Future studies can focus on the long-term effects of creativity on the use of AI tools.

Effective AI integration in education requires understanding the limitations of AI tools and progressive professional development and support (Egara & Mosimege, 2024). A deeper understanding of AI acceptance in the education sector can support teachers in planning training accordingly (Brandhofer & Tegler, 2024). More studies are needed to explore the development of AI acceptance over time in greater depth (Setala et al., 2025)

Using GAI tools can provide step-by-step guides that enhance students' grasp of the problem-solving processes, which can then improve mathematical thinking skills (Egara & Mosimege, 2024). Individual ways of thinking and learning can affect AI integration in education and AI acceptance. Future studies could investigate the mediator of this relationship: whether it is cognitive, affective or experiential dimensions.

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Digital Feedback Literacy Theory for Postsecondary Learning

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Abstract

Too many digital comments evaporate before they become better work; Digital Feedback Literacy Theory (DFLT) explains why breakdowns occur and how to address them across four coordinated domains in postsecondary online and hybrid settings. Digital Feedback Synergy (DFS) specifies instructor design moves that produce cognitive clarity, emotional resonance, and social connection so comments become immediately usable. Tech-Mediated Communication Competence (TMCC) delineates learner skills for navigation, interpretation, emotion regulation, and relational presence so students can work with what they receive. Cognitive-Affective Processing (CAP) consolidates mechanisms that translate comments into next steps by tuning tone, cognitive load, and motivation. Feedback Agency and Transfer (FAT) captures how learners act on guidance, persist through structured re-attempts, and generalize gains across tasks, courses, and contexts. Based on a conceptual synthesis of recent scholarship and practice artifacts, the model yields a rapid diagnostic and a set of design principles and measurement targets that help instructors, designers, and leaders locate failure points and deploy the smallest effective fix. Together, these elements link platform usability and instructor–student rapport to durable feedback use and more equitable outcomes across postsecondary digital learning.

Keywords: digital feedback literacy, Digital Feedback Synergy, Tech-Mediated Communication Competence, cognitive-affective processing, Feedback Agency and Transfer, online and hybrid postsecondary education

Introduction

Digital feedback literacy aims to elicit learner agency in the feedback process and to carry gains forward through transfer, with measurable growth in literacy over time. In postsecondary online and hybrid settings, instructors invest substantial time in written, audio, and video commentary, yet students often overlook or misread that guidance before it becomes visible revision (Nieminen & Carless, 2023). Research on feedback literacy shows that the seek, interpret, and use cycle frequently stalls when learners lack strategies for turning comments into next steps (Carless & Boud, 2018). Work on feedback functions explains how clarity and task focus shape the likelihood that comments translate into action on the subsequent attempt (Hattie & Timperley, 2007). Studies of digital teaching emphasize that low social presence and insufficient emotional support depress persistence with critique, especially under higher cognitive load (Liu et al., 2024). Reviews of feedback models highlight the need to coordinate design elements with learner processes so guidance becomes usable in real courses (Panadero & Lipnevich, 2022). What is needed is a coherent way to make agency, re-attempts, and transfer routine in the everyday realities of postsecondary digital learning.

Existing scholarship explains important pieces of the puzzle, but rarely coordinates them into a cycle that educators can run at speed. Feedback literacy clarifies how learners seek, interpret, and use information about their work, while instructional design and usability research underscore the roles of clarity, timing, and modality in making comments actionable (Carless & Boud, 2018; Panadero & Lipnevich, 2022). Studies on motivation, emotion, and cognitive processing specify why tone, cognitive load, and attention shape uptake, and work on transfer shows that improvement matters most when it travels to later tasks and courses (Hattie & Timperley, 2007; Liu et al., 2024). Digital Feedback Literacy Theory (DFLT) addresses this coordination problem by organizing four domains: Digital Feedback Synergy, Tech-Mediated Communication Competence, Cognitive-Affective Processing, and Feedback Agency and Transfer into a single cycle that educators can deploy, measure, and refine. The goal is to convert comments into plans, plans into revisions, and revisions into durable gains across postsecondary digital learning.

Digital Feedback Literacy Theory converts that coordination problem into a cycle that can be operated at speed and measured in postsecondary digital learning. Drawing on feedback-literacy research, the seek–interpret–use logic is framed as operational moves that connect comments to revision (Carless & Boud, 2018). Building on review work in feedback models, design insights are translated into observable indicators that render comments immediately usable in digital contexts (Panadero & Lipnevich, 2022). To anchor conditions for uptake, evidence on social presence, emotional support, timing, modality, and cognitive load is incorporated as a set of levers that sustain engagement with critique (Liu et al., 2024). Interventions are also aligned with established feedback

functions, so guidance predictably converts into action on the subsequent attempt (Hattie & Timperley, 2007). The sections that follow present the DFLT framework, illustrate each domain with targeted instructor and student moves, and introduce a rapid diagnostic that maps visible symptoms to the smallest effective fix.

Methodology

Design and Approach

A structured conceptual synthesis organizes postsecondary digital feedback research into a single operating cycle for practice. Feedback-literacy scholarship anchors the learner-side logic for how students seek, interpret, and use information about their work, and foundational models frame feedback as information that narrows the gap between current and desired performance (Carless & Boud, 2018; Hattie & Timperley, 2007). Reviews of feedback models and typologies contribute design principles and observable features that make comments immediately usable in courses, while design-for-learning critiques underline why task focus and specificity should be engineered into routine practice (Panadero & Lipnevich, 2022; Boud & Molloy, 2013). Conditions research identifies enabling context, highlighting clarity, dialogic opportunity, and timeliness as course-level levers for uptake (Henderson et al., 2019). In digital settings, social presence and emotional support sustain engagement with critique when cognitive load is high, which defines the conditions under which students are most likely to act on guidance in online and hybrid formats (Liu et al., 2024). Interface effects also matter; co-present grades can crowd out formative signals and interface framing can nudge whether students look beyond a headline mark to actionable cues (Winstone & Boud, 2022; Bulut et al., 2019). The approach integrates these strands into a coordinated cycle that aligns design, competence, processing, and transfer so feedback upgrades the next attempt and accumulates across tasks and courses.

Portability and measurement are built into the approach so it can be operated under standard course constraints. Portability across online and hybrid formats is supported by higher-education work on blended learning's transformative potential and by sector-wide adoption of online delivery that normalizes digital feedback workflows (Garrison & Kanuka, 2004; Means & Neisler, 2021). Measurability is supported by instruments that capture enacted feedback behaviors in higher education, providing a practical basis for tracking change over time (Dawson et al., 2024). Where relational climate constrains uptake, evidence on instructor–student rapport in hybrid and online settings underscores the value of explicitly engineering social presence alongside feedback design (Lammers & Gillaspy, 2013). Design guidance is translated into concise, observable moves, learner competencies are expressed as trainable routines, and processing and transfer are positioned as conditions and behaviors that can be tracked at task, course, and program levels.

Sources and Search Strategy

Peer-reviewed scholarship from 2018 to 2025 anchors the evidence base, while cornerstone works supply enduring mechanisms and definitions. Database searches in ERIC, PsycINFO, Scopus, and Web of Science combined terms such as feedback literacy, digital feedback, online learning, hybrid learning, social presence, cognitive load, emotion regulation, and learning transfer to capture both design factors and learner-side processes (Panadero & Lipnevich, 2022). A graph-based discovery tool, ResearchRabbit, extended coverage through forward and backward citation chaining, co-citation and author-network mapping, and recency filters to surface adjacent and emerging work efficiently; items identified through graph exploration were verified in databases before screening for relevance. A curated bibliography from prior work served as a seed corpus and was reconciled with database outputs so the final set blends recent empirical and review studies with foundational sources that still anchor the field (Carless & Boud, 2018). The outcome is a coherent, current corpus capable of supporting a practical operating cycle for feedback in postsecondary digital learning.

Screening and Selection

Inclusion targeted studies that directly addressed feedback design and usability, learner strategies for working with feedback, cognitive or affective conditions that influence uptake, or transfer across tasks and courses in postsecondary settings. Screening emphasized clarity of contribution to one or more of the four domains that structure the framework, with feedback-function scholarship providing criteria for locating where an intervention should sit in the cycle (Hattie & Timperley, 2007). Exclusion removed K–12-only studies without transferable adult-learning implications, pure technology evaluations lacking feedback processes, and commentaries without substantive conceptual or empirical contribution. The resulting set supports both explanatory mechanisms and actionable guidance for digital environments.

Mapping and Synthesis

Constructs were organized into four coordinating domains so instructor moves, learner skills, processing mechanisms, and transfer behaviors align as a single operating cycle. Feedback-literacy research articulated the seek, interpret, and use logic as concrete actions that connect comments to next-step planning, while review work on feedback models yielded observable design indicators that render guidance immediately usable in courses (Carless & Boud, 2018; Panadero & Lipnevich, 2022). Evidence on timing, modality, cognitive load, emotion regulation, and social presence specified conditions that sustain engagement with critique and increase the likelihood of uptake in online and hybrid contexts (Liu et al., 2024). Analytic memoing and matrixing checked alignment across domains and reduced construct drift during integration so the resulting cycle remains parsimonious and implementable. The synthesis yields a framework that is descriptive enough to explain recurrent breakdowns and prescriptive enough to suggest the smallest effective fix.

Methodological Rigor and Limitations

Rigor rests on balancing recent empirical and review literature with foundational sources to ground mechanisms and on alignment checks that ensure feasibility under standard digital course constraints (Carless & Boud, 2018; Liu et al., 2024). Transparency is supported by explicit inclusion and exclusion criteria, database provenance for all sources, and a reproducible search description that includes graph-based discovery steps. Limitations include the absence of new empirical testing in this article and the need for validation studies that evaluate the diagnostic, measure transfer over time, and examine differential effects across learner profiles. These boundaries define the next step in which claims are examined through classroom interventions and longitudinal designs.

Results

Reliable feedback use emerges when design, learner competence, cognitive–affective processing, and transfer operate as a single cycle in digital courses. Digital Feedback Synergy organizes instructor moves that make comments immediately usable by increasing cognitive clarity, emotional resonance, and social connection so guidance is specific, humane, and ready-to-act (Boud & Molloy, 2013). Tech-Mediated Communication Competence names learner skills for locating feedback, interpreting its intent, regulating emotion around critique, and sustaining relational presence so dialogue can continue across platforms (Carless & Boud, 2018). Cognitive-Affective Processing consolidates mechanisms that convert comments into next-step plans by aligning tone, cognitive load, attention, timing, and modality with motivation and goal setting (Hattie & Timperley, 2007). Feedback Agency and Transfer captures the behavioral arc through which learners act, persist through structured re-attempts, and generalize gains across tasks, courses, and contexts so improvement does not remain assignment-bound. When these domains are coordinated in sequence, comments become plans, plans become revisions, and revisions compound into durable gains across a program. See Figure 1 for a visual representation of the DFLT cycle.

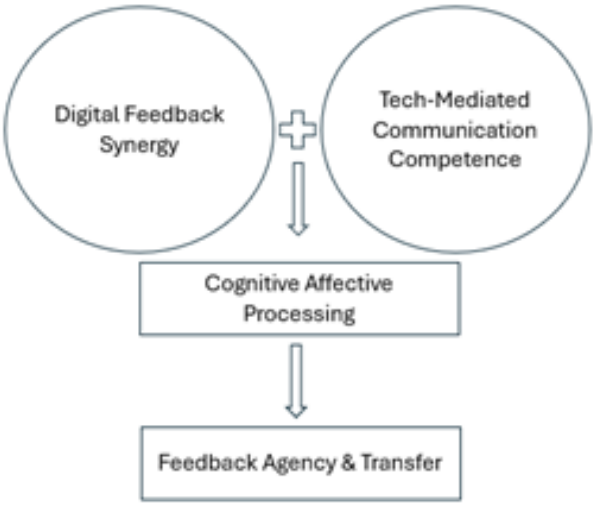

Figure 1. Digital Feedback Literacy Theory (DFLT) cycle.

Predicting Feedback Gaps with DFLT: A Rapid Diagnostic

Table 1 presents a rapid diagnostic tool that aligns common indicators with the DFLT domain most likely at fault and the smallest effective fix, enabling targeted action under typical course constraints. For the full quick-reference version used by instructors and leaders, see Appendix A. The purpose is to shorten the distance between noticing a breakdown and executing a remedy that improves the very next attempt.

Table 1. DFLT rapid diagnostic

Indicators you see	Likely domain	Smallest effective fix
Students say feedback feels vague or overwhelming; many ask, "What does this mean?"	DFS	Rewrite criteria with one short exemplar per criterion; add a 1–2 sentence "why it matters" note; record a 45–60 second audio or video cue to humanize intent
Students cannot find feedback in the LMS or misread the point; few clarifying questions are asked	TMCC	Teach a two-minute routine: find → label → next step; post a screenshot walkthrough of where feedback lives; model one concise clarifying reply
Students read feedback but cannot plan changes; visible discouragement or avoidance	CAP	Add a three-prompt scaffold: "What is the change?", "Why this change?", "First step I can take"; adjust delivery timing and modality to reduce cognitive load
Students revise, but gains do not carry to the next task; the same issues reappear later	FAT	Require a short re-attempt window with a one-line change plan; add a cross-task "apply one lesson" prompt; ask students to log evidence of transfer

Note. This diagnostic maps visible indicators to the most likely DFLT domain and the smallest effective fix. Example application: in a writing course with precise but under-used comments, a TMCC routine (find → label → next step) increased revisions within two cycles. Abbreviations: DFS = Digital Feedback Synergy; TMCC = Tech-Mediated Communication Competence; CAP = Cognitive-Affective Processing; FAT = Feedback Agency and Transfer.

The DFLT cycle (Figure 1) and the rapid diagnostic (Table 1; see Appendix A for the full tool) convert recurrent breakdowns into specific, smallest-effective fixes that fit within ordinary course constraints. The framework specifies where to intervene, the diagnostic shows how to act next, and the pairing makes progress observable on the very next attempt. The Conclusions section distills the implications for practice and research and outlines immediate steps for adoption and evaluation.

Conclusions

Digital Feedback Literacy Theory brings together feedback design, learner competencies, cognitive–affective processing, and transfer into one actionable cycle that turns comments into plans, plans into revisions, and revisions into durable gains. The framework clarifies where breakdowns occur in digital courses, names the skills and conditions that enable uptake, and pairs a rapid diagnostic with smallest-effective-fix guidance so improvement can occur within ordinary constraints. By coordinating design signals, student routines, processing supports, and forward transfer, the cycle makes reliable feedback a routine feature of postsecondary online and hybrid learning rather than a fortunate exception.

The framework provides a common vocabulary and a compact set of moves that can be staged at the task, course, and program levels. Instructors can emphasize clarity, resonance, and connection in feedback design; students can be taught brief routines to find, interpret, and plan; timing and modality can be tuned to lower cognitive load and support emotion; and structured re-attempts with transfer prompts can ensure gains travel. Leaders can align capability-building with these levers and use the diagnostic to localize bottlenecks quickly.

For research, the immediate agenda is validation and refinement: test whether the diagnostic accurately locates gaps, evaluate whether the smallest-fix interventions increase revision and transfer, and track growth in feedback-literacy behaviors with course analytics and established measures across modalities and learner profiles. The framework and tool shift feedback from a one-way comment stream to a continuous improvement system, positioning DFLT for immediate adoption and systematic evaluation.

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Appendix A

Predicting Feedback Gaps with DFLT: Rapid Diagnostic Tool

Table A1. DFLT Diagnostic Tool

Domain	Guiding Questions to Identify Gaps	What a Gap Looks Like
DFS – Digital Feedback Synergy (Instructor Design)	• Is feedback clear, structured, and jargon-free? • Does it resonate emotionally (growth vs. deficit focus)? • Is there relational presence (personalization, multimodality)?	• Students ignore or misinterpret comments • Feedback feels vague, impersonal, or overwhelming
TMCC – Tech-Mediated Communication Competence (Student Competence)	• Can students navigate LMS tools to find and use feedback? • Do they know how to translate comments into actions? • Can they manage emotional responses to feedback?	• Students don't access feedback • Misread meaning • Disengage due to frustration
CAP – Cognitive–Affective Processing (Internalization)	• Are students interpreting feedback cognitively (what to do next)? • Are they processing it emotionally (resilience vs. discouragement)? • Is timing/modality aligned with attention & motivation?	• Students read feedback but don't know what it means • Emotional shutdown instead of action
FAT – Feedback Agency & Transfer (Forward Action)	• Do students act on feedback for revisions/future tasks? • Can they apply lessons across courses/contexts? • Do they see feedback as an opportunity, not just judgment?	• No revisions • Repeat mistakes • Fail to generalize learning

How Leaders/Institutions Can Respond

DFS gap → Instructor training (clarity, multimodality, inclusivity).

TMCC gap → Student training (digital literacy, feedback use strategies).

CAP gap → Timing/emotional scaffolding (guided reflections, resilience support, multimodal presence).

FAT gap → Curricular integration (link feedback to future tasks, build habits of transfer).

Algorithmic Awareness and Appearance Concerns on Social Media: A Correlational Study Among Undergraduates

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Abstract

This study examines the relationship between undergraduate students' algorithmic media content awareness (AMCA) and their appearance-related social media consciousness (ASMC). Using a quantitative, cross-sectional, and correlational design, data were collected from 215 students enrolled at a public university in Turkey through validated Turkish versions of the AMCA and ASMC scales. Descriptive statistics revealed that participants reported moderate levels of AMCA ($M = 3.68$, $SD = .91$) and relatively low-to-moderate levels of ASMC ($M = 2.64$, $SD = .95$). Pearson correlation analysis indicated a significant positive relationship between AMCA and ASMC scores ($r = .28$, $p < .001$). Gender did not significantly predict either AMCA or ASMC; however, heavy social media use (≥5h/day) was associated with higher ASMC. Students from ICT-related fields scored higher on AMCA compared to peers from other disciplines. These findings highlight the nuanced relationship between algorithmic awareness and appearance-related consciousness, underscoring the need for educational interventions that simultaneously enhance algorithmic literacy and address sociocultural pressures within algorithmic media environments.

Keywords: Algorithmic Content Awareness, Appearance-Related Social Media Consciousness

Introduction

The digital transformation of media ecosystems has reshaped how individuals interact with content, largely through algorithm-driven platforms. These platforms curate personalized content based on users' behaviors, a process known as algorithmic curation (Metzler & Garcia, 2024). In this context, understanding users' awareness of algorithmic processes, *algorithmic awareness*, has become a key component of digital literacy and user agency (Oeldorf-Hirsch & Neubaum, 2023). Algorithmic awareness refers to individuals' understanding of how algorithms filter, prioritize, and deliver content. This includes knowledge of automated decision-making, human-algorithm interactions, data privacy, and content personalization (Zarouali et al., 2021). Recent research highlights that younger and more digitally immersed users tend to display higher algorithmic awareness, while disparities persist across age and education levels (Gran et al., 2021). A closely related variable is *appearance-related social media consciousness* (ASMC), defined as individuals' continuous awareness of their appearance in relation to how they are perceived on social media (Choukas-Bradley et al., 2020). ASMC is reinforced by platforms that prioritize visual content and reward engagement with idealized images.

Although algorithmic and appearance-related dynamics are typically studied separately, recent studies point to their interconnection. Algorithms amplify content that receives attention and engagement, often appearance-focused, thereby reinforcing sociocultural beauty norms and intensifying ASMC (Bucher, 2018; Cotter, 2019; Kerner et al., 2021). This suggests a need for digital literacy, including the ability to reflect on how algorithmic infrastructures shape users' emotional, social, and cognitive experiences (Spurava & Kotilainen, 2023).

Another key variable is *social media usage duration*, which moderates users' exposure to algorithmically curated appearance content. High-intensity users may experience heightened ASMC, while frequency of exposure appears to have little influence on algorithmic literacy, which tends to reflect deeper cognitive models rather than surface-level habits (Fardouly & Vartanian, 2016).

This study aims to examine the relationship between undergraduate students' algorithmic media content awareness (AMCA) and ASMC. The study also explores the extent to which demographic factors and social media usage patterns influence both constructs.

Research Questions

This study addresses the following research questions:

1. What is the relationship between undergraduate students' AMCA and ASMC scores?
2. Do AMCA and ASMC scores differ significantly according to students' gender and academic field?

3. How does daily social media usage duration relate to AMCA and ASMC scores?

Method

Research Design

This study employed a quantitative, cross-sectional, and correlational research design to examine the relationship between undergraduate students' AMCA and their ASMC. A correlational design was chosen because it enables the investigation of non-causal associations among naturally occurring variables without experimental manipulation.

Participants

Participants were 215 undergraduate students (71.2% female, 28.8% male) enrolled at a public university in Turkey, selected through convenience sampling. The mean age was 21.29 years (SD = 2.87, range = 18-65). The sample included students from various academic fields, with 24.2% from ICT-related fields and 75.8% from other disciplines.

Regarding digital habits, 54.9% reported daily internet use of 4-6 hours, and 44.7% reported daily social media use of 3-4 hours. Additionally, 19.5% of students reported using social media for 5 or more hours daily.

Table 1. Demographic Characteristics of the Participants

Demographic Variable	Category	n	%
Age	Mean ± SD		21.29 ± 2.87
Gender	Female	153	71.2
	Male	62	28.8
Daily Internet Use	< 1 hour	2	0.9
	1–3 hours	42	19.5
	4–6 hours	118	54.9
	> 6 hours	53	24.7
Daily Social Media Use	< 1 hour	14	6.5
	1–2 hours	59	27.4
	3–4 hours	96	44.7
	5–10 hours	42	19.5
	> 10 hours	4	1.9
Academic Field	ICT Related	52	24.2
	Other fields	163	75.8

Data Collection Instruments

- Demographic Information Form: Included items on age, gender, academic field, and daily social media usage patterns.
- AMCA Scale: The Turkish version of the AMCA scale (Yasan Ak & Kamalı Arslantaş, 2024) consists of 13 items measuring four subdimensions: Content Filtering, Automated Decision-Making, Human-Algorithm Interaction, and Transparency and Privacy. The scale uses a 5-point Likert format (1 = not at all aware, 5 = completely aware). The Turkish adaptation demonstrated strong psychometric properties with an overall Cronbach's alpha of .90.
- ASMC Scale: The Turkish version (Çetinkaya et al., 2022) contains 13 items measuring awareness of self-appearance on social media using a 7-point Likert format. The Turkish adaptation showed good reliability with a Cronbach's alpha of .93.

Data Analysis

Data were analyzed using SPSS. Descriptive statistics, Pearson correlation analysis, independent samples t-tests, and one-way ANOVA were employed.

Results

The normality of AMCA and ASMC scale scores was assessed through both descriptive and inferential statistics. For the AMCA scores, skewness = -.609 and kurtosis = .057, and for ASMC, skewness = .224 and kurtosis = -.737, all falling within the commonly accepted range of ±1, indicating approximately normal distributions. Although the Kolmogorov–Smirnov and Shapiro–Wilk tests were significant ($p < .05$), which technically reject the null hypothesis of normality, these tests are known to be overly sensitive with large samples ($n > 200$). Therefore, based on acceptable skewness and kurtosis values as well as visual inspection (e.g., histograms, not shown), both variables were considered to approximate a normal distribution. Thus, parametric tests were deemed appropriate for subsequent analyses.

Descriptive Statistics

Table 2 presents descriptive statistics for the main study variables. Participants reported moderate levels of AMCA (M = 3.68, SD = .91) and low-to-moderate levels of ASMC (M = 2.64, SD = .95). Both scales demonstrated good internal consistency (AMCA α = .95, ASMC α = .94).

Table 2. Descriptive Statistics

Variable	M	SD	α
1. AMCA Score	3.68	.91	.95
2. ASMC Score	2.64	.95	.94

Note. N = 215.

Correlation Between AMCA and ASMC Scores

As shown in Table 3, there was a significant positive correlation between AMCA and ASMC scores, $r(213) = .28$, $p < .001$. While the effect size is considered small to moderate (Cohen, 1988), this suggests that individuals with higher algorithmic content awareness tend to exhibit higher appearance-related consciousness on social media platforms.

Table 3. Pearson Correlation Between AMCA and ASMC Scores

Variable	1	2
1. AMCA Score	—	.28**
2. ASMC Score		—

Note. $p < .01$.

Correlations Between AMCA Subdimensions and ASMC

Pearson correlation analyses were conducted between the four subdimensions of the AMCA scale and the ASMC score. As presented in Table 4, all four AMCA subdimensions were found to be significantly and positively associated with appearance-related social media consciousness. Specifically:

- Content Filtering showed the strongest correlation with ASMC, $r = .30$, $p < .001$.
- Automated Decision-Making and Human-Algorithm Interaction exhibited moderate correlations, $r = .28$ and $r = .26$ respectively ($p < .001$).
- Transparency and Privacy demonstrated a weaker, yet statistically significant, correlation, $r = .16$, $p = .021$.

These findings indicate that different aspects of algorithmic awareness contribute to appearance-related social media consciousness at varying levels. The strongest association with content filtering implies that users who understand how algorithms control what content is shown are also more aware of how appearance norms are reinforced through such curated content.

Table 4. Pearson Correlations Between AMCA Subdimensions and ASMC

Variable	1	2	3	4	5
1. Content Filtering	—	.80**	.77**	.72**	.30**
2. Automated Decision-Making		—	.74**	.69**	.28**
3. Human-Algorithm Interaction			—	.76**	.26**
4. Transparency and Privacy				—	.16*
5. ASMC Score					—

Note. p < .05. p < .01.
ASMC = Appearance-related Social Media Consciousness

Gender Differences in AMCA and ASMC Scores

As shown in Table 5, the results indicated no statistically significant differences in either AMCA scores, $t(213) = -.70$, $p = .483$, or ASMC scores, $t(213) = 1.53$, $p = .128$. Although female students reported slightly higher ASMC scores (M = 2.70, SD = .97) and male students reported slightly higher AMCA scores (M = 3.75, SD = .86), these differences were not statistically significant. Furthermore, the effect sizes were small (Cohen's $d = .23$ for ASMC; $d = -.11$ for AMCA), indicating minimal practical significance.

Table 5. Independent Samples t-Test Results for Gender Differences in AMCA and ASMC Scores

Variable	Gender	M	SD	*t*(df)	*p*	Cohen's *d*
AMCA Score	Female	3.66	.94	-.70(213)	.483	-.11
	Male	3.75	.86			
ASMC Score	Female	2.70	.97	1.53(213)	.128	.23
	Male	2.48	.87			

Differences in AMCA and ASMC Scores by Daily Social Media Use Duration

To enable robust group comparisons and address sparse category sizes, the original five categories of daily social media use were recoded into three broader groups:

- Low usage: less than 1 hour and 1-2 hours per day (combined),
- Moderate usage: 3-4 hours per day,
- High usage: 5-10 hours and more than 10 hours per day (combined).

A one-way ANOVA and Welch's robust ANOVA were used to examine whether students' scores on the AMCA and ASMC scales significantly differed across the three usage groups.

Differences in AMCA Scores:

There were no significant differences in AMCA scores among social media usage groups, $F(2, 212) = .51$, $p = .600$. This was supported by Welch's robust test, $F(2, 127.15) = .71$, $p = .496$. Post hoc comparisons using the Games-Howell method also yielded no significant pairwise differences ($p > .50$), suggesting that algorithmic awareness levels are stable across different usage durations.

Differences in ASMC Scores:

In contrast, ASMC scores significantly differed across groups, $F(2, 212) = 9.11$, $p < .001$, and Welch's test confirmed this, $F(2, 113.86) = 8.93$, $p < .001$, indicating unequal variances but robust significance.

Post hoc Games-Howell tests revealed the following:

- Students who used social media ≥5 hours/day reported significantly higher ASMC scores than those who used it ≤2 hours/day, *M* difference = .73, $p < .001$.
- They also scored significantly higher than students using it 3-4 hours/day, *M* difference = .48, $p = .006$.
- The difference between ≤2 hours/day and 3-4 hours/day was not significant ($p = .211$).

These results suggest that higher daily social media use is associated with greater awareness of appearance-related social media pressures, whereas algorithmic awareness remains relatively unaffected by usage frequency.

Table 6. Welch ANOVA and Games-Howell Post Hoc Results for ASMC and AMCA by Social Media Use

DV	Group Comparison	M Difference	SE	*p*	95% CI
ASMC	≤2 hrs vs ≥5 hrs	.73	.18	< .001	[–1.15, –0.31]
	3–4 hrs vs ≥5 hrs	.48	.15	.006	[–0.84, –0.12]
	≤2 hrs vs 3–4 hrs	.25	.15	.211	[–0.60, 0.10]
AMCA	All comparisons	n.s.	-	> .50	-

Differences in AMCA and ASMC Scores by Academic Field

To examine whether students' AMCA and ASMC scores differed based on their academic discipline, an independent samples t-test was conducted comparing students from ICT-related fields (e.g., computer science, informatics) and those from other areas. As shown in Table 7, a statistically significant difference was found in AMCA scores between the two groups, $t(213) = -2.04$, $p = .042$. Students in ICT-related fields (M = 3.91, SD = .71) reported significantly higher algorithmic content awareness compared to those in other disciplines (M = 3.61, SD = .96). The effect size was small to moderate, Cohen's $d = -.33$. In contrast, ASMC scores did not differ significantly between the groups, $t(213) = -1.10$, $p = .274$. Although students from ICT fields had slightly higher appearance-related consciousness scores (M = 2.76) than their peers (M = 2.60), the difference was not statistically significant, and the effect size was negligible (Cohen's $d = -.17$).

Table 7. Independent Samples t-Test Results for Differences in AMCA and ASMC Scores by Academic Field

Variable	Field	M	SD	*t*(df)	*p*	Cohen's *d*
AMCA Score	ICT-related	3.91	.71	-2.04(213)	.042	-.33
	Other fields	3.61	.96			
ASMC Score	ICT-related	2.76	.99	-1.10(213)	.274	-.17
	Other fields	2.60	.93			

Conclusions

The findings revealed a moderately positive and statistically significant correlation between AMCA and ASMC scores ($r = .28$, $p < .001$), indicating that students who are more aware of algorithmic mechanisms tend to also be more conscious of appearance-related influences on social media. This result aligns with prior research emphasizing the impact of algorithmic curation on self-presentation norms and user engagement behaviors (Bucher, 2018; Cotter, 2019). Among the AMCA subdimensions, Content Filtering had the strongest association with ASMC, suggesting that participants who understood how algorithms influence what content is shown were more likely to feel appearance-related pressure or awareness. This implies that critical algorithmic awareness may heighten one's sensitivity to the sociocultural dynamics reinforced through algorithmic content delivery. Contrary to expectations, students' AMCA scores did not significantly differ across gender or daily social media usage. These findings suggest that algorithmic awareness may represent a relatively stable cognitive understanding that is not directly shaped by such surface-level factors, though further qualitative exploration could provide deeper insights. In contrast, ASMC scores were significantly influenced by social media usage duration, with students who used social media for five or more hours per day reporting significantly higher appearance-related consciousness. This finding is consistent with studies highlighting the link between prolonged exposure to idealized online content and body image concerns (Fardouly & Vartanian, 2016). The results also underscore the algorithmic amplification of appearance-based content, which may reinforce normative beauty standards. Regarding the academic field, students from ICT-related disciplines scored significantly higher on AMCA compared to their peers from other fields. This finding may reflect their greater familiarity with digital systems and algorithmic logic. However, no significant difference was observed for ASMC, suggesting that technical expertise does not necessarily translate into reduced vulnerability to appearance-based social influence.

This study contributes to the growing body of literature on algorithmic literacy and digital self-perception by demonstrating a measurable link between students' awareness of algorithmic processes and their appearance-related consciousness on social media platforms. The results suggest that promoting algorithmic media literacy may enhance students' critical engagement with social media content and potentially reduce unreflective internalization of beauty ideals. While AMCA was relatively consistent across demographic groups, ASMC was more sensitive to behavioral patterns, especially daily social media exposure. These findings emphasize the need for educational interventions that go beyond technical explanations of algorithms to include critical reflection on their social and psychological implications.

Key Findings

Algorithmic-Appearance Connection: The positive correlation (r = .28) between AMCA and ASMC suggests that understanding algorithmic curation heightens awareness of how appearance-focused content is amplified on social media.

Usage Intensity Effects: Heavy social media users (≥5 hours/day) showed elevated ASMC scores, while AMCA remained stable across usage groups, indicating algorithmic awareness as a stable cognitive trait.

Technical Knowledge Advantage: ICT students demonstrated higher AMCA scores but similar ASMC levels, suggesting technical expertise doesn't reduce appearance-related consciousness.

Practical Implications

Findings suggest three key educational priorities:

- Integrated Media Literacy: Combine technical algorithmic knowledge with sociocultural awareness of appearance norm reinforcement.
- Critical Evaluation Skills: Develop tools for critically assessing algorithmically curated appearance-focused content.
- Targeted Support: Provide specific interventions for high-usage social media users.

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Metaverse vs. Face-to-Face: A Comparative Study of Creative Performance and Perceptions in Gifted Students' Brainstorming

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Abstract

This study comparatively examines the effect of group brainstorming sessions conducted in Metaverse and face-to-face environments on the creative thinking skills and process-related perceptions of gifted middle school students. Adopting a mixed-methods crossover design, the study was conducted with 10 gifted middle school students (5 female, 5 male; M_{age} = 14.4). Participants engaged in brainstorming sessions in both environments, completing tasks on problem finding and problem-solving. Data were collected through scores for fluency, flexibility, and originality from the creativity tasks, along with a 7-dimension perception survey and an open-ended question. The results of the quantitative analysis showed that students achieved statistically significantly higher total creativity and originality) scores in the face-to-face environment compared to the Metaverse environment. However, no significant difference was found between their fluency and flexibility scores. Survey data revealed that participants significantly preferred the face-to-face environment, reported higher levels of enjoyment, and found it more immersive. In contrast, participants reported feeling statistically significantly more comfortable in the Metaverse environment. Supporting these findings, the qualitative data indicated that the face-to-face environment offered advantages in "natural interaction and efficiency," whereas the Metaverse provided benefits in "psychological safety and a reduced fear of judgment." In conclusion, the study revealed that while face-to-face brainstorming is more efficient for creative performance under current technological conditions, the Metaverse holds significant potential, particularly in enhancing participant comfort and psychological safety.

Keywords: Gifted students, Metaverse, brainstorming, creativity, face to face brainstorming

Introduction

Creativity is regarded as a fundamental component of 21st-century skills and plays a critical role in preparing students for the complex demands of the modern world (Herlinawati et al., 2024; Thornhill-Miller et al., 2023). As educational paradigms are reshaped by the impact of digital transformation, contemporary discussions increasingly focus on how such higher-order skills can be fostered, assessed, and aligned with technological change (Isaacs et al., 2024; Silber-Varod et al., 2019). Within this process, gifted students—who require differentiated and enriched learning experiences that go beyond standardized models—emerge both as an opportunity and as a significant challenge.

Giftedness is generally conceptualized as the multidimensional interaction of above-average ability, task commitment, and creativity (Maker, 2021; Renzulli, 2002). At the center of this definition lies creativity, which serves as a core mechanism enabling gifted individuals to transform abstract thinking and high intellectual potential into concrete, original, and innovative solutions (Kaufman et al., 2012; Sternberg, 2018). Accordingly, cultivating creativity in these students is not merely about developing a skill; it is a fundamental educational goal that directly affects their motivation, problem-solving abilities, and psychological well-being (Coştu, 2024; Piske et al., 2023). Maximizing this potential requires the application of specific pedagogical techniques that encourage divergent thinking and intellectual risk-taking.

One of the primary techniques designed to stimulate idea generation is group brainstorming. Traditional face-to-face brainstorming provides a fertile ground for idea development through real-time interaction and rich social cues. However, dynamics such as social pressure and evaluation apprehension may become inhibiting factors, particularly for gifted students who may hesitate to share original ideas for fear of being misunderstood (Taylor et al., 1958). Recent neuroscientific evidence also suggests that while group synergy may enhance creativity, the risk of “herd behavior” can suppress originality (Pick et al., 2024). Beyond these structural challenges in optimizing group dynamics, the very setting in which brainstorming occurs is undergoing profound transformation with the rise of digital technologies.

Virtual brainstorming, emerging with the advancement of digital tools, provides alternatives to some of the psychosocial barriers of the traditional method. Meta-analyses confirm that virtual environments, particularly as group size increases, allow for the generation of a greater number of ideas compared to face-to-face settings (DeRosa et al., 2007; Gong et al., 2022). The most recent form of these environments, the Metaverse, promises new opportunities for creativity through its immersive qualities (Reis et al., 2024). Features such as anonymity,

avatar-based representation, and immersive presence offer the potential to create psychologically safe spaces where gifted students can share bold and original ideas without fear of judgment (Gong et al., 2022; Soumya et al., 2023).

Current literature investigating both the theoretical potential and comparative effectiveness of these environments reveals the multifaceted and complex nature of the issue. On one hand, systematic reviews such as those by Reis et al. (2024) and Gong et al. (2022) detail how Metaverse characteristics—immersion, presence, anonymity, and accessibility—can theoretically support creative processes. On the other hand, empirical research presents a more nuanced picture. For example, Mohamed Fawzy (2024) found that immersive virtual reality (VR) environments yielded higher participation and idea generation compared to video conferencing. In contrast, Thomasin (2023) reported that while a nature-themed VR environment had potential for fostering creativity, technical and ergonomic challenges such as heavy VR headsets and navigation difficulties negatively affected user experience and creative outcomes. Furthermore, the study by Farrokhnia et al. (2025) demonstrated that the success of brainstorming in digital environments depends not only on the environment itself but also on the presence of cognitive supports and structured scaffolds such as SCAMPER.

Taken together, the literature indicates that the Metaverse holds significant potential for fostering creativity by providing psychological safety and lowering participation barriers. Nevertheless, ongoing technological and ergonomic limitations, along with the lack of natural social cues, raise questions about whether it can yet match the natural flow and productivity of face-to-face interactions. Importantly, the comparative effects of these two environments on the creative thinking performance (fluency, flexibility, originality) and subjective experiences of gifted students—who both possess high potential and remain sensitive to social dynamics—represent a critical research gap that warrants further exploration. In this context, the primary aim of this study is to comparatively examine the effects of group brainstorming conducted in virtual (Metaverse) and physical (face-to-face) environments on gifted middle school students' creative thinking performance (fluency, flexibility, originality) and their perceptions of these processes.

Research Problem

The central problem of this study is whether group brainstorming sessions conducted in Metaverse and face-to-face environments create a significant difference in gifted middle school students' creative thinking skills (fluency, flexibility, originality) and their perceptions of the process.

Within the scope of this main problem, the following research questions were addressed:

1. Is there a statistically significant difference between the total creativity scores of gifted middle school students generated in Metaverse and face-to-face environments?
2. Is there a statistically significant difference between the ideas produced by gifted middle school students in Metaverse and face-to-face environments in terms of:
   a. Fluency (total number of ideas),
   b. Flexibility (variety of conceptual categories),
   c. Originality (rarity of ideas)?
3. Is there a statistically significant difference between gifted middle school students' perception scores of Metaverse and face-to-face brainstorming environments in terms of:
   a. Collaboration,
   b. Creativity,
   c. Comfort,
   d. Preference,
   e. Enjoyment,
   f. Representation,
   g. Immersion?
4. How do gifted middle school students make sense of their group brainstorming experiences in Metaverse and face-to-face environments?

Significance of the Study

The integration of digital technologies is reshaping contemporary education, and the Metaverse stands out as one of the most promising yet underexplored domains. Despite its immersive and interactive potential, its influence on higher-order cognitive skills such as creativity—particularly among gifted learners—remains insufficiently examined. This study contributes to the literature on three levels. Theoretically, it bridges Metaverse research with creativity studies by investigating how avatar-based interactions and immersive dynamics affect fluency, flexibility, and originality, while offering a novel framework for understanding creativity in gifted education. Practically, it provides educators and curriculum designers with evidence-based insights into the comparative strengths and limitations of Metaverse and traditional brainstorming, clarifying which environments may best support specific outcomes such as idea generation or learner comfort. Methodologically, by employing a mixed-methods crossover design, the study combines quantitative performance data with qualitative experiential insights, thereby offering a comprehensive model for future research on virtual and physical learning environments.

Methodology

In the study, a crossover design was employed to assess the effects of Metaverse and face-to-face environments on gifted students' creativity performance and process-related perceptions, while their experiences were further explored through a single open-ended question. Experimentally, the study adopted a quasi-experimental design with a crossover comparison. Each participant attended brainstorming sessions in both Metaverse and face-to-face conditions, thereby being exposed to both settings (first Metaverse/then face-to-face, or vice versa). Dividing the students into two groups that experienced the sessions in different orders (Group 1: Face-to-Face first, then Metaverse; Group 2: Metaverse first, then Face-to-Face) was employed as a strategy to eliminate potential bias arising from order effects.

Participants

The study was conducted with 10 gifted middle school students (5 female, 5 male; mean age = 14.4) enrolled in a Science and Art Center (BİLSEM) in Türkiye. Participants were randomly assigned into two groups and participated in brainstorming sessions in different sequences: the first group experienced face-to-face brainstorming followed by Metaverse, while the second group experienced Metaverse first, followed by face-to-face. For participant selection, a convenience sampling strategy was employed. An announcement about the study's purpose and procedure was made at the BİLSEM accessible to the researcher, and volunteers were recruited among enrolled students. Participation was secured through both parental written consent and student assent based on voluntary involvement.

The definition of giftedness adopted in this study followed that of the Turkish Ministry of National Education (MoNE, 2024), which identifies gifted individuals as those who learn more rapidly than their peers, demonstrate creativity, artistic and leadership abilities, excel in specific academic areas, possess strong abstract reasoning skills, prefer independent work in their areas of interest, and display high-level performance. Admission to BİLSEM begins with nominations by primary school teachers (grades 1–3) who identify students with potential in general mental ability, visual arts, or music. Students who rank within the top 20% after a preliminary screening are invited to take an intelligence test, and successful candidates earn admission to BİLSEM. Education at BİLSEM follows a staged model designed to maximize student potential: Compliance Education Program (CEP), Support Education Program (SEP), Recognizing Individual Skills Program (RISP), Developing Special Skills Program (DSSP), and Project Production and Management Program (PPMP). Students identified in the general mental ability domain complete all program stages, while those admitted in visual arts and music begin directly with DSSP. The 10 participants in this study were identified in the general mental ability domain and were receiving instruction within the DSSP.

Data Collection Instruments

Real-Life Creativity Tasks

To evaluate the creative thinking processes of gifted students, this study employed structured creativity tasks consisting of two phases and four tasks (Okuda et al., 1991; Runco & Acar, 2012). Both phases were designed to assess two fundamental skills: problem finding and problem solving. In the first phase, participants were asked to generate problems within a school context, while in the second phase they followed a similar process within a home context.

The first set of tasks focused on the school environment. In the problem-finding task, students were asked to identify problems they had experienced regarding school, teachers, rules, and peer relationships. The aim of this task was for students to generate as many original and meaningful problem statements as possible based on their environmental awareness. Following this, an open-ended problem-solving scenario presented a classroom-based

social conflict: students were disturbed by their peers during an art lesson. They were asked to generate multiple solutions that would allow them to complete their work while also avoiding further warnings from their teacher. This task was intended to reveal students' social problem-solving, self-expression, and idea-generation skills.

The second set of tasks focused on home life. In the problem-finding stage, students were asked to identify problems related to parental relationships, sibling dynamics, household chores, and family rules. This task aimed to evaluate students' capacity to define multidimensional issues within the home context. The subsequent problem-solving scenario described a situation in which a student wished to buy a gift for a friend but was unable to do so due to financial constraints. This task aimed to measure students' capacity to produce solutions using emotional, creative, and practical thinking strategies, particularly by proposing non-material or alternative solutions.

Tasks in both contexts were designed not only to assess problem identification but also to capture students' idea fluency, conceptual flexibility, and originality. These structured open-ended tasks provided a comprehensive evaluation of both cognitive and social aspects of creative thinking. All responses were collected orally, recorded, and transcribed for analysis.

In addition, a questionnaire was administered to assess students' perceptions of both Metaverse and face-to-face environments. The survey asked participants to rate each environment on collaboration, creativity, comfort, representation (avatar or physical presence), preference, enjoyment, and immersion using a 10-point scale (Mohamed Fawzy, 2024). Furthermore, their personal evaluations regarding which environment was more effective for idea generation were obtained through an open-ended question: "When comparing both environments, in which setting did you find idea generation more effective, and why?" This holistic approach enabled a deep analysis of both creative performance and subjective perceptions.

Data Collection Process

Students were randomly divided into two groups of five. Group 1 participated in face-to-face brainstorming sessions first and then in the Metaverse, while Group 2 experienced the reverse sequence (Metaverse first, followed by face-to-face). In the face-to-face condition, brainstorming sessions were conducted around a physical roundtable, whereas in the Metaverse condition, sessions were held in FrameVR around a similar virtual table. FrameVR is a web-based Metaverse platform that allows users to interact in three-dimensional spaces through avatars, create and share content, and collaborate in real time. Accessible via a browser without requiring software installation, the platform supports interaction through voice and text communication, screen sharing, 3D object integration, and virtual whiteboards. In educational contexts, FrameVR enables teachers to design virtual classrooms and campuses that facilitate project-based learning, collaborative activities, and creative thinking processes. Furthermore, its compatibility with multiple devices provides inclusive opportunities for participation, making it an innovative learning ecosystem for both educational and professional collaboration (FrameVR, 2025a, 2025b, 2025c, 2025d).

Each brainstorming session in both face-to-face and Metaverse environments lasted 10 minutes. Visuals of the sessions are presented in Figure 1. Creativity performance was measured both before and after the sessions. Following the sessions, students completed the perception questionnaire and responded to the open-ended comparative question regarding the two environments.

Figure 1 illustrates how students engaged in brainstorming sessions both in a physical classroom and within a Metaverse-based virtual setting. While the face-to-face environment provided direct physical interaction, the Metaverse environment enabled task-based interaction and virtual collaboration through avatars.

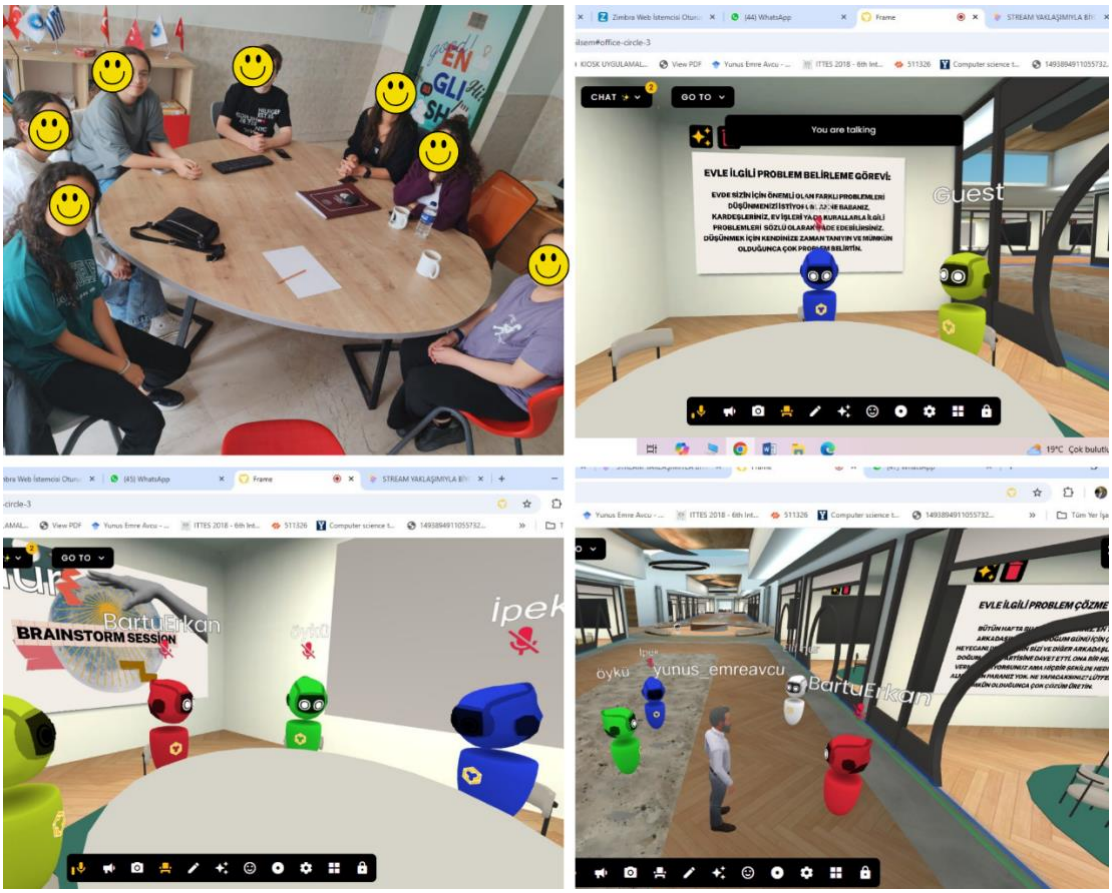

Figure 1. Brainstorming sessions in face-to-face and Metaverse environments.

Data Analysis

The quantitative data obtained in this study were analyzed using descriptive and inferential statistical techniques with the aid of IBM SPSS Statistics 25.

Scoring of Creativity Tasks

Data collected from brainstorming sessions via audio recordings were first transcribed. Transcripts were examined, and all valid, meaningful, and non-redundant ideas (problems or solutions) generated by each participant were listed. These ideas were then scored according to the three core dimensions of creativity—fluency, flexibility, and originality. A "Total Creativity Score" was computed for each participant by summing these three dimensions.

Example Scoring Procedure. To illustrate the scoring process, data from Group 2's Metaverse-based "School-Related Problem Finding" task are presented as an example. Fluency Calculation: All valid, non-redundant problem ideas produced during the task were counted. The group generated a total of 15 distinct ideas; thus, their fluency score for this task was 15. Flexibility Calculation: The 15 ideas were thematically analyzed and categorized into conceptual domains. For example:

- Category 1: Physical Environment and School Rules (e.g., hygiene issues, cafeteria prices)
- Category 2: Structure and Philosophy of the Educational System (e.g., students of different levels in the same class, obligation to succeed in all subjects)
- Category 3: Social and Academic Behavioral Issues (e.g., bullying, cheating)
- Category 4: Teaching–Learning Processes and Opportunities (e.g., recess overlapping with classes)
- This analysis revealed four distinct categories, yielding a flexibility score of 4.

Originality Calculation: Each idea was evaluated for uniqueness based on its frequency within the entire pool of ideas (176 ideas) generated across all sessions.

- Score 0 (Common Idea): Ideas frequently mentioned in both groups, such as "hygiene issues."

- Score 1 (Uncommon Idea): Ideas not mentioned by the other group but generally known, such as "cheating."
- Score 2 (Rare Idea): Highly specific and unique ideas mentioned only in one session, such as "cyber-loafing during online lessons."

Based on this procedure, the group's total originality score for this task was calculated as 15.

Analysis of Questionnaire Data

Students' questionnaire responses, in which they rated both environments across seven dimensions (collaboration, creativity, comfort, representation, preference, enjoyment, and immersion) on a 10-point scale, were analyzed. Missing data from two participants were statistically imputed to preserve distributional trends, and analyses were conducted with N = 10. Descriptive statistics (means and standard deviations) were first calculated for each dimension.

Given the small sample size (N = 10), assumptions of parametric tests were considered unmet, and non-parametric tests were applied. Specifically, the Wilcoxon Signed-Rank Test was used to examine differences in creativity scores and perception scores between the face-to-face and Metaverse conditions. To evaluate the practical significance of observed differences, effect sizes (Rosenthal's r) were calculated from Z values, with interpretation thresholds set at r = .10 (small), r = .30 (medium), and r = .50 (large). A significance level of $p < .05$ was adopted for all analyses.

Additionally, the semi-structured questionnaire administered after the sessions collected qualitative insights into students' perceptions of their experiences in both settings. Students rated each environment across the seven aforementioned dimensions and also provided an open-ended comparative evaluation regarding which setting was more effective for idea generation. Mean scores for each dimension were computed and compared to assess differences in perceptions between the two environments.

Analysis of Qualitative Data

Qualitative data were analyzed using content analysis. Open-ended responses were segmented into meaning units, coded, and grouped under thematic categories. Thematic comparisons were conducted to identify positive and negative views of both Metaverse and face-to-face experiences. Students' reasons for preferences, perceived cognitive and social contributions, and technological interaction experiences were examined in detail. To ensure reliability, two independent researchers carried out the coding, and discrepancies were resolved through discussion until consensus was reached. Thus, the study was supported by both quantitative creativity scores and qualitative student perspectives, enabling a multidimensional interpretation of the findings.

Results

Quantitative Findings

Tables 1, 2, and 3 present the comparative results of gifted students' creative performance across face-to-face and Metaverse environments, highlighting differences in fluency, flexibility, originality, and overall creativity scores.

Table 1. Comparison of group 1's performance across both environments.

Environment	Task	Fluency	Flexibility	Originality	Total Creativity Score
Face-to-Face	Problem Finding	50	4	37	91
	Problem Solving	36	5	28	69
Face-to-Face Total		86	9	65	160
Metaverse	Problem Finding	31	3	14	48
	Problem Solving	30	5	19	54
Metaverse Total		61	8	33	102

According to the results presented in Table 1, the face-to-face environment proved to be more productive for Group 1 than the Metaverse environment in terms of both the number of ideas generated (Fluency: 86 vs. 61) and the rarity of ideas (Originality: 65 vs. 33). In contrast, the diversity of ideas (Flexibility) was relatively similar and remained at a high level across both environments.

Table 2. Comparison of group 2's performance across face-to-face and Metaverse environments.

Environment	Task	Fluency	Flexibility	Originality	Total Creativity Score
Face-to-Face	Problem Finding	15	4	15	34
	Problem Solving	23	4	14	41
Face-to-Face Total		38	8	29	75
Metaverse	Problem Finding	15	3	13	31
	Problem Solving	17	4	11	32
Metaverse Total		32	7	24	63

Table 3. Comparison of group 1 and group 2's performance across face-to-face and Metaverse environments.

Group	Environment	Total Fluency	Total Flexibility	Total Originality	Overall Creativity Score
Group 1 (Face-to-Face First, Then Metaverse)	Face-to-Face	86	9	65	160
	Metaverse	61	8	33	102
Group 2 (Metaverse First, Then Face-to-Face)	Metaverse	38	8	29	75
	Face-to-Face	32	7	24	63

The findings indicate that the environment had an effect on the overall creativity performance of gifted students. When examining the overall totals, it was found that the total creativity score obtained in the face-to-face environment (223 points) was higher than that obtained in the Metaverse environment (177 points). This general trend was particularly evident in the performance of Group 1, who worked first in the face-to-face setting (Face-to-Face: 160, Metaverse: 102).

When the subdimensions of creativity were examined, the primary source of this difference was fluency, that is, the total number of ideas generated. While a total of 118 ideas were produced in face-to-face sessions, this number decreased to 99 in the Metaverse sessions. This suggests that face-to-face interaction played a more stimulating role in enhancing idea generation.

Despite this marked difference in fluency, no substantial difference was observed between the two environments in terms of flexibility, which measures the conceptual diversity of ideas. Students appeared to be capable of thinking across a similar number of different categories in both environments. This finding suggests that the environment had a greater impact on productivity than on the flexibility of thought.

The results of the Wilcoxon Signed-Rank Test and the corresponding effect sizes, conducted to examine the significance of differences between creativity scores (fluency, flexibility, originality, and total score) obtained in the face-to-face and Metaverse environments, are presented in Table 4.

Table 4. Wilcoxon test results for creativity scores across environments.

Creativity Dimension	Environment	*M*	*SD*	*Z*	*p*	Effect Size (*r*)	Interpretation
Fluency	Face-to-Face	11.80	10.99	-1.131	.258	0.25	Not significant
	Metaverse	9.90	5.63				
Flexibility	Face-to-Face	1.60	0.70	0.000	1.000	0.00	Not significant
	Metaverse	1.60	0.52				
Originality	Face-to-Face	8.90	8.32	-2.142	.032	0.48	Significant (Medium–Large)
	Metaverse	5.50	3.69				
Total Creativity	Face-to-Face	22.30	19.47	-2.041	.041	0.46	Significant (Medium–Large)
	Metaverse	17.70	9.07				

Note. N = 10. Results are statistically significant at $p < .05$. Effect sizes (r) were calculated using N = 20 (total number of observations).

According to the results presented in Table 4, a statistically significant difference was found between the face-to-face and Metaverse environments in terms of the Total Creativity Score ($Z = -2.041$, $p < .05$). Scores obtained in the face-to-face environment ($M = 22.30$) were significantly higher than those obtained in the Metaverse

environment (M = 17.70). The calculated effect size (r = .46) indicates that this difference has practical importance at a medium-to-large level.

When the subdimensions of creativity were examined, it was determined that the main source of this significant difference was the dimension of originality. Originality scores in the face-to-face environment were statistically higher than those in the Metaverse environment ($Z = -2.142$, $p < .05$), and this difference also demonstrated a medium-to-large effect size ($r = .48$). In contrast, no statistically significant differences were observed between the two environments for fluency (number of ideas generated) or flexibility (diversity of ideas) ($p > .05$).

Table 5 presents the means and standard deviations of the ratings given by 10 participants on seven perception dimensions (collaboration, creativity, comfort, representation, preference, enjoyment, and immersion) for both the face-to-face and Metaverse environments using a 10-point scale.

Table 5. Descriptive statistics of students' perceptions across environments.

Perception Dimension	Environment	*N*	*M*	*SD*
Collaboration	Face-to-Face	10	7.80	0.79
	Metaverse	10	6.60	0.97
Creativity	Face-to-Face	10	8.30	0.67
	Metaverse	10	7.60	1.58
Comfort	Face-to-Face	10	7.40	1.90
	Metaverse	10	8.70	1.16
Preference	Face-to-Face	10	7.60	1.84
	Metaverse	10	6.00	1.49
Enjoyment	Face-to-Face	10	8.90	0.88
	Metaverse	10	7.00	1.63
Representation	Face-to-Face	10	7.40	1.43
	Metaverse	10	6.10	1.60
Immersion	Face-to-Face	10	8.20	1.32
	Metaverse	10	6.70	1.95

The results of the Mann–Whitney U test conducted to examine the significance of differences between perception scores for the face-to-face and Metaverse environments are presented in Table 6.

Table 6. Comparative analysis of students' perceptions across environments.

Perception Dimension	Environment	*M*	*Z*	*p*	Effect Size (*r*)	Interpretation
Collaboration	Face-to-Face	7.80	-2.310	.021	0.52	Significant (Large Effect)
	Metaverse	6.60				
Creativity	Face-to-Face	8.30	-1.604	.109	0.36	Not significant
	Metaverse	7.60				
Comfort	Face-to-Face	7.40	-2.433	.015	0.54	Significant (Large Effect)
	Metaverse	8.70				
Preference	Face-to-Face	7.60	-2.251	.024	0.50	Significant (Large Effect)
	Metaverse	6.00				
Enjoyment	Face-to-Face	8.90	-3.189	.001	0.71	Significant (Very Large Effect)
	Metaverse	7.00				
Representation	Face-to-Face	7.40	-2.105	.035	0.47	Significant (Medium–Large)
	Metaverse	6.10				
Immersion	Face-to-Face	8.20	-2.766	.006	0.62	Significant (Large Effect)
	Metaverse	6.70				

Note. N = 10. Results are statistically significant at $p < .05$. Effect sizes were interpreted following Cohen's (1988) criteria: r = .10 (small), r = .30 (medium), r = .50 (large).

Students reported statistically significant and large-effect preferences for the face-to-face environment: they favored it more strongly ($p = .024$), experienced significantly greater enjoyment ($p = .001$), perceived it as more immersive ($p = .006$), rated collaboration as better ($p = .021$), and provided more positive evaluations regarding representation ($p = .035$). Consistent with the previous analysis, students felt significantly more comfortable in the Metaverse environment ($p = .015$), which strongly confirms that the primary advantage of the Metaverse lies in

the social and psychological comfort it provides. In contrast, no statistically significant difference was found between the two environments in terms of the "Creativity" perception dimension ($p = .109$), indicating that students perceived their creative potential to be at a similar level in both contexts.

Qualitative Findings

The themes, subthemes, frequencies, percentages, and sample student statements derived from the open-ended responses are presented in Table 7.

Table 7. Frequency and percentage distribution of themes derived from open-ended responses.

Main Theme	Subtheme	Description	*f*	%	Example Student Quote
Effectiveness of Face-to-Face	Fluent and Natural Interaction	Communication being spontaneous and uninterrupted, enabling ideas to build more easily on one another.	3	30%	"Definitely face-to-face. In face-to-face settings, we adapt more easily and can discuss our ideas with friends much better."
	Productivity and Focus	Less distraction and greater idea generation in the face-to-face environment.	2	20%	"In face-to-face settings, I was more productive in terms of ideas and participated more enjoyably."
	Reality, Immersion, and Enjoyment	The "real" interaction experience being more enjoyable, preferable, and immersive.	5	50%	"I would prefer the face-to-face environment because it is much more immersive than the Metaverse environment."
Advantage of Metaverse	Comfort and Impact on Creativity	The comfort and sense of anonymity provided by the Metaverse reducing fear of judgment and positively influencing creativity.	3	30%	"In the Metaverse, the greater comfort of the environment allowed us to generate more creative ideas."

As shown in Table 7, based on the distribution reflected by the sample of 10 participants, the most dominant theme was "Reality, Immersion, and Enjoyment," expressed by half of the participants (50%). This finding strongly highlights the high value students placed on authentic interaction. This was followed by two themes, each emphasized by 30% of the participants: "Fluent and Natural Interaction," identified as an advantage of the face-to-face environment, and "Comfort and Impact on Creativity," identified as a key advantage of the Metaverse environment. The least emphasized theme was "Productivity and Focus," mentioned by 20% of the participants. This frequency distribution confirms that, overall, students prioritized the holistic quality of the face-to-face experience, while also recognizing the psychological comfort offered by the Metaverse as an almost equally important factor.

Discussion

This study compared gifted middle school students' brainstorming experiences in Metaverse and face-to-face environments, revealing the complex relationship between creativity performance and perceptions of the process. The main finding indicates a clear trade-off between the two settings: students achieved statistically significantly higher total creativity and originality scores in the face-to-face environment, while they reported feeling statistically significantly more comfortable in the Metaverse. These findings bridge the gap between theoretical potential and practical application in the literature and open new avenues for discussion.

The most striking result is the superiority of the face-to-face setting in terms of originality, considered the most valuable dimension of creativity. At first glance, this outcome seems to contradict meta-analyses suggesting that virtual environments may surpass face-to-face groups, particularly in terms of fluency, or the total number of ideas generated (DeRosa et al., 2007; Gong et al., 2022). However, the absence of significant differences in fluency and flexibility scores in this study demonstrates that both environments hold similar potential for generating and diversifying ideas, with the main distinction emerging in the quality of ideas. This finding aligns with Thomasin's (2023) argument that the cognitive load and ergonomic challenges of current VR technologies may limit participants' capacity for deeper and more original thinking. Qualitative findings further support this interpretation: students' association of the face-to-face environment with "natural interaction and productivity" suggests that rich social cues, immediate feedback, and uninterrupted communication flows play a critical role in elevating ideas to more complex and original levels.

Conversely, the other key finding—students' sense of greater psychological comfort in the Metaverse—strongly corresponds with theoretical expectations in the literature. Features such as "anonymity," "avatars," and "reduced social pressure," identified in Gong et al.'s (2022) systematic review as central affordances of virtual environments, were reflected in this study as students' reports of feeling "more comfortable" and less concerned about judgment in qualitative responses. This finding empirically confirms Gomez Diago's (2010) notion of brainflowing, whereby virtual environments reduce hierarchy and foster more egalitarian participation. Considering that gifted students may be particularly sensitive to peer judgment due to their unconventional or divergent ideas, the psychological safety afforded by the Metaverse offers a valuable advantage, particularly for including more reserved students in the brainstorming process.

Educational Implications

The findings of this study provide several practical implications for educators and curriculum designers:

- This research demonstrates that there is no single "best" brainstorming environment. Educators should select the setting consciously depending on their objectives. Face-to-face brainstorming may be more suitable for end-of-project evaluations or in-depth problem-solving sessions where originality is critical.
- The Metaverse may serve as a powerful tool in the early stages of brainstorming, encouraging students to generate as many ideas as possible (fluency) without fear of judgment. This approach is particularly effective for integrating new or more reserved students into the process.
- The most effective approach may involve hybrid models that combine the strengths of both environments. Inspired by Korde and Paulus's (2017) integration of individual and group work, a hybrid structure could begin with anonymous or small-group brainstorming in the Metaverse, followed by deeper face-to-face discussions, synthesis, and development of the most promising ideas. Such a model would combine the psychological safety of the Metaverse with the interactional richness of face-to-face collaboration.

Conclusion

This study points to a trade-off under current technological conditions: while face-to-face settings appear more effective in maximizing creative output, the Metaverse holds significant potential when participant comfort and inclusivity are prioritized.

Limitations and Recommendations for Future Research

Although this study contributes meaningfully to the literature, its findings should be interpreted within certain limitations, which also open directions for future research:

- The study was conducted with a small and homogeneous sample of 10 gifted students. Thus, generalizability across age groups, talent domains, or cultural contexts is limited. Replicating the study with larger and more diverse samples would enhance the validity of the findings.
- Participants' limited familiarity with the Metaverse platform and the short duration of the sessions may have influenced performance. As noted by Pituxcoosuvarn et al. (2021), adaptation to new technologies can initially hinder creativity. Future longitudinal research should provide more time for participants to adapt, controlling for novelty effects.
- The use of the FrameVR platform shaped the results of this study. Different Metaverse platforms (e.g., Spatial, Engage), offering varying tools and affordances, may produce different outcomes regarding creativity and perceptions. Comparative studies across platforms could yield deeper insights.
- The proposed hybrid brainstorming model (Metaverse + Face-to-Face) has not yet been empirically tested. Future studies should examine not only single environments but also hybrid models to address this gap in the literature.
- As noted by El Saddik et al. (2025), future Metaverse platforms are expected to increasingly integrate generative AI tools. Research exploring how AI moderators or idea triggers might influence the brainstorming process could provide valuable insights into the future of this field.

Acknowledgements

Endless gratitude is extended to Derya Akpınar, the English teacher of the gifted students, and to Ahmet Harmanda, the director of the Science and Art Center (BİLSEM), whose support made this study possible.

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A Post-implementation Analysis of Digital Transformation in Higher Education Curriculum Management Technology

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Abstract

This study examines user satisfaction following the implementation of a new educational technology for curriculum management, the curriculum management system (CMS). The findings indicate that perceived usefulness, information quality, ease of use, system quality as well as training and support are positively correlated to user satisfaction. Beyond its theoretical contributions, this study also highlights the importance of providing training and support while implementing new educational technologies in practice. These insights offer practical guidance for enhancing user experiences and optimising the effectiveness of new educational technologies in curriculum management.

Keywords: digital transformation, curriculum management system, educational technology, perceived usefulness, training and support.

Introduction

Curriculum development is a core function of the higher learning institutions. It is a process that involves timely responses to evolving government policies, industry partner's requirements, societal changes, and the needs of the current generation of learners. With the ongoing increased investment in digitised educational technology, evaluating these technologies is crucial for efficient management, control, and further improvement. This study assesses user feedback at the post implementation stage of a newly implemented curriculum management system (CMS). A typical CMS supports all the processes involved in the development and design of curriculum including creating the business cases, curriculum design, mapping, collaborative reviews, approvals, maintenance, publishing and storing of curriculum items. The digital transformation project examined in this study transitioned the existing hybrid (manual and online) CMS into a fully online system. This move altered business processes and redefined how value is created in the academic space. Digital transformation is considered as a major disruption, often facing many challenges. Indeed, 70% of technology transformation initiatives failed, attributed to a combination of factors such as poor planning, flawed execution, and a culture of resistance to change (Rohn, 2022).

As co-designing curricula involves many stakeholders, enhancing system efficiency and thus, user satisfaction through the successful implementation of the CMS becomes one of the key elements to achieving operational efficiency in higher learning institutions. The service quality of the CMS can be reflected in the user satisfaction report, and the dimensions to be taken into consideration include system attributes, information attributes, service attributes and relevant technology acceptance aspects (Davis, 1989; DeLone and McLean, 2003; Rogers, 2003). The objective of this study is to investigate the success of the implementation of a new educational technology, namely the CMS, in a higher learning institution, using attributes and theories identified in technology and system research (Wixom and Todd, 2005; Zhang et al., 2021). Theories and frameworks referred to including the Technology Acceptance Model (TAM), Diffusion of Innovations Theory, Information Systems Success model (ISS) and User Satisfaction evaluation frameworks (Davis, 1989; DeLone and McLean, 2003; Rogers, 2003; Wixom and Todd, 2005; Tsai et al., 2019 and Zhang et al., 2021). While there is abundant literature with research on educational and commercial technology such as Learning Management System (LMS), Virtual Reality (VR) and e-commerce, certain technologies such as CMS have received limited attention (Talwar et al., 2020; Shadiev et al., 2020).

Motivations of the digital transformation

After conducting robust reviews involving both internal and external experts, the university concluded that the existing hybrid CMS (using both paper and online data) was outdated and could not keep up with the strategic

vision of the university. The hybrid CMS required lengthy process to upload, locate and download data, has no version control function, absence of collaborative platform and does not offer the flexibility needed to accommodate and support future initiatives and improvements. In contrast, the new CMS is envisaged to include better features such as:

- Improved efficiency
- Better connectivity
- Enhanced quality of educational products
- Good governance
- Agile responses to address short and long-term disruption

The new CMS represents a culmination of work from the vendor, the end users and the information and technology team of the university. Steps involved in this digitisation project include planning, analysis, system design and configuration (prototyping), loading of existing data, testing, and launching. The new CMS covers four main components such as:

- Proposal (for product prioritisation and business case activity)
- Design (domains include vocational education course design, higher education course design, unit/subject design, micro credential course design)
- Collaboration (for collaborative work including review and accreditation functions)
- Higher education course curriculum structure

Since curriculum design is complex, multidimensional data constructs are essential. Therefore, within these core domains, components are further developed with detailed fields to meet various information requirements. These domains are configured and integrated before pilot tests are conducted.

Literature Review

One of the main aims of higher learning education is to produce graduates with the skills and knowledge necessary for future employment. Therefore, developing holistic curriculum needs to incorporate both relevant external and internal factors. External factors such as compliance and registration requirements from accreditation bodies, funding sources, industry's workforce demands, national standards and community inputs are crucial. On the other hand, internal factors revolving around the needs of students and teachers are equally important in the curriculum design process. With hundreds of courses and units being offered concurrently in a higher learning institution and given the constantly evolving social environment, digitisation of the CMS has become inevitable. A digitised CMS would allow swift responses to changes and supports transformative learning processes that promotes both personal and cognitive growth of students.

The Technology Acceptance Model (TAM) proposed by Davis (1989) is one of the most prominent theory used in technology usage behaviour research. It contends that there are causal relationships between constructs such as perceived ease of use, perceived usefulness, system features, attitude of users and the usage behaviour. Attitude towards using a new IT system is identified as critical to the acceptance and sustainability of a new IT system, mobile banking, and other internet-based innovations (Weiner et al., 2009; Venkatesh & Davis, 2000). Perceived usefulness and convenience of use have been posited to positively correlate with behavioural intentions in mobile internet health services, and electronic systems. Moreover, new systems or digital transformations that users find to be easy to learn and practical in supporting task completion are positively correlated with user satisfaction and engagement (Chau & Hu, 2002; Gu et al., 2018; Gawron & Strzelecki, 2021; Wang & Wu, 2024).

The Information System Success Model (ISS) developed by De Lone and MaLean (1992) is another model which has been widely used in studies related to information systems. This model focuses on explaining how factors such as system usage, system quality, information quality, service quality, system benefit (personal/organisation) influence user satisfaction. Among all these features, service quality, information quality and system quality are identified as the top three dimensions affecting user satisfaction (De Lone & MaLean,1992).

A related study by Wixom and Todd (2005) contends that research on information system implementation success has primarily focused on either user satisfaction or the technology acceptance model. With the belief that system features influence both usage and thus satisfaction, they proposed the "user satisfaction - technology acceptance" integrated model, offering an option which are capable of measuring information system success using a unified framework. In a similar study by Taherdoost (2018), the E-Service Technology Acceptance Model (ETAM) was employed to examine user acceptance of e-service technology. This study identified user satisfaction, security and quality as key dimensions, with results suggesting that all three significantly influence the intention to use e-services.

Numerous studies assert that staff training positively impacts job satisfaction and enhances university productivity. It also fosters loyalty and retention among academic staff (Iqbal et al., 2024; Mampuru et al., 2024). Training and support are instrumental in building skills and capabilities needed to adopt new technology, helping to bridge knowledge gaps and build user confidence (Feeney et al., 2023; Farias & Resende, 2020). Farias and Resende (2020), in their study on the impact of training on the implementation of a new electronic system in a higher learning institution discovered that the greater the perceived impacted of training, the higher the acceptance of the new technology. Additionally, increased acceptance of technology is associated with more frequent usage of the new system.

Methodology

This study evaluates user feedback at the post implementation stage of a new educational technology - the digitised CMS. The implementation of this digitised system represents an important evolution, providing a "single source of truth" that connects all stakeholders involved in curriculum management. Based on the literature review, this study adopts relevant dimensions from the Technology Acceptance Model (TAM), the Information Success System Model (ISS) and the Innovation Diffusion Theory (IDT) which are relevant to the context of this study (Davis, 1989; DeLone & McLean, 2003; Rogers, 2003; Wixom & Todd, 2005; Tsai et al., 2019 and Zhang et al., 2021). Guided by the motivation to digitise the CMS, six dimensions were identified from this combination of models: TAM-IDT- ISS to form the core constructs used in this study. These constructs are perceived usefulness, ease of use, information quality, system quality, training and support as well as user satisfaction. The questions used for each construct were adapted from previous research conducted on technology adoption (Hossain et al., 2019; Lewis, 2019). User feedback was collected through a post-implementation survey using questionnaires, providing insights into acceptance and satisfaction on the new system. These findings can inform subsequent system enhancement and training initiatives.

Definition of key constructs:

Constructs	Definition
Perceived usefulness	The extent to which users perceived that the new technology could improve their efficiency and productivity in completing specific tasks. (Davis, 1989)
Ease of use	The extent to which users believe the new system is user friendly. (Davis, 1989)
Information quality	The extent to which information provided meets the needs and expectations of the users. High information quality enables users to make informed decisions and improve overall satisfaction of the system.
System quality	The overall performance and technical characteristics of the system. A high system quality enhances user satisfaction and encourages adoption.
User satisfaction	The degree to which user's expectations are met when interacting with the new technology. Higher user satisfaction indicates that the system fulfills user expectations and contributes to a positive experience.
Training and support	Instructional and support activities that aim to improve knowledge, skills, and abilities in using new technology.

An online survey using questionnaire was administered after a pilot study to collect information for further analysis. Analyses were performed on the data collected to test the following hypotheses:

H_1: User satisfaction is correlated with the perceived usefulness of the CMS.

H_2: User satisfaction is correlated with the ease of use of the CMS.

H_3: User satisfaction is correlated with the information quality of the CMS.

H_4: User satisfaction is correlated with the system quality of the CMS.

H_5: User satisfaction is correlated with the training and support provided for the new educational technology, CMS.

The new CMS was implemented in a dual sector university offering both university (HE) and vocational education and training (VET) courses to domestic and international students. Course coordinators, members of the Faculty Learning and Teaching Committee and Academic Program Committee as well as staff in the Quality office are the heavy users of the CMS while others use the CMS when course and unit amendment, design or re-design need to be performed. Three hundred and sixty registered users of the new CMS were randomly selected as the sample of this study. The online questionnaire was sent out twice to all the samples. This study received 83 autoreplies indicating the unavailability of respondents. A total of 56 (20.21%) fully answered questionnaires were returned and used for further analysis.

Results

Descriptive statistics

Table 1: Participants' profile

Category	Percentage (%)
Professional staff member (HE)	17.86
Academic staff member (HE)	50
Professional staff member (VET)	16.07
Academic staff member (VET)	10.71
Professional staff member (HE & VET)	3.57
Senior executive staff member	1.79

As can be seen in Table 1, in terms of respondents' profile, 50% of the respondents are academic staff member (HE), 17.86% are professional staff member (HE), 16.07% are professional staff member (VET) and 10.71% are professional staff member (VET). These four groups also represent the key personnel in curriculum management for both HE and VET sector within the university. Furthermore, 56.36% of the respondents have experience using both the old and new CMS. The usage rate of the CMS varies across respondents whereby 43.6% of the respondents use CMS for 0-1 time per week, 21.8% use the CMS for 2-3 times per week, 7.3% use the CMS for 4-6 times per week while the remining 27% of the respondents use the CMS more than 6 times per week. On attitudes towards the acceptance of the CMS, 35% of the participants reported that they were enthusiastic during the inception of the CMS while 16% feel confused. This situation significantly improved eight months after the implementation with 53% indicating that they are committed and trusting the CMS while 3.6% still feeling confused. Majority of the academic and professional staff are keen to learn about new technology with 78% of the respondents indicating they either agree or strongly agree that they enjoy learning new skills or relate well to technology.

Correlation analysis

Previous literature contended that constructs including perceived usefulness, ease of use, information quality, system quality as well as training and support are highly correlated to the efficiency, acceptance, and user satisfaction of a new system (DeLone & MaLean, 1992; Chau & Hu, 2002; Wixom & Todd, 2005; Gu et al., 2018; Gawron & Strzelecki, 2021; Wang & Wu, 2024). Hence, Hypothesis 1 to 5 are formed, and correlation analyses are performed to answer whether these features are related to user satisfaction. The findings are presented in Table 2.

Table 2: Correlation analysis on features influencing user satisfaction

Variable	*t-stat*	*p-value*
Perceived usefulness	0.683	0.001**
Ease of use	0.769	0.001**
Information Quality	0.860	0.001**
System quality	0.763	0.001**
Training and support	0.652	0.001**

*Note: **P < 0.05, significant at 95% CI.*

From the results in Table 2, since the *p*-values of the test results for Hypothesis 1 to 5 are less than the significant level of 0.05, the null hypothesis can be rejected. On that account, this study concludes that perceived usefulness, ease of use, information quality, system quality as well as training and support are positively correlated with user satisfaction. The results provide evidence to support the TAM, IDT and ISS model (Davis, 1989; DeLone and McLean, 2003; Rogers, 2003; Wixom and Todd, 2005; Tsai et al., 2019 and Zhang et al., 2021). Furthermore, consistent with Farias and Resende (2020), training was proved to positively influence user satisfaction level.

Conclusions

The study examines post-implementation user satisfaction with a digitised educational technology for curriculum management (CMS) at a university. Constructs from the TAM, IDT and ISS models along with contextually aligned questions from previous research were used in this study. The core constructs utilized are perceived usefulness, ease of use, information quality, system quality and user satisfaction. Additionally, this study integrated

training and support as an additional construct. Overall, approximately 75% of respondents are satisfied with the various functions, features, and performance of the newly implemented CMS.

A total of five hypotheses were tested and the summary of the results are presented in Table 3 below.

Table 3: Summary of hypotheses and results

Hypothesis	Support (yes/no)
H_1: User satisfaction is correlated with the perceived usefulness of the CMS.	Yes
H_2: User satisfaction is correlated with the ease of use of the CMS.	Yes
H_3: User satisfaction is correlated with the information quality of the CMS.	Yes
H_4: User satisfaction is correlated with the quality of the CMS.	Yes
H_5: User satisfaction is correlated with the training and support provided for the new educational technology, CMS.	Yes

From the findings above, perceived usefulness, ease of use, information quality, system quality as well as training and support are all positively correlated with user satisfaction. These results endorse prior research evidence across various technology user groups and study contexts. Furthermore, training and support were found to have positively influence user satisfaction of the new CMS. In conclusion, in addition to its theoretical contributions, this study also highlights the importance of providing adequate training and support when implementing new educational technologies.

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Exploring the Atom Through Scientific Dialogue: An AI-Based Interactive Simulation

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Abstract

This study presents the design and implementation process of an AI-powered interactive simulation application based on the historical development of atomic models. In traditional education, atomic models are often introduced in an abstract and rote-based manner, which hinders students' conceptual understanding and scientific reasoning skills. Addressing this need, the study aims to help students explore atomic theories through active engagement and scientific dialogue.

The application offers a dynamic discussion environment in which six key theorists—John Dalton, J.J. Thomson, Ernest Rutherford, Niels Bohr, James Chadwick, and Werner Heisenberg—who shaped the development of atomic models, engage in mutual interaction. Each scientist is represented with original statements within a scenario-based dialogue flow that reflects their historical period and scientific perspective. These dialogues are not only grounded in historical and scientific accuracy, but also enriched with humorous exchanges, contemporary analogies, and playful elements to provide students with an engaging and enjoyable learning experience.

Students (observers) do not direct the discussion but can interact by asking questions about points of curiosity during the conversation. These questions are answered by the most relevant scientist through a single response generated by the OpenAI GPT-4.0 model, ensuring scientific reliability. After the question is addressed, the scripted discussion resumes from where it left off.

The simulation is user-controlled through buttons such as “Begin Debate,” “Pause Conversation,” and “Resume Conversation,” and the conversations are displayed via a user-friendly interface that makes the learning process both smooth and engaging. Through its interactive simulation structure, the application supports the development of 21st-century skills such as critical thinking, scientific reasoning, and digital literacy, while transforming learning into a more enjoyable and lasting experience. In this regard, the application aims to contribute to the high school chemistry curriculum as an innovative educational tool.

Keywords: Atomic theories, interactive simulation, artificial intelligence, high school student

Introduction

The concept of the atom is one of the cornerstones of the natural sciences, and a correct understanding of this concept is critical for success in disciplines such as chemistry, physics, and biology. In secondary school chemistry curricula, the teaching of atomic models is often abstract and based on rote memorization, which paves the way for the development of misconceptions (Malkawi et al., 2018; Zarkadis et al., 2020; Kaya, 2023). Scientific models serve as a bridge between theories and the real world, making abstract concepts more concrete; however, when not well-structured, they may weaken students’ conceptual understanding. In the case of atomic models in particular, the insufficient reflection of historical and scientific context constitutes a significant shortcoming (Justi & Gilbert, 2000; Mansoor & Rodríguez, 2001; Niaz et al., 2002; Weisi & Zamani, 2015; Cardoso et al., 2020). Interactive digital simulations enable students to visualize abstract concepts, compare models, and engage in scientific thinking processes (Fabrigas & Paglinawan, 2024; Kefalis et al., 2025). For instance, tools such as PhET help develop modeling and critical comparison skills (Wieman et al., 2008; Moore et al., 2014; Haryadi & Pujiastuti, 2020). Furthermore, artificial intelligence and machine learning-based applications have the potential to transform chemistry education by offering advantages such as personalized learning, instant feedback, and dynamic content generation (Iyamuremye et al., 2024; Maity & Deroy, 2024; Wang et al., 2024; Erümit & Sarıalioğlu, 2025).

This research aims to support students in learning atomic models through inquiry within historical and scientific contexts rather than rote memorization, and in constructing concepts meaningfully by linking them to learning psychology and cognitive development (Nadelson et al., 2018; Valeeva et al., 2023). In this regard, the developed AI-powered simulation has been designed to foster conceptual comparison, inquiry, and the ability to establish historical connections.

Methodology

This study was conducted within the scope of Design and Development Research (Richey & Klein, 2014) and aimed to design an AI-powered interactive simulation environment to support the teaching of atomic models.

- How can an AI-powered, interactive simulation environment be designed to support the teaching of atomic models within a historical context?
- On which pedagogical and functional design principles should the developed simulation environment be based in order to support conceptual understanding, scientific reasoning, and 21st-century skills?

The developed simulation application aimed to present atomic models through dialogic debates among six pioneering scientists—Dalton, Thomson, Rutherford, Bohr, Chadwick, and Heisenberg—represented as character avatars. The design process progressed through the following stages:

1. Needs and Context Analysis: The conceptual learning difficulties of high school students regarding atomic models were examined in light of the literature, and a concept map was created based on the 9th-grade chemistry curriculum of the Turkish Ministry of National Education.
2. Scenario Development: Original dialogues were written among the six scientists featured in the curriculum, incorporating historical accuracy, a humorous tone, and pedagogical goals.
3. Digitalization and AI Integration: The created scenario was transformed into an interactive application on the Replit platform, enabling students' questions to be answered by the most relevant scientist character via GPT-4.0-based artificial intelligence.
4. Interface Design: An accessible, user-friendly, and minimalist web interface was developed.
5. Evaluation Module: At the end of the simulation, a multiple-choice test consisting of 10 questions was presented to assess learning outcomes, with each question accompanied by explanatory, personalized feedback provided by the relevant scientist through AI.

This study constitutes a preliminary pilot development process designed in accordance with the curriculum and the cognitive level of the target audience, and no user testing has yet been conducted. Since no participant data were collected, ethical approval was not required.

Design Process

Needs and Context Analysis

In the needs and context analysis, the 9th-grade chemistry curriculum and textbook published by the Ministry of National Education (MoNE, 2024) of the Republic of Türkiye were examined, and the key concepts were identified accordingly. These concepts included the structure of the atom, the historical development of atomic models, the experimental findings underlying these models, and the scientific debate elements such as differences in views among scientists. In this context, a concept map was prepared in accordance with the students' level of conceptual development (Figure 1).

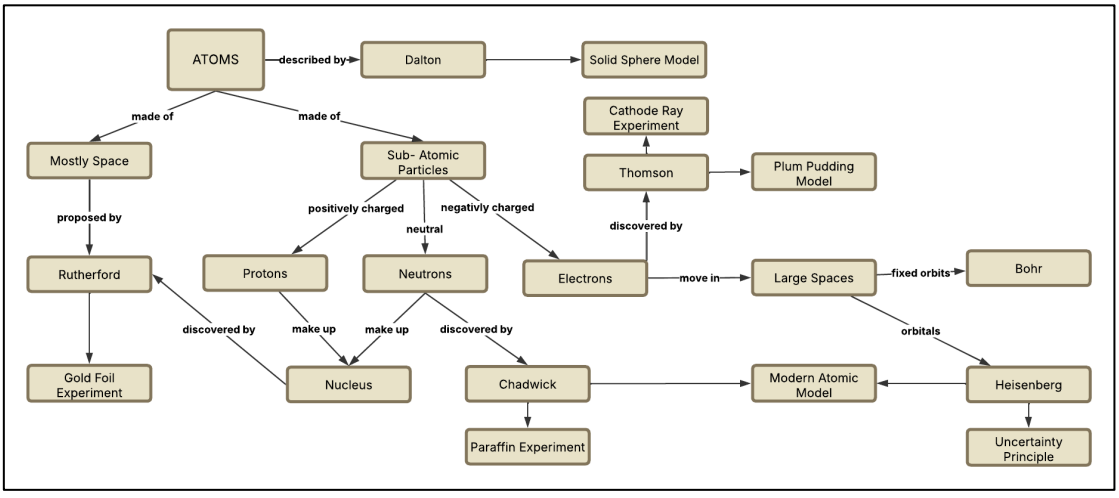

Figure 1. Concept map related to atomic models.

The prepared concept map served as a foundation for structuring the content to be used in the simulation, creating dialogue scenarios, and determining assessment criteria. This analysis process was considered a critical preliminary step both for ensuring pedagogical coherence and for developing an original digital instructional material aligned with the curriculum.

Script and Dialogue Development

The core structure of the simulation is based on dialogues between six prominent scientists representing the historical development of atomic models. This scenario was designed with attention to both scientific accuracy and pedagogical clarity. The dialogues integrate humorous elements, historical references, and theoretical explanations in a balanced manner. The dialogue structure was organized to include elements such as conceptual conflict, comparison, and historical context. Through these interactive discussions, students can establish connections between concepts and intuitively grasp that scientific models evolve as part of an ongoing process.

Technical Implementation of Simulation and Evaluation Process

The prepared dialogue scenario was transformed into an interactive simulation application using Replit's built-in AI agent. This application, named *AtomVerse*, integrates the text-based scenario—grounded in historical accuracy—with character representations and user interactions. It operates through customized system prompts directed to the OpenAI GPT-4.0 model (Figure 2).

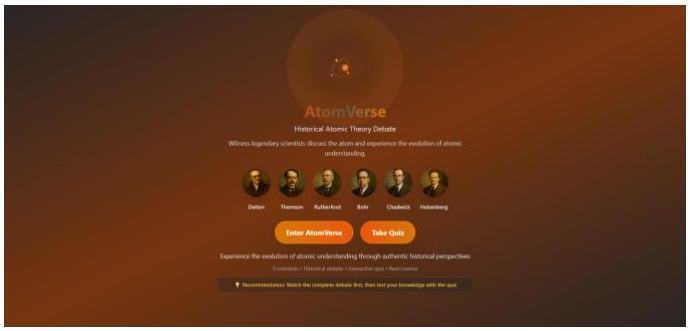

Figure 2. AtomVerse main login screen.

The scientific accuracy and pedagogical relevance of AI-generated responses are directly linked to the quality of the prompts used (Lee & Palmer, 2025; Jacobsen, Rohlmann, & Weber, 2025). Accordingly, the system prompts employed in the simulation were designed to remain within the framework of scientific accuracy while preserving the historical context. These prompts consist of five main components: character introduction (name, period, scientific contributions, and historical context), scientific perspective (approach to the atomic model and conceptual limitations), language and style (period-appropriate expression, balance of humor and explanation), interaction rules (response format and manner), and output format (clarity, pedagogical appropriateness, historical accuracy, and conceptual coherence).

The simulation is structured using three distinct GPT-4.0 prompts, each serving a different function based on student interactions:

1. Targeted character responses to student questions,
2. Explanatory feedback for test questions,
3. A personalized final evaluation based on overall performance analysis.

Each prompt was developed in alignment with the principles of historical context, pedagogical clarity, humorous tone, and scientific accuracy. This structure enables students to take on not only the role of an observer but also that of an active, inquisitive, and responsive participant (Figure 3).

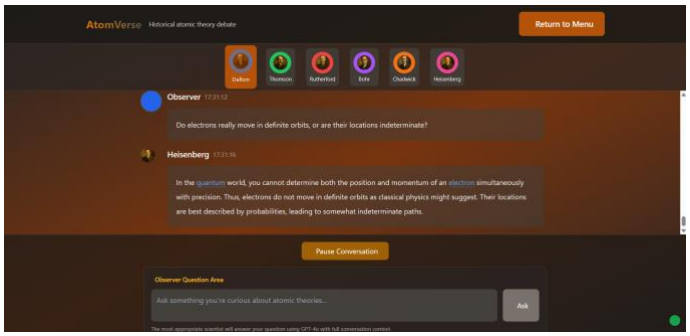

Figure 3. In-simulation interaction screen: Student question and AI character response.

The web interface was developed using React 18, TypeScript, and Tailwind CSS, with a focus on visual simplicity, mobile compatibility, and historical aesthetics. The user experience is enhanced through the use of text bubbles, character icons, information cards, and interactive buttons. At the conclusion of AtomVerse, a 10-item multiple-

choice test module is presented, which not only assesses conceptual learning but also provides explanatory and personalized feedback from the scientist characters via GPT-4.0 (Figure 4). This approach goes beyond traditional assessment methods, offering a reflective and instructive structure that guides students throughout the learning process.

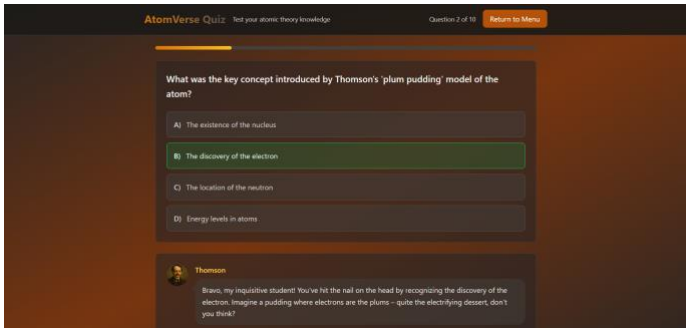

Figure 4. Test screen: Personalized scientist feedback based on student response.

Following the test, the system analyzes the student's overall performance and generates a personalized final evaluation highlighting both strengths and areas for improvement. This analysis summarizes not only which items were answered correctly or incorrectly, but also the extent to which the student has grasped the underlying concepts (Figure 5).

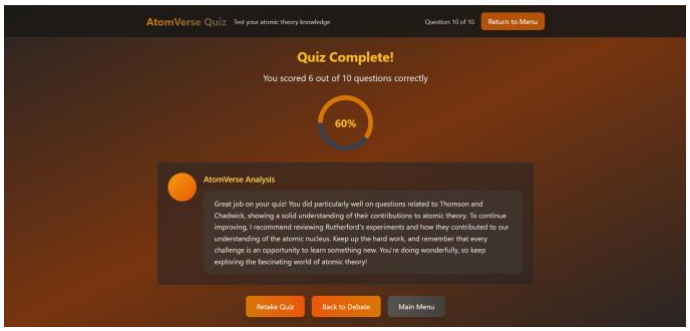

Figure 5. Personalized success analysis: AI summary evaluation based on 10-question test results.

The application can be accessed by scanning the QR code provided in Figure 6.

Figure 6. QR code of Atomverse app.

Results

The developed AtomVerse simulation represents an innovative approach that integrates historical, pedagogical, and technological integrity in the teaching of atomic models. The design enhances students' potential to establish conceptual coherence through a historical development framework and comparative presentation. The representation of scientists with discourse appropriate to their respective eras exemplifies the adaptation of scenario-based learning (Schank, Fano, Bell, & Jona, 1994) and the theory of concept development through sociocultural interaction (Vygotsky & Cole, 1978) into a digital environment. The literature emphasizes that digital simulations contribute to the concretization of abstract scientific concepts (Fabrigas & Paglinawan, 2024; Kefalis et al., 2025). In this context, AtomVerse is expected to offer a personalized learning experience. Humorous elements embedded in character representations may enhance motivation, while interactive dialogues and explanatory feedback in the test module are anticipated to support the development of scientific argumentation skills. Furthermore, the AI-powered overall performance analysis aims to identify students' strengths and areas for improvement, fostering their personal awareness.

Conclusions

This study presents the design and development process of AtomVerse, an AI-powered digital simulation that integrates historical context and interactive elements into the teaching of atomic models. The use of digital simulations in chemistry education is widespread. For example, PhET Interactive Simulations, ChemCollective virtual laboratories, and Labster 3D simulations provide students with safe, interactive, and experimental learning environments. Unlike these examples, AtomVerse stands out by combining historical context, humorous elements, and AI-based personalized feedback in a single platform.

The design process utilized the Replit platform, chosen for its accessible solutions in rapid prototyping, online deployment, AI API integration, user management, and team collaboration. Its browser-based editor–server structure, multilingual support, live preview, WebSocket-enabled communication, and compatibility with React + TypeScript offer a practical development environment for educators with limited coding skills. Alternative platforms (Glitch, CodeSandbox, Firebase + Vercel, Cursor) were considered; however, Replit was found to be more advantageous in terms of accessibility, technical requirements, and AI integration.

A key limitation of this study is the absence of a pilot implementation. This is due to the fact that the topic is taught in the first semester of the 9th grade in Turkey, and no accessible sample group was available during the research period. Furthermore, the scientific accuracy and pedagogical appropriateness of GPT-4.0's responses depend on the quality of the system prompts. Clearly defining these prompts is essential to ensure alignment with historical accuracy and scientific content. Nevertheless, the inclusion of verifiable feedback mechanisms is recommended to enhance reliability.

There is also room for improvement in terms of accessibility. Possible enhancements include text-to-speech for visually impaired students, character voice profiles, and screen reader compatibility. Additionally, multilingual options and simplified language modes could help overcome language barriers.

In conclusion, AtomVerse has the potential to provide a student-centered, interaction-focused, and pedagogically robust learning environment through AI-powered interactive simulations. Future work could focus on developing classroom-compatible versions, adapting the simulation for different age groups, and enhancing accessibility, thereby enabling integration into a broader educational ecosystem.

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Good Practices in Chemistry Education: Designing a Digital Educational Escape Game

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Abstract

Increasing students' interest in chemistry lessons, supporting their learning motivation, and ensuring their active participation are critical for achieving lasting and meaningful learning. In this context, there is a need for innovative and effective teaching practices that capture students' attention and encourage them to think critically. Educational escape games stand out as one of these innovative learning activities that engage students. An educational escape game is a learning activity that allows students to develop their knowledge and skills on specific topics by completing game-based tasks and solving questions and puzzles. In this study, a digital educational escape game was designed to determine and enhance high school students' fundamental laboratory knowledge and skills. The designed game includes scenario-based questions related to basic laboratory knowledge and fundamental chemistry concepts included in the chemistry curriculum. The game was implemented online using digital technologies such as smartphones, computers, and tablets. After playing the game, a survey consisting of Likert-scale, open-ended, and yes/no questions was conducted to determine students' opinions about the educational escape game. The results revealed that the majority of students found the game engaging, enjoyable, and educational. Additionally, students indicated that the game helped them understand the topics and review the content, and they expressed a desire for similar games to be applied to other topics as well. The findings suggest that educational escape games can be effectively used as innovative tools in chemistry education to support teaching and enhance students' interest in the subject.

Keywords: Chemistry education, digital game, educational escape game, high school students.

Introduction

Increasing students' interest in chemistry lessons, supporting their learning motivation, and ensuring their active participation are critical for achieving lasting and meaningful learning (Byusa et al., 2022). In this context, there is a need for innovative and effective teaching practices that capture students' attention and encourage them to think critically. Educational escape games stand out as one of these innovative learning activities that engage students (Taraldsen et al., 2022).

An educational escape game is a learning activity that allows students to develop their knowledge and skills on specific topics by completing game-based tasks and solving questions and puzzles (Maršálek et al., 2024; Nicholson, 2015; Veldkamp et al., 2020; Vergne et al., 2019; Yachin & Barak, 2024). Building on this, the aim of the present study is to design an educational escape game focused on high school chemistry topics and to examine students' opinions regarding the designed game.

Game

The educational escape game was designed by the researchers as a digital educational escape game in accordance with the high school chemistry curriculum, with the aim of determining and developing high school students' fundamental laboratory knowledge and skills. The designed game includes scenario-based questions related to basic laboratory knowledge and fundamental chemistry concepts in the chemistry curriculum.

In this game, secret experiments are conducted at an industrial facility. Players must explore different areas of the facility and exit without being noticed. To leave the facility undetected, they must answer important questions related to these secret experiments conducted in the facility. The facility consists of five different sections. In order to enter each of the five laboratories where the secret experiments take place, players must solve the laboratory codes. The laboratory codes are based on atomic numbers. After solving the codes and entering the laboratories, players progress by answering multiple-choice questions. When they complete all the secret experiments in the

five laboratories by answering the questions within the allotted time, they escape the facility undetected and successfully complete the mission.

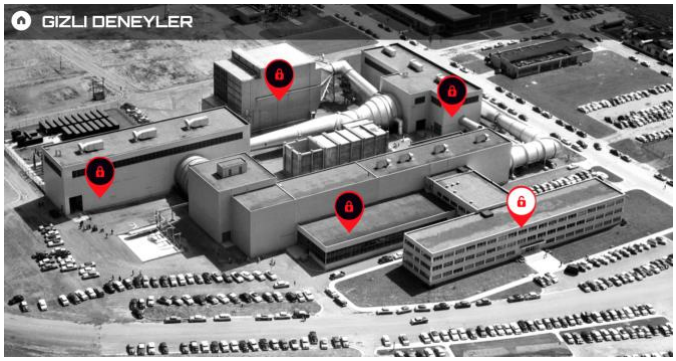

Figure 1. Game setting: industrial facility.

Figure 2. Images from the game.

Methodology

Within the scope of the study, an educational escape game related to high school chemistry topics was designed by the researchers. The content validity and reliability of the designed educational escape game were reviewed by three chemistry teachers and one field expert, and necessary corrections were made. The game was then implemented with 24 students. The sample of this study consists of 24 high school students who volunteered to participate. Of the 24 students, half were female (n = 12) and half were male (n = 12). Following the implementation, a survey was administered to the students. The survey included yes/no questions, Likert-scale questions, and open-ended questions. The quantitative data obtained were analyzed using descriptive analysis, while the qualitative data were analyzed through content analysis (Büyüköztürk et al., 2024).

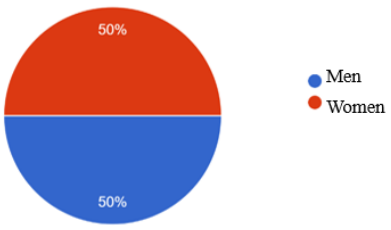

Figure 3. Demographic characteristics of the participants.

Results

The game designed by the researchers was played by 24 high school students. After the implementation, a survey was administered to the students. The survey included yes/no questions, Likert-scale questions, and open-ended questions. The quantitative data obtained from the survey responses were analyzed using descriptive analysis, while the qualitative data were analyzed through content analysis.

When examining the question, "This is an educational escape game. Have you ever played such a game before?", it was found that, with a slight difference, most students (54.2%) had not previously played an educational escape game.

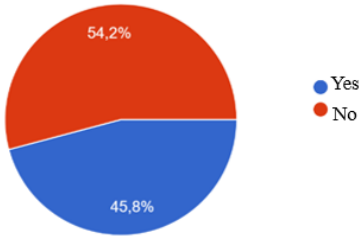

Figure 4. Distribution of participants based on their prior experience with educational escape games.

Students' opinions about the educational escape game were also examined using Likert-scale questions.

Table 1. Percentage distribution of students' opinions on the educational escape game according to the 1–5 Likert scale.

Item No		1	2	3	4	5	
				%			
1	boring	4,2	4,2	20,8	16,7	54,2	fun
2	difficult	4,2	8,3	33,3	29,2	25	easy
3	uninteresting	8,3	4,2	12,5	16,7	58,3	interesting
4	complex	4,2	4,2	20,8	16,7	54,2	understandable
5	disorganized	4,2	4,2	12,5	25	54,2	organized
6	insufficient content	4,2	4,2	8,3	33,3	50	sufficient content
7	did not contribute	8,3	4,2	20,8	20,8	45,8	contributed
8	ineffective	4,2		29,2	20,8	45,8	effective
9	demotivating	4,2	8,3	16,7	25	45,8	motivating
10	not thought-provoking		8,3	16,7	25	50	thought-provoking
11	not instructive	4,2	4,2	4,2	20,8	66,7	instructive

When the survey results were examined, it was found that the majority of students considered the designed educational escape game to be enjoyable (54.2%), engaging (58.3%), understandable (54.2%), educational (66.7%), sufficient in content (50%), and well-organized (54.2%). In addition, students indicated that the game encouraged thinking (50%), was motivating (45.8%), contributed to their learning (45.8%), and was efficient (45.8%). However, some students reported that they found the game complex or challenging, although these percentages remained well below the overall positive perception.

Students' responses to the open-ended questions were analyzed using content analysis.

Table 2. Students' opinions on the educational escape game and sample responses.

	Theme	Sample Student Responses
"How would you describe the game in one or more words?"	Fun/ Enjoyable	S8: "I think it is very good and fun for students with a basic level." S22: "Interesting and enjoyable." S12: "Fun." S15: "Enjoyable to play and instructive."

	Instructive	S1: “It makes learning enjoyable.”
		S5: “A game that encourages learning new information.”
		S17: “An educational game that enables review.”
		S16: “Instructive and enjoyable.”
		S3: “An ideal game to refresh one’s knowledge.”
		S11: “Efficient and instructive.”
	Other	S6: “Normal.”
		S24: “If I were to describe it, the game seems somewhat simplistic, as if it was created without much effort.”
“What did you enjoy most while playing the game?”	Curiosity / Excitement	S20: “Solving it step by step.”
		S9: “While answering the questions, I felt like I was in an exam and wondered what would happen if I made a mistake. Even though it had no real effect, it made me nervous and entertained me. I was curious about the answers. Kudos to whoever created them.”
		S22: “The game’s topic was intriguing; I reached the end without getting bored, and I liked this the most.”
		S5: “Finding the clues ourselves at the beginning of each section.”
		S15: “Instructive and fun, especially as it was my first game.”
	Instructive	S23: “Improving my chemistry knowledge.”
		S4: “The instructive nature of the questions.”
	Visuals / Game Design	S3: “Background visuals.”
		S16: “Visuals.”
		S7: “The design of the environment is very good.”
		S17: “Background.””
	Fun / Enjoyable	S8: “Being generally fun and making me curious about the ending.”
		S21: “Being fun.”
	Other	S10: “Atomic numbers.”
		S18: “Knowing the answers to the questions.”
What difficulties did you encounter while playing the game, or what aspects would you like to see improved?	Time / Time Management	S16: “The seconds were a bit short, but still sufficient.”
		S11: “I think the time given in the game was too short.”
	Difficulty / Higher Level	S14: “I don’t think it was challenging; perhaps slightly more difficult levels could be added.”
		S20: “I think the codes should be harder.”
	Clues / Guidance	S7: “There should be more clues.”
		S15: “In some sections, finding the clues was required, but at the beginning, it would be better if a teacher guided us on what kind of clue to look for. This would make the game more enjoyable and smooth; otherwise, it is difficult to understand what we need to find.”
		S5: “The part about finding clues to enter the laboratory could be further improved.”
		S18: “If the touch area for finding clues were improved a bit, it could be excellent.”
	Game Interface	S3: “The game interface could be improved a little.”
	Positive	S13: “No, it’s an excellent game; I would recommend it to everyone.”
		S22: “I think it is a very good and sufficient game.”
		S19: “There was no difficulty; it was understandable and sufficient.”

When students' responses to the question, "How would you describe the game in one or more words?" were examined, the majority indicated that they found the game fun and enjoyable, and they described it as educational and as a game that helps reinforce knowledge.

When examining what students enjoyed most while playing the game, their responses could be categorized as sections that aroused curiosity and excitement, the educational content of the game, the visuals and game design, and its overall entertainment value. Students generally described the game as intriguing, both enjoyable and educational. They also expressed that they liked the game's topic and design.

When the difficulties encountered during the game and areas for improvement were examined, the prominent themes included time and time management, difficulty level, hints and guidance, and the game interface. Some students mentioned that the allotted time was short or that the game could be prepared at a slightly higher difficulty level. Additionally, students suggested that a few more hints could be added and improvements could be made to the game interface. However, some students evaluated the game as perfect, finding everything sufficient and well-designed.

When examining responses to the question, "Would you like to play the game again after playing it?", it was found that the majority of students (62.5%) wanted to play the game again.

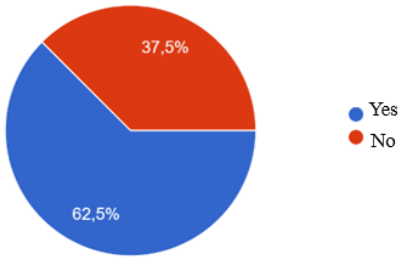

Figure 5. Distribution of participants based on their willingness to play the game again.

Conclusions

The findings indicate that high school students generally evaluated the designed educational escape game positively. These findings are consistent with similar studies (Lien et al., 2019; Naumoska et al., 2023).

The majority of students rated the game as enjoyable, educational, understandable, motivating, and thought-provoking, and a high proportion of students (62.5%) expressed a desire to play the game again. Responses to the open-ended questions revealed that students appreciated the curiosity, excitement, educational content, and visual design of the game, while some students suggested that improvements were needed in terms of time, difficulty level, hints, and the interface.

Overall, these findings suggest that educational escape games can be an effective method to increase students' interest and motivation in learning, as well as to present chemistry topics in an enjoyable and educational way.

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Learning from Losing: Exploring Failure Mechanics in Educational and Serious Games

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Abstract

Failure is often perceived as a negative outcome in both education and gameplay, yet research shows that it can serve as a productive pathway to deeper learning. While educational and serious games increasingly emphasize success and rewards, the design of failure mechanics remains underexplored. This study conducts a qualitative, descriptive content analysis of twelve educational and serious games to investigate how failure is represented, how feedback is provided, and how retry opportunities are structured. The analysis identified five main units of failure (score loss, time loss, health reduction, illness/death, and progress/task failure) and showed that explicit feedback dominates, often supplemented by motivational or punitive tones. Retry mechanics varied in scope and cost, ranging from quick task-level retries to expensive game-level restarts, shaping how players engage with mistakes. Findings suggest that most games frame failure as blocked progress rather than fatal consequences, aligning with educational goals of persistence and reflection. The study concludes with design implications for developing failure systems that transform losing into constructive learning opportunities.

Keywords: Failure mechanics, feedback, retry, educational games, serious games, game-based learning

Introduction

Failure is an inherent part of both learning and play. In educational contexts, mistakes are traditionally framed as setbacks to be avoided, yet contemporary learning sciences emphasize the value of failure as a driver of reflection, problem solving, and resilience (Kapur, 2008; Juul, 2013). Similarly, in games, losing or making mistakes is not simply a negative outcome but a core mechanic that structures player engagement. As Juul (2013) argues, the pain of losing is intertwined with the joy of eventual mastery. Designing failure in ways that are challenging but not discouraging remains one of the central tensions in both game design and pedagogy.

In recent years, educational and serious games have been increasingly adopted to teach skills ranging from financial literacy and civic education to programming and science. These games often emphasize rewards, achievements, and progress, while the design of failure mechanics – how the game communicates mistakes, what penalties are imposed, and how retry opportunities are structured – remains underexplored (Powers & Moore, 2021). Yet, failure design may be just as critical as reward design, as it shapes learners' motivation, persistence, and strategies for improvement.

Theoretical perspectives highlight the potential of failure for learning. Productive failure (Kapur, 2008) emphasizes the importance of initial struggle in fostering deeper understanding. Flow theory (Csikszentmihalyi, 1990) suggests that failure reflects imbalances between challenge and skill, with appropriate calibration keeping players engaged. Self-determination theory (Deci & Ryan, 2000) underscores how failure influences learners' sense of competence, autonomy, and relatedness, key drivers of intrinsic motivation. Together, these frameworks provide a lens for examining how failure in games can either promote or hinder meaningful learning.

Despite this theoretical foundation, empirical research has paid limited attention to how educational and serious games actually implement failure mechanics. Existing studies often describe broad learning outcomes of games but seldom analyze the specific ways that failure is represented (e.g., score loss, time loss, character death), the tone of feedback provided (punitive, neutral, motivational), or the cost and scope of retry mechanisms (cheap vs. expensive retries). This lack of fine-grained analysis leaves open questions about how different designs of failure affect learning and player experience.

To address this gap, the present study conducts a qualitative content analysis of twelve educational and serious games. Specifically, the study examines:

1. What constitutes failure in these games?
2. How do games communicate mistakes to players?
3. What opportunities and costs exist for replaying after failure?

By systematically analyzing failure mechanics across a diverse sample of games, this study aims to contribute to both theory and practice. For researchers, it extends understanding of how failure is operationalized in game-based

learning environments. For designers, it offers practical insights on how to structure failure not as discouragement but as a constructive learning opportunity.

Methodology

This study employed a qualitative, descriptive content analysis design to examine how failure mechanics are represented in educational and serious games. Content analysis was chosen because it enables a systematic and theory-informed exploration of in-game elements such as units of failure, feedback modes, and retry opportunities.

Sample of Games

A purposeful sample of twelve open-access educational and serious games was selected to capture a range of domains, genres, and learning purposes. The sample included games focusing on disaster risk management, civic education, historical simulation, ethics and argumentation, science learning, programming, attention awareness for *ADHD*, mathematics, and problem-solving. This diversity allowed comparison of failure mechanics across different contexts.

Data Analysis

Failure was analyzed across three main dimensions, informed by prior research (Juul, 2013; Powers & Moore, 2021):

- Unit of Failure – What constitutes a failure event (e.g., score loss, time loss, character health, illness/death, progress blocked).
- Feedback Modes and Tone – How the game communicates failure to players (explicit vs. implicit; punitive, neutral, motivational).
- Retry Mechanics – The scope (task-level, chapter-level, game-level) and cost (cheap, moderate, expensive) of retry opportunities.

Each game was played by the researcher until at least two full cycles of failure events were observed. Screenshots, field notes, and gameplay recordings were collected to document how failure was triggered, represented, and resolved. These materials were coded according to the three dimensions. Coding was conducted iteratively by cross-checking gameplay evidence with the conceptual categories drawn from the literature.

Results

Unit of Failure

The analysis revealed that educational and serious games operationalize failure through a range of mechanics, as shown in Figure 1.

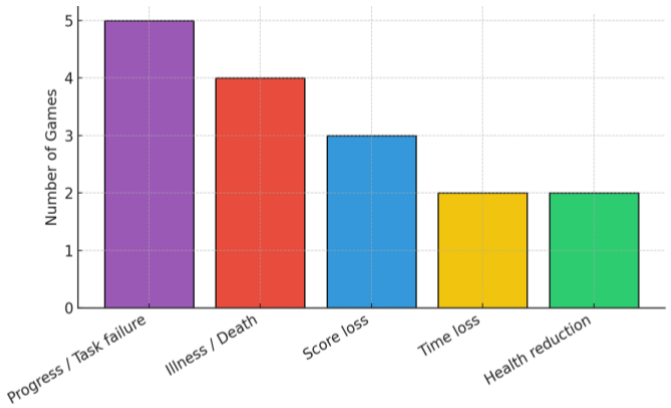

Figure 1. Failure representation mechanics

Progress or task failure was the most common representation, followed by illness or death. Score loss, time constraints, and health reduction were less frequently observed, but still played a role in shaping how players experienced setbacks.

To further differentiate the severity of failure, an examination was conducted to determine whether the identified mechanics resulted in soft or hard consequences, and the outcomes of this analysis are presented in Figure 2, illustrating the relative distribution of these two forms of failure across the analysed games.

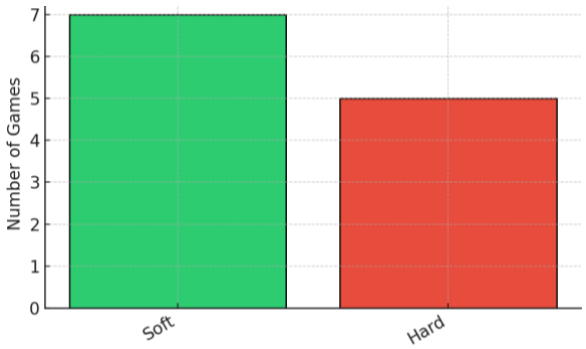

Figure 2. Impact of failure mechanics.

This dual perspective indicates that soft forms of failure (e.g., temporary loss of points, replaying a puzzle, or time penalties) were identified more frequently than hard forms (e.g., death of characters, mission collapse, or irreversible loss of progress), although both types were observed across the analysed games.

Feedback Modes and Tone

The analysis of feedback timing showed that immediate and delayed feedback were distributed equally, with six games adopting each approach

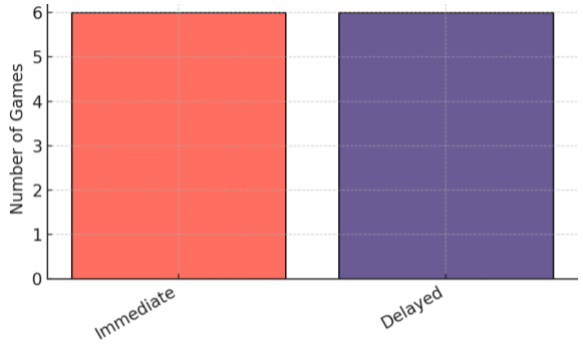

Figure 3. Timing of feedback

To complement the analysis of feedback timing, the form of feedback provided in the games was also examined. The analysis showed that all twelve games relied on explicit feedback, while no instances of implicit feedback were identified (see Figure 4). This suggests that failure communication in educational games is almost exclusively direct and unambiguous, setting the stage for further exploration of feedback tone.

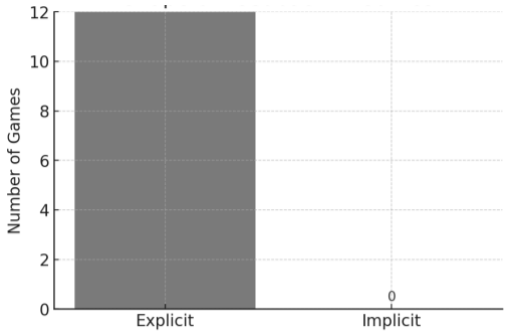

Figure 4. Form of feedback

The tone of feedback provided by the games was examined to determine whether it was primarily punitive, neutral, or motivational. Figure 5 presents the distribution of feedback tones across the twelve analysed games.

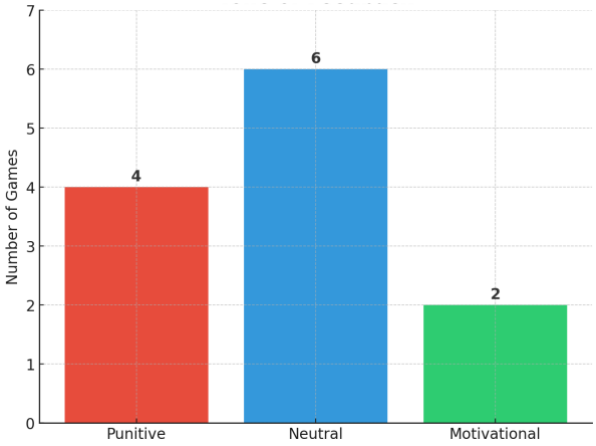

Figure 5. Tone of feedback

The results indicate that neutral feedback was the most common, followed by punitive feedback. Motivational feedback was the least frequent, observed in only two games.

Retry Mechanics

The scope of retry was analysed to determine whether players were required to repeat tasks, chapters, or entire games after failure. Figure 6 presents the distribution of retry scope across the sample.

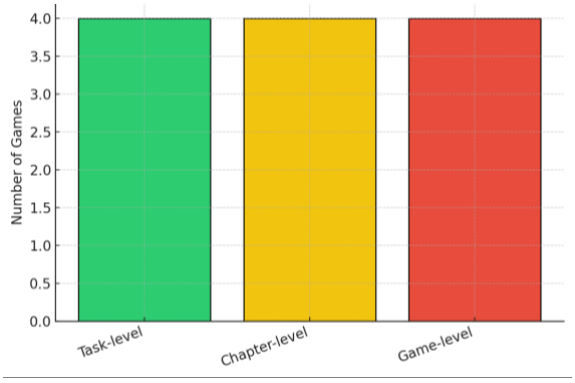

Figure 6. Scope of retry

The findings indicate that retry opportunities were evenly distributed: four games allowed task-level retries, four required chapter-level repetition, and four restarted the game from the beginning.

In addition to the scope of retry, the relative ease or cost of replaying after failure was analysed. This dimension reflects whether retrying was quick and low-cost, moderately demanding, or expensive in terms of lost progress. Figure 7 illustrates the distribution of retry costs across the analysed games.

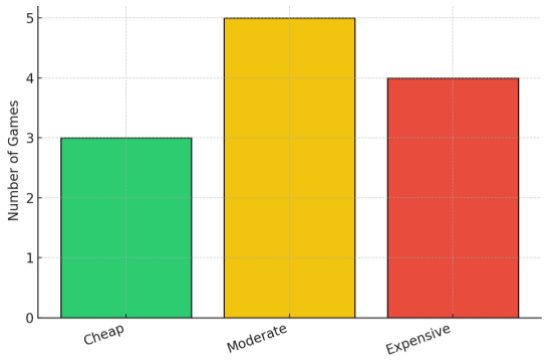

Figure 7. Ease & Cost of Retry

The results showed that three games provided cheap retries, five games required moderate costs, and four games imposed expensive retries.

Retry was also analysed in terms of its pedagogical function, reflecting whether replay supported iterative practice, encouraged reflection, imposed punitive costs, or fostered hybrid awareness. Figure 8 presents the distribution of learning functions across the games.

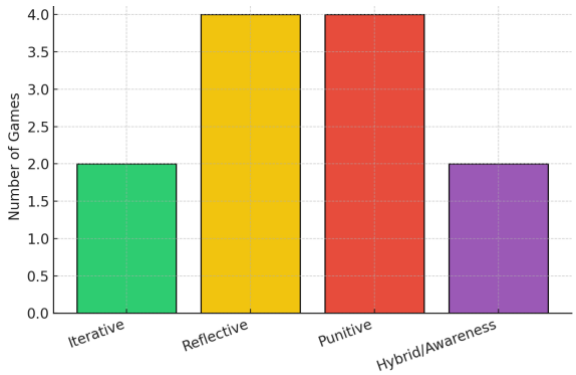

Figure 8. Learning Function of Retry

The results indicated that two games employed retries mainly for iterative learning, four emphasized reflective retries, four relied on punitive retry structures, and two incorporated hybrid or awareness-building functions.

Conclusions

This exploratory study examined how failure is represented in a sample of twelve educational games. The analysis showed that failure most often appeared as progress or task loss, illness/death, and score reduction, while time and health loss were less common. Feedback was predominantly explicit and informational, delivered either immediately or with some delay. However, motivational feedback—which can be critical for sustaining persistence—was rarely observed (Deci & Ryan, 2000). Neutral and punitive tones were more frequent than supportive ones, pointing to an emphasis on correction rather than encouragement.

Retry mechanics were distributed across task, chapter, and game levels, with moderate and expensive retry costs being common. While such structures may increase memorability (Juul, 2013), they also risk discouraging learners

when failure feels overly punitive. Iterative retries were less common, which may limit opportunities for trial-and-error learning (Kapur, 2008).

Given the limited number of games analysed, the findings should not be taken as generalizable to all educational games. Rather, they highlight patterns that warrant further investigation. Future studies with larger and more diverse samples could clarify how different failure mechanics shape learning outcomes. At the same time, the results suggest that more balanced and motivational feedback, together with affordable retry opportunities, may help ensure that failure functions as a productive learning experience (Gee, 2007; Kapur, 2016).

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Development and Evaluation of a Personalized Recommendation System for Ongoing Training of Higher Education Teachers: Research Proposal

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Abstract

With the growing advancement of information and communication technologies, especially in areas such as Data Science and Generative AI, various opportunities have emerged to transform teaching practices and reshape the delivery of higher education. Continuous training for teachers is a crucial factor for adaptation to the digital environment and the new educational context that is unfolding. Traditional methods of professional development for teachers have proven inefficient for the individual and specific needs of each one, making the personalization of the training process an unresolved necessity. It is in this context that recommendation systems (RS) emerge as a promising solution, allowing for the personalization of content and learning strategies according to the needs, interests, and profiles of each teacher. This work proposes the development of a recommendation system aimed at the training of higher education teachers, with the objective of optimizing courses and activities that promote improvements and continuous enhancement. The study addresses the main recommendation techniques, such as collaborative filtering, content-based filtering, and hybrid methods, assessing their applicability in the context of higher education. Furthermore, issues related to explainability, fairness, and transparency in recommendation models are discussed to ensure that systems can be understood and accepted by end users. The study explores the technical feasibility of integrating recommendation systems with learning platforms already used in universities, such as Moodle, Canvas, Blackboard, among others, in addition to analyzing teachers' experiences when using this type of technology. The research aims to test a prototype that combines data from teacher interactions with machine learning technology, with the goal of validating the effectiveness of the recommendation system in promoting continuous training and improving the pedagogical performance of educators. The proposal aims not only to contribute to the advancement of educational technologies but also to provide a solid foundation for the adoption of recommendation systems within the context of teacher training, making the teaching-learning process more efficient and personalized.

Keywords: Recommendation systems, Teacher training, Personalization of learning, Machine learning.

Introduction

The evolution of information and communication technologies, associated with emerging technological approaches such as generative artificial intelligence and data science in the field of education, opens up opportunities for improvements in the teaching process, while also presupposing the acquisition of new skills and knowledge in their areas of training. In this context, it is suggested that higher education institutions and professionals in the field of education adopt a continuous training process as an essential tool to ensure individual development and career progression, but also to improve performance and contribute to the achievement of the overall objectives of their organizations. However, due to the wide range of training programs and courses available in the market, this can pose a challenge or difficulty for these professionals in identifying the training options that best suit their needs and professional goals.

The digital transformation of higher education has accelerated significantly in recent years, driven by innovations and digital interaction with students. Universities are increasingly adopting learning platforms and digital tools to enhance both teaching and learning processes. This shift places additional demands on higher education teachers, who must constantly update their pedagogical and digital competencies.

Traditional training programs often struggle to meet the personalized needs of individual educators. As a result, many teachers face challenges in adapting to new technological environments. Personalized training has emerged as a pressing need, with recommendation systems (RS) standing out as an innovative solution to address this gap.

This article investigates the role of Recommendation Systems in the continuous training of higher education teachers. It presents the findings of interviews conducted with ten specialists in e-learning and teacher training, offering insights into opportunities, challenges, and future directions, as well as a literature review, articles and works by authors published in reputable scientific journals are sought to better understand the current state of recommendation systems for professional development.

By leveraging the field of Artificial Intelligence (AI), more specifically in the areas of deep learning and machine learning, the author points to recommendation systems as an efficient solution for the personalization and optimization of recommended training. Thus, it is assumed that the effectiveness of these systems depends on their ability to accurately personalize recommendations in all aspects related to the professional profile, considering also legal issues. Based on this premise, the author identifies the main problem in this area of application: on one hand, the limitations and quality of recommendations suggested by recommendation systems, and on the other hand, the absence of a recommendation system that assists the continuous learning process of higher education teachers.

Literature Review

Teacher Training in the Digital Era

Teacher professional development is no longer limited to periodic workshops or one-time courses. Continuous and adaptive training is required to align educators with rapidly changing technologies and pedagogical approaches. The literature suggests that training should be flexible, context-specific, and technology-driven (Siemens, 2020; Bates, 2019). According to Wang et al. (2014), due to the abundance of options in many online services, recommendation systems (RS) currently play a significant role as they are mainly used to suggest resources and optimized choices for users to adhere to (p.1)

Higher education teacher competencies in the 21st century

It is common knowledge that professional skills vary according to the context of each region, its culture, expectations, etc. According to the UNESCO report, the skills of a higher education teacher are increasingly broad and require a combination of pedagogical and social skills and techniques. For the Ministry of Education of Mozambique (MINED), competencies can be summarized into 10 specific skills: Mastery of content; Pedagogical skills; Educational technology; Active learning; Curriculum adaptation; Formative assessment; Intercultural competencies; Critical thinking and problem-solving; Collaboration and networking; Continuous professional development. It can thus be noted that most, though not all, of these competencies require training, courses, or teacher capacity-building in order for them to gain the necessary experience and, consequently, also improve the experience conveyed to students.

Legal Frameworks

According to the European position, Learning Analytics has been expressed in the European Commission's report:

> "New Modes of Learning and Teaching in Higher Education". In recommendation, the Commission clearly stated: Member States should ensure that legal frameworks allow higher education institutions to collect and analyse learning data. The full and informed consent of students must be a requirement and the data should only be used for educational purposes", and, in recommendation: "Online platforms should inform users about their privacy and data protection policy in a clear and understandable way. Individuals should always have the choice to anonymise their data."

Recommendation Systems in Education

Education is a sensitive and critical field for any organization; therefore, it must be done in the right way. Considering that it is an ongoing process, it has a direct impact on both individual and organizational goals. The need to change and adopt new technologies at the same time that we re-engineer our behavior in the digital and IA era. For the authors, this represents a change in the learning perspective as well as an opportunity to reshape a tool or key performance indicator of enhancement in the educational process for teachers. It is visible that traditional education is gradually replaced by a combination of LMS, Generative AI, and data science. "Educational

recommender systems differ from traditional ones because they must take into account pedagogical goals, learner diversity, and instructional design." (Manouselis et al., 2012, p. 15)

"Recommender systems in education can support teachers by providing insights into learners' needs and suggesting appropriate learning activities or resources." (Drachsler & Verbert, 2015, p. 248). "Adaptive recommendation is particularly suitable for e-learning systems, where learners' needs and interests evolve over time." (Tang & McCalla, 2005, p. 107)

Recommendation systems are widely used in industries such as e-commerce and entertainment. In education, they are gaining traction to support personalized learning pathways. Techniques include:

- Collaborative Filtering: Based on similarities between users and their preferences.
- Content-Based Filtering: Relies on the characteristics of items and user profiles.
- Hybrid Methods: Combine both approaches for more robust results.

Challenges of RS Adoption in Higher Education

Despite their potential, RS face barriers such as data privacy, algorithmic bias, and lack of transparency. Scholars such as Burke (2017) and Drachsler and Verbert (2015) highlight that "fairness and explainability are key factors for user trust and acceptance, particularly in educational settings".

"Although recommender systems are well established in entertainment and commerce, their application in education is more complex due to pedagogical and ethical considerations." (Bobadilla et al., 2013, p. 110)

Selbst et al. (2018) study found the following:

> One of the main objectives of the fair-ML community is to develop machine learning–based systems that, once introduced into a social context, can achieve social and legal outcomes such as fairness, justice, and efficient processes. Thus, we can refer to: the transparency and explainability of recommendation systems, highlighting the reasons why users are receiving such recommendations; non-discrimination, indicating that recommendation algorithms should not perpetuate existing biases such as racial, gender, or socioeconomic discrimination, and should be fair and equitable for all users; data privacy, highlighting the need for data to be handled securely and responsibly; user control, referring to the user's ability to manage their recommendation preferences and, if they wish, opt out of receiving such recommendations and access and delete their personal data. Among others (p.38).

Related Works

Recommendation systems for higher education teachers have been gaining increasing attention, offering support for the selection of teaching resources, lesson planning, activity sequencing, and pedagogical interventions. Although most of the literature on recommender systems in education is focused on students, recent works highlight teacher-facing approaches, which include continuous personalized recommendations — capable of adapting in near real time based on signals such as student performance, LMS interactions, and teacher feedback (Bhatt, 2025; Dhahri, 2021; Pelánek, 2024; Siafis, 2024; Yazdi, 2024).

These systems generally combine short-term models (sessions, recent interactions) with long-term teacher profiles to maintain the relevance of recommendations throughout the semester. Typical applications include: recommending educational resources, supporting syllabus design and adjustment, identifying pedagogical interventions for at-risk students, and suggesting professional development programs. The techniques employed range from collaborative filtering and content-based methods to hybrid models, knowledge graphs, and reinforcement learning (Pelánek, 2024; Yazdi, 2024). Although the results show increased relevance of recommendations and reduced teacher preparation time, there are significant challenges such as longitudinal evaluation, scalability, privacy, and teacher acceptability (Bhatt, 2025; Siafis, 2024).

Methodology

The study adopted a qualitative approach, conducting semi-structured interviews with ten specialists in e-learning and educational technologies. Participants were selected based on their expertise in teacher training and their involvement with learning platforms. asides thematic analysis was applied to identify key insights regarding the applicability, challenges, and benefits of RS in higher education in the modern era.

Results

In this section, the author presents the results and further discusses various opinions provided by specialists in e-learning, as well as the insights fed by the literature review. In general, the interview focuses on the specialist perspective on personalization of recommendations, the applicability of well-known techniques, and the major challenges during the implementation of a personalized recommendation system.

Specialists' Perspectives on Personalization

All ten interviewees emphasized and agreed that personalization is a critical gap in current teacher training initiatives. Generic training often fails to address teachers' diverse needs, particularly regarding their digital skills and pedagogical strategies.

Applicability of Recommendation Techniques

- Collaborative Filtering: Specialists considered it effective in environments where large datasets of teacher interactions are available.
- Content-Based Filtering: Valued for contexts with limited user data but rich course metadata.
- Hybrid Models: Identified as the most promising, combining personalization accuracy with scalability.

Challenges of Implementation

The experts highlighted three main challenges:

- Explainability: Teachers must understand why specific courses are recommended.
- Fairness: Systems should avoid reinforcing inequalities between digitally advanced and less experienced educators.
- Integration: Technical feasibility of embedding RS into widely used platforms such as Moodle and Canvas.

Integration with Learning Platforms

The integration of RS into existing platforms offers significant opportunities. Moodle and Canvas, with their open-source ecosystems, allow customization and plugin development. Blackboard, though more restrictive, provides APIs for integration.

Specialists suggested that seamless integration would ensure adoption by institutions while reducing resistance from teachers.

Implications for Higher Education

The study's findings reveal that RS can:

- Enhance the efficiency of teacher training by aligning content with individual needs.
- Support continuous professional development, moving beyond one-size-fits-all approaches.
- Promote innovation in pedagogy, as teachers gain confidence with digital tools.
- However, institutions must address challenges of trust, privacy, and ethical use of data to ensure successful implementation.

Proposed Prototype

In this section, the authors describe how such a system might present a teacher's recommended resources, courses, or professional development paths using a hybrid recommendation approach (content-based + collaborative filtering).

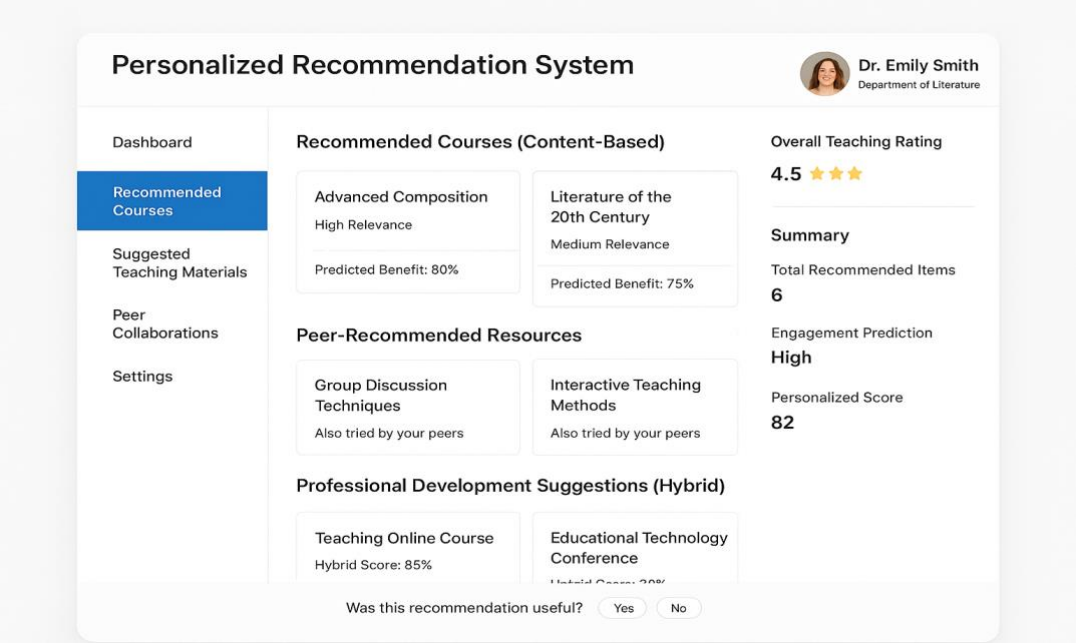

Figure 1. Hybrid Prototype for Personalized Recommendation System.

The above figure 1. prototype shows the main elements and features of the user interface required to perform the Hybrid recommendation. To describe the content, it started with:

Title: Personalized Recommendation System – Teacher Dashboard (Hybrid Prototype)

Header Section

- Teacher Name, Department, Profile Picture
- Overall Teaching Rating / Feedback Summary
- Left Sidebar (Navigation)
- Dashboard
- Recommended Courses
- Suggested Teaching Materials
- Peer Collaborations
- Settings

Main Panel (Hybrid Recommendations)

Section 1: Recommended Courses (Content-Based)

- Cards showing courses that match the teacher's teaching subjects and interests.
- Info on course relevance and predicted benefit.

Section 2: Peer-Recommended Resources (Collaborative Filtering)

- Resources or methods used by teachers with similar profiles.
- Visualized as "Also tried by your peers" cards.

Section 3: Professional Development Suggestions (Hybrid)

- Combined score from content + peer similarity.
- Includes conferences, workshops, and certifications.
- Right Sidebar / Summary Panel
- Quick stats:
- Total recommended items
- Engagement prediction
- Personalized score (how well the system thinks this fits the teacher)
- Footer
- Feedback button: "Was this recommendation useful?"
- Links to improve personalization

Conclusions

Personalized recommendation systems for higher education teachers represent a significant evolution in the way educators receive pedagogical support, lesson planning, and suggestions for teaching resources.

Recent literature shows that these tools not only increase efficiency in lesson preparation but can also improve the quality of instruction and student engagement by aligning recommendations with the specific needs of the course, content, and teacher profile

This research demonstrates that RS holds great promise in transforming teachers' continuous personalized training in higher education. By leveraging collaborative, content-based, and hybrid techniques, institutions can provide more personalized and effective professional development.

The insights from interviews with ten specialists highlight both the opportunities and challenges associated with RS. While personalization and engagement are clear benefits, concerns about transparency and fairness require careful attention.

Despite the advances and widespread adoption, personalized recommendation system faces significant challenges as explained next: Evaluation of these systems remains fragmented, often limited to traditional recommendation metrics such as precision and recall, without fully considering pedagogical impacts and user acceptability (Siafis, 2024).

Issues of privacy, scalability, and recommendation transparency remain critical, especially considering the sensitivity of data from students and teachers involved (Dhahri, 2021).

Acknowledgements

Sincere gratitude to all the specialists who kindly shared their time, experience, and valuable insights during the interviews conducted for this study. Their contributions were essential in deepening the understanding of the challenges and opportunities associated with the integration of recommendation systems into teacher training and e-learning environments.

We also acknowledge the support of the higher education institutions and e-learning centers that facilitated access to these experts, thereby making the research possible.

Our appreciation to colleagues and peers who provided constructive drafting of this article. Their suggestions enriched the work and contributed significantly to its final result.

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Examining Teacher Candidates' Views on Open Educational Resources

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Abstract

This study investigated the integration of open educational resources (OERs) into the learning processes of teacher candidates and the impact of this integration process on their perceptions of professional development. The study was carried out with a sample of 24 teacher candidates who received the elective course of "Open and Distance Learning" at a state university in the Western Black Sea Region during the spring semester of the 2024-2025 academic year. Data were collected through an online questionnaire consisting of open-ended questions and analyzed using the content analysis method. Findings displayed that a large number of the participants were knowledgeable about OERs, and more than half of them were using these resources regularly. YouTube, Khan Academy, and Anadolu University's AKADEMA were revealed to be the most frequently used resources, and these were followed by other types of resources such as open textbooks, lecture slides, and podcasts. The conveniences like free access, content personalization, and access to up-to-date information offered by the OERs enhanced teacher candidates' pedagogical knowledge and material development skills. Nonetheless, technical infrastructure deficiencies, difficulty finding resources, language barriers resulting from the availability of resources predominantly in English, and distrust in the content quality stood out as the main barriers to the effective use of these resources. To popularize the use of OERs among teacher candidates, this study made concrete suggestions such as increasing training for awareness towards OERs at teacher education programs, improving technical infrastructure, establishing quality assurance mechanisms, and promoting the production of content in the native language. While revealing the transformative potential of OERs, these findings also emphasized the necessity of structural and pedagogical improvements for realizing this potential fully.

Keywords: Open Educational Resources, Teacher Candidates, Distance Education

Introduction

Thanks to the acceleration in digital transformation in education, teaching and learning paradigms have undergone a radical reconstruction process. According to the definition provided by UNESCO (2019), Open Educational Resources (OERs), which are situated at the center of this transformation, are "teaching, learning, and research materials that can be freely reused, continuously improved, and rearranged for different purposes". These materials that involve a large spectrum of resources, such as textbooks, modules, several free online courses, videos, podcasts, and simulations, are available through open licenses like Creative Commons. These licenses give the users the right to access, use, adapt, and redistribute the information free of charge and thus enable the democratization of the information. The OER movement plays a crucial role in minimizing the barriers related to costs, especially at the higher education level, and expanding learning opportunities by supporting "quality, inclusive, and equal education", which is the fourth of the United Nations' Sustainable Development Goals (Tlili et al., 2023).

OERs stand out as an effective tool for teacher candidates to enrich their pedagogical knowledge and improve their teaching material development skills within the scope of teacher education. Considering teacher candidates' need for up-to-date, flexible, and accessible materials for their professional development, OERs have an important potential to meet this need. However, full realization of OERs' potential is hindered by some obstacles such as a lack of awareness, technical infrastructure deficiencies, language barriers, and worries about content quality. Studies in the literature show that the effects of OERs vary according to the context. For instance, Van Allen and Katz (2020) highlighted that OERs played a critical role in decreasing the inequalities in education during the pandemic, while a study by Hilton (2020) reported that the use of OERs affected students' academic success positively and decreased the educational costs. In the context of Türkiye, studies investigating the role of OERs in teacher education and teacher candidates' perceptions of these resources are limited in number, which indicates a significant gap in the related literature.

As an attempt to fill this gap in the literature, this study aimed to examine teacher candidates ' views on how they integrate OER into their learning processes and its effects on their professional development with a qualitative approach. Sub-aims of this study were as follows:

1. What is the teacher candidates' level of awareness towards OERs and their opinions about their OER use habits?
2. What are the teacher candidates' opinions about the potential opportunities and obstacles to be encountered during the integration of OERs into their lifelong learning strategies?
3. What are the teacher candidates' opinions about the impacts of the use of OERs on their professional development?

Method

This study employed a qualitative research method to make an in-depth analysis of teacher candidates' experiences and perceptions about the contributions of Open Educational Resources (OERs) to their learning strategies. Consistent with the nature of the study, a phenomenological research design was adopted since the focus was to explore the teacher candidates' personal experiences related to the use of OERs and the subjective meaning they attribute to these experiences. The phenomenological design aims to understand in detail the experiences that individuals have related to a specific phenomenon and the personal interpretations they make about these experiences (Yıldırım & Şimşek, 2018). Accordingly, qualitative data collection techniques were used in this study.

Participants

Participants of this study were 24 teacher candidates (aged between 18 and 22) who took the elective professional knowledge course of "Open and Distance Learning" (available for students from multiple departments) during the spring semester of the 2024-2025 academic year. Teacher candidates received training in various sections of this course on OERs. The participants were selected through the convenience sampling method, one of the purposeful sampling methods. The demographics of the participants were presented in Table 1.

Table 1. Characteristics of the Participants

Characteristic	Category	Number (n)	Percentage (%)
Gender	Female	14	58.3
	Male	10	41.7
Branch	Social Studies	9	37.5
	Maths	7	29.2
	Science	4	16.7
	Turkish	4	16.7

Data Collection and Analysis

Data were collected through an online questionnaire developed based on the sub-aims of the study and including three open-ended questions. The teacher candidates who volunteered to participate in the study answered the following three questions in the online form shared via Google Forms:

1. What is your level of knowledge about OERs, and how often do you use these resources? What kind of OERs do you prefer to use and why?
2. Which opportunities and obstacles do you encounter while integrating OERs into your learning processes?
3. How do you think the use of OERs contributes to your professional development as a teacher candidate?

The data were analyzed using the content analysis method. Content analysis is a qualitative data analysis method in which written, oral, or visual data are interpreted by coding and categorizing systematically (Yıldırım & Şimşek, 2018). In the analysis process, a second researcher independently coded the data, and themes and sub-themes were

identified, ensuring intercoder reliability. The participants were referred to by coding as P-1, P-2, etc. in the direct excerpts from the answers to the questionnaire.

Findings

Findings were structured and presented in accordance with the three sub-aims of the study.

1. Awareness towards OERs and OER Use Habits

Table 2. Codes and Frequencies Related to Teacher Candidates' Awareness towards OERs and OER Use Habits

Theme	Sub-Theme	Code	Frequency(f)
Awareness and Use	Awareness Level	Being knowledgeable about OERs	22
	Frequency of Use	Hearing the concept of OERs for the first time in class	2
		Using regularly (a few times a week)	15
		Using occasionally (when needed)	9
	Preferred Types of OERs	YouTube (Educational Channels)	17
		Khan Academy	15
		Anadolu University's AKADEMA &Open Library	7
		Open Textbooks (PDFs, e-books)	7
		Lecture Slides (SlideShare, etc.)	6
		Podcasts (Education-focused)	5
		Other Online Courses (Atademix, Coursera, etc.)	4
		Ankara University's Open Course Platform	2
		Council of Higher Education (CoHE) Courses Platform	2
		TUBITAK Open Course Platform	2
		Turkish Academy of Sciences (TUBA) Open Course Platform	2
		Open Course Portals of Universities	1

As seen in Table 2, while a vast majority of the participants (f=22) expressed that they were knowledgeable about the concept of OERs, more than half of them (f=15) stated that they used these resources regularly. The most remarkable ones of these resources that stood out with a high frequency were YouTube (f=17) and Khan Academy (f=15). These two are followed by local ones, Anadolu University's open library and AKADEMA (f=7). Accessibility and audio-visual richness of these platforms were emphasized by the participants as the main reasons for preferring them. Open textbooks, lecture slides, and podcasts, which are more structured resources, had lower frequencies of use among the participants. It was striking that only a few participants were knowledgeable about local and academic initiatives such as CoHE, TUBA, and TUBITAK Open Course Platforms.

Excerpts from the Participants' Opinions:

- *"There are educational channels on YouTube for almost every subject. Watching videos to understand a complicated subject is more enjoyable than just reading about it. Therefore, this is the resource that I most often resort to." (P-7)*
- *"Content related to especially my branch, Maths, on Khan Academy is great. I benefit from the lecture videos and exercises a lot while getting ready for my classes." (P-11)*
- *"I heard about AKADEMA Open Course Platform during this class. Its content is reliable and of high quality, yet it needs more promotion. Most of my classmates didn't know of it." (P-2)*
- *"I use open textbooks especially when I cannot find lecture notes or those I have are inefficient. Taking notes on the PDF files that I can access and download freely is a great convenience." (P-18).)*

2. Opportunities and Obstacles Encountered in the Integration of OERs

Table 3. Codes and Frequencies Related to Opportunities and Obstacles Encountered in the Integration of AEK into the Learning Process

Theme	Sub-Theme	Code	Frequency (f)
Opportunities and Obstacles	Opportunities	Free access / Cost Advantage	17
		Opportunity to download/ customize/ adapt the content	15
		Access to various and up-to-date information	14
		Flexibility of time and place	9
		Gaining different perspectives	2
	Obstacles	Technical/access problems and infrastructure deficiencies	15
		Searching/Finding is difficult/time-consuming	12
		Language barrier (availability of resources predominantly in English)	11
		Worries about the quality and accuracy of the content	8
		Information pollution and clutter	2
		Risk of internet addiction	1

According to the findings displayed in Table 3, teacher candidates regarded free access (f=17) as the biggest opportunity offered by the use of OERs. This was followed by the advantages such as the opportunity to customize the materials according to their courses (f=15), and access to various and up-to-date information (f=14). Among the obstacles faced, technical/access, infrastructure deficiencies (f=15) take the first place. Having difficulty finding resources comes second (f=12). Especially, the language barrier resulting from the availability of resources predominantly in English (f=11) and worries about the quality and accuracy of the content caused by the unreliability of any information on the internet (f=8) were expressed as the other important obstacles.

Excerpts from the Participants' Opinions:

- *"The biggest advantage of them is that they are free of charge. Instead of buying expensive books as a student, I can make up for my knowledge deficiencies thanks to open lecture notes and videos. But I am having difficulty accessing some sites, they are running slowly." (P-5)*
- *"I can edit a presentation on the internet according to my class. I add or omit the parts as I wish. This reduces the burden of preparing materials a lot. I can't download large files because I have limited internet quota." (P-14)*
- *"My biggest problem is foreign languages. The highest quality resources are mostly in English. Even if I use translation tools, the translation is not as effective as the original, and this makes me slower." (P-21)*
- *"There are sometimes so many resources that it gets harder for us to decide which one is more proper or better. We may get lost in information pollution. It is difficult to find reliable resources." (P-9)*

3. Impacts of the Use of OERs on Teacher Candidates' Perceptions of Professional Development

Table 4. Codes and Frequencies Related to the Impacts of the Use of OERs on Teacher Candidates' Perceptions of Professional Development

Theme	Sub-Theme	Code	Frequency (f)
Impacts on Professional Development	Positive Contributions	Enriching pedagogical knowledge and teaching methods	15
		Increasing course material development skills	13
		Keeping subject matter knowledge up-to-date	10
		Ability to integrate technology into teaching	7
		Acquiring self-directed learning skills	2
		Developing resource finding strategies	1
		Understanding the importance of effective content	1
	Negative Aspects / Challenges	Confusion resulting from unstructured content	7
		Difficulty of time management (searching for and finding appropriate sources)	1
		Worry about obtaining accurate information	1

As Table 4 reveals, a large number of the participants thought that OERs contributed positively to their professional development. The most prominent contributions were seen in enriching the pedagogical knowledge and teaching methods (f=15) and increasing course material development skills (f=13). The teacher candidates stated that they were able to observe various teaching techniques and follow the developments in their fields. In contrast to these contributions of OERs, some of the participants (f=7) pointed out that especially unstructured and disorganized content could be time-wasting and confusing, and finding the right resource took too much time.

Excerpts from the Participants' Opinions:

- *"Listening to the same subject from different lecturers with different approaches broadens my horizons. In this way, I create my own teaching style." (P-23)*
- *"Thanks to the OERs, I develop already existing materials instead of creating any from scratch. For example, I watch a science experiment beforehand and think over how to apply it in my class." (P=4)*
- *"They make me gain the habit of continuously learning new things. I will go on using these resources to stay up-to-date after I graduate. This is absolutely a lifelong learning." (P=15)*
- *"While making research on a subject, I sometimes click on so many tabs that I diverge from what I am searching for. Lack of systematicity and excessive disorganization of the resources reduce my productivity." (P-19)*

Discussion and Conclusion

This study revealed that the integration of OERs into teacher candidates' learning processes offered important opportunities while also bringing along some structural difficulties. A large part of the participants knew the OERs and were actively using popular platforms such as YouTube, Khan Academy, and AKADEMA, which indicates that these platforms have become a major tool for learning. The finding that the advantages of OERs, such as free access, content personalization, and access to up-to-date information, support the self-directed learning processes of the teacher candidates is consistent with the claims in the literature that OERs increase accessibility and flexibility in education (Hilton, 2020).

One of the most remarkable findings of the study was the positive impact of Open Educational Resources (OERs) on teacher candidates' professional development. The participants in this study expressed that they were able to enrich their pedagogical knowledge and improve their course material development skills thanks to OERs. This result depicts that OERs not only facilitate access to information but also promote student-centered and innovative teaching practices known as OER-enabled pedagogy (Biddle & Clinton-Lisell, 2023). Similarly, a study by Özdemir and Bonk (2017) indicated that Turkish teachers believe that OERs increase student achievement, but the

time required to search, select, and implement OERs is the biggest challenge. However, there are some crucial obstacles to the full utilization of this potential, such as technical infrastructure deficiencies, language barriers, and worries about the content quality. Especially the availability of resources predominantly in English entails a limitation for users like those in Türkiye, where resources are mostly in English (Shareefa et al., 2023). In a study conducted by Sunar et al. (2020), it was stated that the cross-platform use of OER supports learning processes, but users have difficulties in finding and integrating appropriate content (Sunar et al., 2020).

In the context of Türkiye, the limited use of open course platforms of universities due to local initiatives such as CoHE, TUBA, and TUBITAK Open Course Platforms makes it clear that these platforms of universities should be promoted more efficiently, and the production of high-quality OERS in the native language should be increased. The confusion resulting from unstructured content indicates that teacher candidates need guidance not only for accessing and using the OERs effectively, but also for improving their skills to select, evaluate, and pedagogically integrate these resources. Public and private institutions should focus their attention on the universities' processes of developing OERs that include high-quality content. It is inevitable for information societies in which online learning is now at the center to increase the number of OERs that have proven their effectiveness in the lifelong learning experiences of teacher candidates, other students, and even all individuals of society, and encompass content richness, language support, and ease of use. In this sense, increasing awareness towards OERs has similarly become a critical duty for today's educational institutions.

Recommendations

In line with the findings, the following recommendations were made in this study for a more efficient integration of OERs into teacher education:

- **Awareness and Education:** Applied course modules and workshops about what OERs are, how to find them, how to perform their quality control, and how to use them pedagogically should be added to the curriculum of teacher education programs
- **Technical Infrastructure:** Internet access and technical equipment at universities and schools should be enhanced to enable the trouble-free use of OERs. AEK sites and applications must be user-friendly and use a fast infrastructure.
- **Quality Assurance and Access:** Educational Authorities or universities should develop easily accessible portals that are enriched with explanations in Turkish and compile the OERs meeting specific quality standards.
- **Encouragement of Local Content Production:** Lecturers and teacher candidates should be encouraged to produce Turkish OERs (lecture videos, modules, presentations, etc.) related to their own fields and be assisted technically and pedagogically in the production of the content.
- **Integration into the Curriculum:** A badly-structured / haphazard use of OERs should be prevented by integrating them systematically into the course plans and learning objectives.

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Psychological Counseling and Guidance Teacher Candidates' Opinions and Application Perspectives on Augmented and Virtual Reality Technologies

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Abstract

This study aimed to examine psychological counseling and guidance (PCG) teacher candidates' opinions on augmented reality (AR) and virtual reality (VR) technologies in various contexts, adopting a qualitative approach. The study was carried out with 28 teacher candidates at a state university in the Western Black Sea Region and structured in line with the four sub-aims of the study: (1) benefits of AR/VR technologies and self-efficacy perceptions, (2) opinions about the pedagogical integration of AR/VR technologies, (3) challenges in the integration of AR/VR technologies and solution proposals, and (4) motivations for using AR/VR technologies. Data were collected through a questionnaire including four open-ended questions on Google Forms and analyzed using the content analysis method. Findings revealed that teacher candidates thought that AR/VR technologies increased students' motivation, made complicated concepts more concrete, and offered experimental-psychological case/scenario-based learning environment opportunities. Although most of the teacher candidates felt themselves competent in using these technologies, they were hesitant to use them for some reasons, such as limited experience and the need for technical support. High costs, deficiencies in the technical infrastructure, and insufficiency of teacher training on AR/VR were found to be the main obstacles to the integration of these technologies into education. The study highlighted the need for a comprehensive teacher education, investments in the infrastructure, and the development of curriculum-appropriate content for the effective use of AR/VR technologies. In line with the research results, suggestions such as the integration of these technologies into teacher training programs and increasing professional and financial support were presented.

Future studies conducted with more extensive and diverse samples may enhance the generalizability of the findings.

Keywords: Augmented Reality, Virtual Reality, Teacher Education, Pedagogical Integration

Introduction

Education systems have been experiencing a significant transformation process with the advent of innovative technologies such as augmented reality (AR) and virtual reality (VR). While AR enriches the learning environments by adding digital elements to the physical world, VR supports students' immersive and experiential learning processes by offering completely virtual environments. These technologies are remarkable with their capacity for increasing student engagement, visualizing abstract concepts, and offering personalized learning opportunities (Cai et al., 2021; Mystakidis et al., 2022). However, effective use of these technologies in the classes depends directly on teachers' motivations for using these technologies, pedagogical skills, and self-efficacy perceptions.

Studies about teachers' perceptions of AR/VR technologies have recently increased in number. For example, it was found through an extensive questionnaire for teachers that VR technologies were approached positively in general, but a lack of technical support and insufficiency of education on VR obstructed their integration into education (Khukalenko et al., 2022). Mystakidis et al. (2022) reported that AR applications at the higher education level increased student engagement and achievement. Nevertheless, there are just a few qualitative studies that concentrate on teacher candidates' perceptions of AR/VR Technologies in specific fields of teaching, such as Psychological Counseling and Guidance (PCG). PCG teachers are teaching professionals who focus their attention on not only academic but also emotional and social development of the students. Therefore, the way they integrate

AR/VR technologies into their professional practices should be appropriate for the particular needs of this field. This gap in the existing literature signals the importance and necessity of such a study.

Adopting a qualitative approach, this study seeks to thoroughly examine the PCG teacher candidates' opinions about the general benefits of AR/VR technologies, their self-efficacy perceptions of using these technologies, and their views about the pedagogical integration of these technologies, the potential challenges they entail, and the motivations behind using them. It is aimed in this study to present valuable data to understand the potential and applicability of AR/VR technologies in the PCG education by contributing to the development of teacher education programs and educational policies.

Aim and Sub-Aims of the Study

The primary aim of this study is to reveal PCG teacher candidates' opinions about AR/VR technologies in various contexts from a qualitative perspective. Accordingly, their views about the benefits and pedagogical integration of these resources, the challenges they face, and their motivations for using them were also explored. Following this primary aim, answers to the sub-aims below were also sought:

1. What are PCG teacher candidates' opinions about the educational benefits of AR/VR technologies and their self-efficacy perceptions on using these technologies?
2. How do PCG teacher candidates plan to pedagogically integrate AR/VR technologies into their future teaching practices?
3. Which potential challenges do PCG teacher candidates see in the integration of AR/VR technologies into educational settings, and what are their solution proposals to these challenges?
4. What are the PCG teacher candidates' motivations for the AR/VR-supported teaching?

Method

Research Model

This study employed a phenomenological design utilizing a qualitative research approach. Phenomenological designs focus on comprehending the essence of individuals' experiences related to a certain phenomenon (Yıldırım & Şimşek, 2021); therefore, using this design in the current study provides a proper framework to understand teacher candidates' perceptions of AR/VR technologies.

Participants

The study was conducted with 28 second-year teacher candidates who took the "Teaching Technologies" course at the PCG Department of Education Faculty at a state university in Türkiye in the spring semester of the 2023-2024 academic year. The participants were selected through the convenience sampling method, and the participation was based on the principle of voluntary consent.

Table 1: Demographics of the Participants

Variable	Category	Number(n)	Percentage (%)
Gender	Female	21	75
	Male	7	25
Previous AR/VR Experience (before the course)	Yes	10	35.7
	Partially	9	32.1
	No	9	32.1
Undergraduate Program	PCG (Psychological Counseling and Guidance)	28	100

Data Collection Tool

Data were collected using a questionnaire consisting of four open-ended questions on Google Forms. The questions were cautiously written to address each sub-aim and collect in-depth data:

1. What do you think about the general benefits of AR/VR technologies in education, and how competent do you feel yourself in using these technologies?
2. For which pedagogical purposes and with what kind of practices do you plan to utilize AR/VR technologies?
3. What kind of challenges can you face in the integration of AR/VR technologies into educational settings, and what are your solution proposals to these challenges?
4. How do the AR/VR-supported learning environments affect your motivation as a teacher candidate?

Data Collection Process

Data were collected after carrying out a two-week theoretical training and offering short-term practical experiences on AR/VR technologies within the scope of the "Teaching Technologies" course. A Google Forms link was shared with the participants, and they were informed that their answers would be gathered based on their voluntary consent and kept anonymously. Consequently, the study was conducted with 28 voluntary teacher candidates answering the open-ended questions in the form.

Data Analysis

Data were analyzed using the content analysis method proposed by Yıldırım and Şimşek (2021). The analysis process was composed of the phases of getting familiar with the data, creating meaningful codes, synthesizing the codes under categories, identifying the themes, editing the themes, and interpreting the findings. Two researchers coded the data independently to ensure the reliability of the study, and the consistency between the coders was found to be 85%.

Findings

Findings were obtained as a result of the content analysis performed according to the four sub-aims of the study and presented in tables arranged for each theme.

Finding 1: Educational Benefits of AR/VR Technologies and Self-Efficacy Perceptions of Teacher Candidates

Table 2: Themes Related to Educational Benefits of AR/VR Technologies and Self-Efficacy Perceptions of Teacher Candidates

Main Theme	Sub-Theme	Code	f
Educational Benefits and Self-Efficacy	Benefits	Increase in Motivation	18
		Ease of Visualization	14
		Experiential Learning	12
		Interactive Learning	11
		Addressing Individual Differences	10
		Real World Connection	10
		Supporting Distance Learning	6
		Encouraging Creative Thinking	5
		Accessibility for Disabled People	2
		Continuity of Technology	1
		Ease of Simulation	1
	Self-Efficacy Perceptions	Feeling Competent (Yes)	20

		Feeling Partially Competent	6
		Feeling incompetent (No)	2
	Factors Affecting Competence	Need for More Training	6
		Need for Technical Support	4
		Limited Application Experience	3
		Search for Peer Support	1

As seen in Table 2, teacher candidates specified the increase in student motivation, the visualization of complicated topics, experiential and interactive learning opportunities, addressing individual differences, and connecting with the real world as the benefits of AR/VR technologies. Regarding the self-efficacy perceptions, while a large number of the participants (20/28) regarded themselves as competent in using these technologies, six of them regarded themselves as partially competent, and two of them described themselves as incompetent in using them. The primary factors that affected their competence perceptions were revealed to be the need for more training, the need for technical support, and the limited application experience.

Direct Excerpts:

- *AR/VR technologies make the lessons much more engaging and reinforce learning. I see myself as competent in using these technologies. They are not difficult to use." (P4)*
- *"I have theoretical knowledge, but I will feel more competent if I practise more." (P13)*
- *"Since I have no experience, I do not feel competent in these technologies. I do not know where to start." (P26)*
- *"These technologies enable students to learn according to their individual differences and at their own pace. With the videos and visuals in them, they motivate students for effective learning." (P15)*
- *"If we get more applied training, we can use these technologies much better after graduating. It is a big advantage that they transform the theoretical information into three-dimensional, detailed visuals." (P18)*

Finding 2: Opinions about the Pedagogical Integration of AR/VR

Table 3: Themes Related to the Opinions about the Pedagogical Integration of AR/VR

Main Theme	Sub-Theme	Code	f
Pedagogical Applications	Interactive and Student-Centered Learning	Virtual Tour Applications	18
		3D Visualization and Modeling	15
		Personalized Learning Methods	12
		Psychological case/Scenario-Based Learning	11
		Cooperative Project Works	10
		Development of Problem-Solving Skills	8
		Creative Content Production	5
		Emotion Management Skills	2
	Challenges in the integration of AR/VR	Difficulty in Integrating into the Curriculum	12
		Lack of Effective Pedagogical Design	10
		Difficulty in Finding Appropriate Content for the Topic	7
		Difficulty of Assessment and Evaluation	1

According to Table 3, teacher candidates plan to use AR/VR technologies for student-centered practices such as virtual tours, 3D modeling, personalized learning paths, psychological case/scenario-based learning, cooperative project work, and development of problem-solving skills. Innovative ideas such as emotion management

simulations, particularly in the field of PCG, were also proposed. However, they think they will face challenges in integrating AR/VR into the curriculum, making an effective pedagogical design, and finding appropriate content for the course.

Direct Excerpts:

- *"Using VR in the counselling course, we can make up scenarios about bullying and anxiety and thus improve students' social skills in a safe, three-dimensional environment." (P7)*
- *"I want to visualize complicated concepts like the structure of the brain three-dimensionally, but I do not exactly know how and with which objective of the curriculum to connect this. In addition, I think the students can work on AR cooperatively and solve the problem in the scenario." (P16)*
- *"AR/VR can be very useful in creating learning paths according to the students' individual needs. By using 3D animations, they can learn at their own pace and visit virtual museums." (P21)*
- *"We can take our students to Ancient Rome or an arts gallery with virtual tours. Other scenarios can also serve the individual learning." (P11)*

Finding 3: Challenges in AR/VR Integration and Solution Proposals

Table 4: Themes Related to Challenges in AR/VR Integration and Solution Proposals

Main Theme	Sub-Theme	Code	f
Integration Challenges and Solutions	Technological and Pedagogical Obstacles	High costs	20
		Insufficient Teacher Training on AR/VR	15
		Technical Infrastructure Deficiencies at Schools	13
		Insufficiency of Technical Support	12
		Difficulty of Developing Content	10
		Digital Fatigue and Concerns about Health	5
		Ethical and Data Privacy Concerns	2
		Prejudices of the school administration	1
		Divergence from the Topic	1
	Solution Proposals	Institutional Investment and Governmental Support	16
		Comprehensive and Applied Training	12
		Developing Open-Source/Free Content Platforms	11
		Employment of Technical Support Staff at Schools	7
		Dissemination of Pilot Applications	2
		Applications Proper for Students' Levels	1

As it is clear in Table 4, teacher candidates expressed high costs, insufficient teacher training on AR/VR, technical infrastructure deficiencies at schools, and insufficiency of technical support as the biggest obstacles to the integration of AR/VR. Moreover, they pointed out the digital fatigue and concerns about health that occur as a result of long-term use of these technologies as another important obstacle to using AR/VR. They proposed institutional investment in schools, developing open-source and free content, employment of technical support staff at schools as solutions to the challenges in the integration process.

Direct Excerpts:

- *"VR glasses are too expensive. It is almost impossible to buy them using the budget of school. This problem can be solved with governmental support and projects. In addition, there may be a need for technical support staff and trainers." (P5)*
- *"Internet connection is slow at schools, and computers are too old. It is very difficult to use AR/VR with such a poor infrastructure." (P18)*
- *"No matter how much we want to use them, we cannot utilize these technologies comfortably in the class unless we get a thorough in-service training on how to use them effectively. Free training platforms may become widespread for teachers of all branches." (P23)*
- *"If there were an information technology or technical support specialist at schools, we could get help from them for any problem. This can make using these technologies much easier. Even though we have such specialists, these technologies, especially the VR technology, are still too expensive for public schools." (P12)*

Finding 4: Motivations for Using AR/VR Technologies in Learning Environments

Table 5: Themes Related to Motivations for Using AR/VR Technologies

Main Theme	Sub-Theme	Code	f
Motivation	Reasons for High Motivation	Innovative/Engaging Potential of Technology	16
		Capacity for Increasing Student Engagement	13
		Enabling Fun Learning	11
		Offering Professional Development Opportunities	10
		Facilitation of Achieving Learning Goals	9
		Making Learning Permanent	2
		Creating a Competitive Environment	1
		Being Eye-Catching	1
		Opportunity for Cooperation	1
		Being Connected to Technology	1
	Factors Reducing Motivation	Limited Experience and Lack of Knowledge	10
		Technical Concerns	8
		Need for Counseling and Mentoring	5
		Difficulty in Time Management	1
		Useless Glasses	1
		Useless Technologies/Applications	1

According to Table 5, most of the teacher candidates had high levels of motivation for learning environments AR/VR technologies were used. Innovative potential of these technologies, their capacity for increasing student engagement, enabling fun learning, offering professional development opportunities, and belief in the facilitation of achieving learning goals were the underlying reasons for such motivation. However, the factors such as limited experience with these technologies, technical concerns, need for counseling and mentoring, and useless technologies/applications were regarded as slightly reducing the teacher candidates' motivation for using them.

Direct Excerpts:

- *"AR/VR makes classes much more engaging than the traditional methods, which motivates me a lot as a teacher, and these technologies play a significant role in our professional development." (P6)*
- *"I dream about how actively the students will participate in classes thanks to these technologies. This is very exciting. Managing the class time can be difficult." (P20)*
- *"Since I have limited experience and worry that ' what if I fail to use or a technical problem occurs?', I hesitate to use them." (P25)*

- *"Teaching in the class by using AR/VR contributes to my professional development. Therefore, I am enthusiastic about improving myself in this area. I believe my students will be more eager to participate in the class as I create such effective environments." (P14)*

Discussion and Conclusion

This study unraveled that PCG teacher candidates had positive opinions about the educational potential of AR/VR technologies, yet there were some significant obstacles to be eliminated in order to realize this potential. The teacher candidates agreed on the major benefits of these technologies, such as an increase in students' motivation, visualization of complicated concepts, and experiential learning opportunities. Most of the teacher candidates felt themselves competent in using these technologies, which indicates a positive attitude towards technology among PCG teacher candidates. This finding resonates with the studies positing that the use of VR can increase teacher candidates' self-efficacy levels (Nissim et al., 2020). Nevertheless, lower levels of self-efficacy felt by some of the teacher candidates due to limited experience and need for technical support denote the need for more applied training (Major et al., 2022). This finding underlines that there should be more applied workshops on AR/VR besides the theoretical courses about these technologies in teacher education programs.

In the context of pedagogical integration of AR/VR, teacher candidates intend to use these technologies for student-centered practices such as virtual tours, 3D modeling, and personalized learning. This refers to that teacher candidates regard AR/VR technologies not only as a tool for teaching but also as a pedagogical transformation element. However, the uncertainties and concerns they experience about the integration of AR/VR into the curriculum manifest that the effective use of technology requires their compatibility with the curriculum and a sound pedagogical design (Mystakidis et al., 2022).

The finding that the biggest obstacles to this integration were listed as high costs, technical infrastructure deficiencies, and insufficient teacher training on AR/VR corroborates with the findings of other studies in the literature (Li et al., 2025). These findings support that the promotion of AR/VR in educational settings can be possible with not only individual attempts but also institutional investments in the infrastructure of schools and extensive training programs.

Finally, teacher candidates' high levels of motivation were found to be derived from the innovative potential of AR/VR and their capacity for increasing student engagement. This result is consistent with the literature suggesting that VR enhances student engagement and cognitive gains (Makransky & Petersen, 2021). Consequently, for an effective use of AR/VR in education, this study shows that there is a need for a multi-dimensional approach which includes applied teacher education, infrastructural investments, and development of accessible and curriculum-appropriate content. All these findings can serve as a pathfinder for education policy makers and teacher education programs to maximize the potential of AR/VR technologies in the field of PCG.

Recommendations

Teacher education programs should offer applied courses and workshops on not only the technical use of AR/VR technologies but also the pedagogical integration of them.

- Educational institutions should be provided with financial and technical support for establishing the necessary hardware and software infrastructure to use AR/VR technologies.
- Platforms and projects that promote the development of free and open-source AR/VR content compatible with different courses and course objectives should be supported.
- User-friendly AR/VR interfaces should be designed for a more comfortable use of these technologies by teachers and students, and technical units should be set up at schools to offer educational and solution-oriented technical support.

Limitations

This study is limited to a sample of 28 PCG teacher candidates at a single state university. Future studies can increase the generalizability of the findings by examining this phenomenon more comprehensively with larger samples and mixed-method research designs.

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Student Attitudes Toward the Use of Artificial Intelligence in Education

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Abstract

This study aimed to examine students' awareness, understanding, and attitudes toward AI in education, as well as their experiences with AI-based tools for learning. A total of 242 primary and secondary school students participated in a online survey consisting of both dichotomous and Likert-scale questions.

Results show that nearly all participants (99%) have heard of the term "artificial intelligence" or "AI," and a large proportion (79.3%) reported a good or very good understanding of what AI is (ratings 4 or 5 on a 5-point scale). Furthermore, 81.4% of students stated that they had used an application or website that utilizes AI for educational purposes.

Students generally held positive views on the potential of AI to enhance education. When asked whether AI can make learning better and more engaging, 61.6% responded positively (ratings 4 and 5), while only 17.8% expressed disagreement (ratings 1 and 2). However, perceptions of teacher readiness lag behind: only 7.9% of students felt their teachers knew enough about AI to apply it in class (rating 4 or 5), whereas 53.7% rated their teachers' AI competence as poor (ratings 1 or 2).

Among those who used AI tools for learning, 56.6% rated their experience as highly satisfying (ratings 4 or 5), while only a small minority (5.8%) rated it negatively. These results suggest that students are not only familiar with AI but also willing to engage with it in educational settings and they perceive it as a useful aid to learning.

However, the findings also reveal concerns about the extent to which teachers are equipped to support the integration of AI in the classroom. This discrepancy between student readiness and perception of teacher competence highlights the need for targeted professional development programs aimed at improving educators' digital and AI-related competencies.

In conclusion, while students appear well-prepared and positive about the use of AI in education, successful implementation will depend on systemic efforts to close the knowledge and skills gap among teaching staff. These insights can inform policy development, curriculum design and teacher training strategies to support effective and responsible integration of AI in education.

Keywords: Artificial Intelligence in Education; Student Perceptions; Educational Technology

Introduction

Artificial Intelligence (AI) has transitioned from a futuristic concept to a practical tool that is reshaping modern society. Its influence is pervasive, impacting industries from healthcare to finance, and its entry into the field of education promises a paradigm shift in teaching and learning methodologies (Mhlanga, 2024). At the secondary school level, AI-driven technologies offer the potential for personalized learning paths, instant feedback, and access to vast information resources, thereby making education more accessible, efficient, and engaging (Zawacki-Richter et al., 2019). As these tools become more sophisticated and widespread, secondary schools face the critical task of integrating them thoughtfully and effectively.

The success of this integration, however, does not solely depend on technology itself, but heavily on the perceptions and readiness of its primary users: students and educators. While much of the discourse focuses on the technological capabilities of AI, the human factor remains paramount. Student acceptance, usage patterns, and attitudes are key indicators of whether these new technologies will be adopted successfully or met with resistance, especially during the formative years of secondary education.

This study focuses on the secondary school student perspective within the Croatian educational landscape. As a nation navigating the digital transformation, understanding how Croatian adolescents perceive and interact with AI is essential for shaping national educational strategies. This research aims to answer the following questions:

1. What is the level of awareness and self-assessed understanding of AI among Croatian secondary school students?

2. To what extent have these students utilized AI-powered applications for learning?

3. What are their attitudes towards the potential of AI to improve the learning experience?
4. How do they perceive their teachers' preparedness to implement AI in the classroom?

By exploring these questions, this paper provides valuable insights for educators, policymakers, and technology developers, highlighting both the enthusiasm of the student body and the critical barriers to implementation that need to be addressed at the secondary level.

Literature Review

The discourse on AI in education is multifaceted, covering pedagogical potential, implementation challenges, and ethical considerations. Globally, AI is recognized for its capacity to create adaptive learning environments that cater to individual student needs, a concept often referred to as Personalized Learning (Ouyang & Jiao, 2021). These systems can analyse a student's performance in real-time and adjust the difficulty and content of tasks, providing a customized educational journey that traditional models cannot easily replicate. Furthermore, AI tools, such as intelligent tutoring systems and AI-powered research assistants, can automate routine tasks, freeing up educator time for more meaningful, high-impact interactions with students (Chen et al., 2020).

Despite the recognized potential, the adoption of AI in educational settings is not uniform and faces significant hurdles. A primary challenge is the digital divide, which encompasses not only access to technology but also the digital literacy required to use it effectively (Weng et al., 2024). For students to benefit from AI, they must possess a foundational understanding of the technology, a competency that secondary education is increasingly expected to foster.

Another critical factor is the role of the educator. The integration of AI requires a shift in the teacher's role from a primary source of information to a facilitator of learning. This necessitates comprehensive professional development and training to equip teachers with the skills to use AI tools effectively and pedagogically (Røkenes et al., 2022). Research consistently shows that teacher attitudes and competencies are among the most significant predictors of technology integration in the classroom. A lack of confidence or knowledge can create a major barrier, regardless of student enthusiasm or institutional investment. This study builds on this existing literature by providing a specific national context, examining the alignment—or misalignment—between secondary school student perceptions and the perceived readiness of the educational system in Croatia.

Methodology

This study employed a quantitative, cross-sectional survey design to collect data on student perceptions of AI in education. This approach was chosen to efficiently gather descriptive data from a relatively large sample to identify trends and attitudes.

The sample consisted of 242 students currently enrolled in secondary schools in Croatia. The participants were recruited through online platforms and school networks. Participation was voluntary and anonymous.

The data collection instrument was a structured online questionnaire. The questionnaire consisted of seven items designed to measure the key variables of the study. These included:

- A dichotomous (Yes/No) question to gauge awareness of the term "AI".
- A 5-point Likert scale question to measure self-assessed understanding of AI (1 = Very poor understanding, 5 = Excellent understanding).
- A dichotomous (Yes/No) question on the prior use of AI-powered applications for learning.
- A 5-point Likert scale question asking students who had used AI tools to rate their experience (1 = Very negative, 5 = Very positive).
- A 5-point Likert scale question assessing the perceived potential of AI to make learning better and more interesting (1 = Not at all, 5 = Very much).
- A 5-point Likert scale question measuring the perception of teachers' knowledge of AI for use in teaching (1 = Not nearly enough, 5 = More than enough).

The questionnaire was created using a standard online survey tool and the link was distributed electronically. The introductory page of the survey explained the purpose of the research and assured participants of their anonymity. Data was collected over a period of four weeks.

Upon closing the survey, the collected data was exported for analysis. Descriptive statistics, including frequencies and percentages, were calculated for all variables. The results were compiled into tables to provide a clear and comprehensive overview of the findings.

Results

The analysis of the 242 completed surveys yielded the following results, which directly address the research questions.

4.1. Awareness and understanding of AI

There is near-universal awareness of the term "Artificial Intelligence" or "AI" among the student population surveyed. As shown in Table 1, 99% of respondents (n=240) confirmed they had heard of the term.

Table 1. Awareness of the Term "AI"

	Yes	No
Have you heard of the term "artificial intelligence" or "AI"?	240 (99.2%)	2 (0.8%)

Regarding their self-assessed level of understanding, the responses were positively skewed. A significant majority, 79.33%, rated their understanding as a 4 or 5 on a 5-point scale. Specifically, 44.21% (n=107) reported an "excellent" understanding (5), and 35.12% (n=85) reported a "good" understanding (4). Only a small fraction felt their understanding was poor (Table 2).

Table 2. Self-Assessed Understanding of AI.

	1 Very poor understanding	2	3	4	5 Excellent understanding
How well do you understand what artificial intelligence is?	3 (1.2%)	8 (3.3%)	39 (16.1%)	85 (35.1%)	107 (44.2%)

4.2. Usage and Experience with AI Tools for Learning

A large majority of students, 81.40% (n=197), reported having used an application or website that utilizes AI for learning or teaching. To gauge the quality of these interactions, these experienced users were asked to rate their experience on a 5-point scale. The feedback was predominantly positive, with 56.61% of students providing a favorable rating of either 4 (32.23%) or 5 (24.38%). A significant portion of students (29.34%) remained neutral with a rating of 3. In contrast, a smaller minority expressed a negative experience, with 14.05% of students selecting a rating of 1 or 2. This indicates that for the vast majority of students who have engaged with AI learning tools, the experience has been beneficial or, at worst, neutral, with very few reporting a strongly negative interaction (Table 3).

Table 3. Rating of Experience with AI Learning Tools.

	1 Very negative	2	3	4	5 Very positive
If you have used	14 (5.8%)	20 (8.3%)	71 (29.3%)	78 (32.2%)	59 (24.4%)

AI learning tools, how did you like it?					

4.3. Perceived Potential of AI in Education

Students are generally optimistic about the role AI can play in enhancing their education. When asked if AI could make learning better and more interesting, 61.57% of respondents chose a 4 or 5 on the scale, signaling strong agreement (Table 4).

Table 4. Can AI Make Learning Better and More Interesting?

	1 Not at all	2	3	4	5 Very much
What do you think, can artificial intelligence help make learning better and more interesting?	11 (4.6%)	32 (13.2%)	50 (20.7%)	89 (36.8%)	60 (24.8%)

4.4. Perception of Teacher Readiness

In stark contrast to their personal readiness and optimism, students expressed significant doubt about their teachers' preparedness to use AI. An overwhelming 92.15% of students rated their teachers' knowledge of AI as a 3 or lower. More than half of the respondents (53.72%) chose the lowest two ratings (1 or 2), indicating a strong perception that educators are not equipped to integrate these tools into their teaching (Table 5). Only 7.85% felt their teachers were adequately knowledgeable.

Table 5. Do Teachers Know Enough About AI to Use It in Teaching?

	1 Not nearly enough	2	3	4	5 More than enough
Do you think your teachers know enough about artificial intelligence to be able to use it in their classes?	33 (13.6%)	97 (40.1%)	93 (38.4%)	13 (5.4%)	6 (2.5%)

Discussion

The findings of this study offer a compelling snapshot of student perspectives on AI in Croatian secondary education. The near-universal awareness (99%) of AI is notable, but the high level of self-reported understanding (79% rating it 4 or 5) and usage (81%) among high school students is particularly striking. It suggests that this generation is not just passively encountering AI but is actively and independently using these technologies for their studies before even entering higher education. Their largely positive experience ratings indicate they are already finding value in these tools.

This high level of student engagement and optimism about AI's potential to improve learning is a powerful asset for the educational system. It indicates a "pull" from the student side for more technologically advanced pedagogical approaches. Students see the potential for AI to create more dynamic and effective learning experiences, aligning with the benefits touted in existing literature (Ouyang & Jiao, 2021).

However, the most critical finding of this study is the dramatic disconnect between student readiness and their perception of teacher readiness. The data paints a picture of a student body that is ready, willing and able to embrace AI, while viewing their educators as largely unprepared for this technological shift. The fact that over 92% of students doubt their teachers' proficiency in this area is a significant warning. This perception, whether fully accurate or not, can undermine the effective implementation of AI tools, as it may lead to a lack of trust in AI-based initiatives led by instructors. This finding strongly supports the argument made by Allman et al. (2021) that teacher training is the lynchpin for successful technology integration. Without confident and competent educators to guide the process, even the most advanced AI tools may fail to achieve their pedagogical goals.

This study has several limitations. The sample, while reasonably sized, was one of convenience and may not be fully representative of all secondary school students in Croatia. The data is self-reported, which can be subject to bias; for instance, students may overestimate their understanding of AI. Future research could employ more objective measures of understanding and expand the sample to include different types of secondary schools (e.g., vocational vs. general) and regions.

Conclusions

This study reveals a clear and promising trend: Croatian secondary school students are highly aware of, actively using and optimistic about the potential of Artificial Intelligence in their education. They represent a motivated and receptive audience for the integration of innovative, AI-powered learning tools well before they reach university.

However, this optimism is tempered by a significant concern regarding the capabilities of their educators. The perceived lack of teacher readiness is the single greatest barrier highlighted by this research. The central implication of this study is unequivocal: for Croatia to successfully harness the power of AI in education, the focus must shift urgently and decisively towards comprehensive and continuous professional development for secondary school teachers. Educational institutions and policymakers must invest in training programs that not only build technical skills but also foster pedagogical innovation, enabling teachers to move from being perceived as unprepared to becoming confident facilitators of 21st-century learning. Bridging this gap is not just a recommendation; it is an imperative for the future of secondary education in the age of AI.

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Instructor situational awareness in the learning process with game codesign in higher education: A research proposal

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Abstract

The learning process with game codesign has proven to be a pedagogical strategy that allows students to deepen their technical knowledge and skills in practical situations. However, the involvement of multiple actors and the diversity of contexts of higher education institutions require that the instructor has situational awareness and can guide pedagogical decisions in real-time when teaching or orchestrating instruction. This research aims to develop an instrument that supports teachers/instructors/professors in situational awareness during the learning process through codesign, which enables the collection, organization, and utilization of information on students' needs and the adaptation of the learning process to meet these needs. This approach seeks to ensure the progress of activities in the specific context of higher education institutions. The purpose is to ensure an informed and adapted pedagogical approach during the learning process through codesign. The methodology to be followed is Design Science Research (DSR), structured into six stages, and will result in the development of an artifact that enables instructors to gain situational awareness of the learning process through co-design for pedagogical orchestration. Validation will be conducted through a combination of surveys, focus groups, and peer review. The study aims to contribute to future studies on models that enable real-time situational awareness for instructors, allowing them to make informed pedagogical decisions through codesign.

Keywords: Game Codesign, teachers, instructors, Situational Awareness, Learning Process, Pedagogical Orchestration.

Introduction

Learning through codesign has proved to be a pedagogical strategy, according to Sunday et al. (2025). They made use of the codesign with tools such as Scratch in which they created COVID-19 dissemination games, among Nigerian secondary school students, for in-depth understanding of computational thinking concepts in practical situations. This is to reinforce technical mastery in decomposition, abstraction, and algorithmic reasoning. Agbo et al. (2021) demonstrated that the codesign of mini games in online environments favors the development of computational thinking by allowing students to relate contextual narratives to games and collaborate in the creation of games.

The approach of codesign involves the active participation of students, teachers, developers, and experts in the process of co-creating games. This approach allows students to learn while designing, creating and evaluating artifacts, such as games, around word problems. (Sunday et al., 2025)

According to Wang et al. (2023), the learning process with codesign is sustained through the idealization and prototyping of games, where students identify typical elements of games, such as clear goals, progressive challenges, immediate feedback, and interactivity. This reinforces in students the learning process of codesign from games to computational thinking.

Codesign for learning needs to incorporate situational awareness to balance the learning objective and the creation of the game, with the participation of the teacher as a fundamental actor for this awareness. The presence of teachers ensured equal attention to learning, as they brought knowledge "in situ" fundamental to the students and the learning environment to align the game with the curriculum and the school reality. (Ding et al., 2025)

Despite the recognition of the pedagogical potential of codesign, it is necessary to reflect on the challenges that arise in its implementation, emphasizing the importance of ensuring the teacher a situational awareness to monitor the learning process with codesign.

Counter Argument

The learning process with codesign that involves different actors, with different experiences, ages and roles, can bring challenges to the teacher on an integrated and situated view of the real needs of the learning environment.

The study of Havukainen et al. (2025), describes that although intergenerational participation has resulted in the production of creative games based on the observation of children's play. The authors indicate that secondary school students had difficulties in faithfully interpreting the symbolic meanings of the actions of younger children. This limited the full transfer of the game context to the final digital design.

This limitation compromised the fidelity of the game context in the transposition to the final digital design. When those involved try to observe and translate the reality of a group, the absence of qualified pedagogical mediation leads to games decontextualized with the learning objectives.

The teacher must articulate, in a critical and informed way, the different perceptions, experiences and learning objectives to ensure that emerging ideas are oriented towards concrete pedagogical outcomes.

The study of Gaydos (2021) argues that many educational games fail not because of a lack of technical quality or pedagogical intentionality, but because they do not adequately consider the context in which they will be applied.

By reporting the experience in the development of educational games in Singapore, the author shows that, despite institutional investment and the production of theoretically sound games, effective adoption in schools was limited. The main reason identified for this failure was the lack of attention to contextual factors and the practical needs of teachers, such as the time available in class, the learning objectives and the profile of the students. (Gaydos, 2021)

The author emphasizes that an educational game, by itself, does not change teaching practices or guarantee meaningful learning, especially if it is not accompanied by strategies that support the teacher in his pedagogical integration. He argues that the disconnect between game design and classroom reality compromises its applicability and effectiveness. (Gaydos, 2021)

This disconnection can be mitigated if the teacher has an instrument that allows him to have a contextualized, continuous and systematic reading of the learning process during the use of the game. That is, a resource that offers you real-time indicators on student engagement, alignment with educational objectives, and emerging difficulties.

The findings of Sunday et al. (2025) show that the initial enthusiasm of students is sufficient to guarantee the success of the learning process with codesign, which is a simplistic view. It disregards the concrete challenges faced, especially in contexts marked by structural limitations in educational institutions. Through workshops, the authors observed that, despite the initial enthusiasm and the learning of relevant concepts such as decomposition and abstraction, several obstacles compromised the learning process with codesign.

Among the main obstacles identified, the lack of adequate technological infrastructure, the scarce teacher training and the absence of instruments that would allow the teacher to monitor the progress of students and guide learning in a contextualized way stand out. At various points in the process, teachers could not understand which groups were advancing, which were deviating from pedagogical objectives, or what difficulties they were facing. (Sunday et al., 2025)

Although many approaches to learning with codesign present promising results, such as in the development of competences, these studies support assumptions that are not verified in the complex reality of higher education.

The study by Li et al. (2023), which directly addresses the context of higher education, argues for the development of a serious game, called Easy Induction created with university students, through a structured codesign process mediated by three participatory workshops. Although the students showed enthusiasm and involvement, the challenges of adaptation such as difficulty in accessing information, lack of knowledge of physical space and low social participation revealed that meaningful learning does not result only from collaboration or motivation.

The quantitative findings by Li et al. (2023) demonstrated that the use of pre- and post-tests was the only way to achieve notable gains in the sense of belonging, the ability to access institutional resources, and the acquisition of knowledge about the university. Usability and user experience scales were also used. The educator's situational awareness of the context's dynamics and limitations contributes to their active participation.

Thus, contrary to the simplistic views that attribute success of learning with codesign to student motivation or to the spontaneity of teacher adaptation. The studies analyzed here highlight the need to develop instruments that support teachers in the collection and organization of information in real time. Only based on this situational awareness is it possible to make informed pedagogical decisions throughout the learning process with codesign in higher education.

In summary, the studies presented converge to the identification of a recurring problem: the difficulty of the teacher having in real time the situational awareness about the learning process with codesign of games with higher education students to allow the capacity of pedagogical orchestration of the learning process with codesign?

That said, this position paper raises the creation of an instrument capable of supporting teachers in situational awareness for pedagogical action in the learning process with codesign in higher education. Based on the premise that the instrument will be able to provide real-time indicators on the needs of students, their difficulties, and the alignment of activities with pedagogical objectives. Next, this position is argued, based on the evidence and gaps identified, seeking to support the need and relevance of a more in-depth investigation into this possibility.

Argument

Despite promising evidence on the use of codesign in learning, as documented by Sunday et al. (2025) and Agbo et al. (2021), it remains unclear how this process can be effectively sustained in the context of higher education. The studies that point to benefits also point to limitations, which suggest that there are still little aspects explored in teacher mediation in this type of approach.

The work by Li et al. (2023), although carried out with university students, does not specify how such instruments could be appropriated directly by the teacher to maintain situational awareness.

The authors Bergen et al. (2020) reinforce the importance of structured support tools for participatory codesign workshops, however there are few studies that focus on the development of specific instruments that promote the teacher's situational awareness in codesign learning environments.

The studies by Ding et al. (2025), as observed, tend to describe the presence of the teacher as a positive factor, without detailing how the information that supports their performance is collected and used.

It is pertinent to investigate what type of artifact can support pedagogical orchestration in codesign contexts in higher education. This research is not limited to a tool but proposes designing a model that allows the teacher to understand the critical dimensions in the learning process with codesign in real time. This is done through data systematization for a more informed pedagogical performance.

Given the main objective of the research, based on the research problem, the following research questions arise:

- *RQ1: What kind of information do teachers need to gather to develop situational awareness about the specific needs of students during the codesign learning process?*

This question arises from the realization that the teacher requires information about the students' profiles, their difficulties, levels of involvement, and progress in the activities. As previously mentioned with the Sunday et al. (2025) and Havukainen et al. (2025) It is important to collect and organize information about the students, which allows the teacher to adjust the pedagogical mediation, keeping the focus on the learning process with Codesign.

- *RQ2: How can teachers adapt the learning process with codesign in conditions and limitations of the context of higher education institutions that compromise this process?*

This question focuses on the context of higher education institutions as discussed in the studies of Ding et al. (2025) and Gaydos (2021), on the weak adaptation of the codesign process to infrastructural realities, unavailability of resources, technological and other constraints. It is pertinent for the teacher to adapt the strategies of codesign without compromising learning outcomes.

- *RQ3: What strategies should be considered in the design of an instrument that allows the teacher to maintain situational awareness to make appropriate decisions during the learning process with codesign?*

This question is based on the need to create an artifact that helps the teacher to identify which data should be collected systematically in real time.

Conclusions

The learning process with codesign represents a learning strategy to develop skills in students. However, for this approach to be effective, it is essential that the teacher have situational awareness throughout the learning process.

The argument presented here shows that the absence of mechanisms that support the collection of contextual and pedagogical data in real time compromises the teacher's ability to make decisions adjusted to the needs of students. It also highlights the structural limitations of the environment of higher education institutions.

Unlike previous studies that focus on the codesign process from the student perspective, this research focuses on the role of the teacher in real-time pedagogical orchestration, an aspect that has been little explored until now.

To operationalize this research proposal, the methodology Design Science Research, as outlined by Peffers et al. (2007). The instrument allows the teacher to identify students' needs (RQ1), identify contextual constraints of higher education institutions that affect the process of codesign (RQ2), and make informed and adaptive pedagogical decisions, aligned with the learning objectives (RQ3). The action plan will be structured in the following steps:

- Problem Identification and Motivation: An in-depth survey of the limitations faced by teachers in mediating processes with codesign will be conducted, including a systematic literature review Kitchenham & Charters (2007) and interviews with teachers in higher education institutions.
- Definition of Objectives: Based on the needs analysis, the functional and pedagogical requirements will be defined for the development of an artifact that supports pedagogical decision-making based on real-time data.
- Design and Development of the Artifact: which will involve the codesign of a model prototype that can integrate support for interactive visualizations of educational data, with the support of web technologies, in collaboration with teachers, ICT specialists, and students.
- Demonstration: the artifact will be applied in a real context of higher education, in learning experiences with codesign, to observe its applicability.
- Evaluation: The artifact will be evaluated and validated by quali-quantitative methods, including surveys, focus groups, direct observation, and peer review.
- Communication and Dissemination: The results will be systematized and disseminated to the scientific and educational community for future scientific studies.

Acknowledgements

I would like to express my sincere gratitude to my supervisors of the PhD program in Web Science and Technology at Universidade Aberta, Portugal, for their invaluable support and guidance throughout this journey, as well as to Instituto Superior Dom Bosco for the generous opportunity and sponsorship granted for the realization of this course.

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Digital Educational Tools in Action: How Future Computer Science Teachers Prepare for the Classroom

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Abstract

Students of the teacher training program in computer science at the Faculty of Humanities and Social Sciences, University of Zagreb, undertake teaching practice in the summer semester of the second year of their graduate studies. Students attend teaching practice in primary and secondary schools in order to further develop their skills in delivering computer science lessons. In this way, students are prepared for their future teaching careers.

The guiding principle of our teacher education program is that a modern well-educated teachers begin to develop their digital teaching competencies during their studies. Accordingly, by attending methodical courses, students acquire knowledge and develop skills in using digital educational tools for the purpose of creating digital educational materials.

Qualified students already create digital educational materials during their teaching practice, thereby modernizing their lessons.

This paper presents a comparison of two generations of students (2023/2024 and 2024/2025) who, during their teaching practice (in 2024 and 2025), were required to deliver their lessons. Each student was expected to prepare one lesson that included a self-created digital educational materials and one lesson that did not include a self-created digital educational materials.

During their teaching practice, students engaged in self-monitoring of their lesson preparation based on defined categories:

a) Developing the idea (reflection) for the lesson;
b) Preparing educational materials;
c) Writing the teaching preparation;
d) Practicing the delivery of the lesson.

This paper provides an analysis of self-monitoring at both the generational and intergenerational levels.

Keywords: digital educational tools; digital educational materials; students; teaching practice; computer science

Introduction

The preparation of future teachers of the subject Computer Science is based on professional and pedagogical knowledge and skills acquired during university education (Yadav, Connolly, Berges, Chytas, Franklin, Hijón-Neira, Macann, Margulieux, Ottenbreit-Leftwich, & Warner, 2022), which is also supported by Roganov and Roganov (2024), who particularly emphasize the ability to recognize the pedagogical importance of using educational activities. Getting acquainted with the possibilities of the digital learning environment (Aidarbekova, Abildina, Odintsova, Mukhametzhanova, & Toibazarova, 2021), where, on the one hand, ready-made open educational materials (resources) will be used (Altynbekova, Bostanov, Kenesbayev, Ongarbayeva, Sadirmekova, 2024), while, on the other hand, the focus will be on the independent pedagogical use of digital tools in education (Dancsa, Štempeľová, Takáč & Annuš, 2023). Ongarbayeva, Kaldybaev, Kasymaliev, Kozhasheva, and Yermekova (2021), specifically for the purpose of developing digital educational materials for Computer Science, propose a methodological concept for future Computer Science teachers, which is based on three components: knowledge of digital educational materials, the skill of creating digital educational materials, and the motivation to do so. This claim is also supported by Roganov and Roganov (2023), who stress the importance of preparing a modern lesson during which future teachers, as Blyznyuk (2024) adds, educate new digitally literate generations.

Methodology

Students of the teacher training program in computer science at the Faculty of Humanities and Social Sciences, University of Zagreb, undertake teaching practice in the summer semester of the second year of their graduate studies. Students attend teaching practice in primary and secondary schools in order to further develop their skills in delivering computer science lessons. In this way, students are prepared for their future teaching careers.

Students, before they go to teaching practice, attend methodical courses, acquire knowledge and develop skills in using digital educational tools for the purpose of creating digital educational material.

Qualified students already create digital educational material during their teaching practice, thereby modernizing their lessons.

This paper presents a comparison of two generations of students (2023/2024 and 2024/2025) who, during their teaching practice (in 2024 and 2025), were required to deliver their lessons. Each student was expected to prepare one lesson that included a self-created digital educational material and one lesson that did not include a self-created digital educational material.

Each student was expected to self monitor of his lesson preparation based on defined categories:
a)Developing the idea (reflection) for the lesson;
b)Preparing educational materials;
c)Writing the teaching preparation;
d) Practicing the delivery of the lesson.
Each student had to fulfill online form.

This paper provides an analysis of self-monitoring at both the generational and intergenerational levels.

Results

Table 1. Generation 2023/2024 – Reflection, preparation, writing and rehearsal of a teaching unit that includes Digital educational material (DEM) and a teaching unit that does not include DEM

Category	Descriptive Statistics	Teaching unit with DEM	Teaching unit without DEM
Developing the idea (reflection) about the teaching unit	Mean	115.0	86.25
	Std. Deviation	150.5	68.44
Preparing teaching materials	Mean	91.25	63.75
	Std. Deviation	70.14	37.39
Writing the teaching scenario	Mean	243.8	254.4
	Std. Deviation	201.8	196.2
Teaching unit - number of characters	Mean	18,300	15,090
	Std. Deviation	7,775	4,985
Rehearsing the delivery of the teaching unit	Mean	90.00	96.88
	Std. Deviation	30.00	30.00

Table 1 presents data for the 2023/2024 student cohort (N = 8). Each student reflected on, prepared, wrote, and rehearsed the delivery of one teaching unit that included at least one Digital educational material (DEM) and one teaching unit that did not include DEM. In Table 1, the data are expressed in minutes (developing the idea [reflection] about the teaching unit, preparing teaching materials, writing the teaching scenario, rehearsing the delivery of the teaching unit) and in the number of characters used for writing the teaching scenarios.

The data show that, during the preparatory activities for the teaching unit including DEM, students on average spent more time reflecting on the teaching unit (115.0 minutes) and preparing teaching materials (91.25 minutes) compared to the teaching unit without DEM. This can be explained by the fact that students require more time to develop the idea for implementing a teaching unit that involves creating digital educational material. This is also evident in the teaching unit itself, as it contains a higher average number of characters (18,300).

On the other hand, students spent less time writing the teaching scenario (243.8 minutes) for the teaching unit that included DEM compared to the unit without DEM. A review of the teaching scenarios showed that most students wrote the teaching scenario for the DEM-based teaching unit after completing the scenario for the unit without DEM. Consequently, students spent less time writing the plan for the teaching unit that involved DEM and also spent less time rehearsing its delivery (90.00 minutes).

Table 2. Generation 2024/2025 – Reflection, preparation, writing and rehearsal of a teaching unit that includes Digital educational material (DEM) and a teaching unit that does not include DEM

Category	Descriptive Statistics	Teaching unit with DEM	Teaching unit without DEM
Developing the idea (reflection) about the teaching unit	Mean	89.29	70.71
	Std. Deviation	78.55	61.94
Preparing teaching materials	Mean	168.6	149.3
	Std. Deviation	130.1	110.6
Writing the teaching scenario	Mean	247.1	231.4
	Std. Deviation	67.51	87.83
Teaching unit-number of characters	Mean	13,150	11,500
	Std. Deviation	5,743	3,789
Rehearsing the delivery of the teaching unit	Mean	75.00	63.57
	Std. Deviation	46.99	42.00

Table 2 presents data for the 2024/2025 student cohort (N = 7). Each student reflected on, prepared, wrote, and rehearsed the delivery of one teaching unit that included at least one Digital Educational Material (DEM) and one teaching unit that did not include DEM. In Table 2, the data are expressed in minutes (developing the idea (reflection) about the teaching unit, preparing teaching materials, writing the teaching scenario, rehearsing the delivery of the teaching unit) and in the number of characters used for writing the teaching scenarios.

The data show that, during the preparatory activities for the teaching unit including DEM, students on average spent more time reflecting on the teaching unit (89.29 minutes) and preparing teaching materials (168.6 minutes) compared to the teaching unit without DEM. This can be explained by the fact that students require more time to develop the idea for implementing a teaching unit that involves creating digital educational material. This is also evident in the teaching unit itself, as it contains a higher average number of characters (13,150).

Furthermore, students spent more time writing the teaching scenario (247.1 minutes) for the teaching unit that included DEM compared to the unit without DEM. A review of the teaching scenarios revealed that most students wrote the plan for the DEM-based teaching unit before completing the scenario for the unit without DEM. Consequently, students spent more time both writing the plan for the teaching unit that involved DEM (247.1 minutes) and rehearsing its delivery (75.00 minutes).

Table 3. Cumulative data for both cohorts combined (2023/2024 and 2024/2025)

Category	Descriptive Statistics	Teaching unit with DEM	Teaching unit without DEM
Developing the idea (reflection) about the teaching unit	Mean	103.0	79.00
	Std. Deviation	118.9	63.65
Preparing teaching materials	Mean	127.3	103.7
	Std. Deviation	106.3	88.85
Writing the teaching scenario	Mean	245.3	243.7
	Std. Deviation	149.4	150.6
Teaching unit-number of characters	Mean	15,900	13,420
	Std. Deviation	7,172	4,692
	Mean	83.00	81.33

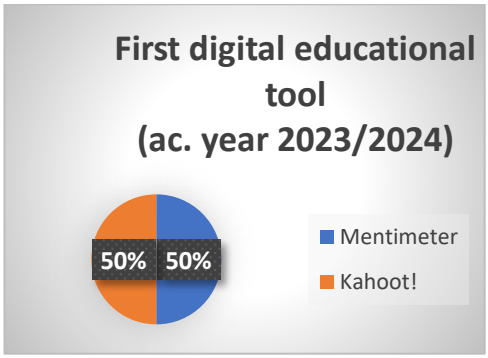
Rehearsing the delivery of the teaching unit	Std. Deviation	58.73	58.90

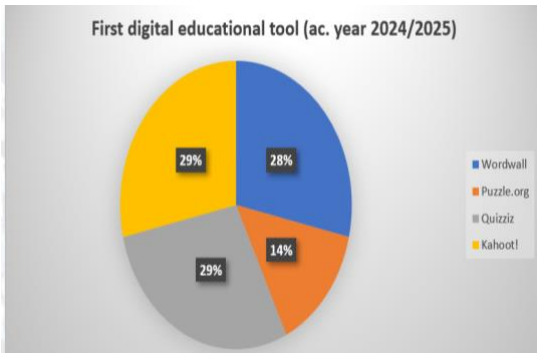
Table 3 presents the cumulative data for both cohorts combined (2023/2024 and 2024/2025; N = 15). The table shows that, for all phases (from developing the idea to rehearsing the teaching unit), students on average spent more time on activities related to teaching units that included DEM compared to units without DEM.

The preparation of a teaching unit that includes DEM follows the same preparatory phases as a unit without DEM. However, for a unit that includes DEM, at least one digital educational tool must be used to create at least one digital educational material. Consequently, reflection on the teaching unit and preparation of teaching materials require a longer period, which also results in more time spent writing a longer teaching scenario and rehearsing the delivery of the teaching unit.

Nevertheless, the results of the conducted t-test indicate that there is no statistically significant difference between teaching units that include DEM and those that do not. The study has a major limitation due to the small sample size, and therefore it should be repeated with a larger sample.

Graph 1. First digital educational tool used for creating digital educational material (DEM) (2023/2024 and 2024/2025)





Graph 1 presents the first digital educational tool used by the two student cohorts (2023/2024 and 2024/2025) to prepare educational materials for teaching lesson that included digital educational material (DEM). Each student was required to use at least one digital educational tool for a single teaching lesson.

The results show that students in both cohorts used digital educational tools they had been introduced to during methodical courses at the Faculty for creating the first DEM. In the 2023/2024 cohort, four students used Mentimeter and four students used Kahoot!, representing 100% of the students who utilized familiar tools for creating DEM in teaching lesson that included DEM.

In the 2024/2025 cohort, two students used Wordwall, two used Quizizz, and two used Kahoot!, representing 86% of the students who created DEM using tools they had learned during Faculty courses. One student used Puzzel.org, a digital educational tool that was not introduced in practical exercises, but only mentioned in theoretical lectures.

A smaller number of students used two or three DEM in their teaching lessons. In the 2023/2024 cohort, two students prepared two DEM, while in the 2024/2025 cohort, one student prepared two DEM. All these students used tools they were familiar with from the Faculty courses. Only one student in the 2023/2024 prepared three DEM, and for the third DEM, the student chose a tool he had not previously used. For the purpose of the teching practice, no one prepared three DEM in the 2024/2025.

Conclusions

Paper presents a comparison of two generations of students (2023/2024 and 2024/2025) who, during their teaching practice (in 2024 and 2025), were required to deliver their lessons. Each student was expected to prepare one lesson that included a self-created digital educational materials and one lesson that did not include a self-created digital educational materials.

The research revealed that:

- Across both cohorts, students consistently spent more time reflecting and preparing materials for DEM-based teaching lessons.

- Teaching prepartions for DEM-based lessons were generally longer in terms of characters, reflecting the additional content and structure required.
- Time spent writing and rehearsing teaching lessons varied between cohorts, influenced by the order in which DEM-based and non-DEM prepartions were prepared.
- Despite the observed trends, no statistically significant differences were found between DEM-based and non-DEM lessons, likely due to the small sample size.
- Students primarily used digital tools they had previously learned in Faculty courses to create Digital Educational Materials, highlighting that prior experience strongly influences tool choice in teacher training.

These findings highlight the additional cognitive and practical effort involved in integrating digital educational material into teaching units and suggest that further research with larger samples is necessary.

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Pre-service teachers' acceptance of Machine Learning (ML) tools for primary education students

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Abstract

Research highlights that as we are in the age of Artificial Intelligence (AI), it is essential and necessary to introduce AI, at all levels of education, to prepare young people for society of the 21st century. Machine Learning (ML) as a subfield of AI using algorithms trained on data to produce adaptable models that can perform a variety of complex tasks is integrated into various aspects of our lives but very few people understand the algorithms and technology behind it. This creates new challenges in education for integrating machine learning concepts and tools, since at primary school level, helping students understand possibilities and limitations and increase interest in the area as well as contextualize ML concepts through their societal impact. Teachers' knowledge, skills and attitudes as well as facilitation conditions formulating their acceptance of Machine Learning (ML) tools for their students. This study aims to discuss Pre-service teachers' acceptance of Machine Learning (ML) tools for primary education students. Twelve pre-service primary school teachers participated in a short course on "AI in education" that included project-based activities for their introduction to Machine Learning (ML) fundamentals and teaching them to their students. The Pictoblox, Machine Learning for kids and MakeCode Programming tools and Quarky, Nezha, Micro:bit and Smart AI lens kits used for this purpose. The participating pre-service teachers answered the questions of semi-conducted interviews to explore their acceptance of the tools for using them in their teaching. The interview questions were based on the Unified Theory of Acceptance and Use of Technology (UTAUT), the Technological Pedagogical and Content Knowledge (TPACK) model and the Technology-Organization-Environment (TOE) framework as the theoretical basis. Results discuss the acceptance in terms of Performance Expectancy, Effort Expectancy, Social Influence, ML technological knowledge, ML technological pedagogical content knowledge, Perceived Trend, Government Support, Legal Framework, Top Management Support and Intention to use.

Keywords: Artificial Intelligence, Machine Learning tools, primary school students, pre-service teachers' acceptance.

Introduction

Given that we are in the era of Artificial Intelligence (AI), it is essential and necessary to introduce AI at all levels of education to prepare young people for 21st century society. AI is increasingly being integrated into technologies for users, but algorithms can be non-transparent to them, who often do not recognize that they are interacting with AI (Long & Magerko, 2020). These misunderstandings can limit individuals' ability to effectively use, collaborate with, and act as critical users of AI (Fast & Horvitz, 2017). Both AI technologies design and education contribute to public misconceptions about AI. Black box algorithms can cause misunderstandings about AI. Even with more transparent technologies, a lack of user's technical knowledge can lead to misconceptions (Burrell, 2016). Emerging research explores ways to promote knowledge of AI to non-technical populations. It is a trend for educational institutes and educators to publish guides on how to integrate AI into primary and secondary school curricula and for researchers to explore ways to engage young students in creative programming activities related to AI (Zimmerman, 2018; Karatrantou et al., 2025a). The "*AI for K12*" working group is currently developing a set of standards for primary and secondary school grades to define what each grade should know about AI (Touretzky et al., 2019a). The group has identified five "*big ideas*" of artificial intelligence to guide the development of the standards: 1) *Computers understand the world using sensors*, 2) *Agents maintain models/representations of the world and use them for reasoning*, 3) *Computers can learn from data*, 4) *The interaction of agents with humans is a significant challenge for artificial intelligence developers* and 5) *Artificial intelligence applications can affect society both positively and negatively* (Touretzky et al., 2019a). Machine Learning (ML), as a subfield of AI that uses data-trained algorithms to produce models that can perform a variety of complex tasks, is integrated into various aspects of our lives, but very few people understand the algorithms and technology behind it. This creates new challenges in education for integrating ML concepts and tools, helping students understand the possibilities and limitations and increasing their interest in the field as well. The knowledge, skills, and attitudes of teachers, as well as the facilitating conditions shape their acceptance of ML

tools for their students. Several authors have argued that we are in the era of Artificial Intelligence (AI) Thinking, with schools playing a key role (Ramos Rivadeneira & Jiménez Toledo, 2024; Karatrantou et al., 2025b).

Machine learning (ML) in Education

In the constantly evolving digital era, the field of education has undergone profound and significant changes. The adoption of innovative technologies has transformed the way teaching and learning are addressed. ML has emerged as an extremely important tool that can profoundly influence education, by enabling data analysis, pattern recognition, and the personalization of learning experiences (Ramos Rivadeneira & Jiménez Toledo, 2024). It emphasizes the practice of personalizing learning, in which algorithms allow educational content and activities to be tailored to the individual needs of students, which can be translated into a more effective and engaging learning process. A key factor is the analysis of educational data. Through ML, educational institutions can identify patterns and trends in student performance, which directly influences decision-making to improve academic programs. Furthermore, algorithms can identify students who may face challenges in their learning process, allowing for a timely intervention and the delivery of personalized support to overcome obstacles and achieve more successful progress (Marques et al., 2020; Shao et al., 2025).

Teaching Machine learning (ML)

Nowadays, new challenges are emerging for education in the field of information technology, as students need to understand the concepts of AI from an early age so that they are not just consumers of AI, but creators of smart solutions (Kandlhofer et al., 2016; Touretzky et al., 2019b). Access to basic AI knowledge can reduce the risk of social or economic exclusion and can encourage more students to consider pursuing a career in STEM as well. Although there are currently many courses focusing on programming and robotics, primary and secondary education must incorporate the teaching of AI concepts covering five major ideas for primary and secondary education audiences: *perception*, *representation and reasoning*, *learning*, *physical interaction*, and *social impact*. In this context, ML emerges as an important area of knowledge, as it fosters a huge range of applications, from speech recognition systems to smart assistants, driverless cars, healthcare, etc (Wollowski et al., 2016; Touretzky et al., 2019a). Teaching fundamental concepts and techniques of AI (including ML) has traditionally been limited to higher education level. Computer science education is included in K-12 education around the world, but it rarely covers AI content (Hubwieser et al., 2015). In recent years, several initiatives and projects have emerged that seek to educate primary and secondary school students about AI, such as the *'AI for K-12*' initiative (Touretzky et al., 2019a), which has begun to develop guidelines for this purpose. The guidelines are based on several big ideas, such as teaching computers to learn from data, the challenges involved in the physical interaction of AI agents with humans, and the positive and negative impacts of AI on society. New AI courses, tools, and workshops have been launched to teach AI in schools in the US, China, and Europe (Pacheco et al., 2023). However, witnessing the lack of adequate training for teachers and the absence of pedagogically appropriate teaching scenarios and curricula, it is also evident that there is a need for further and deeper research in this area (Pacheco et al., 2023).

Aim and Research Questions

AI creates new challenges in education for integrating ML concepts and tools, since at primary school level, helping students understand possibilities and limitations and increase interest in the area as well as contextualize ML concepts through their societal impact. Teachers' knowledge, skills and attitudes but also facilitation conditions can formulate their acceptance of Machine Learning (ML) tools for their students. The study aims to discuss pre-service teachers' acceptance of Machine Learning (ML) tools for their primary education students. The research questions can be formulated as:

- What is pre-service teachers' acceptance of Machine Learning (ML) tools for primary education students in terms of *Performance Expectancy, Effort Expectancy, Social Influence, ML technological pedagogical content knowledge, Perceived Trend, Government Support, Legal Framework, Top Management Support* and *Intention to use*?
- Do pre-service teachers consider important for primary school students to learn about AI and ML and why? Which tools would they use with their students, and in what framework they should use such learning activities in their classroom?

Methodology

The study was qualitative research with semi-conducted interviews as the research tool. It can be considered as a case study as the sampling of the research was convenient and the participants were pre-service primary school teachers/university students attending the 4th year of their studies at the department of 'Educational Sciences and

Social Work' of University of Patras in Greece. Twelve (12) pre-service teachers participated in the study, attending a short course on "AI in education" that included project-based activities for their introduction to Machine Learning (ML) fundamentals to be able to teach them to their students and answering the interview questions voluntarily and anonymously. A thematic analysis was applied to their answers question.

Research tool

A semi-conducted interview used as a research tool. The interview questions were based on the *Unified Theory of Acceptance and Use of Technology* (UTAUT) (An et al., 2023; Ates & Polat, 2025), the *Technological Pedagogical and Content Knowledge* (TPACK) *model* (An et al., 2023; Runge et al., 2025) and the *Technology Organization Environment* (TOE) *framework* (Ates & Polat, 2025), adopting their adaption for the acceptance of robots and AI in education by teachers, as the theoretical basis of the study as well as for the questions of the interview. The interview was based on eighteen (18) questions: *two (2) questions concerning Performance Expectancy, one (1) question concerning Effort Expectancy, one (1) question concerning Social Influence, two (2) questions concerning ML technological pedagogical content knowledge, one (1) question concerning Perceived Trend, three (3) questions concerning Government Support, one (1) question concerning Legal Framework, one (1) question concerning Top Management Support and one (1) question concerning and one (1) question concerning Intention to use.* Additionally, there were four (4) questions concerning *if pre-service teachers consider important for primary school students to learn about AI and ML and why, which of the tools used in the workshop they would use with their students, if they prefer to combine educational Robotics and ML learning activities with their students, in what framework they should use such learning activities in their classroom*.

Special attention paid to ensure the validity and reliability of the research tools and the research: The translation and adaptation of the questions of each scale followed the back-translation procedure (Brislin, 1970). Two experts (one expert in Pedagogy in primary education and one expert in AI technologies in education) reviewed the questions to ensure the content validity. The same experts reviewed the learning activity worksheets to ensure their suitability for the purposes of the study. To ensure face validity of both worksheets and the interview questions a pilot implementation of the learning activities with a group of participants and a pilot interview with one participant took place (Creswell, 2011). To ensure the reliability of the content analysis, code reproducibility was tested with the participation of two additional coders (Krippendorff, 2004). To train the coders' pilot content analysis of one interview was conducted by all three coders and then the percentage of agreement among the coders was used to measure reliability that was calculated equal to 0.94, a value that considered satisfactory.

The procedure

Twelve pre-service primary school teachers participated in a short course on "*AI in education*" that included project-based activities for their introduction to Machine Learning (ML) fundamentals and be able to teach them to their students. The workshop had a duration of 30 hours. The *Pictoblox* (https://thestempedia.com/product/pictoblox/), *Machine Learning for kids* (https://machinelearningforkids.co.uk/) and *MakeCode* (https://makecode.microbit.org/) *Programming* tools and *Quarky* (https://thestempedia.com/product/quarky), *Nezha* (https://wiki.elecfreaks.com/en/microbit/building-blocks/nezha-inventors-kit/), *Micro:bit* (https://microbit.org/) and *Smart AI lens* (https://www.elecfreaks.com/learn-en/microbitplanetX/ai/Plant_X_EF05035.html) kits used for this purpose. The participants answered the questions of semi-conducted interviews after the end of the workshop.

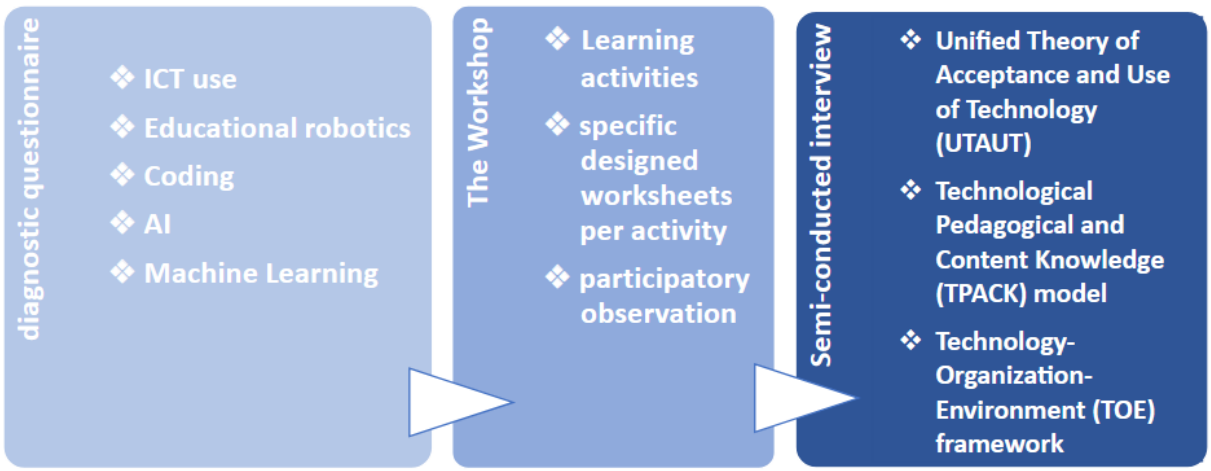

Figure 1. The research procedure.

The participants

Nine (9) of the participants were women and three (3) were men. All (12#12) of them had attended the course *Coding and Educational Robotics*, an elective course during their studies. Six (6) of the participants (6#12) were certified in the use of ICT. All (12#12) of them had discussed about AI during their lessons, 4 of them (4#12) had attended a short seminar on the use of AI in education but none was aware of what ML is and how it works.

Results

The thematic analysis of the answers of the participants per question offered the below discussed findings to give answers to the research questions of the study.

Performance Expectancy

All (12#12) pre-service teachers answered that the ML tools they were trained with will help them to teach AI and ML fundamentals effectively to their students, as they are flexible and can be adapted to various subjects and lessons (7#12), easy to use (5#12), and can stimulate students' interest (4#12). They stated that their students could learn about various concepts and technology fundamentals (10#12), would understand how various AI and ML applications that exist in their daily lives work and make decisions (8#12), would develop their critical thinking (7#12), would learn to plan/design simple applications (6#12), would learn to collaborate (5#12), and would realize ethical rules governing the use of AI and ML applications in their daily lives (4#12).

Effort Expectancy

All (12#12) participants stated that the ML tools they introduced are easy to use and do not require any effort, but time is needed to be familiar with them and their functions and abilities.

Social Influence

Nine of the participants (9#12) noted that the use of ML tools in their classroom will be appreciated by their colleagues and the school administration, increasing their respect and appreciation for them. Three of the participants (3#12) believe that fellow teachers will ask them for help so that they too can incorporate ML tools into their teaching, and they said that they are willing to offer their help to their colleagues (3#12). But, there were three of the participants (3#12) who report that their colleagues and school administrators would not appreciate the use of ML tools in their classroom because their colleagues and school administrators are: older in age (3#12), unaware of new teaching practices (3#12), believe that such tools do not meet their teaching needs (2#12).

ML technological pedagogical content knowledge

Eight of the participants (8#12) were not familiar with the basic principles of machine learning before the workshop, while 4 of the participants (4#12) were familiar with the basic principles of machine learning due to their participation to a course in Educational Robotics (7#12) during their undergraduate studies. Nine of the participants (9#12) do not feel adequately prepared to teach basic principles of ML to their students, while 3 of the participants (3#12) feel adequately prepared for that. Eleven of the participants (11#12) mentioned the need for additional training in ML tools in order to be able to teach basic principles of ML to their students in the future. Eleven of the participants (11#12) stated that they are able to use appropriate teaching strategies to teach their students the basic principles of ML, while only one of the participants (1#12) stated that she feels not able to use appropriate teaching strategies to teach basic principles of ML to her students. Four of the participants (4#12) reported that during their Practicum they had used appropriate teaching strategies to teach various subjects using educational robotics kits. Eleven of the participants (11#12) pointed out that they need additional training in the use of ML tools in education in order to effectively use appropriate teaching strategies.

Perceived Trend

All (12#12) participants reported that the use of ML tools is a new trend in education. Eleven of the participants (11#12) noted that they would like to attend a training program on the use of ML tools in education, and six of the participants (6#12) would like to attend a postgraduate program on the use of ML tools in education, as they believe that the use of ML tools will be a long-term trend in education.

Government Support

Ten of the participants (10#12) reported that the State encourages the integration of AI and ML tools in education through the educational robotics kits it offers to schools, while two of the participants (2#12) stated that the State does not encourage the integration of AI and ML tools in education. Nine of the participants (9#12) pointed out that although the State has equipped schools with educational robotics kits, these are not used by teachers, as they are not adequately trained. In fact, 7 of the participants (7#12) reported that teachers are not trained, as there is no

motivation to be trained. Eight of the participants (8#12) noted that the State's efforts to encourage the integration of TN and ML tools are not effective and mentioned the need for additional action by the State.

Legal Framework

All (12#12) participants claimed that the State does not provide educational training programs for teachers on the use of ICT and ML tools. Eight of the participants (8#12) argue that the State does not provide support to teachers for their participation in seminars and conferences on ICT and MM, while four of the participants (4#12) report that the State does provide support to teachers for their participation in seminars and conferences on TN and MM topics, by allowing them to be absent for educational and scientific purposes. Nine of the participants (9#12) reported that there is no state structure that supports the use of IT and AI tools in education, while 3 of the participants (3#12) stated that there is a state structure that supports the use of AI tools in education. Nine of the participants (9#12) point out that school counselors do not support the use of AI tools in education as they maybe do not understand the usefulness of such tools for educational purposes, but 3 of the participants (3#12) reported that school counselors support the use of AI tools in education.

Top Management Support

Seven of the participants (7#12) reported that school administrators do not encourage the integration of such tools into the educational process, as school principals: are responsible for a multitude of administrative tasks (6#12), are elderly (5#12), have not been trained in the integration of AI tools in education (4#12) and have not been taught relevant technological educational tools and applications during their studies (3#12).

Intention to use

All (12#12) participants answered that they will use ML tools with their students in the future as part of their teaching because they are easy to use (9#12), enjoyable for students to use (8#12), can increase students' interest in the subject being taught (7#12), and can be flexibly adapted to various subjects in the curriculum (7#12).

Why and How to use

All pre-service teachers (12#12) consider it important for young students to learn the basic principles of AI and ML and to be able to create their own simple AI and ML applications. It is important because students will learn to code (9#12), understand how AI and ML applications work in their daily lives (8#12), become familiar with the use of AI applications that already exist in their daily lives (7#12), and be able to use the skills and abilities they acquired at a young age in their future work, especially nowadays with the penetration of AI in many professional fields (5#12). The participants would use ML tools to teach basic AI principles to their students, and they prefer to use Nezha (8#12), Micro:bit and Smart AI lens kits (5#12), Quarky (4#12) robotics kit and Pictoblox (7#12) and machine Learning for kids (5#12) coding environments. Eight of the participants (8#12) reported that they would use AI tools to teach students in all grades of primary school. Four of the participants (4#12) stated that they would use AI tools to teach students in grades 3 and above, i.e., aged 8 and above. Eleven of the participants (11#12) would use ML tools in combination with educational robotics, while only one of the participants (1#12) would use ML tools but with no combination with educational robotics. All (12#12) participants would use AI tools with their students horizontally across various subjects. Four of the participants (4#12) stated that they would first use AI tools during short Workshop courses to familiarize students with the use of AI tools in the frame of out-curriculum activities.

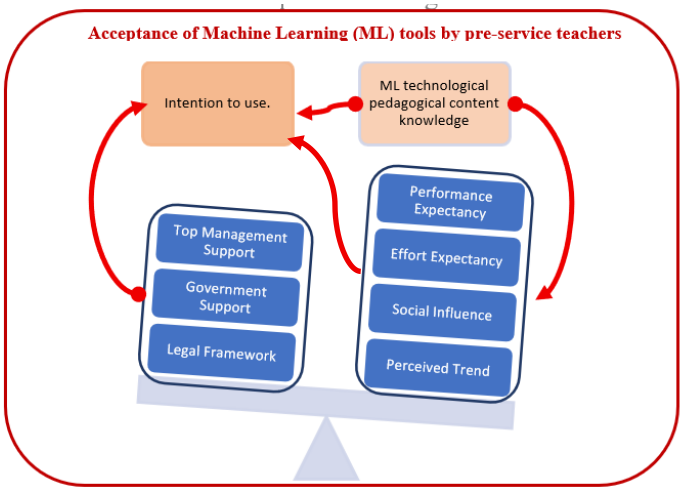

Figure 2. A graphically presentation of the basic study concepts and key results of participants' answers.

Conclusions

The answers to the research questions as derived by the thematic analysis of the answers of the participants per question can be summarized below:

- *Performance Expectancy*: All pre-service teachers answered that the ML tools will help them to teach AI fundamentals to their students, as they are flexible and can be adapted to various subjects and lessons, easy to use, and can stimulate students' interest. Their students could learn about various concepts and technology fundamentals, would understand how various AI and ML applications that exist in their daily lives work and make decisions, would develop their critical thinking, would learn to plan/design simple applications, to collaborate, and would realize ethical rules governing the use of AI and ML applications in their daily lives.
- *Effort Expectancy*: All participants stated that the ML tools are easy to use and do not require any effort, but time is needed to be familiar with them and their functions and abilities.
- *Social Influence*: Most participants noted that the use of ML tools in their classroom will be appreciated by their colleagues and the school administration, increasing their respect and appreciation for them. Only few participants, older in age, reported that their colleagues and school administrators would not appreciate the use of ML tools in their classroom.
- *ML technological pedagogical content knowledge*: Most participants were not familiar with the basic principles of machine learning before the workshop, do not feel adequately prepared to teach basic principles of ML to their students, mention the need for additional training in ML tools to be able to teach basic principles of ML to their students in the future. Most of them stated that they can use appropriate teaching strategies to teach their students the basic principles of ML but they need additional training in the use of ML tools in education to effectively use appropriate teaching strategies.
- *Perceived Trend*: All participants reported that the use of ML tools is a new trend in education most of them would like to attend a training program or a postgraduate program on the use of ML tools in education, as they believe that the use of ML tools will be a long-term trend in education.
- *Government Support*: Most participants reported that the State encourages the integration of AI and ML tools in education through the educational robotics kits it offers to schools, these are not used by teachers, as they are not adequately trained.
- *Legal Framework*: All participants claimed that the State does not provide enough and appropriate educational training programs for teachers on the use of ICT and ML tools.
- *Top Management Support*: Most participants reported that school administrators do not encourage the integration of such tools into the educational process, as school principals: are responsible for a multitude of administrative tasks, are elderly, have not been trained in the integration of AI tools in education and have not been taught relevant technological educational tools and applications during their studies.
- *Intention to use*: Most participants will use ML tools with their students in the future as part of their teaching because they are easy to use, enjoyable for students to use, can increase students' interest in the subject being taught, and can be flexibly adapted to various subjects in the curriculum.
- *Why and How to use*: All pre-service teachers consider it important for young students to learn the basic principles of AI and ML and to be able to create their own simple AI and ML applications. It is important because students will learn to code, understand how AI and ML applications work in their daily lives, become familiar with the use of AI applications that already exist in their daily lives, and be able to use the skills and abilities they acquired at a young age in their future work, especially nowadays with the penetration of AI in many professional fields. Most participants would use ML tools in combination with educational robotics, and all would use AI tools with their students horizontally across various subjects

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Mathematical support of adaptive learning based on a fuzzy non-deterministic automaton and a graph representation of educational content

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Abstract

Modern distance education faces the challenge of effectively integrating heterogeneous learning materials and achieving deep personalization of the learning process. The absence of unified standards and the limitations of traditional methods reduce the quality of education. This work is dedicated to the development of mathematical software for universal adaptive learning tools. The proposed methodology formalizes the structure of educational content as directed graphs, where nodes are didactic units (slides) and edges are controlled transitions. The core of the adaptive mechanism is an individual learner model, represented as a fuzzy non-deterministic automaton built on expert assessments and performance analysis. This automaton, controlled by solving compositional equations, allows the system to make informed decisions about the learning trajectory, dynamically forming optimal strategies. The main result is the creation of a comprehensive mathematical apparatus for managing the non-linear and dynamic aspects of the individual learning process. The use of fuzzy logic enables the system to handle uncertainty and consider the learner's subjective assessments, while the proposed graph-based content structuring approach unifies the representation of diverse materials. Practical implementation paves the way for creating intelligent tutors that provide real-time individualized learning.

Keywords: Automatic-graph's model, fuzzy non-deterministic automaton, adaptive learning, integration of learning materials.

Introduction

Modern distance education is confronted with a dual challenge: the necessity for the effective integration of heterogeneous learning materials, which vary in format and content, and the acute need for deep personalization of the learning process for each individual learner. The absence of unified standards and the inherent limitations of static, traditional teaching methods significantly diminish its quality and effectiveness, necessitating the development of new, flexible, and intelligent methodological approaches. In response to these challenges, this work is focused on developing the mathematical software required to create universal instrumental tools for adaptive learning.

The problem is exacerbated by the use of disparate standards across modern systems, which severely hinders the integration of different platforms. The variety of content formats—including text, graphics, audio, video, and simulations—creates substantial difficulties in achieving their consistent use, as each format requires distinct approaches to storage and processing. This lack of unified standards leads to the fragmentation of information, complicating access and ultimately diminishing educational effectiveness. Consequently, there is a pressing need for new methodological approaches and technological solutions that can unify data, including the development of universal formats for content exchange.

A key aspect of modern distance learning is the personalization required to meet individual student needs, including their preparation level, learning style, and personal characteristics. Contemporary research (Dudar et al., 2021) demonstrates that standard, static methods fail to provide real-time adaptation, which decreases learning efficiency. Therefore, there is an urgent need for specialized mechanisms that can analyze a learner's performance and automatically adjust the learning process, modifying delivery paths and pace. The integration of such adaptive technologies would not only increase learner motivation and independence but also provide a foundation for future innovation, strengthening the competitiveness of distance education systems.

The core of the adaptive mechanism is an individual learner model, presented as a fuzzy non-deterministic automaton. This model is constructed based on the expert evaluations of the instructor and is continuously refined through the analysis of data on learner performance. Governed by the solving of special compositional equations, this automaton allows the system to make well-founded decisions regarding the subsequent learning trajectory, dynamically forming and correcting optimal learning strategies based on the individual characteristics and progress

of the learner. The use of fuzzy logic tools enables the system to successfully operate with the uncertainty inherent in the educational process, taking into account the learner's subjective assessments of parameters such as task difficulty or the appeal of a particular learning method, as well as integrating their prior experience.

The primary objective of this work is the creation of a comprehensive mathematical apparatus that allows for the effective management of the non-linear and dynamic aspects of the individual learning process. The proposed graph-based approach to content structuring offers a unified method for representing heterogeneous materials, serving as a critical first step towards developing universal exchange formats and solving the problem of absent standards. The practical implementation of these developed provisions opens the way for creating instrumental systems that function as intelligent tutors, capable of providing individualized learning in real time. Such systems can proactively construct optimal learning paths, identify and transform potentially ineffective learning strategies, and integrate the nuanced pedagogical understanding of the instructor into a computer-based environment, thereby aiming to significantly enhance the quality, flexibility, and overall effectiveness of distance education.

Literature Review

The construction of an intelligent adaptive distance learning environment is a topic of numerous studies, as the development of technology creates a need to adapt existing educational resources to new conditions. In particular, study (Dudar & Litvin, 2024) emphasizes how the integration of heterogeneous materials can contribute to improving the quality of education in online learning environments. The authors note that integration should involve not only the technical capabilities of the platform but also methodological features capable of ensuring the effective assimilation of material by learners. A key aspect is the use of adaptive technologies that allow the material to be automatically adjusted according to the needs and pace of the learner.

Study (He & Jiang, 2020) examines the use of machine learning algorithms to automate the creation of adaptive learning paths for each learner. The authors propose new approaches to course formation, focusing not only on the level of knowledge but also on types of learning styles, by using technologies capable of analyzing learner behavior during the learning process.

An important topic in the analysis of research is also the integration of gamification elements. The authors of study (Karataiev & Shubin, 2023) emphasize that the use of game mechanics, such as ratings, levels, and rewards, not only improves learner motivation but also stimulates their active participation in the learning process, which can significantly improve academic performance and problem-solving abilities.

Work (Karataiev et al., 2023) examines the potential drawbacks that may arise from the inadequate integration of multimedia and electronic materials into the learning process. The authors emphasize that although technologies can significantly improve learning, their implementation requires careful planning and a strategic approach to avoid "technological overload," which can reduce learning effectiveness. Successful technology integration must be based not only on technical provision but also on a deep understanding of pedagogical principles.

Thus, based on the above research, it can be concluded that the construction of an intelligent educational environment for adaptive distance learning is a complex and multifaceted process. The success of such a system depends not only on the selection and integration of modern technologies—artificial intelligence tools, and gamification modules—but also on the ability to dynamically adapt educational content to the individual needs of learners, based on monitoring data of their performance. Only a combination of all these components—technological power, pedagogical literacy, and continuous adaptation—will allow for the creation of a truly stimulating, flexible, and effective educational environment capable of meeting the challenges of the modern digital era.

Methodology

The research is founded on a comprehensive methodology that integrates theoretical analysis with constructive modeling to create a novel mathematical apparatus for the structuring and personalization of content within distance learning systems (Tranfield et al., 2003). The entire scope of work was systematically divided into three interconnected stages: a preparatory theoretical analysis, the development and formalization of the core automaton-graph model, and finally, the development and verification of the algorithmic core.

The initial phase consisted of a deep preparatory theoretical analysis of secondary sources. This involved a thorough review of existing literature in the fields of adaptive learning, graph theory, automaton theory, and the application of fuzzy logic within educational systems. The primary objective of this stage was to identify the inherent limitations of traditional methods, particularly their inability to effectively integrate heterogeneous

materials and adapt to the individual needs of learners. The findings from this analysis resulted in the formation of the study's conceptual framework, which guided the subsequent research.

The second stage was dedicated to the development and formalization of the automaton-graph model. This phase proceeded along two parallel tracks. First, a structure for the unified representation of educational content was created in the form of a directed graph, where nodes represent didactic units (slides) and edges signify controlled transitions between them. Concurrently, an individual learner model was developed, employing fuzzy logic to accurately reflect the uncertainty and subjectivity inherent in the learning process. This learner model was conceptualized as a fuzzy non-deterministic automaton, in which the automaton's states correspond to the results of assessments, and its transitions are determined by a combination of expert evaluations and empirical academic performance data.

The third and final stage involved the development of the system's algorithmic core and its subsequent verification. To enable dynamic management of the educational trajectory, principles of dynamic programming were applied. Specific algorithms were engineered to solve compositional equations, which in turn facilitate the selection of the optimal method for material delivery at any given point. As the research is theoretical in nature, the model's verification was conducted by assessing its internal logical consistency. For this purpose, a novel criterion termed the "coefficient of freedom of choice" was introduced to evaluate the effectiveness of a given learning strategy and its potential for transformation. The viability and robustness of the model were ultimately demonstrated by its ability to logically and consistently achieve predefined educational objectives within various simulated scenarios.

Results

Information within the nodes of a learning course should be broken down into small semantic units called slides. Slides can be of two types: interactive and informational. Informational slides consist only of objects for displaying text and graphic information, playing audio and video fragments, and buttons for controlling the learning process. Interactive slides, in addition to the listed objects, may also contain objects that implement various types of test tasks to organize feedback with the learner and for the operational control of knowledge assimilation, as well as for the learner to acquire necessary skills. In the current version of the developed system, a binomial model of a pedagogical test is used for interactive slides (Kyrychenko & Malikin, 2022). Within this model, the result of each task is evaluated on a binary scale: 1 if the learner successfully completed the tasks in the given interactive slide; 0 otherwise. Thus, in a learning course, each interactive slide has at least two outgoing edges: one corresponds to the successful completion of the test task, and the other to an incorrect solution. With this approach, the number of interactive slides in an interactive learning block, as well as the number of questions in the final testing block, is determined by the following parameters: N is the required number of interactive slides; p is the probability of successful completion of the test task (the learner's true score, characterizing the true level of learning); d is the reliability of determining the parameter p; Φ_0 is the probability integral (Laplace function); ε is the accuracy of determining the learner's true score p.

During personal contact with a learner, an instructor has the opportunity to determine their personal qualities and individual characteristics. This allows the instructor to adequately adjust the learning process by changing the form and content of the material, tactics, and strategy of teaching, and sometimes even the teaching methodology. For this, the instructor uses a subjectively perceived model of the learner. In the case of computer-based (distance) learning, the instructor has practically no such opportunity (Omran et al., 2021).

It is logical to consider this form of learning as a human-machine system, in which both the learner and the instructor act as human operators. While the learner manages the knowledge acquisition system, the instructor indirectly manages the learning process. As in the design of any human-machine system, when creating an intelligent computer-based learning system, the issue of redistributing functions between the human and the computing tools must be addressed. For this purpose, it is proposed to use an individual learner model during the learning process, which is built on the basis of expert assessments (Pellissier-Tanon et al., 2020). It is assumed that the learning process is a sequential series of mastering individual sections of the educational material. Each stage of learning ends with a test. The learner can control their learning process by choosing methods for mastering the educational material.

We will understand the learner model as a fuzzy non-deterministic automaton of the form (Shubin et al., 2021):

$$A = \langle U, X, Y, s_0, \delta, \sigma \rangle, \quad (1)$$

where $U = \{U_1, U_2, \dots, U_m\}$ is a finite set of inputs, m is the number of automaton inputs; $X = \{X_1, X_2, \dots, X_n\}$ is a finite set of states, n is the number of automaton states; $Y = \{Y_1, Y_2, \dots, Y_p\}$ is a finite set of outputs, p is the number of automaton outputs; $\delta: X \times U \times X \longrightarrow [0, 1]$ is the transition function; $\sigma: X \times Y \longrightarrow L$ is the output function; S_0 is the initial state.

The function δ generates a set of fuzzy transition matrices:

$$T = \left\{\delta_{X_i, X_j}(U)\right\}, 1 \le i \le j \le n. \quad (2)$$

Among the set of automaton states, a set of final (concluding) states X_n is distinguished. We are interested in a type of automaton for which each state X_i $(i = 1, \dots, n)$ depends on the previous state X_{i-1}. Such a dependency can be determined by the sequence of sub-goal implementation, execution priority, etc.

Thus, in this case, the automaton can be defined as a fuzzy graph (Shubin et al., 2021):

$$G = \{\mu_G(X_{i-1}, X_i) \in M\}, \quad (3)$$

where M is the set of memberships of the elements $X_{i-1} \times X$.

In this view, the learning objective is decomposed into i sequential (in terms of material mastery time) subtasks. We will interpret X_i as the set of results of the i-th test, Y_j $(j = 1, \dots, p)$ as the set of time intervals for learning, and L as the set of revenues associated with the implementation of the chosen learning method (mastery of the material) $u \in U$ over the time interval Y_j.

The states of the subtasks and the management decisions that occur over time will be treated as fuzzy events in the interval Y_k $(1 \le k \le p)$. With this approach, the transition function can be defined by experts and reflect existing learning experience, based on the practical experience of presenting educational material. However, this does not take into account the learning outcome depending on the time of its implementation, nor the personal characteristics of knowledge acquisition by a specific individual. To account for this circumstance, it is necessary to construct an individualized transition function. For this purpose, initial information from the learner is used, which contains a forecast of the application of a particular method of material assimilation depending on the possible test results in the form of a function : $X_i \times U_l \longrightarrow [0,1]$, where $l = 1, \dots, m$, and m is the total number of available learning methods, as well as a forecast of the transition of the controlled learning process from the initial state S_0 in the first step of the solution, depending on the constraints on available resources. The automaton model is programmed based on this information. For this, a system of compositional equations of the form (Shubin & Karataiev, 2023) is solved at each step:

$$\begin{cases} \mu(X_i)/U_l = \mu(X_{i-1})/U_{l-1}\ o\ \delta(X_{i-1}, X_i)/U_l \\ \mu(U_l) = \mu(X_{i-1})\ o\ \mu(X_{i-1}, X_i)/U_l \end{cases}, \quad (4)$$

where "o" is the sign of the "composition" operation; $\mu(X_i)/U_l, \mu(X_{i-1})/U_{l-1}$ are fuzzy estimates of the possibility of the controlled process being in states X_i, X_{i-1}, when applying the learning material mastery methods U_l and U_{l-1}, respectively; $\mu(U_l)$ is a fuzzy estimate of the learner's choice of the material mastery method U_l.

The obtained estimates are grouped in pairs based on the following condition:

$$\mu(U_l) \le \mu(X_i)/U_l, \quad (5)$$

The formation of pairs according to this principle is consistent with the real choice of a solution: the test result with the maximum possibility estimate should correspond to the method of mastering the educational material also with the maximum estimate of its application by the learner. The selection of pairs allows for the identification of the most probable connections by methods of material assimilation between the test results of each learning stage. In this case, each assimilation method that marks a connection is characterized by a fuzzy estimate of its use by the learner and a fuzzy estimate of the learning cost (normalized income), subjectively perceived by the learner, depending, for example, on the time or complexity of mastering the educational material.

From the initial state to the states of the first decision-making step, arcs are drawn, labeled with those methods of mastering the educational material whose use, according to the forecast, allows achieving the results of the intermediate test at the first stage of learning, characterized by the highest estimate. Depending on the labeling of these arcs and on the basis of the formed pairs "method of material mastery" - "test results," labeled arcs are drawn from the first to the n-th stage of learning.

As a result of these constructions, we obtain a fuzzy non-deterministic automaton that models the behavior of the learner under different results of intermediate testing. Applying the approach used in dynamic programming, it is possible to identify classes of learner strategies. First and foremost is the class whose strategies allow achieving the learning goal and are characterized by the maximum estimates of the connections between test results (Svato et al., 2020). To isolate such strategies, the results corresponding to the learning goal are determined on the set of final test results. Then, the test results at the $(n-1)$-th step are isolated, the transition from which to the target states of the n-th step is characterized by methods of mastering the educational material with an estimate equal to:

$$\alpha(U_{n-1}) = \max_{Y_{n-1}}\big(min(\mu U_{n-1}), \sigma_{X_{n-1},U_{n-1}}\big), \tag{6}$$

A similar procedure is performed for each decision step, up to the state S_0. The use of this procedure allows for the identification of possible learning strategies, which are weighted paths on the graph from the vertex S_0 to the vertices from the set X_n. Each q-th path is a sequence weighted by the methods of mastering the educational material of the form:

$$S_q = \big(S_0, U_0, X_1^{r_1}, U_1 \dots, X_{n-1}^{r_{n-1}}, U_{n-1}, X_n^{r_n}\big), \tag{7}$$

where r_t, $t \in \{1, \dots, n\}$ is the number of results of the t-th test. The elements (results of the final test) of the set X_n may have different values for the learner, which is reflected by setting a fuzzy goal on X_n with a membership function:

$$\mu(g) = \{\mu(X_n^1, \dots, X_n^h)\}, \tag{8}$$

where h is the dimension of the set X_n; $\mu(X_n^\pi), \pi \in \{1, \dots, h\}$ is the membership function of the test result to the fuzzy goal g.

In this case, each strategy from class π can be evaluated as follows:

$$\beta\big(S_q^\pi\big) = min\big(\alpha(U_0), \alpha(U_1), \dots, \alpha(U_{n-1}), \mu(X_n^\pi)\big), \tag{9}$$

The strategy that has the estimate:

$$\max_q \Big(\beta\big(S_q^\pi\big)\Big), \tag{10}$$

best corresponds to the individual style of knowledge acquisition of the learner, but may not always correspond to the maximum membership function of the test result with respect to the goal g. The contradiction obtained during the construction of the learning model can be avoided by using the following methods: using such an organization of learning support that would take into account only the final goal, i.e., the state of the fuzzy goal with the maximum membership function; changing the initial transition and output matrices; changing the learner's preferences.

In the first case, mixed strategies formed by parts of strategies from classes π should be used. The need to form a mixed strategy determines the transformation of a strategy from a certain class, chosen based on criterion (9), into a strategy from another class, based on the following criterion:

$$\max_\pi \big(\mu(X_n^\pi)\big), \tag{11}$$

Obviously, the need for transformation arises in cases where the chosen initial strategy ceases to be effective with respect to the fuzzily defined goal. In this case, it is important to determine the spatio-temporal points of the graph (vertices) where such a transformation is possible. For this purpose, we introduce the concept of the learner's coefficient of freedom of choice (Yang et al., 2022), which we will understand as the ratio of the number of permissible strategies from the class: S_q^π з $\beta\big(S_q^\pi\big) \geq \varepsilon$ to the total number of strategies from the same class. Here, ε means the threshold of the learner's capabilities in achieving their goal, provided they use an individual style of mastering the educational material. The smaller the value of the coefficient of freedom of choice, the fewer options the learner has to achieve the set goal without changing their individual strategy.

Conclusions

This scientific paper details the development of mathematical software for creating universal adaptive learning tools. The core of this work is an individual learner model, formalized as a fuzzy non-deterministic automaton, which effectively manages the complex and dynamic aspects of the individual learning process. By leveraging fuzzy logic, the system can handle uncertainty and adapt in real-time. A pivotal result is that the proposed graph-based model for content organization also offers a viable solution to the lack of unified standards by unifying the representation of heterogeneous materials.

The practical implementation of these findings enables the creation of instrumental systems that function as intelligent tutors, capable of proactively constructing and correcting optimal learning paths. This dual potential for deep personalization and content standardization can significantly enhance the quality and overall effectiveness of educational programs in the digital sphere. In summary, the results of this work lay a solid scientific foundation for a new generation of educational solutions that are truly personalized, flexible, and highly effective.

Prospects for further scientific inquiry are broad and include the application of advanced AI, such as generative models (GANs, LLMs) for dynamic content creation, conversational AI tutors, reinforcement learning for optimizing learning strategies, and the integration of gamification to increase learner motivation and engagement. The continued development of these innovations holds significant potential for radically improving the quality and accessibility of educational services.

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Learner Engagement and Technology-Mediated Group Assessment in Research Methodology among Marketing Management Undergraduates in Distance Education

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Abstract

A deep understanding of research methodology is a fundamental requirement for a marketing management course, as it equips the learners to identify, analyze and make rational decisions about consumer behaviors and market trends, leading to better strategies and improved marketing outcomes. The 'Research Methodology for Marketing Management' course which was offered as a distant learning mode in 2024 at the Open University of Sri Lanka, revealed a failure rate of 37%. Course teachers have also observed limited engagement in learning activities; plagiarism, AI generated content, lack of in-depth understanding, and over-reliance on secondary sources in learners' individual assignments. Therefore, with the hope of improving learner performance it was decided to change one of the continuous assessments, which was previously an individual assignment, to a technology mediated group learning experience, with a series of assessment tasks to be completed collaboratively. In this, learners were asked to identify a research area related to marketing management, analyze related research, identify gaps, limitations and future directions in research, and finally to come up with a research proposal presentation, justifying a research problem. In order to improve learner engagement and proceed with the assessment activity, a multiple technology intervention was utilized: a social media tool 'WhatsApp' was used to build asynchronous peer interactions; the LMS 'Wiki' was used for collaborative report writing, Video conferencing tool 'ZOOM' was used for synchronous group discussions, decision making and final presentations. The purpose of this study is to explore, to what extent this technology mediated online group learning experience enhanced learner engagement and performance in the research methodology course. Both quantitative and qualitative research methods were used to collect data. A questionnaire was administered among the learners to collect quantitative data. Ten (10) focus group discussions of learners and teacher interviews were conducted to gather qualitative data. Results of this study highlights the use of technology mediated group assessment activity provided learners' the opportunities for dialogue, volunteer leadership, role-sharing, peer feedback for enhanced students' cognitive processing. Significant improvements in academic performances were also observed. Although a majority of learners (90%) engaged successfully in the learning process, limited participation was also observed from one group (10 learners). From an overall perspective, this study provides implications for designing distance learning courses and create dynamic learning opportunities to co-construct knowledge through technology mediated collaborative learning.

Keywords: Distance learning, Group assessments, Learner engagement, Technology mediated learning.

Introduction

The 'MMU5498 Research Methodology for Marketing Management' is a level 5 course with a credit load of 4, offered by the Open University of Sri Lanka (OUSL), and it is a mandatory course before learners start their research project in the final year. The main focus of this course is to enhance learners' rational decision making by using information in an ethical manner through an investigation of a research process and design a problem - based research proposal. Teachers' previous experience in delivering this course for the distance learning undergraduates of OUSL in 2024 academic year, revealed a high failure rate of 37% in their individual assignment, with limited participation in interactive learning sessions and limited engagement in activities in the Learning Management System (LMS). In addition, plagiarism, AI generated content, lack of in depth understanding of the relevant concepts, and over-reliance on secondary sources were also observed in learners' individual assignments. Therefore, to improve learner engagement and performance, the assessment task of this course was changed to a technology mediated online collaborative group learning experience, with a series of assessment tasks to be completed collaboratively instead of the traditional individual home assignment. Hence under this new assessment task, learners were asked to demonstrate their competencies in identifying and analysing scholarly research, demonstrate their knowledge and application of research principles, exhibit creativity, teamwork and collaboration through technology mediated group-based research activities in the process of learning research methodology for marketing.

The purpose of this study is to explore how this technology mediated online collaborative group learning experience enhanced learner engagement and how knowledge construction happened during this process.

Hence the following research questions were investigated in this study

1. How do learners engage in knowledge construction during the technology mediated group learning experience?
2. What are the perceptions of learners regarding learning experience through collaborative assessment?

Conceptual Framework

Conceptual used in this study was mainly based two fundamental concepts: the framework of Computer Supported Collaborative Learning (CSCL), and Assessment for Learning (AfL).

The framework of Computer Supported Collaborative Learning (CSCL), is a pedagogical approach that explores how learners construct knowledge in a collaborative learning environment using digital tools. CSCL can bring learners together to learn collaboratively in small groups in learning communities (Gerry & Suthers, 2014). It emphasises learning through collaboration with other learners than directly from the teacher. Therefore, the role of the CSCL is to support collaboration, by providing media for communication and scaffolding for productive interactions. CSCL systems typically provide a combination of media to provide communication in the form of chat, email, discussion forums, video conferencing, instant messaging, etc. and add special functionality to them, such as organizing forums or chat conversations into threads, sharing files easily, tracking conversations, saving videos or chat sessions for later review, or managing group activities etc. The theoretical underpinning of CSCL is deeply rooted in Vygotsky's concept of Zone of Proximal Development (ZPD), the central concept in sociocultural theory (Shabani, Khatib & Ebadi, 2010). In that Vygotsky states, learning is a social process, and much of what we learn is co-constructed through interaction with others, especially with the interaction with more knowledgeable other, viz. peers or instructors. Hence scaffolding is a central process for the learners to move through ZPD. CSCL facilitates scaffolding through synchronous and asynchronous collaborations, where peers act as scaffolding agents in discussions, feedback, and in collaborative problem-solving. In addition, computers can also offer automated scaffolds such as prompts and feedback.

Assessments for learning (AfL) is a formative assessment approach, where assessments are used during the learning process to provide learners with feedback to fulfil their potential and to assist them in reaching the desired outcomes. AfL includes learning strategies such as questioning to assess understanding, providing feedback to improve, peer assessments to assess each others work, self assessments to reflect on their own understanding and progress. CSCL facilitates AfL by providing collaborative tasks to co create knowledge, discussion forms and chats for questioning and feedback, version histories / Log reports for review and reflect, Instructors as facilitates to provide formative guidance, Peer reviewing opportunities to scaffold learning.

Methodology

Designing the technology mediated group assessment task

Assessment Task: The learners were instructed to identify a research area related to marketing management, analyze related research, identify gaps, limitations and future directions in research, and finally to come up with a research proposal presentation, justifying a research problem. The group assessment was designed with a series of assessment tasks to be completed in a technology mediated learning environment.

Technology Intervention: The instructions were shared on LMS and guided the students to familiarize themselves with the instructions by demonstrating how to find a good research article in Zoom classes. In order to improve learner engagement and proceed with the assessment activity, a multiple technology intervention: a social media tool ‘WhatsApp’ was used to build asynchronous peer interactions; the LMS ‘Wiki’ was used for collaborative report writing, the Video conferencing tool ‘ZOOM’ was used for synchronous group discussions, decision making and final presentations.

Leaner Groups: The total number of learners in this course were 102 and teacher formed 10 groups consisting atleast two members from the regional centers. Ten groups were created in WhatsApp and shared QR codes in LMS informing the students to join with the relevant groups.

Evaluation: The evaluation was taken place in 3 stages

1. WhatsApp – the students were asked to discuss and share the research articles in the area they would like to conduct a research study. The interaction was observed by the teacher and supported to finalise a research article for each group.

2. A zoom meeting was held, and the students have to insert a summary of the article they have selected: the research gap addressed, the theory, methodology and limitations and future directions. The students were asked to update the wiki by discussing with the group members. The evaluation done based on the level of interaction of the students in Zoom and based on their contribution to the Wiki. Student were given one week to edit and change the content they entered. The teacher was the evaluator and moved to each group and spent around 20 minutes discussing and supporting the students to finalise the answers.
3. Finally, the students were asked to select a research gap from the study based on any mentioned criteria and develop a power point poster on research title, objectives, Methodology proposed. The evaluation was conducted by an examiner to every 2 groups by forming five breakout rooms and assigning an evaluator to each group. The marks allocated for the peer reviews as well. As a summary to improve learner engagement and proceed with the assessment activity, a multiple technology intervention: a social media tool 'WhatsApp' was used to build asynchronous peer interactions; the LMS 'Wiki' was used for collaborative report writing, Video conferencing tool 'ZOOM' was used for synchronous group discussions, decision making and final presentations.

Research Methods

Both quantitative and qualitative research methods were used to collect data of the learner perceptions on the course delivery. A questionnaire that comprised 29 questions on a 7-point scale and two demographic questions: gender and age, was administered among the learners to collect quantitative data, while Ten (10) focused group discussions of learners and teacher interviews were conducted to gather qualitative data. The survey questionnaire was developed based on Gijbels et al. (2006) seven key factors on constructivists learning environment. The questionnaire was distributed online via the WhatsApp group. A total of 81 students out of 102 (79.41%) responded to the survey questionnaire.

Results

The findings revealed that learning through technology-mediated online group experiences enhance learner competencies in the research methodology for marketing management course. In order to address the study objectives, the frequencies of the learner perceptions identified through the survey were divided into 3 categories. Table 01 shows the ranges such as Low (1 -3.59), Moderate (3.6 -4.59) and High (4.6 -7).

Table 1. Ranking Ranges

Categories	Low	Moderate	High
Ranges	1 - 3.59	3.6 -4.59	4.6 -7

Then 81 responses to the instrument were shown in the Table 2 as follows.

Table2 . Student Percentions Ranking

Variable	High	Moderate	Low
Arguments discussions debates	66 (75.3%)	14 (17.3%)	6(7.4%)
Conceptual conflicts and dilemmas	18 (22.2%)	36 (44.4%)	27 (33.3%)
Sharing ideas with others	68 (84%)	10 (12.7%)	3 (3.7%)
Materials and resources targeted toward solutions	44 (54.3%)	34 (42%)	3 (3.7%)
Motivation	65 (80.2%)	16 (19.8%)	0 (0%)

Meeting students needs by the teacher	75 (92.6%)	6 (7.4%)	0 (0%)
Making meaning, real-life examples	74 (91.4%)	7(8.6%)	0 (0%)

According to Table 2 the learner percetion on their learning experience was highly positve.

Arguments, discussions and debates

In supporting how the arguments, discussions and debates were suported the students for learning and their perception, 75.3% of learners perceive it as positively impacted, while a student from the group 01 responded as follows.

"*I learned a lot from other peers with their ideas and specially doubts are cleared when discussing and getting things done together" – Group 01 participant.*

The teacher who assessed the Group 03 and 04 reported that

"There were lots of arguments between the groups" – Teacher who assessed Group 03 – 04

Conceptual conflicts and delimas

Further, Conceptual conflicts and delimas exprienced by the learners during the assignment is at moderate level (44.4%) . However, in some groups the conceptual conflicts at the intial stage of the assessment: selecting the research area, research articles were expressed by some groups. For an example

"*Actually group assessment encourage us with various thinking patterns. We have selected several articles. Had different opinions. Even we are working in online platform finally we did our best for the assignment" Group 07 participant* Making Meaning, Real Life examples (91.4%)

Sharing ideas with friends

The frequency ranking shows that majority (84%) of the learners happy about allowing them to share and express the ideas with the group members while 12.7 % of the respondents were at moderate level while 3.7 percent had a low level on this regard. The students expressed that this assessment as an opportunty to interact with their friends in centers

"I really appreciate the group activities because we get collaboration benefits among friends from different centers'.

A teacher expressed the outcome of the sharing ideas with friends as encouragement and support for the group members to provide well organised the answers in peer review sessions and Q & A sessions.

"Group 01 students are well organised. All the team members actively participated and gave good answers in Q&A session and peer evaluation session" Teacher who assessed group 01 -02

Materials and resource targeted toward solution

The learner perceptions on materials and resource targeted toward solution was high (54.3%), however, there is considerable number of students have moderate level (42%) of perception on the provided materials and resources. However, it was not highlighted during the focus group discussions conducted just after the assessment.

Meeting Students Needs for the assessment

Meeting student needs by the teacher was ranked by the majority as highly positve (92.6%). Supporting that a statement a learner expressed as follows.

"Our lecturer facilitated with materials, how to find the article and guided us for searching good articles. Thanks to our lecturer to support us." Group 08 participant

Motivation

The learners (80.2%) pointed out that the assessment experience enhanced their motivation towards learning the subject. A learner in Group 07 expressed his experience as follows.

"*This assignment encourages us to think out of the box and speak out. really enjoy this and learned more.it helped to Learn and get more ideas about the theory practically, helped to share ideas and obtained ideas and knowledge from co learners as well...*" *Group 07 participant*

Further, a teacher expressed her experience at final evaluation as follows:

" In my assessment group the students were asked lot of questions from their peer group. It was an amazing about their active engagement" – Teacher who assessed group 07 -08

The Teachers too expressed that the different conflicts of interests in groups as follows.

"Some group members have doubts and conflicts of interest. Therefore, in one group I saw different answers for the same question" Teacher who assessed group 05 -06

Making Meaning, Real Life examples

The assessment is making meaning and relating to real life was expressed by 91.4% of the respondents. Following are some of the example statements expressed by the students and evices to continoue the assesment for the future as well.

It's one of the best ways to gain knowledge and get the experience I really felt challenge myself and engaged with other students. But I ended up with more insights and knowledge gain" – Group 04

"Good activities Good knowledge and experience for research methodology" – Group 07.

" I think it's good to proceed continuously for others too. Thank you". Group 01

Conclusions

The objectives of this study were to understand how learners engaging in knowledge construction during the technology mediated group learning experience and the learner perceptions based on learning experience of collaborative assessment of research methodology subject with the use of technology mediated new learning environment with multiple technologies: LMS Wiki, WhatsApp and Zoom. The results implied that teachers could meet the students' needs via online utilizing multiple technologies. Further, multiple technologies also create more engagement opportunities and connect students in different centers and students recommended to adopt the assessment in future. Similarly, Capone and Lepore (2022) implied that the use of completely the distance virtual teacher instructed assessments did not negatively influence the student's learning experience. It has allowed satisfactory results to be achieved in terms of acquiring research skills. Lu and Cutumisu (2022) also pointed out that the student engagement can be encouraged through developing more self-regulated learning and assessments in online settings. Further they highlighted that it mitigates the attendance issue as well as the absence of interaction in class in online classes. From an overall perspective, this study provides implications for designing distance learning courses and create dynamic learning opportunities to co-construct knowledge through technology mediated collaborative learning. T/heoretically this constructivism as an adoption of new learning environment with multiple technologies; and initiating group based collaborative problem-solving assessment in understanding the basics of research methodology specifically focused on Marketing Management undergraduates. The study has several limitations since it studied only one batch of the students. The students' internet connectivity, device availability, and digital literacy have affected their engagement to the assessment and response biasness. Further competencies and attitudes with use English language, influence of group dynamic issues affect for the responses are not considered in the study. Hence, this study can be further extended with the final performances of the students as a comparative study and in assessment designing pedagogy for Marketing Management students. Further the study can be enriched by studying the learner attitudes, emotions and values of group engagement.

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A Bibliometric Analysis of Research on Bloom's Taxonomy and Its Revised Version (1980–2025): Trends, Themes, and Scholarly Impact

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Abstract

This study presents a comprehensive bibliometric analysis of scholarly literature on Bloom's Taxonomy and its revised version, covering the period from 1980 to 2025. Drawing on data retrieved from the Web of Science Core Collection, the study employs bibliometric techniques using VOSviewer and the Bibliometrix R package to examine publication trends, citation patterns, prolific authors, core journals, and thematic developments in the field. The findings reveal a significant increase in research interest following the 2001 revision of the taxonomy, with notable contributions from countries such as Türkiye, Indonesia, and Malaysia. Despite a growing volume of publications, the citation impact remains concentrated in a small number of high-influence works. Keyword analysis highlights persistent themes such as education, students, and science, while co-word and thematic evolution analyses indicate a shift toward digital learning, competency-based education, and interdisciplinary integration. Core sources were identified using Bradford's Law, confirming the centrality of both national and international journals and conferences. The study concludes with recommendations for future research, including increased international collaboration, deeper theoretical engagement, and greater application of Bloom's framework in emerging educational technologies.

Keywords: Bloom's Taxonomy, Revised Taxonomy, Bibliometric Analysis, Curriculum Development, Learning Objectives, Educational Assessment

Introduction

Ensuring quality in education requires a systematic approach to management, evaluation, and continuous improvement of learning outcomes (Bakioğlu & Baltacı, 2010). High-quality education depends on curriculum frameworks that are built upon well-defined standards, ranging from needs assessment and goal setting to content organization, instructional design, and assessment strategies (Demirel, 2006; Erden, 1998; Sönmez, 2010; Özçelik, 1998). Among these elements, the clear articulation and classification of educational objectives are particularly critical, as they serve as benchmarks for measuring the discrepancy between current and desired student performance (Kirkpatrick & Kirkpatrick, 2010; Semerci, 2007;

Stufflebeam, 2001; Stufflebeam & Coryn, 2014; Şencan & Erdoğmuş, 2001; Uşun, 2012). Regardless of the underlying educational philosophy, all curricula aim to achieve specific learning outcomes, which guide instructional planning and assessment practices.

A significant milestone in the systematic classification of educational objectives was achieved with the publication of *The Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain* by Bloom and his colleagues in 1956. Over the subsequent decades, Bloom's Taxonomy became a cornerstone for curriculum design and assessment practices worldwide, including in Türkiye and the United States. The taxonomy was later complemented by Krathwohl, Bloom, and Masia's (1964) affective domain taxonomy, which provided a comprehensive framework for addressing emotional and attitudinal learning outcomes (Anderson et al., 2010).

Bloom's framework organizes learning outcomes into a hierarchical structure ranging from simple to complex and from concrete to abstract, enabling educators to design instructional experiences that build progressively on prior knowledge. Subsequent scholars expanded and adapted these classifications for the cognitive, affective, and psychomotor domains (Dave, 1969; Gardner, 1993; Guilford, 1967; Harrow, 1972; Simpson, 1966; Sönmez, 2010). This hierarchical approach not only guides curriculum design but also ensures alignment between learning activities, instructional methods, and assessment.

Research Gap

Despite the extensive body of literature on Bloom's Taxonomy and its revisions, there is still a need for a systematic bibliometric analysis that maps the intellectual structure, key contributors, and thematic evolution of this research area. Previous studies have often focused on theoretical discussions or practical applications of the taxonomy in specific disciplines, but few have comprehensively examined how scholarly interest has evolved over time, particularly since the taxonomy's revision in 2001. Moreover, the integration of Bloom's Taxonomy into emerging educational contexts, such as digital learning environments, competency-based education, and STEM, remains underexplored in bibliometric terms. This study addresses this gap by conducting a longitudinal bibliometric analysis of research on Bloom's Taxonomy and its revised version from 1980 to 2025, highlighting key trends, influential works, and emerging themes that shape the future of curriculum and assessment design.

Purpose of the Study

The primary objective of this study is to offer a comprehensive bibliometric overview of research related to Bloom's Taxonomy and its revised version over a 45-year period (1980–2025). By employing quantitative bibliometric techniques, this study seeks to illuminate the intellectual and thematic evolution of this foundational educational framework. Specifically, the study aims to:

1. Examine longitudinal publication trends and the temporal distribution of scholarly output;

2. Identify the most prolific and influential authors, institutions, and countries contributing to the field;

3. Analyze citation networks and co-authorship patterns to uncover collaborative dynamics and knowledge diffusion;

4. Map the conceptual structure of the research domain through co-word and thematic evolution analyses;

5. Highlight emerging areas of inquiry, including the application of Bloom's Taxonomy in technology-enhanced learning, competency-based curricula, and STEM education contexts.

Through these objectives, the study endeavors to provide meaningful insights into how the taxonomy has been adapted, extended, and critiqued in diverse educational research settings, thereby offering valuable guidance for scholars, curriculum developers, and policymakers.

Methodology

This study employs a quantitative bibliometric research design to systematically analyze scholarly publications related to Bloom's Taxonomy and its revised version over the period 1980–2025. Bibliometric analysis, as a scientific mapping method, allows for the identification of publication trends, intellectual structures, thematic developments, and influential contributors within a given research domain.

Data Source and Search Strategy

The data for this study were retrieved from the Web of Science Core Collection (WoSCC), which is recognized for its high-quality indexing of peer-reviewed scholarly literature. A comprehensive search was conducted using the keywords: *"Bloom's Taxonomy"*, *"Revised Bloom's Taxonomy"*, and variations thereof within article titles, abstracts, and keywords. The search was limited to publications indexed between 1980 and 2025, covering journal articles, conference proceedings, and book chapters. Only documents in English were included to ensure consistency in content analysis.

Data Cleaning and Inclusion Criteria

Following the initial search, duplicate entries, retracted papers, and non-relevant documents (e.g., those referencing "bloom" in unrelated contexts such as botany or chemistry) were manually excluded. The final dataset comprised 212 unique records relevant to the educational use of Bloom's Taxonomy. Bibliographic data, including author names,

affiliations, titles, abstracts, keywords, source journals, and citation counts, were exported in BibTeX and CSV formats for analysis.

Analytical Tools and Procedures

Bibliometrix R-package (version 2025.05.1) and its web-based interface, Biblioshiny, were employed for conducting descriptive and inferential statistical analyses. These included annual scientific production, authorship productivity (Lotka's Law), source dynamics (Bradford's Law), most globally cited documents, thematic evolution, and collaboration networks.

The combined use of these tools provided both macro-level (productivity, impact) and micro-level (semantic and structural) insights into the literature on Bloom's Taxonomy. The visualizations and quantitative metrics are presented in the findings section, followed by interpretive commentary.

Findings

Annual Scientific Production

Annual scientific production refers to the number of documents published each year within the defined research domain. It serves as a key indicator of the field's intellectual vitality and the evolution of scholarly interest over time.

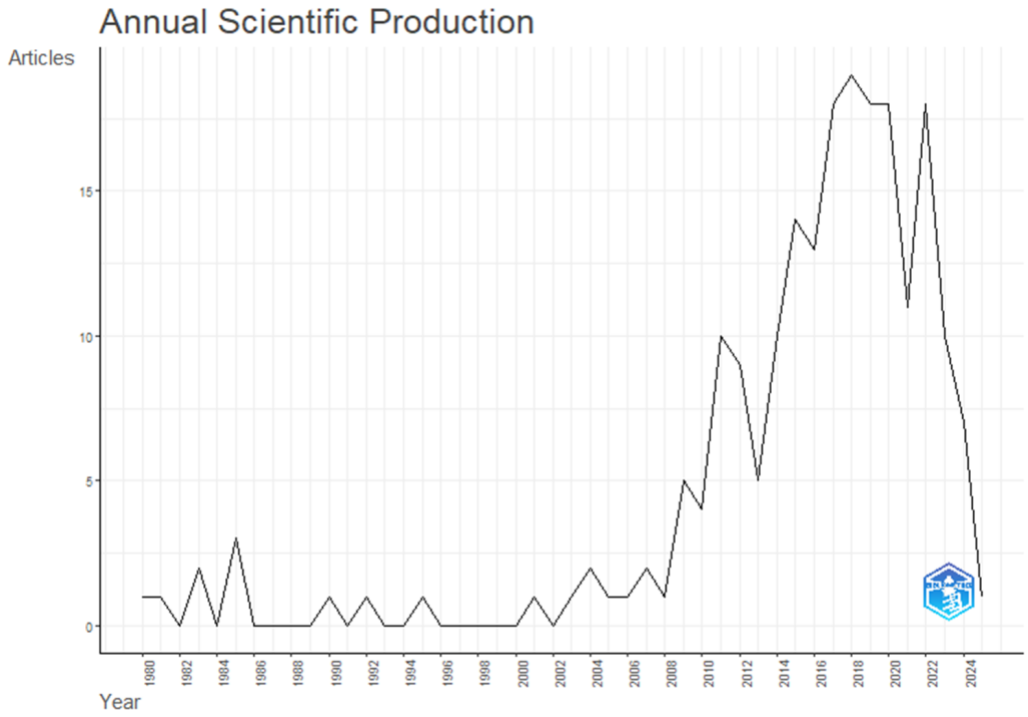
Figure 1 illustrates the yearly distribution of publications on Bloom's Taxonomy and its revised version from 1980 to 2025. While the initial years showed minimal scholarly output, the trend began to rise steadily in the early 2000s—coinciding with the publication of the revised taxonomy by Anderson and Krathwohl (2001). This revision appears to have served as a catalytic event, stimulating renewed academic engagement with Bloom's cognitive framework, especially within educational assessment, instructional design, and curriculum theory.

The period between 2010 and 2020 witnessed a marked increase in publication volume, reflecting broader trends in educational reform, digital pedagogy, and global curriculum alignment initiatives. The peak in publications appears to occur around 2018, potentially due to the intensified demand for remote learning frameworks during the COVID-19 pandemic, which revived interest in structured learning outcomes and competency-based education models.

Although a slight decline is observable in the final years (e.g., 2024–2025), this may reflect indexing lags in recent publications rather than a substantive drop in scholarly interest.

This pattern highlights the enduring relevance of Bloom's Taxonomy across educational paradigms and affirms its adaptability to evolving pedagogical landscapes.

Figure 1. Annual Scientific Production



Average Citations per Year

The "Average Citations per Year" metric reflects the mean number of citations received annually by the documents published in the field, providing insights into the scholarly impact and visibility of the research over time.

As shown in Figure 2, citation activity has varied significantly across the studied period (1980–2025). In the early decades (1980s and 1990s), the average citation rate remained relatively low, likely due to the limited number of publications and the nascency of systematic curriculum evaluation discourse in indexed literature. However, a notable increase in citation rates began to emerge in the early 2000s, corresponding with the revised Bloom's Taxonomy proposed by Anderson and Krathwohl (2001), which reinvigorated scholarly attention toward cognitive domains in education.

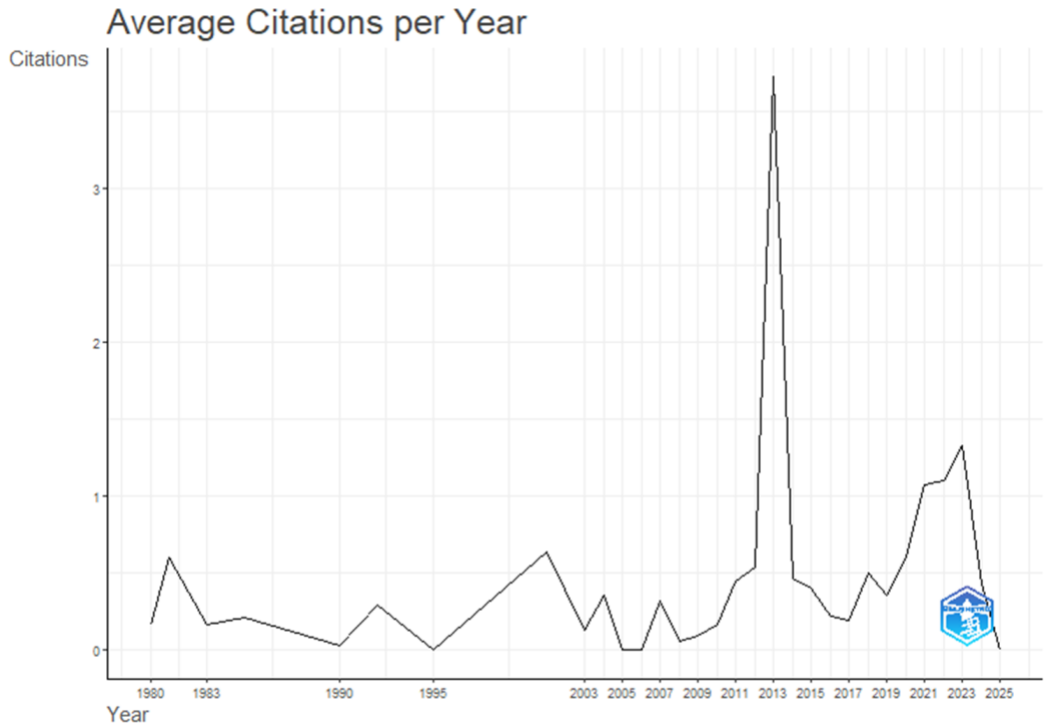
The highest average citations per year are observed around 2013, suggesting that several foundational or widely referenced publications appeared in that time frame. This trend underscores a growing reliance on Bloom's Taxonomy not only as a theoretical framework but also as a practical tool in designing outcomes-based curricula, formative assessment strategies, and technology-enhanced learning environments.

In recent years (2020–2025), although the number of publications has increased, the average citation per year appears to have plateaued or slightly declined. This phenomenon is typical in bibliometric analyses and can be attributed to the recency effect—newer publications have

had less time to accumulate citations. It should not be interpreted as a decline in research quality or relevance but rather as a natural lag in citation accrual.

Overall, the citation trajectory confirms that Bloom's Taxonomy continues to serve as a core conceptual anchor in educational research, while also indicating evolving patterns of usage and scholarly attention over time.

Figure 2. Average Citations per Year



Most Relevant Sources

The "most relevant sources" represent the publication venues that have produced the highest number of documents related to Bloom's Taxonomy and its revised version between 1980 and 2025. As shown in Figure 3, the top sources include a combination of peer-reviewed academic journals and high-impact conference proceedings, reflecting both traditional and emergent dissemination pathways within the educational research community.

The leading source is:

- Pamukkale University Faculty of Education Journal, with 5 publications, affirming its role as a key national platform for curriculum development and pedagogical studies in Türkiye.

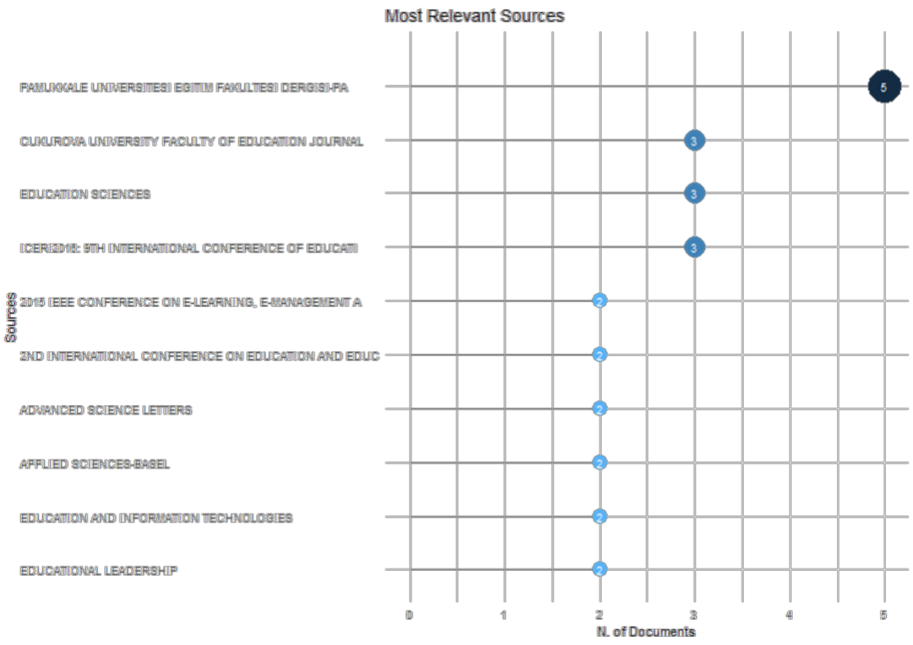
Three other sources are tied with 3 publications each:

- Cukurova University Faculty of Education Journal,
- Education Sciences – an internationally indexed open-access journal, and
- ICERI2016: 9th International Conference of Education, Research and Innovation – reflecting the impact of conference-based dissemination in technology-enhanced education.

This distribution highlights a notable blend of Türkiye-based education journals, international peer-reviewed outlets, and indexed conference proceedings. The strong presence of conference literature suggests an active dialogue on Bloom's Taxonomy in the context of emerging technologies, instructional design innovations, and globalized education reform.

Moreover, the inclusion of open-access and interdisciplinary journals such as *Education Sciences* and *iJET* (International Journal of Emerging Technologies in Learning) indicates the growing visibility of Bloom's framework in digitally mediated and globally networked education ecosystems.

Figure 3. Most Relevant Sources



Core Sources According to Bradford's Law

Bradford's Law is a bibliometric model used to identify core journals—those that produce the highest concentration of articles on a specific topic (Figure 4). The literature is typically divided into three productivity zones:

- Zone 1 contains the most productive journals (core),

- Zone 2 includes moderately productive journals,
- Zone 3 comprises a long tail of journals contributing a small number of articles.

According to the data, the following sources constitute Zone 1, the core zone for publications on Bloom's Taxonomy and its revised version:

1. Pamukkale University Faculty of Education Journal, – 5 publications
2. Cukurova University Faculty of Education Journal, – 3 publications
3. Education Sciences – 3 publications
4. ICERI2016: 9th International Conference on Education, Research and Innovation – 3 publications
5. 2015 IEEE Conference on E-Learning, E-Management, and E-Services – 2 publications

These sources form the nucleus of scholarly communication in the field, collectively accounting for a substantial portion of the total output. Their inclusion in Zone 1 suggests a consistent interest in publishing research related to instructional objectives, assessment frameworks, and learning taxonomies.

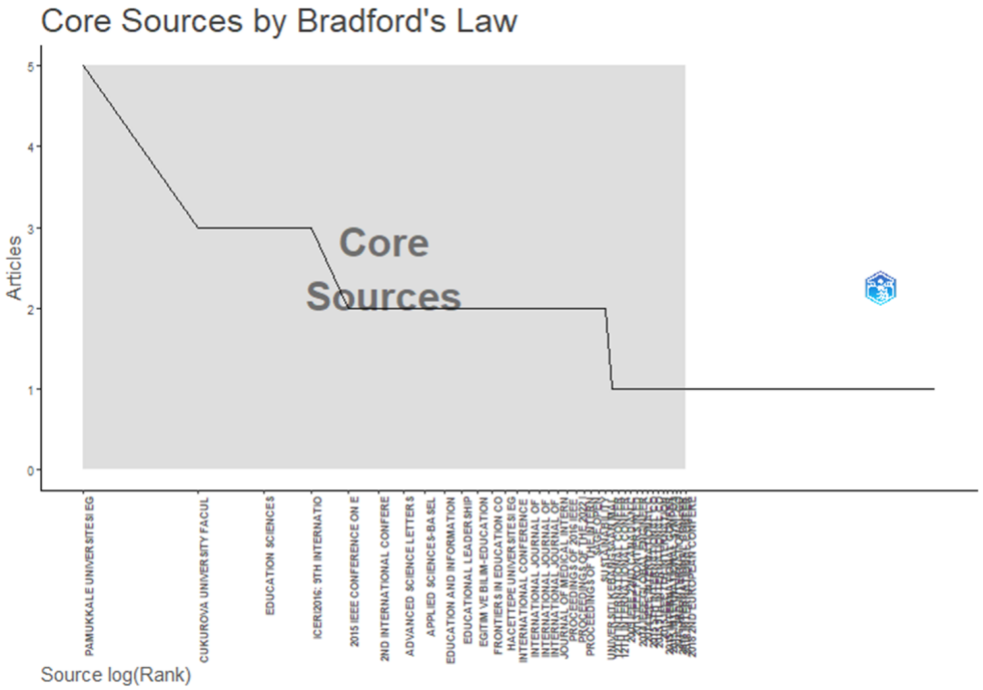
Notably, the list includes:

- National academic journals (e.g., Pamukkale and Cukurova university journals),
- An international peer-reviewed journal (*Education Sciences*), and
- Major educational technology conferences (ICERI and IEEE), which highlights the interdisciplinary and applied nature of research in this area.

This mixture of journals and conferences illustrates that scholarship on Bloom's Taxonomy extends beyond traditional pedagogy, finding relevance in digital learning environments, STEM education, and international educational reforms.

The identification of these core sources is particularly valuable for researchers and practitioners seeking to publish strategically, track emerging research fronts, or conduct systematic reviews within the domain.

Figure 4. Core Sources by Bradford's Law



Most Relevant Authors

The "most relevant authors" are identified by their number of publications related to Bloom's Taxonomy and its revised version between 1980 and 2025. As shown in Figure 5, the authors with the highest scholarly output reflect an internationally distributed research base, indicating global academic engagement with learning taxonomies.

The three most prolific authors—each with 4 publications—are:

- Francesa J.,
- Mohamed H., and
- Troussas C.

These scholars have contributed notably to areas such as intelligent tutoring systems, technology-supported pedagogy, and instructional design, often incorporating Bloom's framework into digital and adaptive learning environments.

They are followed by authors with 3 publications, including:

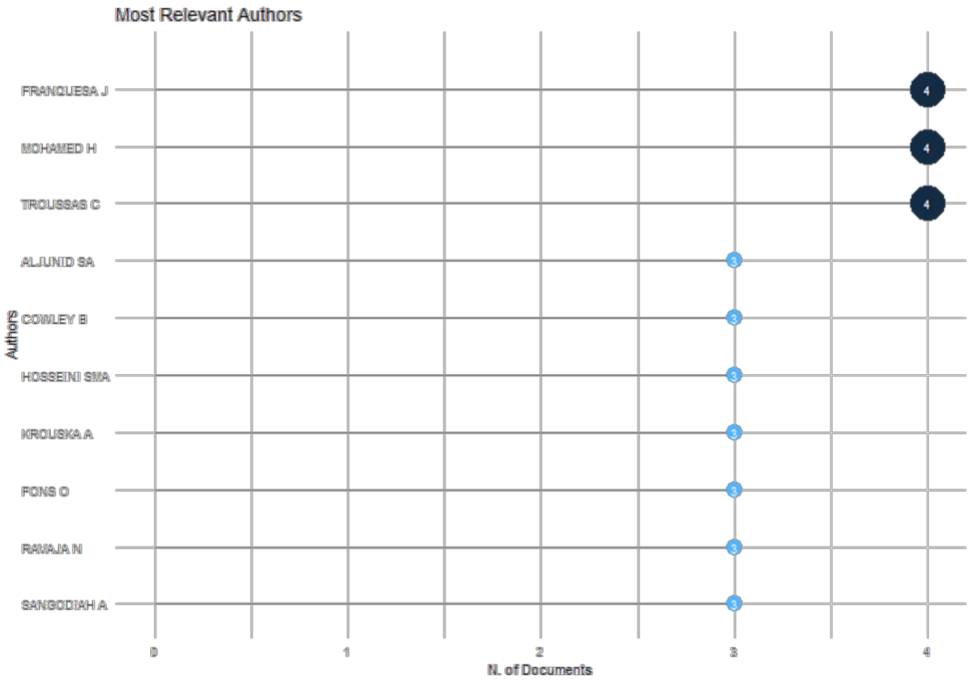
- Aljunid S. A.
- Cowley B. etc.

This list also includes contributors with highly fractionalized publication contributions, suggesting frequent co-authorship and interdisciplinary collaboration.

Unlike previous assumptions of national concentration, the most relevant authors in this dataset represent a diverse global scholarly community, further emphasizing the taxonomy's applicability across educational systems, languages, and learning modalities.

Moreover, the use of fractionalized article counting in the analysis (i.e., adjusting credit for co-authorship) supports a more nuanced view of academic productivity in this field. The results also hint at growing collaboration between educational researchers and computer scientists, especially in the context of AI-driven personalized learning, automated assessment, and learning analytics—all areas where Bloom's hierarchical objectives offer a conceptual backbone.

Figure 5. Most Relevant Authors



Keyword Frequency Analysis: Word Cloud and TreeMap Interpretation

To identify the most prominent concepts within the Bloom's Taxonomy research landscape, a keyword frequency analysis was conducted using the Word Cloud (Figure 6) and Tree Map

(Figure 7) visualizations. Both tools display terms by frequency of occurrence, offering a snapshot of dominant research themes and conceptual emphases across the corpus.

The most frequently occurring terms include:

- "Education" (n = 11)
- "Students" (n = 8)
- "Bloom's Taxonomy" (n = 6)
- "Science" (n = 6)
- "Knowledge" (n = 5)

The recurrence of the term "education" at the top aligns with the taxonomy's foundational role in instructional planning, curriculum development, and learning assessment. Its frequency underscores the field-wide relevance of Bloom's framework, particularly in the context of educational theory and practice.

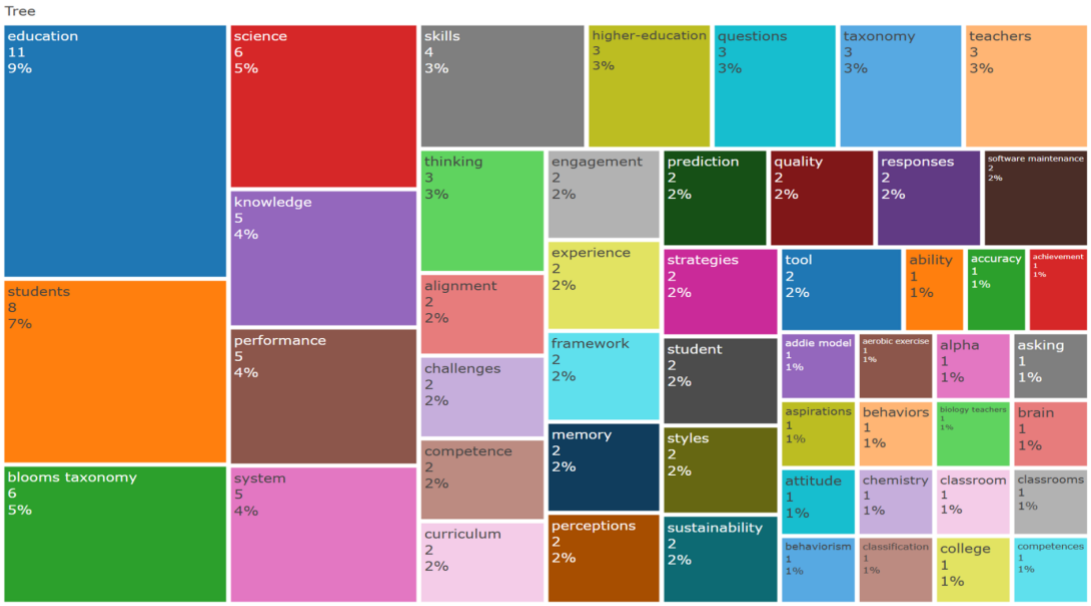
The prominence of "students" highlights the learner-centered orientation of most studies, reflecting a concern with how learning objectives influence student performance, engagement, and cognitive development. Meanwhile, the term "Bloom's Taxonomy" itself signals a strong direct engagement with the theoretical model and its practical adaptations.

Interestingly, terms such as "science" and "knowledge" suggest a significant number of studies applying the taxonomy in STEM education, where structuring learning objectives across cognitive levels is critical for developing analytical and problem-solving skills.

Overall, the Word Cloud and TreeMap provide complementary confirmation of the taxonomy's pedagogical centrality and conceptual reach, particularly in linking curriculum theory with measurable student outcomes in both general education and subject-specific domains.

Figure 6. Word Cloud

Tree Map (Figure 7)



Geographic Distribution of Corresponding Authors

An analysis of corresponding authors' affiliations provides insight into the geographic landscape of scholarly leadership in the field of Bloom's Taxonomy. As shown in Figure 8, the distribution is internationally diverse, with notable contributions from both Global South and Global North countries.

The country with the highest number of corresponding authors is Indonesia, contributing 25 documents (11.96% of the total), of which 23 are single-country publications (SCP) and 2 are

multi-country collaborations (MCP). This reflects a strong national research agenda around curriculum and pedagogy, possibly aligned with systemic educational reforms and teacher training initiatives in the region.

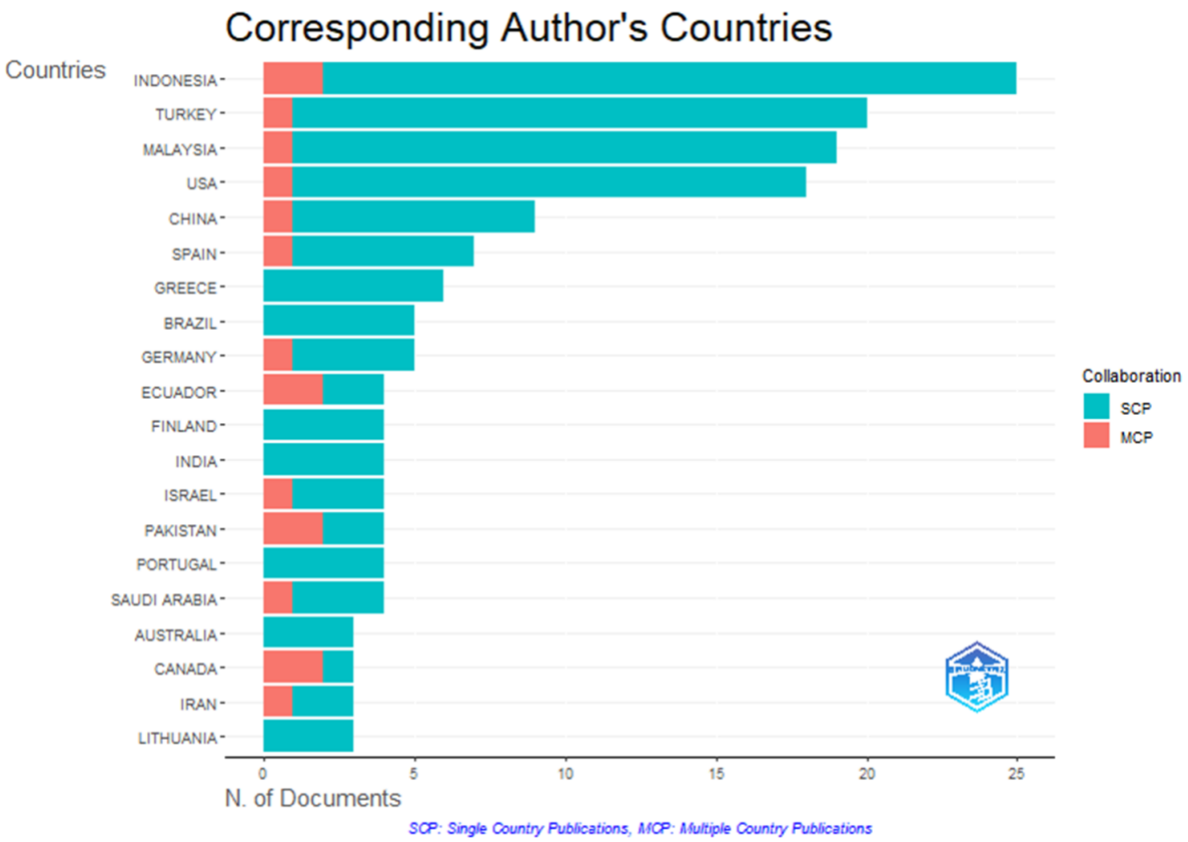
Türkiye ranks second with 20 documents (9.57%), of which 19 are SCP and only 1 involves international collaboration. This pattern suggests a robust domestic research culture focused on instructional design and learning outcomes, yet with limited global co-authorship engagement. The predominance of single-country papers could also be indicative of the local application and adaptation of Bloom's framework within Türkiye's national education policies.

Malaysia and the United States follow closely, with 19 and 18 documents respectively. Both countries exhibit a similar structure—primarily single-country papers—with only 1 international collaboration each. These figures affirm their sustained scholarly interest in pedagogical taxonomies, particularly in the context of higher education and technology-enhanced learning.

China contributes 9 documents, including a slightly higher proportion of MCP (11.11%), suggesting increasing involvement in international academic networks.

The data indicate that while Bloom's Taxonomy is a globally adopted framework, its application and research leadership are concentrated in specific educational systems, particularly in Asia. The relatively low levels of MCP across countries highlight the potential for enhanced international collaboration, which could enrich comparative perspectives and cross-cultural validation of learning outcomes frameworks.

Figure 8. Corresponding Author's Countries



Collaboration World Map

The Collaboration World Map (Figure 9) visualizes international co-authorship patterns by tracking the frequency of joint publications between countries. This analysis highlights the extent and diversity of global research partnerships in the field of Bloom's Taxonomy.

The data reveal a low but geographically dispersed level of international collaboration, with each identified country-pair appearing only once in the dataset. Examples include:

- Bulgaria – Italy
- China – Canada
- China – United Kingdom
- Denmark – Poland
- Ecuador – Cuba

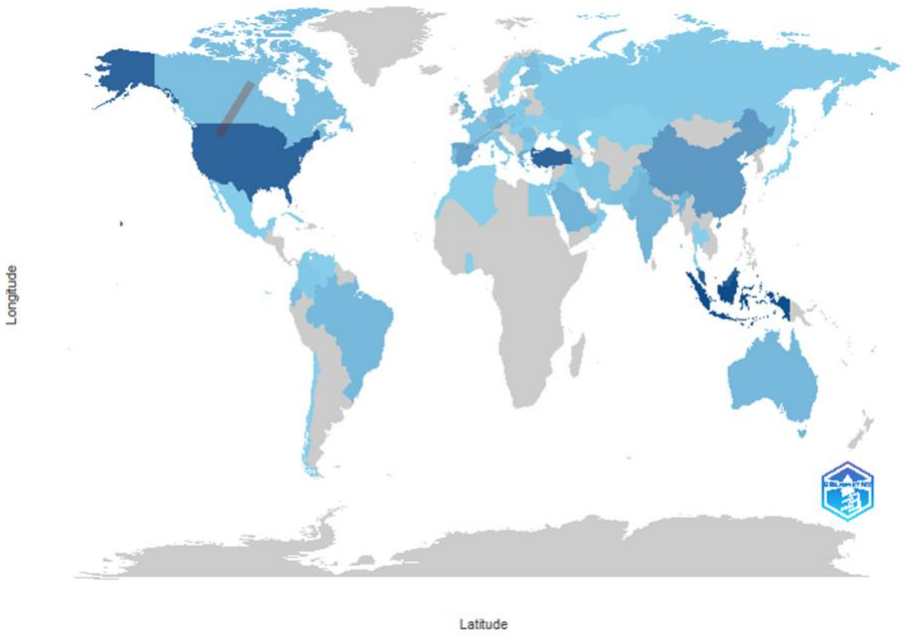
The presence of these partnerships indicates that while bilateral collaborations exist, they tend to be sporadic and regionally scattered, rather than embedded within large, persistent international research networks. This pattern may be due to the applied nature of research on

Bloom's Taxonomy, which is often aligned with national curriculum reforms and local pedagogical practices, limiting the scale of multinational co-authorship.

That said, countries like China, which appears in multiple international pairings (e.g., with both Canada and the UK), may be emerging as bridging actors in the global research landscape. Similarly, the appearance of partnerships spanning Europe, Asia, and Latin America suggests that Bloom's framework serves as a common conceptual tool across diverse educational systems.

However, the overall frequency of international collaboration is limited, and the findings point to a need for stronger global research networks. Expanding multi-country projects could enhance cross-cultural validation of learning objectives and foster more inclusive educational models that reflect both global standards and local adaptations.

Figure 9. The Collaboration World Map



Country Scientific Production

The analysis of country-level scientific (Figure 10) output provides a clear picture of which nations are leading contributors to the scholarly discourse on Bloom's Taxonomy and its revised version. According to the dataset, Türkiye ranks first in total publications, with 46 documents, followed closely by:

- Indonesia – 43 publications

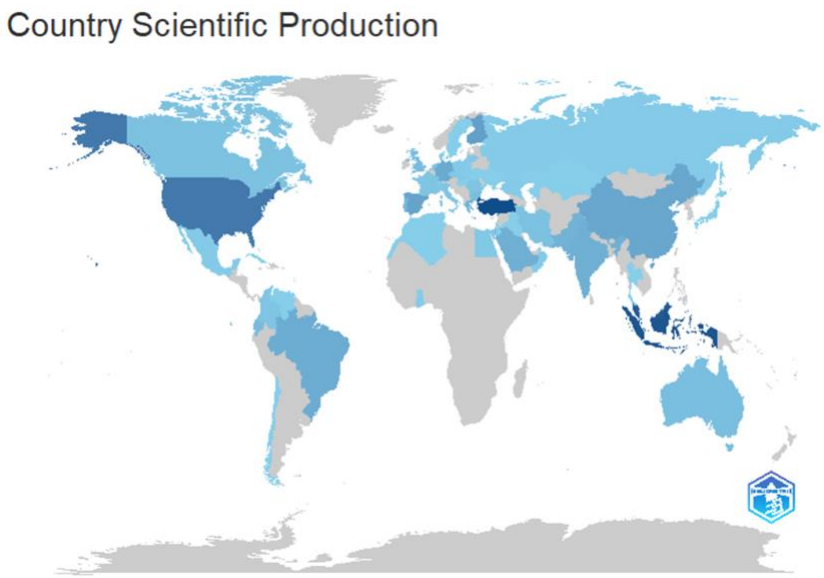
- Malaysia – 41 publications
- United States – 30 publications
- Finland – 16 publications

This distribution suggests a regional shift in research productivity, where countries in the Global South—particularly in Southeast Asia and Türkiye—have taken a central role in exploring and applying Bloom's Taxonomy within their educational systems.

The high output from Türkiye, Indonesia, and Malaysia reflects a strong national investment in curriculum development, teacher education, and instructional planning—areas where Bloom's framework is frequently operationalized. Moreover, these countries have undergone significant educational reforms in recent decades, often requiring the articulation of learning outcomes, competencies, and assessment models aligned with Bloom's hierarchy.

While the United States remains a key intellectual origin of Bloom's Taxonomy, its relative ranking (4th) suggests that its role has evolved more toward citation leadership and theoretical influence, whereas production is increasingly diversified globally.

Figure 10. Country Scientific Production



Country Production Over Time

The longitudinal view of country-level output, presented in Country Production Over Time, reveals distinct phases of engagement:

- In the 1980s and early 1990s, the United States dominated the field, producing foundational studies and setting the theoretical agenda. Notable spikes in U.S. output occurred in 1985 and 1992, corresponding to increased academic interest in learning

outcomes and instructional objectives.

- From the early 2000s onward, there is a noticeable rise in productivity from Türkiye, Malaysia, and Indonesia, indicating that the taxonomy was being actively adopted in national educational reforms and teacher training programs. This shift aligns with the post-2001 period, following the publication of Anderson and Krathwohl's revised taxonomy.

- In recent years (post-2015), Indonesia and Malaysia have shown sharp increases, with publication peaks that often surpass those of traditionally dominant Western countries. This reflects both increased local academic capacity and a growing demand for structured educational evaluation frameworks in rapidly developing education systems.

This transition underscores a broader global democratization of educational research, wherein the practical application of Bloom's Taxonomy is now led by regions once considered consumers—rather than producers—of pedagogical theory.

Most Cited Countries

The analysis of the most cited countries (Figure 11) reveals not only where research on Bloom's Taxonomy is being produced, but also where it is having the greatest scholarly impact in terms of citations. Citation counts serve as a proxy for research visibility, influence, and academic recognition within the global knowledge network.

As shown in Figure 11, the country with the highest total citation count is:

- Israel, with 221 citations across its publications, averaging 55.2 citations per article. This remarkably high average indicates that Israeli scholars have produced a small number of highly influential publications, likely foundational or methodological in nature, that have been widely cited by the global academic community.

Following Israel, other top countries include:

- United States – 163 total citations, 9.1 average per article

- Malaysia – 76 total citations, 4.0 average per article

- Türkiye – 75 total citations, 3.8 average per article

- Greece – 66 total citations, 11.0 average per article

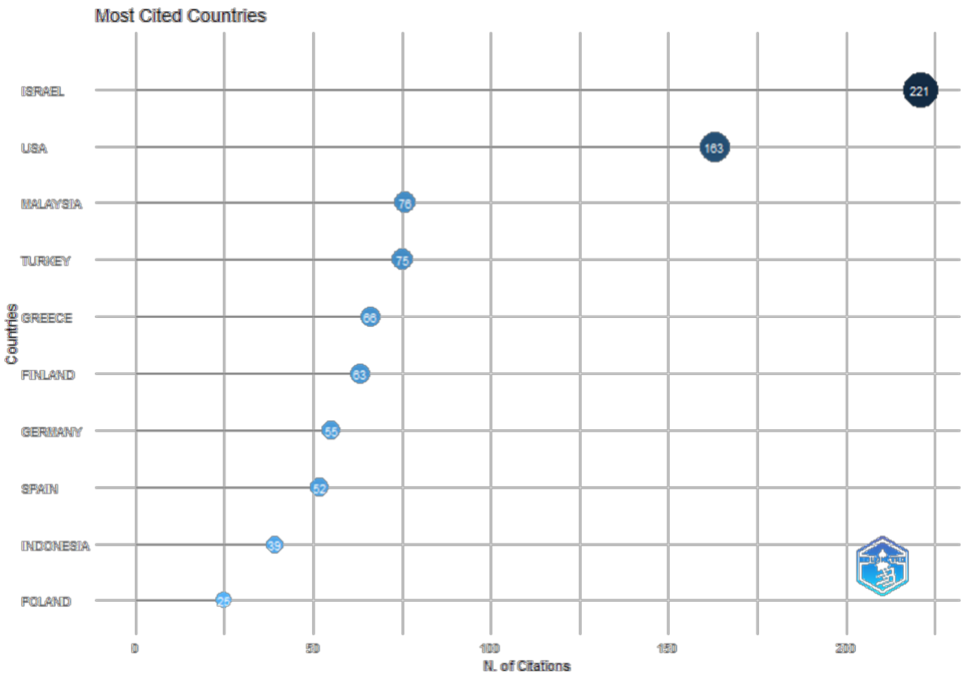
While the USA continues to be a major intellectual contributor, its average citation rate per article is notably lower than Israel's or Greece's, suggesting that its influence is spread across a broader number of studies rather than concentrated in a few seminal works.

The appearance of Malaysia and Türkiye in the top five highlights their emerging role not just in publication volume, but in scholarly impact. However, their average citations per article remain modest, which may indicate that while research activity is high, further efforts are needed to enhance international visibility, citation practices, and publication in high-impact journals.

The case of Greece, with a relatively high average citation count (11.0), demonstrates that even with fewer publications, strategic focus on high-quality or globally relevant research topics can yield strong academic influence.

These findings underscore the need for balanced scholarly strategies that prioritize both quantity and quality, as well as collaborative dissemination efforts that can enhance citation performance across national boundaries.

Figure 11. Most Cited Countries



Discussion

This bibliometric analysis offers a comprehensive overview of the evolution, structure, and global diffusion of research on Bloom's Taxonomy and its revised version between 1980 and 2025. The findings reveal several significant trends and insights that contribute to our understanding of the field's intellectual and practical development.

First, the temporal distribution of publications indicates a steady increase in scholarly interest following the 2001 revision of the taxonomy, with publication peaks aligning with broader educational reforms and the rise of digital learning paradigms. Notably, the taxonomy's relevance has been revitalized by increasing demands for competency-based education, outcome-driven instructional design, and technology-enhanced pedagogy.

The analysis of average citations per year reveals that while publication volume has grown, citation impact remains concentrated in a few highly influential works. This suggests a distinction between volume-driven growth and conceptual impact, highlighting the need for quality-focused contributions that can shape future discourse.

The most relevant sources and authors point to a blend of national and international engagement. Journals such as *Pamukkale University Faculty of Education Journal*, *Cukurova University Faculty of Education Journal*, *Education Sciences*, and *International Journal of Instruction* serve as core outlets, while authors such as Francesa J., Mohamed H., and Troussas C. stand out as key contributors. These findings confirm that the taxonomy is not only applied globally but also interpreted through context-specific lenses, particularly in teacher education, curriculum evaluation, and instructional technology.

Geographic data further support this perspective. While the United States maintains a strong foundational role, countries such as Türkiye, Indonesia, and Malaysia have emerged as leading contributors in terms of both publication output and scholarly engagement. The presence of Israel and Greece among the most cited countries—despite having fewer publications—illustrates the power of selective, high-impact research.

At the same time, collaboration patterns remain limited. Most publications are single-country authored, and international co-authorship is sparse. This suggests a need for more global research partnerships, especially considering the widespread adoption of Bloom’s framework across cultural and educational contexts. The Collaboration World Map underscores this point, revealing scattered bilateral links but no sustained transnational networks.

From a conceptual perspective, keyword frequency analyses (word cloud and tree map) confirm the continued relevance of terms such as “education,” “students,” “Bloom’s Taxonomy,” “science,” and “knowledge.” These align with the taxonomy’s core application areas while pointing to its cross-disciplinary reach, particularly in STEM education and digital learning environments.

Finally, Bradford’s Law helped identify a small number of core sources that account for a disproportionate share of the literature. This insight is critical for researchers aiming to strategically position their work within the field’s most active and influential venues.

In sum, the findings suggest that research on Bloom’s Taxonomy remains vibrant, globally relevant, and methodologically diverse. However, the field would benefit from:

- Strengthened international collaboration,
- Greater focus on citation impact and theoretical contributions, and
- Continued integration with emerging pedagogical technologies.

These directions offer valuable opportunities for scholars, educators, and policymakers seeking to leverage Bloom's hierarchical model in designing evidence-informed, future-ready learning environments.

Conclusion and Recommendations

This study presents the first comprehensive bibliometric analysis of research on Bloom's Taxonomy and its revised version over a 45-year period (1980–2025), mapping the field's intellectual landscape, thematic development, and global scholarly engagement. The findings underscore the taxonomy's enduring relevance in curriculum design, instructional planning, and assessment frameworks, while also highlighting emerging trajectories in technology-enhanced learning, competency-based education, and cross-disciplinary pedagogical innovation.

The analysis reveals a substantial body of literature anchored in both foundational theory and practical application, with a marked increase in publication volume following the 2001 revision of the taxonomy. Countries such as Türkiye, Indonesia, and Malaysia have emerged as key contributors, reflecting localized efforts to align instructional objectives with educational reforms. However, citation patterns and collaboration metrics suggest that scholarly impact remains unevenly distributed, and international cooperation remains limited.

Keyword analysis further confirms the taxonomy's alignment with core educational themes—such as knowledge acquisition, science education, and learner-centered approaches—while Bradford's Law analysis identifies core publication venues that shape the field's discourse.

Recommendations for Future Research and Practice

Based on the bibliometric findings, several recommendations can be made to advance the field:

1. **Encourage Cross-National Collaboration**
   Future research should prioritize international partnerships, especially between Global North and Global South institutions, to foster knowledge exchange and comparative studies that reflect diverse educational realities.

2. **Focus on Theoretical Advancement and Conceptual Integration**
   While Bloom's Taxonomy is widely applied, there is a need for deeper theoretical work that integrates it with contemporary learning theories, such as connectivism,

constructivism, and socio-cultural perspectives. Researchers should critically explore the taxonomy's adaptability to non-Western epistemologies and emergent digital learning ecosystems.

3. **Enhance Publication Strategies and Citation Visibility**
   Scholars, particularly in high-output countries like Türkiye, Indonesia, and Malaysia, should aim to publish in internationally indexed, peer-reviewed journals and engage in active citation practices to increase the global impact and visibility of their work.

4. **Apply Bloom's Framework to Interdisciplinary and Technological Contexts**
   Researchers are encouraged to explore the taxonomy's relevance in AI-driven personalized learning, digital assessment systems, and STEM-integrated curricula, where hierarchical learning objectives can provide structure for adaptive instruction and analytics-based feedback loops.

5. **Leverage Core Sources and Bibliometric Tools**
   Academics entering this research space should focus their submissions to the core journals identified by Bradford's Law, while using bibliometric tools such as Biblioshiny and VOSviewer to monitor trends, identify gaps, and position their work strategically.

In conclusion, Bloom's Taxonomy continues to serve as a conceptual compass for educational theory and practice. However, its evolving role in a rapidly digitizing, globalizing, and diversifying world demands both critical reflection and innovative adaptation. By combining theoretical depth with methodological innovation and international cooperation, the next generation of research can ensure that Bloom's legacy remains relevant and transformative in 21st-century education.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of generative AI and AI-assisted technologies in the writing process

Declaration of Generative AI Use

During the preparation of this manuscript, the authors used ChatGPT (OpenAI, version 4.0) to assist with language editing, clarity improvements, and paraphrasing under the authors' full direction and review. No content was generated autonomously by the tool without author input. All substantive academic content, analysis, and interpretations are the authors' own. The authors take full responsibility for the integrity and accuracy of the manuscript.

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Design and Evaluation of a Web 2.0-Supported Socioscientific Activity on Artificial Intelligence in the Military and Defense Field

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Abstract

It is undeniable that future teachers will encounter numerous socioscientific issues related to artificial intelligence (AI) and its applications. Therefore, it is of great importance that pre-service science teachers become aware of socioscientific issues concerning AI during their learning processes, actively participate in reasoning, and make evaluations from a socioscientific perspective. Based on these considerations, the aim of this study was to develop a Web 2.0-supported activity focusing on the applications of AI in the military and defense field and to evaluate pre-service teachers' views regarding the activity. The study was conducted using a case study design, one of the qualitative research methods. The participant group consisted of fourth-year pre-service science teachers (n = 10) studying at a public university. In the study, a problem-scenario activity related to AI applications in the military and defense field was designed using the Web 2.0 tool Padlet. The data collection tools included pre-service teachers' written responses on Padlet, semi-structured interview forms, and field notes. Content analysis was employed for data analysis. The findings of the study revealed themes such as opportunities and positive effects of artificial intelligence applications in the military and defense field, risks and negative effects, recommendations on usage of controlled and ethics, preference for domestic and national technology, and concerns and fears. Pre-service science teachers highlighted possible threats regarding the use of AI in the military and defense, such as system errors, cyberattacks, and diplomatic crises, while also emphasizing opportunities such as the potential to reduce human casualties, the decisive role of AI technologies in the future of countries, the preference for domestic and national production, and thus reducing technological dependence on foreign sources. In addition, there are concerns and fears that the use of AI-supported applications in the military and defense field may worsen wars and become extremely detrimental once they move beyond human control. The study contributes to the literature by presenting an original example of integrating complex socio-scientific issues such as AI into science teacher education through Web 2.0 tools.

Keywords: Artificial Intelligence; Socio-scientific issues; Web 2.0 tools; Padlet.

Introduction

The rapid emergence of new and advanced technologies continuously reshapes the knowledge, skills, and roles expected from today's and future citizens, both in their professional life and daily routines. The World Economic Forum (2025) highlights that the leading technological trend expected to shape job transformations between 2025 and 2030 is artificial intelligence and information processing technologies, followed by robotics and autonomous systems.

Artificial intelligence (AI) functions as a supportive tool by providing time and location independent learning opportunities, facilitating data-driven rapid decision-making, and delivering timely feedback enabling, personalized learning however, it also gives rise to significant moral and ethical challenges, including algorithmic bias and discrimination, unequal access, accountability issues, diminished social interaction, and data privacy concerns (Chen et al., 2020; Kim et al., 2022; Luckin et al., 2016; Popenici & Kerr, 2017; Sevil & Gökoğlu, 2024; Temur, 2025; UNESCO, 2021). AI finds applications across a diverse array of sectors, including medicine and healthcare, social media, military and defense, autonomous vehicles, agriculture, law, and banking (Banerjee et al., 2018; Çilhoroz & Işık, 2021; Gaire, 2023; İşcan ve Durgun, 2024; Surden, 2019; Mun et al., 2022).

AI and its application areas represent a socioscientific issue in the context of science education, encompassing ethical and moral dimensions, both positive and negative aspects, uncertainty, and the need for risk management, which have sparked global discussions. The teaching of socioscientific issues (SSIs) aims to enhance individuals' scientific literacy levels, help them understand the nature of science, and enable them to make informed decisions on societal issues (Sadler, 2004; Zeidler, 2014).

When studies examining artificial intelligence and its applications from a socioscientific perspective are reviewed, only a very limited number of studies can be found (Mun et al., 2022; Tekin & Aslan, 2025). Mun et al. (2022), in their study examining the decisions of 7th-grade students regarding autonomous vehicles, reported that students felt anxious about artificial intelligence systems and expressed opposing views, while also explaining the reasons

for their opinions. The authors further emphasized that students explored multiple perspectives during decision-making and exhibited patterns such as experiencing conflicts while reaching consensus as a group. Tekin and Aslan (2025), on the other hand, demonstrated through a sample implementation that the culturo-techno-contextual approach is an appropriate method for teaching artificial intelligence as a socioscientific issue. In other studies, AI and machine learning models were used as tools to examine the effectiveness of teaching different topics other than AI itself (Liu & Tu, 2024). Zhang (2019) contributed to the literature by presenting a modular instructional program design that integrates socioscientific issues with AI ethics, including learning objectives, content, and pedagogical strategies. Building on this perspective, the present study designed and evaluated a Web 2.0-supported socioscientific activity addressing Artificial Intelligence in the Military and Defense domain.

Methodology

This study employed a case study design, a qualitative research approach that enables researchers to collect comprehensive and detailed information about a particular phenomenon and understand it deeply within its natural context (Creswell, 2013). Specifically, a Padlet-based problem scenario activity titled "AI in Military and Defense" was conducted with pre-service science teachers. Their responses to this activity were analyzed to explore how they evaluate a real-life situation within a socioscientific context.

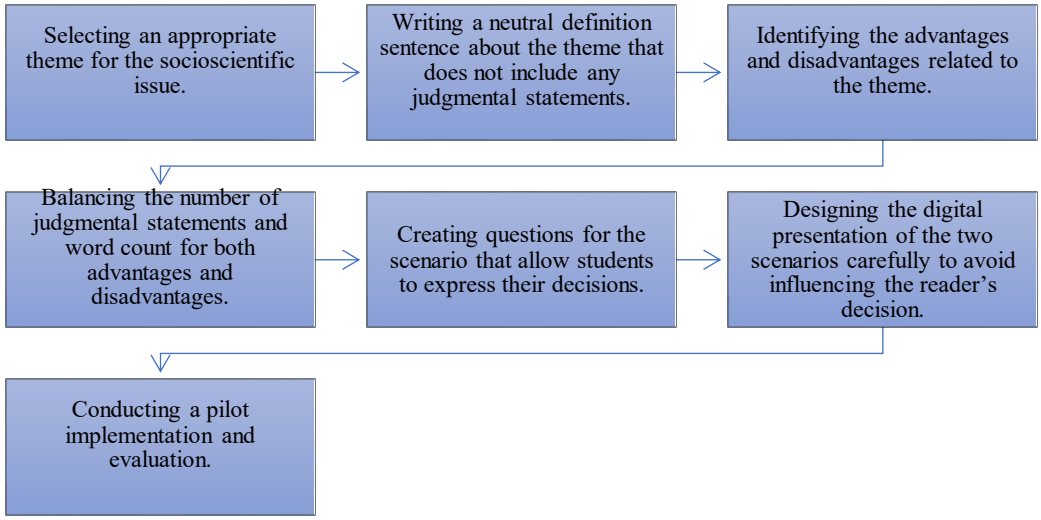
Participants

The study group consisted of 10 fourth-year pre-service science teachers enrolled in the course "FBE00120 Socioscientific Issues and Their Teaching in Science Education" at a Faculty of Education in the Aegean Region during the 2024–2025 spring semester, all of whom voluntarily agreed to participate in the research. Participants were selected through purposeful sampling, a method that allows for the selection of individuals who are most suitable for the research objectives and can contribute based on their experience and knowledge (Patton, 2002). The main rationale for choosing this group was that the participants already had prior knowledge and experience regarding the characteristics of socioscientific issues. The group included three male and seven female pre-service science teachers, with grade point averages ranging from 2.50 to 3.40.

Data collection tools

A problem scenario activity was developed using the Padlet Web 2.0 tool, under the theme "AI in Military and Defense." The activity specifically focused on the socioscientific issues of Project Maven by the U.S. Department of Defense and Turkey's AI-supported UAV (Unmanned Aerial Vehicle) projects, AKINCI and Bayraktar TB2. Detailed information regarding the activity is provided in Appendix 1. The development of the activity followed a systematic procedure and is presented as follows (Figure 1). The primary qualitative data collection tool of the study consists of the open-ended questions in the activity developed using the Padlet Web 2.0 tool. The second data collection tool of the study is a form containing open-ended questions in document format, developed by the researchers and reviewed by two experts in the field of science education. Thirdly, the field notes taken by the second researcher during the implementation process constitute the third data source.

Figure 1. Steps for developing the activity



Data Analyses

In the study, the participants' responses to the open-ended questions embedded in the socioscientific scenario activity developed via the Padlet Web 2.0 tool, together with their responses to the document-based form comprising open-ended questions on the applications of AI in the military and defense domain, were transcribed and consolidated into a single written corpus. This corpus was subjected to content analysis by the first researcher, through which codes and themes were generated. Furthermore, pre-service science teachers' verbal reflections concerning the functionality of the activity, expressed during classroom discussions, were documented as field notes by the second researcher and subsequently analyzed using content analysis, resulting in the identification of additional codes and themes. The emergent codes, themes, and illustrative direct quotations from the pre-service science teachers are presented in the Results section.

Results

Five themes (T) and twenty-one codes (C) were identified regarding the socioscientific issue of AI in the military and defense field: Opportunities and Positive Effects (T1), Risks and Negative Effects (T2) Recommendations on usage of controlled and ethics (T3), National and independence of technology (T4). The codes related to these themes, along with direct quotations, are presented in Table 1.

Table 1. Themes and codes regarding the use of AI in the military and defense field

Theme 1: Opportunities and positive effects C1: The potential to reduce human casualties C2: Providing efficiency and convenience C3: Effective use through training and awareness-raising C4: Being beneficial in the field of defense C5: The technological level becoming a determinant for the country's future	**Direct quotations of pre-service science teachers' (PST) views** PST2: *"With artificial intelligence, the number of people who will die may decrease, because artificial intelligence will have replaced soldiers."* PST7*: "By assigning simple tasks to artificial intelligence, we can achieve more efficient military operations."* PST9*: "First of all, I would train it in a way that all soldiers could use it and raise public awareness."* PST8*: "I would use artificial intelligence in every field and teach it to those who don't know it. For me, AI means convenience. I would like there to be convenience in the world and would develop it."* PST3*: "With artificial intelligence, wars based on human power will completely disappear, and the country's future will be determined by how advanced its artificial intelligence is."*
Theme 2: Risks and negative effects C6: Threat to humans and societies C7: Risk of Systemic Failure C8: Risk of Cyber Attack C9: Diplomatic Crisis C10: Loss of Life and Property	PST1*: "It may cause more human deaths, the deaths of innocent people, and diplomatic crises."* PST3*: "I think it poses a threat; with cyberattacks, more loss of life may occur."* PST6*: "The use of artificial intelligence has both advantages and disadvantages. System errors need to be fixed. Any misperception may also result in loss of life and property."* PST10*: "Although artificial intelligence is highly developed, it may also lead to dangerous consequences."*
Theme 3: Recommendations on usage of controlled and ethics C11: The need for rigorous testing and supervision C12: Recommendations for the use in accordance with ethical principles C13: Military training and public awareness C14: Being under human control and supervision	PST1*: "I would frequently check it, work to bring it to its best version, and then want it to be used. That way, errors and the deaths of innocent people can be prevented."* PST2*: "I would raise awareness so that all soldiers learn to use it. I would also raise public awareness."* PST4*: "If I were a leader, I would use AI as a system that protects all people and assists decision-making processes. Ethical rules, human oversight, national security priority..."* PST6*: "I would want it to be used with human assistance and control in situations that are difficult to manage. That way, any error would be immediately corrected by human personnel."* PST7*: "I would use it in accordance with ethical and moral principles."*
Theme 4: Domestic and national technology C15: Reducing external dependency C16: Economic and technological development C17: Preference for domestic systems in terms of security C18: Preference for systems developed through field experience.	PST1*: "I would choose projects based on domestic and national production because this way we can reduce external dependency."* PST4*: "My preference is systems developed through field experience focusing on local and national production. Because these systems increase the country's defense independence, reduce external dependency, and may be more reliable. In addition, domestic production contributes to the national economy and supports technological development."* PST9*: "A system focusing on domestic and national production is important for the development of my country."*

Theme 5: Concerns and fears	PST4*: "...If decisions are made by artificial intelligence, there is a risk of making mistakes and unethical decisions. If it develops uncontrollably, it could pose great danger.*
C19: The belief that artificial intelligence could be dangerous	PST8*: "I think these wars will not end. It seems like artificial intelligence will make wars more terrifying. If it is used in the field of defense, it would make more sense. Please, let AI not multiply wars."*
C20: The fear of going beyond human control	"PST10*: "Although artificial intelligence is highly advanced, it may also lead to dangerous consequences."*
C21: Wars becoming more terrifying	

Table 2 shows that pre-service science teachers, under the theme of *"Opportunities and Positive Effects (T1)"* regarding the use of AI in the military and defense field, emphasized its potential to reduce human casualties, provide efficiency and convenience, enable effective use through training and awareness, be beneficial in the field of defense, and serve as a determining factor for the country's future. The participants indicated that, with AI, human-driven wars could decrease, and higher efficiency could be achieved in military operations. Under the theme of *"Risks and Negative Effects"*, they noted that AI could pose a threat to humans and society, entail risks of system failures and cyberattacks, lead to diplomatic crises, and result in loss of life and property. Under the theme of "*Recommendations on Usage of Controlled and Ethics"*, the participants emphasized that AI should be maintained under strict supervision and oversight, used in accordance with ethical principles, and that both military personnel and the public should be made aware of its proper use. They further suggested that human support and oversight would help mitigate potential errors. Under the theme of *"Domestic and National Technology"*, the participants indicated that domestic systems should be preferred to reduce external dependency and to support the country's economy and security. They emphasized that projects based on domestic and national production could enhance the nation's defense independence, decrease reliance on foreign sources, and contribute to the national economy. Finally, under the theme of *"Concerns and*" Fears, some pre-service science teachers expressed their apprehensions that AI could be dangerous, might escape human control, and could make wars more frightening. According to the participants, AI may produce unethical outcomes in decision-making processes and could pose serious threats if it develops uncontrollably.

An examination of the researcher's field notes regarding pre-service science teachers' views on the Padlet (Web 2.0)-based socioscientific activity related to the use of AI in the military and defense field led to the findings presented in table 3.

Table 3. Themes and codes derived from the researcher's field notes on the socioscientific activity implemented via the padlet Web 2.0 tool

T1: Positive features of the socioscientific activity implemented via the Padlet Web 2.0 tool	**Direct quotations of pre-service science teachers' (PST) views**
C1: Provides benefits C2: Facilitates effective communication C3: Promotes freedom of written expression C4: Enhances awareness of diverse perspectives C5: Supports and fosters learning	PST 2: *The activity was highly beneficial. Engaging in online discussions via Padlet provided a more effective communication environment for students who may have difficulty expressing themselves in face-to-face interactions. The freedom of written expression allowed ideas to be conveyed more clearly.* PST 5: *Organizing this type of activity on Padlet was very impressive. Being able to access other students' perspectives, observe different viewpoints, and make comparisons supported the learning process.*
T2: Areas for improvement and recommendations for the socioscientific activity ımplemented via the Padlet Web 2.0 Tool C6: Adding an "Undecided" option in addition to "Agree" and "Disagree" C7: Organizing the page layout as a single text with accompanying questions C8: Removing the "like" button to maintain neutrality	PST 7: *It could be beneficial to add an alternative option such as "Undecided" or "Other" among the choices provided in the activity, as some students may hold views that do not fit the existing options.* PST 8: *Presenting the two texts as a single, cohesive unit could facilitate content tracking. Additionally, keeping the questions fixed on the right side of the text may enhance visibility, as the current layout can appear somewhat scattered and confusing.* PST 10: *Removing the "like" button in the activity could help maintain neutrality. Students may be inclined to read only the most liked opinions, which can lead to some contributions being overlooked.*

An examination of Table 3 indicates that pre-service science teachers' views on the Padlet Web 2.0-based socioscientific activity are organized under two main themes. Under the theme of *"Positive Features",* the activity was reported to be beneficial, to provide freedom of written expression and an effective communication environment, to make diverse perspectives visible, and to support learning. Under the theme of *"Areas for Improvement and Recommendations"*, it was emphasized that an "Undecided" option should be added, the page layout should be presented in a more organized manner, and the "like" button should be removed to maintain neutrality.

Conclusions

The study revealed that pre-service science teachers perceive both opportunities and risks associated with the use of AI in military and defense contexts and emphasize the importance of ethical and human-controlled applications as well as the use of domestic and national technologies to achieve technological independence. Furthermore, the Padlet-based socioscientific activity was found to support communication, freedom of expression, and learning, although certain aspects require further improvement. The findings also suggest that in a niche area such as AI applications in military and defense, discussing current socioscientific issues through Web 2.0 tools like Padlet can enhance pre-service teachers' communication, written expression, and critical thinking skills. Similarly, online discussion activities could be developed for socioscientific scenarios addressing AI in other application domains. Additionally, it is recommended that the activity design incorporate an "Undecided" option and interface arrangements that preserve neutrality.

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Appendix 1

Bridging the Digital Divide: A Hybrid AI-Traditional Approach to Enhancing Undergraduate Distance Learning Through Strategic Media Integration

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Abstract

Distance Learning, structured around educational media and utilizing electronic media as the primary medium, represents a method where undergraduate learners and instructors do not meet face-to-face. However, it facilitates the transfer of experiences that can accommodate individual differences through online electronic media platforms specifically designed for undergraduate education. This approach enables undergraduate students to study independently and effectively, following the components of the educational system organization: environment, input factors, processes, outcomes, and feedback for control and improvement. The media input factors are categorized to include text, still images, animations, audio, video, and various multimedia elements that help stimulate interest and effectively support undergraduate online learning. These can be divided into two categories: media input through new technology and traditional media input methods. Given the advancement of AI technology, which has developed with remarkable leaps in speed, time efficiency, cost reduction, requiring fewer personnel, and not necessitating highly specialized skills, it has been applied to media input using AI technology in undergraduate online education contexts. This includes generating: text-to-image, text-to-slides, text and image-to-video, and other applications. However, it still cannot completely replace traditional media input methods, particularly video content that records knowledge delivered by actual instructors who possess credible knowledge, skills, and experience relevant to undergraduate curriculum requirements, with a traditional media production. Therefore, it is beneficial for undergraduate online instructors to apply various media from AI tools in actual teaching, following these steps in the AI utilization process: 1. Planning and design phase, 2. Development and creation phase, 3. Accuracy and credibility validation phase 4. Implementation and regulatory compliance phase 5. Ethical awareness and prioritization phase

Keywords: AI-integrated education, undergraduate distance learning, hybrid media approach

Introduction

The Office of Educational Technology at Sukhothai Thammathirat Open University, Thailand, serves as the university's sole unit responsible for educational media production. Guided by its mission statement—"Creating valuable media, developing professional personnel, and integrating technology to enhance work quality and promote lifelong learning"—the office undertakes comprehensive academic responsibilities encompassing systematic organization, design, research and development of educational media and technology, production of educational materials, and provision of multimedia services within the distance learning system to optimize student learning efficiency. The university's educational media portfolio includes e-learning modules, video clips, and television programs. The production of these materials requires the preparation of various components, including text, still images, and animations, which are assembled into complete media packages for student use each academic semester. These components must either be imported or produced by graphic designers possessing specialized knowledge and skills in media production. However, the office faces significant capacity constraints: the limited number of personnel, coupled with substantial workload demands each semester, creates a pronounced disparity between production requirements and available human resources. Consequently, the process of importing and preparing source materials for media production is time-intensive. On average, manuscripts must be submitted to graphic designers at least two weeks in advance, while complex manuscripts with extensive content require approximately one month for completion before proceeding to subsequent production stages. The evolution of educational media production has undergone continuous development, transitioning from analog to digital systems and progressing through successive waves of technological advancement to the current AI era. AI is increasingly recognized as a valuable assistant and an effective tool for enhancing workflow processes. In response to this technological paradigm shift, the Office of Educational Technology has initiated the integration of AI tools into the media production workflow, specifically targeting the source graphic import process.

Methodology

The scope of this study, graphic production encompasses the preparation of slides comprising text, still images, diagrams, and animations for the creation of lecture video clips. These materials are designed to support instructors in delivering online e-learning courses via the Moodle (Learning Management System: LMS). The production workflow commences with the instructor's manuscript and culminates in the delivery of presentation-ready slides for instructional purposes with 1 program 1 graphic designer.

Traditional process	text	still images	diagrams	animations	
Content of a manuscript (Ms.Word/Ms.PPT)	Copy>Paste To PPT or Canva	Use free images online	Create* Setting flow chart	Create* Setting effect	complete slide
Ai process	**text**	**still images**	**diagrams**	**animations**	
Content of a manuscript (Ms.Word/Ms.PPT)	AI Generator Prompt/Proof	AI Generator Prompt/Proof	AI Generator Prompt/Proof	AI Generator Prompt/Proof	complete slide

* depends on specialized individual skills and is relatively time-consuming

Figure 1. Traditional process and Ai process for graphic production study

Results

The findings revealed that through the adaptation of graphic designer workflows, AI can effectively serve as an assistant and provide substantial support throughout this process: The AI utilization process: 1. Planning and design phase, 2. Development and creation phase, 3. Accuracy and credibility validation 4. Implementation and regulatory compliance phase 5. Ethical awareness and prioritization phase.

1. Planning and design phase

The planning and design phase serves as a pivotal preliminary process that defines the expected end results and involves meticulous step-by-step planning throughout the entire workflow from beginning to end. This involves defining slide design themes, components, and stylistic approaches; creating Google email accounts; and equipping designers with basic knowledge of popular, free AI tools.

2. Development and creation phase,

The development and creation phase constitutes a pivotal stage for generating design deliverables that fulfill specifications while accommodating various limitations. Tool selection is determined by graphic classification. In application, graphic designers utilize or customize publicly accessible prompt templates to enhance temporal efficiency in the production process

	Ai generator	AI Tools/ Applications	Prompt
text	Text to slide	Gemini, Canva	provide examples or apply/modify existing prompt templates that are commonly shared
still images	Text to images	ChatGPT, Gemini, Canva	
diagrams	sketch to images	ChatGPT, Gemini, Canva	
animations	Text to animations İmages to animations	Canva, VEED.IO	

Figure 2. Development and creation phase of The AI utilization process

3. Accuracy and credibility validation

The accuracy and credibility validation phase represents a critical quality assurance stage focused on verifying output accuracy, particularly concerning spelling and character rendering, which may be susceptible to distortion during the generation process. Designers must perform meticulous verification before operational implementation. This validation protocol extends to generated imagery; any identified inaccuracies require iterative correction to ensure fidelity.

4. Implementation and regulatory compliance phase

Regarding copyright and utilization, this remains a subject of international debate across multiple countries. In Thailand, ownership of AI-generated works has not been definitively established, as Thai copyright law stipulates that the "creator" must be a natural person—specifically, a human being—and does not extend to systems or programs lacking legal personality or natural personhood. Nevertheless, it is advisable to include attribution indicating that the work was generated using AI.

5. Ethical awareness and prioritization phase.

AI-generated content has evolved significantly, achieving high levels of realism. Individuals lacking awareness may be unable to distinguish AI-generated materials from authentic ones. Therefore, AI tools should not be used in ways that could cause misunderstanding or subsequent adverse consequences

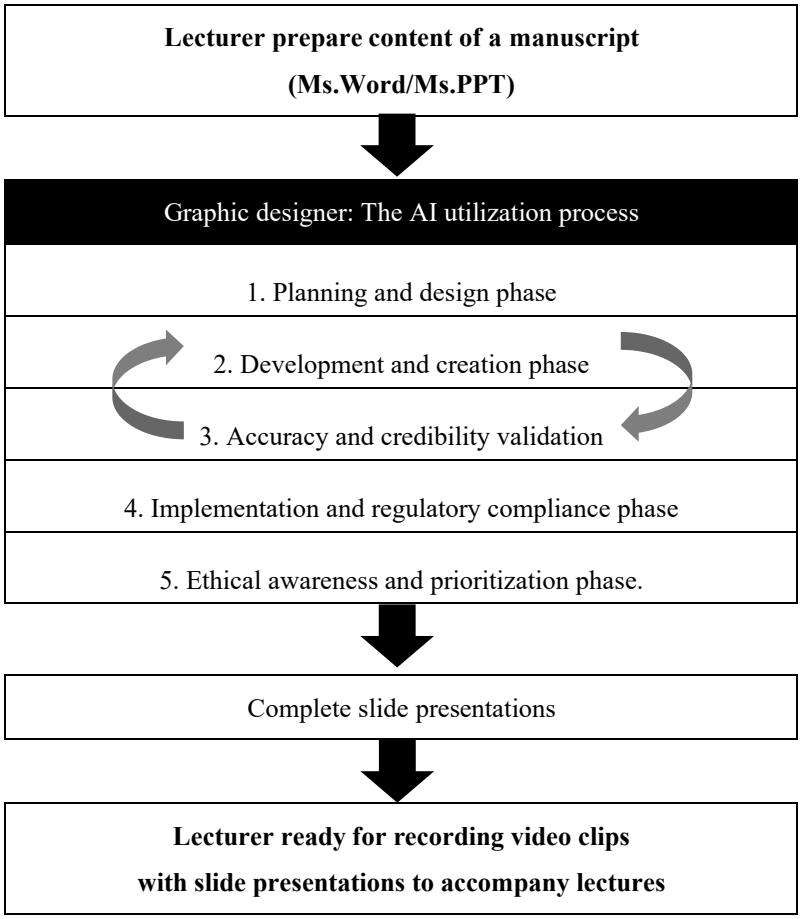

Figure 3. An application of the AI utilization process

Conclusions

Although AI possesses the capability to generate diverse outputs and serves as an excellent tool for developing instructional media, within the educational context—particularly in the institutional framework—instructors utilize educational media as channels for knowledge transmission, requiring credibility and accuracy. This is especially critical for distance education students, who require interaction between instructors and learners due to the absence of traditional classroom settings. Consequently, AI is employed exclusively within the context of media production development. Moreover, experienced instructors possess distinctive characteristics that are difficult to replicate. Regarding graphic designers' reception of AI usage, the technology represents a novel innovation that reduces work time for certain tasks. However, initial implementation requires understanding of various applications to grasp fundamental operational principles, as outlined in Phase 1: Planning and design phase. For Phase 2: Development and creation phase, commonly used programs were selected, demonstrating enhanced convenience and work efficiency. Slide preparation incorporating text, still images, diagrams, and animations benefited significantly from AI integration. Phase 3: Accuracy and credibility validation emphasizes that AI-assisted outputs must undergo consistent post-generation verification, particularly for textual elements. For visual components, AI facilitates the generation of original images, eliminating the need to source potentially copyrighted images from the internet. AI effectively generates diagrams from draft manuscripts, substantially reducing production time. Animation development follows similar patterns. Notably, the availability of ready-made prompts is essential for time reduction, markedly differing from traditional workflows. Critical considerations include Phase 4: Implementation and regulatory compliance phase and Phase 5: Ethical awareness and prioritization phase, particularly regarding copyright and ethical dimensions. The hybrid approach combining AI and traditional methods serves as a bridge—bridging the digital divide—effectively supporting the development of instructional media production processes within distance education systems.

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Using Artificial Intelligence to Support Meaningful Learning and Cognitive Processing

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Abstract

Although definitive predictions regarding the long-term impact of artificial intelligence (AI) on cognitive development within learning processes are yet to be established, it is essential to structure these technologies in ways that foster cognitive development and competencies. Such a structure, which is pivotal for meaningful learning, should be designed with careful consideration of the cognitive processing stages of selection, organization, and integration. In this respect, this study aims to offer insights into how and at what stages AI can be utilized in educational activities to support meaningful learning. Drawing on the cognitive theory of multimedia learning, the study systematically examines the potential of AI-supported educational activities to facilitate cognitive processing stages. Through searches in the WoS and Scopus databases using the keywords "artificial intelligence", "multimedia", and "meaningful learning", 12 out of 46 studies were included in the research and analyzed with the identification, evaluation, and synthesis approach. The analyses were validated using Elicit.ai, an AI-supported systematic literature review tool, resulting in the exclusion of 3 out of the 12 studies from the study. To support meaningful learning in line with the study's objectives, the AI approaches applicable to each cognitive processing stage and the corresponding learning outcomes that can be obtained in this direction were evaluated separately for each stage. The findings reveal that AI approaches and applications provide significant advantages in supporting cognitive processes and promoting meaningful learning within educational activities. However, to fully leverage these advantages and enhance learning outcomes, it is critical to adopt distinct AI approaches tailored to the selection, organization, and integration stages in the cognitive processing process. In this context, both theoretical and practical recommendations focusing on cognitive processes were offered to foresee and structure the long-term impact of AI within a pedagogically grounded framework. Also, the critical role of the educators on AI use through the lens of cognitive processing and development, and the need for teacher training for these processes, were emphasized.

Keywords: Artificial intelligence in education, meaningful learning, cognitive theory of multimedia learning, cognitive processing.

Introduction

Artificial intelligence (AI) in education is continually transforming both the educational paradigm and human knowledge and cognition by providing effective and efficient approaches to support, improve, and enhance learning (Hwang et al., 2020; Jose et al., 2025). Offering adaptable learning environments and personalized learning experiences, as well as data-driven communication, feedback, and evaluations, AI technologies provide numerous advantages in processing information and facilitating meaningful learning through interactive and human-centered learning experiences (Giannakos et al., 2025; Mutlu-Bayraktar, 2024). In this regard, structuring the use of AI in education by considering the information processing and meaningful learning is important.

According to Mayer's (2009) cognitive theory of multimedia learning, students achieve meaningful learning by processing information in three basic cognitive stages: selecting (paying attention to information), organizing (structuring the selected information into coherent mental representations), and integrating (relating information to prior knowledge). Meaningful learning, which occurs when students actively engage with information rather than being passive recipients of information, can be supported by various technological methods and approaches. In this regard, the efficient and effective structuring of cognitive processing processes in the context of the technology to be used is of critical importance for meaningful learning. Therefore, while there is no definitive prediction regarding the long-term impact of AI technologies on students' cognitive skills and meaningful learning (Cukurova, 2025), the use of AI in education should be structured in a way that supports cognitive development and competencies (Jose et al., 2024; Zhai et al., 2024).

Building on the aforementioned considerations, this study examines how the use of AI in education can be improved to foster meaningful learning through cognitive processing stages. Specifically, it explores how AI-supported approaches can optimize the processes of selection, organization, and integration, and thereby contribute

to improved learning outcomes. By synthesizing theoretical perspectives with empirical evidence, the aim is to provide educators, policymakers, and researchers with a framework for leveraging AI in ways that promote cognitive development and personalized learning at the K-12 level. In this context, the guiding research question is: "How can AI-supported approaches in educational activities reinforce students' cognitive processing processes—the selection, organization, and integration stages—and facilitate meaningful learning?"

Methodology

This study aims to synthesize existing research on how AI can be utilized in education to structure cognitive processing and support meaningful learning. To achieve this goal, a systematic literature review approach was adopted to identify, evaluate, and synthesize studies related to the topic (Lame, 2019). This approach enables the collection of relevant evidence on a specific topic that meets predetermined eligibility criteria and addresses formulated research questions (Gough et al., 2017; Nightingale, 2009).

Searching Criteria

A comprehensive search was conducted in the WoS and SCOPUS databases to identify studies on the relevant subject. The databases were searched using the keywords “artificial intelligence”, “multimedia”, and “meaningful learning”. Based on this search, 46 articles and proceedings written in English and published between 2020 and 2025 were identified that addressed the use of AI at the K-12 level in the context of cognitive theory of multimedia learning, cognitive processing processes, and meaningful learning. 17 studies were excluded because they either did not address at least one of the cognitive processing stages or their full texts were not available. The remaining studies were further evaluated using Elicit.ai, an AI-supported systematic screening tool, which identified 12 studies as suitable for the scope of this research. To ensure the accuracy of the findings, all 46 studies were re-examined. Following this retrospective evaluation, 12 studies were confirmed as relevant, of which 9 were found to be directly aligned with the research objectives and were therefore included in the study. The studies were analyzed thematically under three main headings: the AI approach used, the manner in which AI tools were applied, and the learning outcomes obtained accordingly. Each study was evaluated based on the three fundamental stages of cognitive processing: the stages of selection, organization, and integration. Each study addressed was analyzed separately. Furthermore, the cognitive processes discussed in the studies were analyzed to determine how they approached cognitive structure.

Results

This study aims to synthesize three fundamental cognitive processing stages by reviewing relevant literature to demonstrate how AI technologies can support students’ cognitive processing (selection, organization, and integration) at the K-12 level and in facilitating meaningful learning. The studies examined in this context revealed themes related to computational thinking and cognitive processing. Moreover, the AI technologies and cognitive processes addressed in these studies were found to be varied and heterogeneous.

Table 1. Cognitive processes considered

Cognitive Process	Frequency
Computational thinking	2
AI literacy	2
Algorithmic thinking skills	1
Problem solving	1
Cognitive and affective learning	1
Scientific discovery learning	1

The cognitive processes discussed in the studies are not directly based on the three basic stages (selection, organization, integration) found in the cognitive theory of multimedia learning; rather, they encompass cognitive competencies. Therefore, there is no standard approach focusing on cognitive processes in AI integration in education. This situation may support the lack of a long-term prediction for AI integration mentioned by Cukurova (2025). Therefore, future research should consider the long-term effects of AI use in education (Jose et al., 2025).

When the cognitive processes in the reviewed studies are evaluated in the context of Mayer's (2009) three basic cognitive stages, a synthesis can be made as follows regarding the AI method, application approaches, and learning outcomes that can be used to support these cognitive stages.

Table 2. Using AI to support cognitive stages

Cognitive Stage	AI Approach	Application Approach	Learning Outcomes
Selection [Chiu et al., 2023; Halkiopoulus & Gkintoni, 2024; Lee & Kwon, 2024; Martin et al., 2023; Semwaiko et al.., 2024; Yim & Su, 2024]	Intelligent agents, personalized learning environments, chatbots	Data selection for Machine Learning tasks, Customized content presentation, and interactive information retrieval	Increased ability to identify relevant information, Increased interaction with learning material
Organization [Halkiopoulus & Gkintoni, 2024; Liu et al., 2024; Yim & Su, 2024]	Computational thinking tools, visual programming environments, adaptive learning systems	Algorithm development, Visual structuring of concepts, Personalized content structuring	Advanced computational thinking skills, Better understanding of logical structures, Increased ability to organize information
Integration [Aravantinos et al., 2024; Yu Elim, 2024]	AI-supported project-based learning, AI-supported pedagogical approaches	Real-world AI projects, Integration of AI with Bloom's taxonomy, Discussions on the societal impact of AI	Better application of AI concepts, development of higher-order thinking skills, and a better understanding of the broader implications of AI

As shown in the analysis of the studies (Table 2), different approaches and practices can be adopted within the cognitive processing stages to foster meaningful learning. In this regard, intelligent agents, personalized learning environments, and chatbots can be employed in the selection stage to help students identify meaningful and relevant content within large bodies of information. Such tools can facilitate students' access to meaningful knowledge by filtering out irrelevant or overwhelming data. Studies emphasizing the selection stage often focused on intelligent agents and chatbots that filter large volumes of data to highlight relevant information. While these applications were found effective in guiding attention and reducing cognitive overload, few studies systematically measured their long-term impact on students' ability to independently select meaningful content.

In the organization stage, AI can be leveraged to structure information logically, thereby supporting students in transforming content into coherent mental models. In this respect, AI tools and adaptable learning environments that strengthen students' computational learning skills play a critical role. At this stage, computational thinking tools and adaptive learning systems were frequently integrated into curricula. These tools promoted the development of algorithmic reasoning and concept structuring skills. However, variation was observed in the extent to which these approaches explicitly mapped onto Mayer's framework, suggesting a gap between technological affordances and established cognitive theory.

The final phase of meaningful learning, the integration stage, emerged as the least represented in the reviewed literature. This stage represents that the acquired information must be integrated with prior knowledge to ensure that new information conveys deep meaning (Mayer, 2009). Care should be taken to ensure that the AI approaches used are AI-supported pedagogical approaches, such as project-based learning. In this context, competencies such as student engagement and higher-order thinking skills may need to be considered because learning is an experience shaped not only by the assimilation of knowledge but also by interactions with the real world (Mutlu-Bayraktar, 2024). Therefore, it is essential to integrate AI that addresses social, affective, and cognitive dimensions of learning to foster social competence, emotional intelligence, and metacognitive abilities (Cukurova, 2025; Mutlu-Bayraktar, 2024). Although project-based learning and AI-supported pedagogical approaches were identified as promising, empirical evidence on their sustained impact on higher-order thinking and transfer of knowledge was limited. This imbalance indicates that while selection and organization are relatively well-supported by existing AI tools, integration—arguably the stage most crucial for meaningful learning—requires more targeted research and application.

Conclusions

This study highlights that although there is no standard approach focusing on cognitive processes in AI use in education, AI technologies offer significant opportunities and advantages in supporting cognitive processing and meaningful learning in educational activities at the K-12 level. Evidence suggests that when AI applications are deliberately structured in accordance with the selection, organization, and integration stages of cognitive processing, they can provide both students and educators with a learning experience that is richer, more engaging, and cognitively more robust. However, to optimally utilize the benefits of AI, various measures must be taken. Such a comprehensive approach that AI serves as a tool for meaningful learning rather than merely a means of technological enhancement.

The findings underscore the urgent need for comprehensive pedagogical, theoretical, and practical frameworks to guide the effective use of AI in the educational environment. The reviewed studies demonstrate that while AI technologies have promising potential to support cognitive development, their integration into education remains inconsistent and fragmented. The lack of foresight into deeper understanding and more effective implementation of meaningful learning reflects a broader problem in educational technology research: While technological innovation often drives new tools, pedagogical adaptation often lags. Therefore, rather than employing AI merely as a tool, it is essential to leverage it as a mediating agent that actively structures cognitive processes and guides learners toward more meaningful and effective learning experiences.

Within the scope of this study, it can be concluded that for AI technologies to be effectively used in education, they must be contextualized under the guidance of cognitive theories. It was observed that most of the reviewed studies used AI systems solely as tools in the selection and organization stages of cognitive processing. This suggests that the studies conducted on this topic implicitly reflect the foundations of both Mayer (2009) and other pedagogical approaches that offer similar perspectives. Therefore, due to the limited explanatory power of the studies conducted, it becomes difficult to predict the long-term effects of AI use in education on cognitive contexts (Cukurova, 2025; Gkintoni et al., 2025). In this context, it is believed that, in addition to technology-focused studies, research focusing on theoretically grounded cognitive processes is needed. Specifically, for meaningful learning to occur, AI must not only be used as a tool for selecting information (selecting stage) and transforming selected information into coherent mental representations (organizing stage), but also as a tool for integrating information with prior knowledge (integrating stage). Because integration involves connecting new knowledge to prior knowledge, it is deeply related to higher-order thinking, metacognition, and real-world applications. Designing AI-supported pedagogical models that explicitly target integration, such as project-based or inquiry-based learning, could significantly advance both theory and practice. Looking ahead, more long-term, experimental studies are needed to assess the long-term effects of AI on students' cognitive development, higher-order thinking, and metacognitive abilities (Gkintoni et al., 2025; Jose et al., 2025).

Finally, the reviewed studies found no emphasis on educators as the subjects of educational processes in the use of AI. The teacher's role is crucial, particularly in structuring cognitive processes, in identifying the target audience and their needs, developing targeted designs, and integrating the right technologies into these designs. The findings frequently depict support for students' autonomous work. However, supporting student autonomy depends on teachers' understanding, acceptance, and pedagogical integration (Roblyer, 2016). Therefore, without adequate teacher training and professional development, the potential of AI to support meaningful learning cannot be fully realized. It is crucial to remember that teacher training and professional development are essential for developing confidence, competence, and critical perspectives in the use of AI.

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Bridging the Gap through Insights & Strategies in Revitalizing Chemistry Education for Today's Engineering Students

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Abstract

Everything around us is changing, and that inevitably has an effect on the learning process and retention rates in the classrooms. Education system has undergone maximum disruption after pandemic, and students entering into professional courses are facing challenges in addressing the chemistry curriculum at the freshman level of engineering. With engineering as the major, very little emphasis and motivation is observed by the students towards sciences. In this context building pedagogies that are more flexible, accessible, affordable, and relevant are to be taken care off by educators for sustenance in educating the present digital natives. Further every student deserves the best opportunity to develop their skills and knowledge at the very first stage of education.

One such theme aiming to our rescue is transforming our classrooms to be owned by both faculty and students towards happy and effective learning and thereby create a Win-Win situation with emerging technologies like AI. This happens through action plan designed by faculty as facilitators of learning, designing activities on threshold concepts, emphasising real world connectivity of subject and inclusiveness by imparting participative behaviour among students. The current study includes these continuous efforts to enhance pedagogical approaches, embrace technological advancements, and address inclusivity challenges so as to ensure that chemistry education continues to evolve and meet the needs of a changing world apart from enhancing engagement & retention levels of learners.

Introduction

Chemistry education plays a pivotal role in shaping the life of scientists, healthcare professionals, and engineers (1). A deep understanding of the subject promotes critical thinking, problem solving approach (2), practical application, and innovative spirit among engineering graduates. This fosters scientific literacy (3) and provides a platform for individuals to look for careers in diversified fields such as material science, environmental science, medicine, and engineering. Teaching chemistry is essential in connecting the fundamental knowledge to the application and developing beneficial products for humanity such as faster computer chips, superconducting materials, conducting polymers, corrosion resistance materials, biodegradable polymers, cost effective and eco-friendly energy storage devices, etc.

Apart from these facts, both students & faculty often perceive chemistry as a challenging subject because it is not immediately linked to a specific degree in engineering. Therefore, teaching chemistry to engineering students should demonstrate the application of the subject to their domain and daily life, as students anticipate learning the actual life application of these topics. Most of the institutions adopt a basic chemistry curriculum which is almost similar to the syllabus studied in 12th standard. Due to the vastness of the topics covered in the 12th standard (4), the students are demotivated with most of the concepts to be memorized without any logic involved. Hence effective pedagogical approaches (5) and innovative support systems are the need of the hour to address this perception and attract students to promote confidence in learning.

In the era of customization and addressing the digital natives' adequate resources are vital for robust chemistry education. The use of technology (6) enhances learning experiences, allowing students to visualize complex concepts with ease. Apart from traditional lecture-based (7) approaches (8), active learning strategies like group activities, flipped classroom, team projects, inquiry-based learning etc. would encourage students to ask questions, foster curiosity and promote student engagement and participation.

Objective of the study:

1. Training faculty to act as facilitators of learning.
2. Identifying the threshold concepts towards creating activities.
3. Delivering the subject in line with real world applications.
4. Developing participatory activities.
5. Creating collaborative and engaged learning environments.

Strategical Framework Timeline

a) Action plan for Facilitators in Fostering Learning:

Inclusive education works primarily by accepting, recognizing, and attending to student differences (9) and diversity (which might include physical, cognitive, academic, social, and emotional). Therefore, it would be ideal to set up get-to-know meetings (using PADLET) at the start of the semester (figure 1). Encouraging all students to feel accepted (10), suitably challenged, and supported in their endeavours, is the guiding concept underlying this.

Fig 1 PADLET

Padlet is a platform which fosters sharing and connecting of views and leads to fruitful discussions between students-students & students-faculty and understand one another.

b) KWL Charts as Energisers:

KWL stands for "Know, Want-to-know, and Learned," and it's a useful strategy for purposeful reading. It encourages inquisitiveness and customized education. Our capacity to learn effectively and retain what we have learnt significantly improves when we use the KWL chart. It inspires students to reflect on their education, their prior knowledge, their current beliefs, and their future research goals. Sasson (2008) said that K-W-L technique can help the teachers to make students more interested in learning to read, because the students will think about what they want to know and what they have learned. Besides that, K-W-L technique Fig 2, used by the educators will help students towards brainstorming (12), better digestion and understanding of lessons.

UNIT- CORROSION AND ITS CONTROL

K What do I already know about this subject?	W What do I want to learn about this subject?	L What did I learn about this subject?
• Definition of corrosion • Tarnishing of silver • How this conversion of metal into oxide or hydroxide takes place. • Factors responsible for corrosion, • The mechanism involved in corrosion • Degradation, (mainly due to exposure to moisture in air) tarnishing of silver • Carbon fiber coating and galvanizing as some simple ways to avoid corrosion.	• Differences between dry and wet corrosion. • Pilling Bedworth rule • Mechanism of corrosion • Types of corrosion • Similarities and differences between differential aeration and differential metal corrosion. Passivity. • Importance of alloys, • Classification and necessity of alloys. • Applications in our daily life.	

Fig 2 Framework of KWL Chart

Therefore, the KWL chart facilitates the activation of the students' prior knowledge, piques their curiosity by asking what they would like to know more about the subject, and then aids in their reflection on the session following its conclusion.

The next stage of this inclusiveness was to identify the skills of the faculty team, discuss the active learning pedagogies to be adopted, and identify the threshold concepts of the subject/course of concern for better implementation.

Designing Activities on Threshold Concepts:

The first and foremost requirement for designing is micro and macro lesson planning of the course, followed by identifying the threshold concepts and exploring the activities suitable for implementation in line with time management and then designing engaging activities. A sample of micro planning implemented in the semester for a topic is listed in Table1.

Table.1 Sample of Microteaching Plan

COURSE OUTCOME	UNIT - POLYMERS SCIENCE (10 PERIODS)	LAYOUT
CO 1	• Polymers- Definition, terminology (monomers, homo-polymer, co-polymer, polymerization, functionality, tacticity, degree of polymerization).	Asynchronous
	• Types of polymerization: Addition, Condensation and Co-polymerisation- definition, examples (no mechanism).	Asynchronous
	• Properties of polymers- Crystallinity, Solubility of polymers, Melting point and Glass transition temperature, Viscoelasticity: Definition, influencing factors, significance.	Synchronous
	• Fabrication of polymers – List the types, explain compression, extrusion, blowing and thermoforming moulding procedures, advantages, limitations and uses.	Synchronous
	• Synthesis, properties and uses of PET, PTFE, PMMA, polycarbonate.	Asynchronous
	• Synthesis, properties and uses of Bakelite and urea formaldehyde.	
	• Conducting polymers: Definition, classification & applications.	Asynchronous
	• FRPs: Definition, types of fibres: glass, carbon, aramid fibres-features and applications.	Asynchronous

SUB-TOPIC	SYNCHRONOUS/ASYNCHRONOUS
Polymers-definition	1. Ppt 2. Few online videos about the introduction of polymers.
Types of polymerization- Addition Condensation Copolymerization	1. Ppt with voice over (LIVE) 2. Activity which includes **finding examples** and relating them to types of polymerizations
Properties of polymers- Crystallinity, Melting point, Glass transition, Viscoelasticity, Solubility of polymers	1. Ppt with voice over (LIVE) 2. Few online videos to understand the properties 3. **Building up a scenario** to relate all the properties
Fabrication of polymers: Compression, Extrusion, Blowing, Thermoforming	1. Ppt with definition of all types of fabrications (LIVE) 2. Activity which includes finding uses and applications of all types of fabrications – **Cheat Sheet** 3. **Match the following**-which includes matching the appropriate uses & applications with types of fabrications
Synthesis, properties and uses of: • PET, PTFE, PMMA, Polycarbonate • Bakelite, Urea formaldehyde	1. **Concept maps** including definitions, uses and properties 2. Activity where students need to prepare a table which highlights differences and similarities between all types of plastics.
Conducting polymers- Definitions, Classifications, Applications	1. Ppt (LIVE) 2. Activity-creating detailed **concept map** about conducting polymers
FRPs- Definition, features, types & applications	1. Ppt 2. Activity-creating detailed **concept map** about FRPs

This plan also addresses synchronous & asynchronous modes of learning as addressed during pandemic (13,14). Synchronous mode is real time where students & instructors engage together with the course content, whereas asynchronous classes are more relaxed with students accessing class materials during different hours. Asynchronous learning involves access to lectures, reading materials and assignments can be completed during one- or two-week period. This mode addresses the slow learners in compensating the learning of the advanced learners.

Apart from the micro planning, to manage time effectively a list of possible activities to be implemented during a semester are planned well ahead by the faculty addressing the particular subject/course(Table 2).

Table 2. Sample of unit wise Activities based on Threshold Concepts

Unit-1 Water and its treatment

Topic	Activity
Types, Ranges and Units of Hardness	Match the following
Estimation of hardness	Pictorial filling of gaps
Potable water	Flipped classroom (Video)
Break point of chlorination	Think, pair and share – With Graph
Boiler troubles	Gap fill Exercise

Unit-2 Polymer Science

Topic	Activity
Types of Polymerization	Think, pair and share
Properties	MCQs
Moulding Techniques	Choice board
Synthesis	Cheat sheet
Conducting polymers, FRPs, SMPs	Concept maps

Unit-3 Energy sources and Battery technology

Topic	Activity
Proximate and ultimate analysis	Concept map, each one teach one
Cracking	Pictorial Presentation
Knocking, octane and cetane rating	Gap fill exercise
Mechanism of Hydrogen fuel	Cheat sheet
Battery and fuel cell	Cheat sheet and concept maps

Emphasising the Real-World Connectivity of Subject: The methodology implemented here is coined collectively under WIT & WIL-where WIT stands for Why am I teaching and What I am teaching which is the faculty perspective and WIL stands for Why am I learning and What I am learning- student perspective. It is a teaching-learning process of our institute which aims towards bridging the gap between institutional academic systems and industry requirements in connection with real world applications. On this context the units in Chemistry syllabus were mapped by taking the scenario-Chemistry in the Anatomy of Car (Fig 3), so as to make students understand the connectivity of their learning in line with real world.

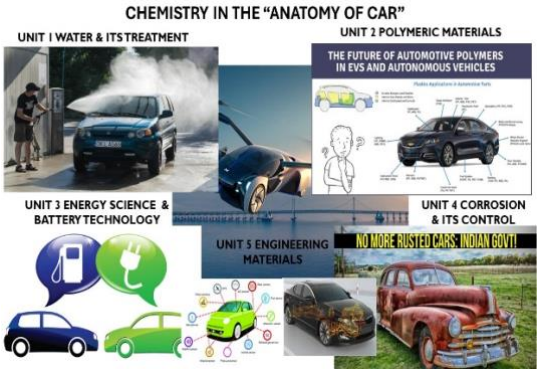
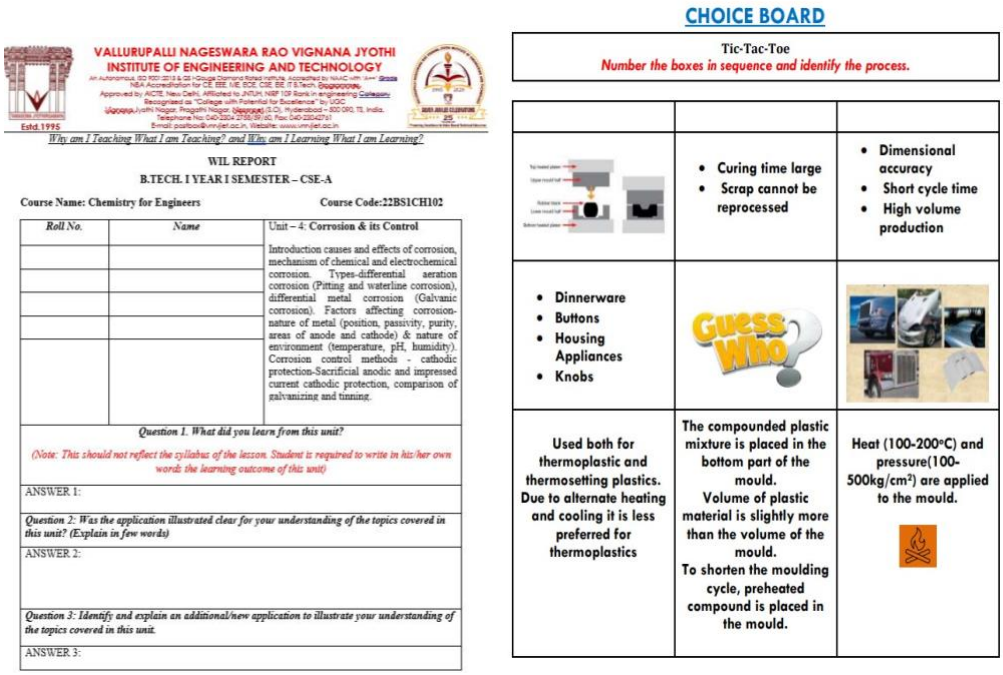


Fig. 3 WIT Scenario

Creating Participatory & Collaborative Environments:

Interaction, participation, and collaboration helps students to exchange ideas, share views apart from team building. Participatory behaviour & collaborative learning motivates learners in solving problems by drawing their own experience & skills, open questioning, and peer teaching. These activities apart from encouraging engagement levels, further improve communication skills, inspire creativity, builds trust, and improves confidence.



VALLURUPALLI NAGESWARA RAO VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

Estd. 1995

Why am I Teaching What I am Teaching? and Why am I Learning What I am Learning?

WIL REPORT

B.TECH. I YEAR I SEMESTER – CSE-A

Course Name: Chemistry for Engineers Course Code:22BS1CH102

Roll No.	Name	Unit – 4: Corrosion & its Control
		Introduction causes and effects of corrosion, mechanism of chemical and electrochemical corrosion. Types-differential aeration corrosion (Pitting and waterline corrosion), differential metal corrosion (Galvanic corrosion). Factors affecting corrosion-nature of metal (position, passivity, purity, areas of anode and cathode) & nature of environment (temperature, pH, humidity). Corrosion control methods - cathodic protection-Sacrificial anodic and impressed current cathodic protection, comparison of galvanizing and tinning.

Question 1. What did you learn from this unit?

(Note: This should not reflect the syllabus of the lesson. Student is required to write in his/her own words the learning outcome of this unit)

ANSWER 1:

Question 2: Was the application illustrated clear for your understanding of the topics covered in this unit? (Explain in few words)

ANSWER 2:

Question 3: Identify and explain an additional/new application to illustrate your understanding of the topics covered in this unit.

ANSWER 3:

CHOICE BOARD

Tic-Tac-Toe

Number the boxes in sequence and identify the process.

	• Curing time large • Scrap cannot be reprocessed	• Dimensional accuracy • Short cycle time • High volume production
• Dinnerware • Buttons • Housing Appliances • Knobs		
Used both for thermoplastic and thermosetting plastics. Due to alternate heating and cooling it is less preferred for thermoplastics	The compounded plastic mixture is placed in the bottom part of the mould. Volume of plastic material is slightly more than the volume of the mould. To shorten the moulding cycle, preheated compound is placed in the mould.	Heat (100-200°C) and pressure(100-500kg/cm²) are applied to the mould.

Fig. 4 Participatory & Collaborative activities

The activities crafted (Fig 4), created effective & inclusive environments enhancing the enthusiasm of the students coming forward with ideas of designing activities in order to make their learning explorable & engaging. This intrusion also helped in reducing the load on faculty in designing more activities and helped in understanding the student's perceptions for the same. Apart from the pool of activities available as repository, it further provided feedback in reorienting the activities and managing the time effectively in a semester.

Insights of Students Perspectives:

The evidence for the impact is well established by the survey conducted with the students regarding the pedagogical approaches and learnings. The inferences drawn from survey highlighted the fact that activity-based learning (Fig.5) was much preferred in comparison to lectures. The inclusion of Padlet (Fig 6) for enhancing connectivity and interactions was well appreciated by the students.

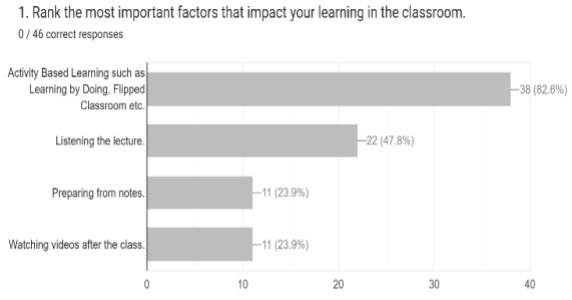


Fig. 5 Learning in the Classroom

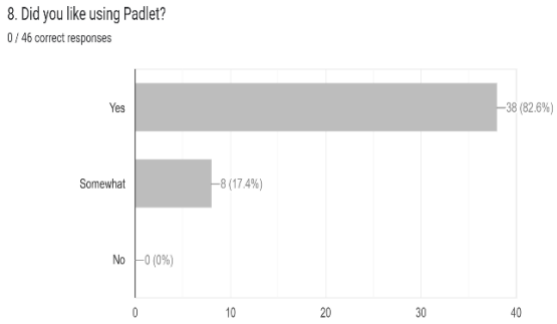


Fig.6 Padlet Usage

The connectivity of the topics outlined in the syllabus by employing WIT & WIL (Fig.7) gave the essence of the curriculum in line with real life scenarios. It improved the interest of students in the subject by creating relevance to the world around them and how the material relates to current topics outside academia. Further it improved, in students' thinking creatively, working together and combining multiple information sources towards authentic learning (15). Students equipped with these critical thinking skills could take ownership in designing real world applicability scenarios of the subject (chemistry in shopping malls, college premises, movie theaters, aircraft, environment, metro trains etc.), and enjoyed the learning by relating their life outside of the classroom (Fig.8)

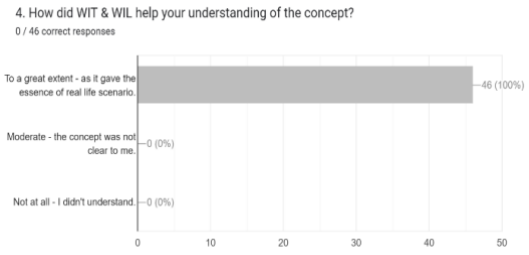


Fig. 7 WIT & WIL

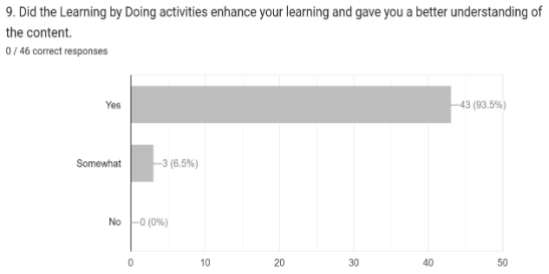


Fig.8 Learning by Doing

Activities like choice board and WIL reports preparation, which involved participation and collaboration kept the students involved, engaged, and interested in the subject (Fig 9). Collaboration aims towards utilization of the experience, knowledge, and skills of everyone involved in the team thereby making the learning of subject fruitfully (Fig 10).

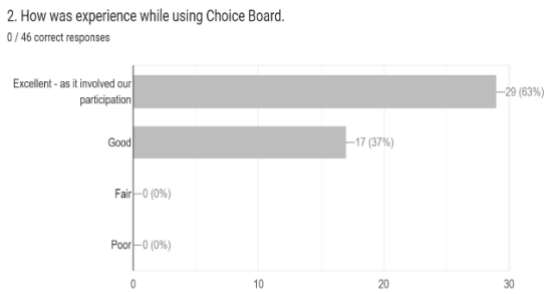


Fig. 9 Choice Board Activity

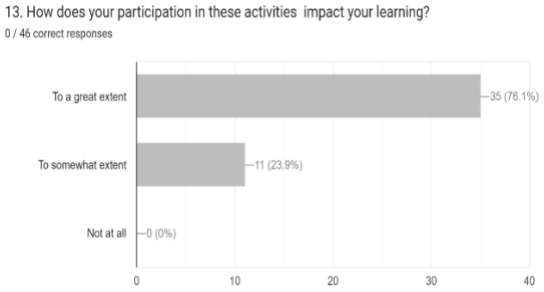


Fig.10 Participation Impact

The survey also helped in re-iterating the activities, rubrics and helped in addressing the time management challenges aiming towards completion of the syllabus apart from addressing the learning by the slow, moderate & advanced learners.

The result analysis (Fig.11) obtained from the semester end examinations over consecutive years depicted the influences of all the measures taken in line with objectives of this study and improved the pass percentage of the students from 75% to 95% in Chemistry. The slight decrease in the year 2021-22 is aimed towards the struck of pandemic, where the network issues played a major role in disrupting the connectivity, especially in rural areas.

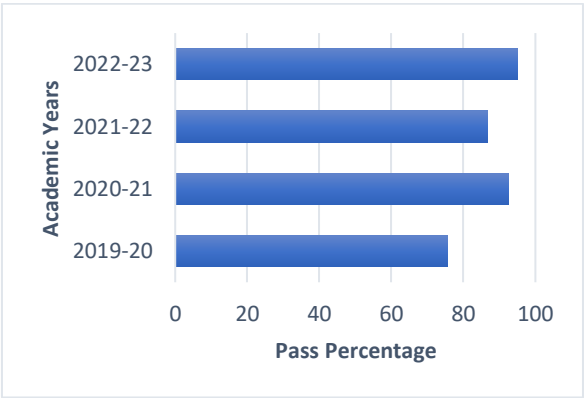


Fig 11. Result Analysis of the End Examinations

Closure:

Redesigning our classrooms such that both teachers and students own them in promoting joyful and productive learning ultimately leads to a Win-Win situation. This is accomplished through action plans created by faculty members who serve as learning facilitators in motivating students (16). These plans emphasize inclusivity by encouraging students to participate in class and emphasize the connection between the subject matter and the real world. Apart from improving student engagement and retention, the current study resulted in improving the grades even in non-technical subject like chemistry, which continues to evolve and meet the needs of the changing world.

Table 3. Impact Measures & Performance Indicators

Key Impact Measures	Key Performance Indicators
More involvement in class leads to a sense of responsibility and belonging, thereby creating interest towards the subject.	Recognize & articulate the need for effective learning environments aiming towards inclusiveness & engagement.
Motivates the students to attend classes, captures attention for longer periods, stay focused, enhances interaction with teachers and among peers.	Identify the activities and design a road map to execute them in a time frame.
Enhancing critical thinking, retaining information, easier to remember for exams and design creative activities.	Explore, Evaluate, Reframe & Refine the procedures, tools & techniques for credibility of results.

The impact of the current study and the measures to be taken care of for continuous improvement in learning is outlined in Table 3. The table speaks about the impact measures and key performance indicators which provides information regarding progress & achievements. It also helps in continuous improvement & thereby maintain standards of education by fostering creativity, engagement, and lifelong learning abilities.

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Rethinking High School Curricula through AI and Green Skills: EcoAI EduNetwork Initiative (EAIEN)

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Abstract

Artificial intelligence (AI) promises to transform not only how students learn but also what knowledge, skills, and attitudes education systems must prioritize. Building on this perspective, the EcoAI EduNetwork Initiative (EAIEN) addresses a critical gap in current debates, which often remain limited to integrating AI tools into classrooms or teaching AI literacy in isolation. Instead, EAIEN proposes a comprehensive approach that aligns AI-driven methodologies with the urgent need for green skills education, in line with European Union and OECD priorities. The primary objective of the project is to establish a robust green skills education ecosystem through a dynamic Open Educational Resources (OER) hub. This hub leverages AI technologies to design innovative teaching practices, adaptable learning pathways, and engaging resources that empower both teachers and students. By embedding AI not only as a tool but also as a driver of curriculum transformation, EAIEN introduces a forward-looking model for integrating sustainability and digital competence at the core of secondary education. This paper presents the conceptual framework, design principles, and expected impact of the EAIEN project. It argues that combining AI literacy with green skills is essential for preparing future generations to address societal challenges, thereby responding to a fundamental question: not only how education should integrate AI, but how AI reshapes what education should prioritize.

Keywords: AI Literacy, green skills, AI in Education, High School Curricula, Secondary Education

Introduction

The accelerating advancement of artificial intelligence (AI) and the escalating urgency of sustainability education are together redefining the core purposes of education across the globe. While most discussions on AI in education focus on its technical integration or the development of isolated AI literacy programs, these approaches often fall short of recognizing AI's broader pedagogical and ethical implications. AI is not just a tool for enhancing how students learn; it fundamentally shifts what students need to learn to thrive in a rapidly evolving world (Bushuyev et al., 2024). Simultaneously, the climate as crisis demands that sustainability become a core component of educational curricula. The development of "green skills" such as environmental literacy, systems thinking, and sustainable problem-solving is increasingly seen as critical for preparing students for future economies and societies (Aggarwal, 2023). Green education, supported by AI, holds the potential to enhance environmental stewardship and promote sustainable development outcomes. Recent studies show that integrating AI and sustainability into curricula aligns with emerging labor market trends that prioritize skill-based hiring in AI and green job sectors. Skills such as AI fluency and environmental knowledge are now more valued than traditional degrees in many job markets (Gonzalez Ehlinger & Stephany, 2023). This evolution underscores the necessity for education systems to evolve from subject-based instruction to future-facing competencies that blend digital and green literacies. Recognizing this dual transformation, the EcoAI EduNetwork Initiative (EAIEN) proposes a novel educational model that integrates AI literacy with green skills as foundational components of secondary school curricula. As a European cooperation project funded under Erasmus+ (KA220-SCH), EAIEN aims to create a scalable, policy-aligned framework that responds to the priorities on digital transformation and sustainable development. By embedding ethical, environmental, and digital dimensions into mainstream education, EAIEN not only fosters critical 21st-century competencies but also prepares learners to act as informed, responsible agents in an AI-powered and climate-challenged world.

Background and Rationale

Artificial Intelligence (AI) is not merely a technological advancement; it represents a transformative force reshaping societies, economies, and the skills required to thrive within them. According to the OECD's ongoing AI and the Future of Skills initiative, education systems must urgently reevaluate their frameworks to align with AI's growing role across sectors (OECD, 2023). This call to action echoes broader policy imperatives across Europe that identify digital competence and sustainability as core 21st-century competences. Yet, despite their

strategic relevance, these themes are still largely addressed in silos. In current practice, AI literacy is often reduced to tool-oriented training or basic exposure to algorithms and coding, with limited emphasis on critical thinking, ethics, or societal impact (Ndungu, 2024). This restricts learners' ability to understand AI as a social and environmental force, beyond its technical utility. Similarly, green skills such as environmental responsibility, systems thinking, and sustainability problem-solving are commonly introduced through disconnected environmental projects or extracurricular initiatives, often divorced from the digital and data-driven realities of the future workforce (Aggarwal, 2023). Meanwhile, labor markets increasingly demand professionals who combine AI-related competencies with sustainability awareness. Employers are shifting toward *skills-based hiring* models, prioritizing capabilities such as machine learning and environmental analysis over formal degrees (Gonzalez Ehlinger & Stephany, 2023). Thus, the divide between green and digital literacy in education represents not just a pedagogical gap, but an economic risk. The EcoAI EduNetwork Initiative (EAIEN) positions itself directly at this intersection, arguing for a systemic integration of AI literacy and green competences into secondary curricula. Its approach is grounded in the understanding that preparing future generations to navigate and lead in a world shaped by climate change, technological acceleration, and shifting job markets requires a dual-literacy framework. By aligning with the EU Green Deal, OECD CERI, and Erasmus+ priorities, EAIEN contributes to a model of schooling where environmental and digital challenges are addressed simultaneously by cultivating learners who are not only tech-savvy but also sustainability-minded global citizens. A structured approach to digital literacy training for students, based on SDGs, highlights the necessity of aligning digital skills with sustainable development goals. It supports EAIEN's methodology of embedding digital competence into the broader sustainability agenda (Shelyugina, 2022).

Conceptual Framework

The EcoAI EduNetwork Initiative (EAIEN) is grounded in a conceptual framework that acknowledges the deep interconnection between sustainability, digital competence, and pedagogical innovation. Rather than addressing these as separate or parallel priorities, the initiative integrates them into a cohesive educational model. This model is designed to respond not only to current educational needs but also to broader European Union objectives that emphasize the development of key competences and the support of teachers and school leadership in navigating rapidly changing learning environments. A recent curriculum model for secondary schools illustrates how AI education can be combined with sustainability through system thinking and computational competencies. This framework aligns closely with EAIEN's emphasis on integrating emerging technologies with ecological awareness (Cai et al., 2023). At the core of the initiative is a commitment to embedding green skills into the secondary school curriculum as foundational competences. Instead of isolating sustainability into standalone subjects, EAIEN promotes an ecosystem approach, integrating environmental awareness, resource management, and sustainable practices across all disciplines. Through project-based learning, experiential activities, and open educational resources (OER), students are encouraged to apply sustainability concepts in real-world contexts, fostering both critical thinking and social responsibility. Artificial intelligence, in this framework, is positioned not only as a topic of instruction but also as a pedagogical enabler. AI supports personalized learning pathways, enhances the co-creation of educational materials, and empowers educators through targeted training in AI literacy. These tools help teachers adapt their instruction to students' individual needs while also fostering digital fluency and ethical awareness of AI's societal impact. In doing so, the initiative aligns with global calls to rethink what and how we teach in the age of intelligent technologies. Finally, EAIEN promotes international cooperation by building a cross-border learning community. Through shared digital platforms, intercultural exchange programs, and collaborative professional development, the project aims to connect local educational practices with global sustainability and digital transformation efforts. By fostering both competence and collaboration, this integrated framework advances EU policy goals and prepares future generations to respond confidently to ecological and technological disruption.

Methodology and Project Design

The EcoAI EduNetwork Initiative (EAIEN) is grounded in a participatory and collaborative methodology that actively involves teachers, students, academic institutions, and a specialized educational technology SME across all stages of the project. Rather than applying a top-down model, the project emphasizes co-creation processes where stakeholders contribute directly to shaping outputs. This inclusive design ensures that the outcomes are contextually relevant, adaptable to local needs, and practical for real-world educational settings. The project is structured around four interconnected work packages, each addressing distinct but complementary goals. The first package focuses on project management, establishing a framework for coordination, quality assurance, and communication among all partners. The second package centers on building a green skills education ecosystem, where curriculum modules and AI-powered open educational resources (OERs) are developed to integrate sustainability across disciplines. This includes teacher training programs on green pedagogy, AI literacy, and digital competence. The third work package introduces a cross-border dimension through mobility programs,

intercultural workshops, and collaborative student projects between schools in Turkey and Romania. The final package is dedicated to dissemination and exploitation, ensuring project visibility through publications, online platforms, and contributions to the Erasmus+ Project Results Platform. Methodologically, the project blends design-based research (DBR), participatory design, and transnational collaboration. DBR is employed in an iterative cycle to develop, test, and refine the educational materials, ensuring they remain evidence-based and scalable. Participatory design allows students and teachers to contribute directly to the creation of AI-generated OERs, embedding their perspectives and classroom realities into the process. Transnational collaboration, facilitated by the diverse cultural and institutional backgrounds of the consortium, enriches the outputs with a broader European and global perspective. A recent study found that gender and geographical context significantly affect students' performance in social and sustainability-related skills, underlining the need for inclusive and equitable education practices- an important dimension in EAIEN's transnational approach (de Miguel González & Sebastián-López, 2022). Another defining feature of EAIEN's approach is the dual role of artificial intelligence. AI serves both as a subject of learning and as a pedagogical tool. Students and teachers build AI literacy through engagement with its ethical, technical, and societal dimensions. At the same time, AI tools are used to personalize learning pathways, generate educational content, and analyze learning data. This holistic integration ensures that digital transformation is not treated as a supplementary innovation but as a central force driving meaningful and future-ready education.

Expected Project Results

The EcoAI EduNetwork Initiative (EAIEN) is expected to generate a set of concrete outputs while also contributing to long-term systemic change in education. At the core of these outputs is the creation of a comprehensive Open Educational Resources (OER) hub dedicated to green skills and AI literacy. It will remain continuously updated, as teachers and students will be directly engaged in its development, ensuring that the content reflects both pedagogical innovation and real classroom experiences. By serving simultaneously as a knowledge base and a collaborative platform, the OER hub will provide both scalability and sustainability, offering resources that can be transferred to different schools and countries. Another significant result of the project is the empowerment of teachers through professional development. EAIEN aims to strengthen teachers' competences in two key areas: green skills and AI integration. Through structured training programs, workshops, and peer-to-peer learning opportunities, educators will acquire the ability to embed sustainability competences across the curriculum while also learning to adopt and critically evaluate AI tools in their teaching practices. This dual focus is expected to transform teachers into agents of change who can not only implement innovative practices in their own classrooms but also disseminate them within their institutions and national education systems. Students will also be at the heart of the project's impact. Through innovative and student-centered activities, they will develop awareness of sustainability and gain the digital skills necessary to navigate an increasingly AI-driven world. The combination of sustainability education and AI literacy will enable students to understand complex global challenges while equipping them with the competences to act responsibly. Moreover, mobility programs and intercultural exchanges will broaden their perspectives, foster collaboration, and cultivate a sense of global citizenship. These experiences will ensure that learners are not only academically prepared but also capable of engaging as active and responsible participants in future societies. Beyond the immediate outcomes, EAIEN also seeks to influence policy and promote systemic change. By disseminating project results through conferences, publications, and the Erasmus+ Project Results Platform, the initiative aims to advocate for the integration of green skills and AI literacy into national curricula. Evidence generated from pilot implementations and evaluation activities will inform recommendations for educational policymakers, highlighting the importance of aligning curriculum priorities with the realities of ecological and technological transformation. In this way, the project positions itself as a replicable model for curriculum reform that can extend beyond the consortium countries and contribute to a broader European agenda. In sum, the anticipated impacts of EAIEN include stronger teacher competences, greater student engagement, and enhanced cross-cultural collaboration, as well as the creation of a scalable model for integrating sustainability and AI into education. By combining practical resources with systemic advocacy, the project aims to act as a catalyst for rethinking high school education in Europe, ensuring that future generations are prepared to meet the dual challenges of environmental sustainability and digital transformation.

Discussion

The EcoAI EduNetwork Initiative (EAIEN) distinguishes itself in the educational innovation landscape by merging green competences with AI-driven pedagogical design into a single, holistic framework. While existing projects often focus either on environmental education or on digital transformation, EAIEN recognizes that the ecological crisis and technological disruption are deeply interconnected challenges of the 21st century. Its conceptual and methodological design responds to this reality by embedding sustainability and AI literacy as mutually reinforcing competences within high school curricula. At the core of this innovation is the development

of an Open Educational Resources (OER) hub. Unlike traditional repositories, this hub leverages artificial intelligence to create adaptive, dynamic, and scalable learning materials. Teachers and students not only access ready-to-use content but also co-create resources with AI support, cultivating both creativity and critical digital skills. Through this process, AI becomes not only a tool for efficiency but also a catalyst for participatory knowledge construction. Furthermore, the project's international collaboration dimension ensures that innovation transcends local boundaries. The consortium brings together diverse actors—universities, secondary schools, and an education technology SME—from Turkey, Romania, and Greece. This diversity enriches the design of curricula and teaching strategies, while mobility programs and intercultural exchanges provide authentic opportunities for learners to develop global citizenship and teamwork competences. From a policy perspective, EAIEN directly addresses the OECD's fundamental question: not only how education should integrate AI, but how AI reshapes what education should prioritize. Current debates often emphasize tool integration or digital literacy in isolation. EAIEN goes further by reframing AI as both subject matter (to be critically understood) and a methodological driver (to personalize and transform pedagogy). This dual role challenges traditional curriculum boundaries and provides a model for education systems to adapt to rapidly shifting societal needs. The alignment of green competences with AI literacy is particularly forward-looking. Green competences prepare students to make sustainable decisions and contribute to environmental stewardship, while AI literacy equips them to navigate and shape a digitally mediated world. Together, these competences offer a dual-capacity blueprint for the next generation: young people who are not only technologically adept but also environmentally responsible. Finally, the project demonstrates how innovation in education must be both systemic and practical. Systemic, because it requires rethinking educational priorities at the curriculum and policy levels; and practical, because it provides concrete tools, resources, and training for teachers and students. By combining these two levels of innovation, EAIEN positions itself as a transformative initiative, capable of influencing both classroom practice and broader educational agendas in Europe and beyond.

Conclusion

The EcoAI EduNetwork Initiative (EAIEN) represents a forward-looking and transformative model for reimagining secondary education in the context of ecological and technological disruption. By integrating sustainability competences with digital literacy and AI-driven methodologies, the project moves beyond incremental reform and proposes a holistic reconfiguration of what and how students should learn. Education stands as a critical driver in addressing the interconnected challenges of sustainability and rapid technological advancement (Feinstein & Mach, 2020). Raising awareness, shaping behaviors, and empowering collective action through sustainability and green skills education remains essential, yet green skills and sustainability content is still largely absent from many national curricula. For education systems to be truly effective in responding to the climate crisis, they must adopt interdisciplinary, critical, and cross-cultural approaches that reflect the complexity of the issue (Perkins et al., 2018). At the same time, rapid technological transformation demands that students acquire digital, AI, and data literacies to thrive in increasingly complex labor markets. Addressing either of these challenges in isolation is insufficient; instead, educational policies must pursue integrated models that combine ecological awareness with digital innovation. There is a global consensus on the need to embed critical thinking, systems thinking, and action competence into curricula to prepare students for sustainability challenges. A scoping review emphasizes the importance of a holistic integration of cognitive, affective, and behavioral components in developing sustainability competencies in secondary education (Sposab & Rieckmann, 2024). Its conceptual framework and methodological design place equal emphasis on the development of innovative resources, the empowerment of teachers, and the active engagement of students, while its transnational dimension ensures that outcomes are informed by diverse cultural perspectives and educational traditions. In doing so, EAIEN responds not only to immediate classroom needs but also to wider European and global policy priorities, particularly those related to sustainable development and digital transformation. As education systems grapple with the dual challenges of climate change and rapid technological advancement, EAIEN offers a scalable and adaptable framework that can inspire broader curricular reforms. Its model demonstrates that preparing students for the future requires the simultaneous cultivation of green skills, AI literacy, and global citizenship, positioning young people to act as both technologically adept and environmentally responsible citizens. By embedding innovation at the intersection of pedagogy, policy, and practice, the initiative underscores the vital role of collaborative, cross-border projects in shaping resilient and future-ready education systems. Ultimately, EAIEN illustrates how curriculum

innovation, when anchored in both sustainability and digital competence, can equip future generations with the knowledge, skills, and values needed to address the complex challenges of the 21st century.

Acknowledgements

This work was carried out within the framework of the Erasmus+ KA220-SSCH project named EcoAI EduNetwork Initiative (EAIEN) funded by European Union and Turkish National Agency. We would like to express our sincere gratitude to all partner institutions from Turkey, Romania, and Greece for their commitment, collaboration, and expertise throughout the project. The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Türkiye'de Nitelikli Eğitime Erişimde Derinleşen Eşitsizlikler: Dijital Uçurum

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Özet

Covid-19 sürecine bağlı olarak yerel ve evrensel boyutta dünya çapında kısa süre içinde eğitimde yaşanan sorunlara yönelik çalışmalar yapılmıştır. Konuyla ilgili alan yazında yapılan çok sayıdaki araştırmalar tarafından, eğitim yöneticileri, öğretmenler, öğrenciler ve velilerin online eğitim sürecine erişimde teknolojik alt yapı ve donanıma sahip olmadığı tespit edilmiştir. Hazırlıksız yakanılan online eğitim alanında çok sayıda araştırma ortaya konulmasına karşın yerelde, oldukça sınırlı sayıdaki araştırmada dijital uçurum kırsal ve kentsel bağlamda online eğitimde yaşanılan sorunlar üzerine yapılan daha çok yapılan araştırmaların sonuçlarında alt sonuçlar olarak yer bulmuştur. Dijital eşitsizlik, ülkeler bazındaki kıyaslamalarla ele alınır. Digital divide (dijital eşitsizlik/uçurum) İngilizce dâhil pek çok dilde metaforik (eğretilemeli) bir kavramdır. Dijital eşitsizlikler yerine dijital uçurum denmesinin en önemli nedenlerinden biri kavramın yalnızca teknik yetersizliğe işaret etmeyip aslında toplumsal bir sorunsalı yansıtmasıdır. Covid-19 sürecine bağlı zorunlu uzaktan eğitim süreci, eğitimde bozulan dengeleri ile dijital eşitsizliği en derin şekilde yaşandığı bir dönemin başlangıcı olmuştur. Türkiye'de eğitimde dijital eşitsizlik, özellikle uzaktan eğitim süreçlerinde belirgin hale gelmiş olup konuyla ilgili alan yazında yapılan araştırmalar tarafından, öğrenciler arasındaki dijital uçurumu gözler önüne serilmiştir. Bu bağlamda Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumun hangi boyutlarda gerçekleştiğinin incelenmesine ihtiyaç duyulmaktadır. Bu temel amaç doğrultusunda Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumun tüm boyutlarıyla sentezlenmesine gidilecektir. Çalışma, nitel araştırma desenlerinden doküman incelemesine bağlı literatür tarama modelinde bir çalışmadır. Bu bağlamda çalışmanın temel amacını ortaya koyabilmek için farklı boyutlardan incelenmesinde açıklayıcı araştırma tasarımı kullanılmıştır. Açıklayıcı araştırma tasarımı, bir araştırma konusu arayışında akademik literatürün incelenmesi anlamına gelmektedir. Bu nedenle bu çalışmada, Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumu ortaya koyan araştırmaların nitel bulguları yorumlanıp değerlendirilerek, benzer ve farklı sonuçlar ortaya konularak, eleştirel bir bakış açısıyla bir sentezlenmeye gidilecektir.

Anahtar Kelimeler: Covid 19, online eğitim, eğitime erişim, eşitsizlik, dijital uçurum

Abstract

Due to the Covid-19 process, studies have been conducted both locally and globally on the problems experienced in education within a short period of time. Numerous studies in the literature have identified that education administrators, teachers, students, and parents lacked the technological infrastructure and equipment necessary to access online education. Although many studies have been produced in the field of online education, which caught societies unprepared, only a limited number of local studies have specifically addressed the digital divide in rural and urban contexts; in most cases, these issues appeared merely as sub-findings in research results. Digital inequality is generally examined through cross-country comparisons. The term digital divide is a metaphorical concept in English and in many other languages. One of the main reasons for using the expression digital divide instead of digital inequalities is that the concept does not merely point to technical deficiencies but actually reflects a broader social problem. The compulsory distance education process triggered by Covid-19 marked the beginning of a period in which the disrupted balances in education revealed the digital divide most acutely. In Turkey, digital inequality in education became particularly apparent during distance learning processes. Studies in the literature have made visible the digital divide among students. In this context, it is necessary to examine in which dimensions the deepening digital divide in access to quality education in Turkey has occurred. For this purpose, this study aims to synthesize all dimensions of the deepening digital divide in access to quality education in Turkey. The study employs a document analysis-based literature review design, one of the qualitative research methods. In order to reveal the main aim of the study, an explanatory research design was used to examine the issue from different dimensions. Explanatory research design refers to the examination of academic literature in the search for a research topic. Therefore, in this study, qualitative findings of research on the deepening digital divide in access to quality education in Turkey were interpreted and evaluated, and similar and different results were identified, leading to a synthesis through a critical perspective.

Keywords: Covid-19, Online education, access to education, inequality, digital divide

Giriş

Beklenmedik bir şekilde karşılaşılan Covid-19 sürecine Milli Eğitim Bakanlığı (MEB), eğitim yöneticileri, okul yöneticileri, öğretmenler, veliler ve öğrenciler olmak üzere tüm paydaşlar hazırlıksız yakalanmışlardır. Covid-19 salgınıyla birlikte bir zorunluluk olarak Türkiye de dâhil olmak üzere 195 ülkede eğitim durdurulmuştur. Salgın nedeniyle Türkiye'de ilkokul, ortaokul, liseler ve yükseköğretim kurumlarında, 16-30 Mart 2020 tarihleri arasında iki hafta süreyle yüz yüze eğitime ara verilmiştir. Bu süreçte dünya çapındaki ülkeler eğitime uzaktan devam etme kararı alırken Türkiye'de bu gelişmelere eşdeğer olarak Milli Eğitim Bakanlığı tarafından ilkokul, ortaokul ve liseler için ulusal uzaktan öğrenme platformu Eğitim Bilişim Ağı (EBA) ve televizyon kanalı Türkiye Radyo Televizyon (TRT) aracılığıyla sürdürülmesi kararlaştırılarak 23 Mart 2020 tarihinde uygulamaya geçilmiştir. Salgın nedeniyle, 16 Mart 2020 ve 06 Eylül 2021 tarihleri döneminde öğrencilerle eğitimler yüz yüze gerçekleştirilemeyerek EBA üzerinden online olarak yürütülmüştür.

Covid-19 sürecine bağlı olarak yerel ve evrensel boyutta dünya çapında kısa süre içinde eğitimde yaşanan sorunlara yönelik çalışmalar yapılmıştır. Konuyla ilgili alan yazında yapılan çok sayıdaki araştırmalar tarafından, eğitim yöneticileri, öğretmenler, öğrenciler ve velilerin online eğitim sürecine erişimde teknolojik alt yapı ve donanıma sahip olmadığı tespit edilmiştir. Hazırlıksız yakanılan online eğitim alanında çok sayıda araştırma ortaya konulmasına karşın yerelde, oldukça sınırlı sayıdaki araştırmada dijital uçurum kırsal ve kentsel bağlamda online eğitimde yaşanılan sorunlar üzerine yapılan daha çok yapılan araştırmaların sonuçlarında alt sonuçlar olarak yer bulmuştur. Dijital eşitsizlik, ülkeler bazındaki kıyaslamalarla ele alınır. Digital divide (dijital eşitsizlik/uçurum) İngilizce dâhil pek çok dilde metaforik (eğretilemeli) bir kavramdır. Dijital eşitsizlikler yerine dijital uçurum denmesinin en önemli nedenlerinden biri kavramın yalnızca teknik yetersizliğe işaret etmeyip aslında toplumsal bir sorunsalı yansıtmasıdır.

Dijital uçurumun eğitim bağlamında ele alınışı, yalnızca teknolojik donanıma sahip olup olmama meselesiyle sınırlı değildir. Warschauer (2003), dijital eşitsizliği salt teknik bir eksiklik olarak değil, sosyo-kültürel, ekonomik ve pedagojik boyutları olan çok katmanlı bir sorun olarak değerlendirmektedir. Bu nedenle, Covid-19 sürecinde derinleşen dijital uçurumun, Türkiye'de nitelikli eğitime erişimde yarattığı engelleri anlamak için yalnızca cihaz ve internet erişimine odaklanmak yeterli olmamaktadır. Öğrencilerin çevrimiçi öğrenme sürecine aktif katılımını belirleyen faktörler arasında dijital okuryazarlık düzeyi, ebeveyn desteği, öğretmenlerin çevrimiçi pedagojik yeterlikleri ve eğitim kurumlarının teknolojiye uyum stratejileri de kritik rol oynamaktadır (Selwyn, 2016; Van Dijk, 2020).

Türkiye özelinde yapılan araştırmalar, dijital uçurumun özellikle sosyo-ekonomik düzey, bölgesel farklılıklar ve ebeveyn eğitim düzeyi ile yakından ilişkili olduğunu göstermektedir. TEDMEM (2021) raporunda, düşük gelirli ailelerden gelen öğrencilerin uzaktan eğitim sürecinde internet ve donanım eksikliği nedeniyle derslere katılım oranlarının oldukça düşük olduğu vurgulanmıştır. Benzer şekilde, Gündoğdu ve Yıldırım (2021) kırsal bölgelerde yaşayan öğrencilerin yalnızca teknik yetersizlik değil, aynı zamanda aile içi destek mekanizmalarının zayıflığı nedeniyle de uzaktan eğitimde dezavantajlı konuma düştüğünü ortaya koymuştur.

Uluslararası düzeyde de benzer bulgular gözlenmiştir. UNESCO (2020) raporuna göre, dünya genelinde 1,5 milyar öğrenci Covid 19 sürecinde eğitimine uzaktan devam etmek zorunda kalmış, ancak özellikle gelişmekte olan ülkelerde milyonlarca çocuk internet erişimi olmadığı için eğitim dışına itilmiştir. Bu durum, dijital uçurumun küresel ölçekte sosyal eşitsizliklerle doğrudan bağlantılı olduğunu göstermektedir. Dolayısıyla dijital eşitsizlik, yalnızca "teknolojik bir boşluk" değil, aynı zamanda toplumsal fırsat eşitsizliğini derinleştiren yapısal bir sorun olarak ele alınmalıdır (Robinson vd., 2015). Bu bağlamda, Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumun incelenmesi, üç temel boyutta ele alınabilir:

Erişim: Donanım ve internet altyapısına ulaşım.
Kullanım: Öğrencilerin ve öğretmenlerin dijital araçları etkin kullanma becerileri.
Çıktı: Dijital araçların öğrenme çıktıları üzerindeki etkisi ve eğitimde fırsat eşitliğine yansıması (Van Dijk, 2020).

Nitelikli eğitime erişimdeki bu üç boyut Türkiye'de eğitim politikalarının yeniden yapılandırılması ve dijital kapsayıcılığın artırılması için önemli bir temel sunmaktadır. Özellikle kırsal-kentsel ayrımlar, sosyo-ekonomik düzey farklılıkları ve toplumsal cinsiyet boyutu, dijital uçurumun nitelikli eğitime erişimde nasıl farklı biçimlerde tezahür ettiğini anlamak açısından kritik önemdedir (Livingstone ve Helsper, 2007).

Covid-19 sürecine bağlı zorunlu uzaktan eğitim süreci, eğitimde bozulan dengeleri ile dijital eşitsizliği en derin şekilde yaşandığı bir dönemin başlangıcı olmuştur. Türkiye'de eğitimde dijital eşitsizlik, özellikle uzaktan eğitim süreçlerinde belirgin hale gelmiş olup konuyla ilgili alan yazında yapılan araştırmalar tarafından, öğrenciler arasındaki dijital uçurumu gözler önüne serilmiştir. Bu bağlamda Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumun hangi boyutlarda gerçekleştiğinin incelenmesine ihtiyaç duyulmaktadır. Bu temel amaç

doğrultusunda Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumun tüm boyutlarıyla sentezlenmesine gidilecektir.

Yöntem

Bu çalışma, nitel araştırma desenlerinden doküman incelemesine dayalı literatür tarama modeli ile hazırlanmıştır. Bu bağlamda çalışmanın temel amacını ortaya koyabilmek için farklı boyutlardan incelenmesinde açıklayıcı araştırma tasarımı kullanılmıştır. Doküman incelemesine dayalı literatür tarama modeli, araştırmacının belirli bir konu ile ilgili daha önce yayımlanmış akademik çalışmalar, resmi raporlar, kitaplar, tezler ve diğer belgeleri sistematik olarak inceleyerek veri toplamasına dayanan nitel bir araştırma yöntemidir (Bowen, 2009). Bu model, araştırmanın temel amacını ortaya koymak, var olan bilgileri sentezlemek ve boşlukları belirlemek için oldukça uygundur. Bowen (2009) modeli sürecinin aşamaları: 1) Araştırma sorularının belirlenmesi, 2) Kaynakların seçimi, 3) Veri toplama ve sınıflandırma, 4) Analiz ve sentezleme, 5) Sonuçların raporlanmasıdır.

Araştırmada açıklayıcı araştırma tasarımı benimsenmiş; incelenen çalışmaların bulguları kategorilere ayrılmış, benzer ve farklı yönleri sentezlenmiştir. Açıklayıcı araştırma tasarımı, bir araştırma konusu arayışında akademik literatürün incelenmesi anlamına gelmektedir. Bu nedenle bu çalışmada, Türkiye'de nitelikli eğitime erişimde derinleşen dijital uçurumu ortaya koyan araştırmaların nitel bulguları yorumlanıp değerlendirilerek, benzer ve farklı sonuçlar ortaya konularak, eleştirel bir bakış açısıyla bir sentezlenmeye gidilecektir.

Doküman incelemesine dayalı literatür tarama modeli, özellikle hazırlıksız yakalanılan Covid-19 sürecinde online eğitimde yaşanan etik dışı davranışlar gibi alanlarda, hızlı ve kapsamlı veri toplamak için uygun bir yöntem olarak tercih edilmiştir. Bu sayede, Türkiye'de ve dünya genelinde elde edilmiş bulgular eleştirel bir perspektifle değerlendirilebilmiş ve mevcut araştırmalar arasında bir sentez oluşturulmuştur.

Braun ve Clark'ın (2016) tematik içerik analiz tekniği kullanılarak çözümlenmiştir. Sürecin aşamaları:

1) Verilerin tanınması
2) İlk kodların oluşturulması
3) Temaların araştırılması
4) Temaların gözden geçirilmesi
5) Temaların tanımlaması ve isimlendirilmesi
6) Raporun oluşturulması

Sonuç

Yapılan tematik içerik analizi sonucu nitelikli eğitime erişimdeki eşitsizlikler kategoriler halinde aşağıda verilmiştir.

Ana Tema	**Nitelikli Eğitime Erişimde Eşitsizlikler**
Alt Temalar	**Örnek İfadeler**
Sosyo-ekonomik faktörler ve dijital eşitsizlik	Gelir düzeyine bağlı farklılıklar Ailelerin eğitim seviyesi Ailelerin dijital okuryazarlık düzeyi Dezavantajlı grupların (mülteciler, mevsimlik işçi çocukları, engelli bireyler) durumu
Bölgesel ve mekânsal farklılıklar	Kırsal-kentsel konum Merkezi şehirler ve taşra bölgeleri arasındaki eğitim fırsatları İnternet altyapısı ve erişim sorunları
COVID-19 sürecindeki dijital derinleşme	COVID-19 sürecinde uzaktan eğitim uygulamaları EBA (Eğitim Bilişim Ağı) erişim sorunları Öğrencilerin cihaz, internet ve içerik erişimindeki yazılım ve donanıma ait eşitsizlikler
Dijital okuryazarlık ve kullanım becerileri	Öğrencilerin dijital beceri yeterlikleri Öğretmenlerin dijital pedagojik yeterlikleri Aile katılımı

Sosyo-ekonomik Faktörler ve Dijital Eşitsizlik

Covid-19 sürecinde online eğitime geçiş, öğrencilerin sosyo-ekonomik durumuna bağlı olarak eşitsizlikleri derinleştirmiştir. Bozkurt (2020) ve Geçer, Yıldırım ve Akgül (2022) tarafından yapılan çalışmalar, düşük gelirli ailelerin çocuklarının internet erişimi, bilgisayar veya tablet gibi cihazlara erişimde sıkıntı yaşadığını

göstermektedir. Bu durum, öğrenciler arasında öğrenme fırsatlarının eşitsizleşmesine yol açmış ve akademik başarı farklarını artırmıştır. Ayrıca, öğrencilerin ev ortamlarında ders çalışma imkânlarının farklılık göstermesi de eğitimde fırsat eşitliğinin sağlanmasını zorlaştırmıştır.

Bölgesel ve Mekânsal Farklılıklar

Türkiye'nin farklı bölgelerindeki altyapı ve eğitim kaynakları arasındaki farklar, online eğitimin etkinliğini etkilemiştir. Özellikle kırsal ve az gelişmiş bölgelerde internet altyapısı yetersizliği ve donanım eksikliği, öğrencilerin uzaktan eğitime erişimini sınırlamıştır (Akbulut ve Şahin, 2021). Şehir merkezlerinde ise teknolojik imkânlar ve öğretmen desteği daha fazla bulunması bölgesel bir dijital uçurum yaratmaktadır. Bu farklılıklar, eğitimde mekânsal eşitsizliğin dijital ortamda da devam ettiğini göstermektedir.

COVID-19 Sürecindeki Dijital Derinleşme

Covid-19 süreci, dijitalleşmenin hızlanmasına neden olmuş ve eğitimde dijital derinleşmeyi ortaya koymuştur. Online dersler, dijital materyaller ve EBA platformunun kullanımı yaygınlaşmış, ancak bu sürecin yönetimi çoğu öğretmen ve öğrenci için yeni bir deneyim olmuştur (Çelik ve Arslan, 2021; Hotaman, 2025). Dijital derinleşme, eğitimde fırsat eşitliği sağlama potansiyeline sahip olmakla birlikte, hazırlıksız yakalanan paydaşlar için etik ve teknik sorunları da artırmıştır.

Dijital Okuryazarlık ve Kullanım Becerileri

Öğrencilerin ve öğretmenlerin dijital okuryazarlık seviyeleri, online eğitimde başarının belirleyici unsurlarından biri olmuştur. Düşük dijital okuryazarlık, platformları etkili kullanamama, ödev ve sınav süreçlerinde sorunlar yaşama ve motivasyon kaybı gibi problemlere yol açmıştır (Darga, 2023; Altıntaş ve Kara, 2022). Öğretmenlerin dijital pedagojik becerilerinin yetersiz olması, öğrencilerin çevrim içi eğitimden maksimum düzeyde faydalanmasını engellemiş ve eğitimde kaliteyi düşürmüştür.

Tartışma

Covid-19 sürecinde Türkiye'de yaşanan zorunlu uzaktan eğitim, dijital eşitsizliği ve eğitimde fırsat adaletsizliğini en derin biçimde ortaya koymuştur. Yapılan araştırmalar, dijital uçurumun yalnızca teknolojik donanım eksikliğinden ibaret olmadığını, sosyo-ekonomik, bölgesel ve pedagojik boyutlarıyla çok katmanlı bir sorun olduğunu göstermektedir (Warschauer, 2003; Van Dijk, 2020).

Araştırmanın sonuçları bağlamında sosyo-ekonomik faktörler, dijital eşitsizliğin en belirgin belirleyicileri arasında yer almıştır. Gelir düzeyi düşük ailelerin çocukları, cihaz ve internet erişiminde ciddi eksiklikler yaşamış, buna ilaveten ailelerin eğitim ve dijital okuryazarlık düzeyleri de çocukların çevrimiçi öğrenme süreçlerine etkin katılımını sınırlandırmıştır (TEDMEM, 2021; Gündoğdu ve Yıldırım, 2021). Dezavantajlı gruplar, özellikle mülteciler, mevsimlik işçi çocukları ve engelli bireyler, bu süreçte eğitimden daha fazla uzaklaşmış, dijital uçurumun derinleşmesine neden olmuştur (UNESCO, 2020).

Gelir düzeyine bağlı farklılıklarda dijital uçurumun en belirgin boyutlarından biri, hane gelir düzeyine bağlı olarak ortaya çıkan cihaz ve internet erişimindeki farklılıklardır. Düşük gelirli ailelerde öğrencilerin bilgisayar ya da tablet gibi araçlara sahip olamaması, çoğu durumda tek bir cihazın aile içinde paylaşılması, eğitime erişimde ciddi engeller yaratmaktadır (TEDMEM, 2021). Robinson ve arkadaşlarına (2015) göre dijital eşitsizlik, ekonomik kaynakların sınırlılığı ile doğrudan bağlantılıdır ve bu durum öğrenme fırsatlarını da eşitsiz kılar.

Ailenin eğitim düzeyi, çocukların uzaktan eğitime katılımında belirleyici bir faktör olmuştur. Eğitim düzeyi düşük ebeveynlerin çocuklarına rehberlik yapamaması, öğrencilerin çevrimiçi öğrenme sürecinde akademik başarısını olumsuz etkilemiştir (Gündoğdu ve Yıldırım, 2021). Selwyn (2016), ebeveynlerin eğitsel sermayesinin, çocukların dijital öğrenme deneyimlerinde önemli bir rol oynadığını vurgulamaktadır.

Ailenin dijital okuryazarlık düzeyi, teknik donanımın ötesinde, ebeveynlerin dijital okuryazarlık becerilerindeki yetersizlikler de öğrencilerin öğrenme süreçlerini zorlaştırmıştır. Van Dijk (2020), dijital uçurumun yalnızca "erişim" değil aynı zamanda "kullanım" boyutunda da incelenmesi gerektiğini belirtmektedir. Bu bağlamda ailelerin dijital araçları etkin kullanamaması, özellikle küçük yaş gruplarındaki öğrenciler için destek eksikliği yaratmıştır.

Dezavantajlı gruplarda mülteciler, mevsimlik tarım işçilerinin çocukları ve engelli bireyler, Covid-19 sürecinde dijital eşitsizliği en yoğun şekilde deneyimleyen gruplar arasında yer almıştır. UNESCO (2020), mülteci ve göçmen çocukların büyük kısmının uzaktan eğitime erişemediğini, bunun uzun vadede sosyal dışlanma riskini artırdığını ortaya koymaktadır. Türkiye özelinde, Suriyeli mülteci çocukların EBA'ya erişim sorunları ve dil bariyerleri nedeniyle eğitimin dışında kalma oranlarının oldukça yüksek olduğu belirtilmiştir (TEDMEM, 2021).

Bölgesel farklılıklar, dijital uçurumun diğer kritik boyutunu oluşturmuştur. Kırsal ve taşra bölgelerde internet altyapısı eksikliği ve okulların dijital kapasitesinin sınırlı olması, öğrencilerin çevrimiçi derslere erişimini ve katılımını zorlaştırmıştır (Gündoğdu & Yıldırım, 2021; Warschauer, 2003). Metropol alanlarda görece daha iyi altyapı ve dijital içerik imkanları olsa da, kırsal alanlardaki öğrencilerle aradaki eğitim fırsatları farkı pandemi süreciyle daha da belirginleşmiştir. COVID-19 süreci, dijital uçurumun hem erişim hem kullanım boyutlarını derinleştirmiştir. EBA platformuna erişim ve dijital içeriklere ulaşım konusundaki sınırlılıklar, öğrenciler arasındaki eşitsizliği artırmıştır (TEDMEM, 2021). Ayrıca, öğrencilerin dijital beceri yeterliklerindeki farklılıklar ve öğretmenlerin dijital pedagojik kapasitesindeki yetersizlikler, uzaktan eğitimin niteliğini sınırlamış, eğitimde fırsat eşitsizliğini pekiştirmiştir (Selwyn, 2016; Van Dijk, 2020). Bu sonuçlar, dijital uçurumun sadece teknik bir eksiklik değil, toplumsal ve yapısal bir sorun olduğunu göstermektedir. Öğrencilerin çevrimiçi öğrenme deneyimlerini etkileyen faktörler, bireysel ve kurumsal düzeyde bir arada değerlendirilmediği takdirde, eğitim politikalarının eşitsizliği azaltmada etkili olamayacağı açıktır. Sonuç olarak, dijital eşitsizliği azaltmak için yalnızca teknolojik altyapı sağlamak yeterli değildir; sosyo-ekonomik destek, öğretmen ve öğrenci dijital becerilerinin geliştirilmesi ve dezavantajlı gruplara özel müdahaleler de gerekmektedir (Livingstone ve Helsper, 2007; Robinson vd., 2015).

Araştırmanın sonuçları bağlamında, bölgesel ve mekânsal farklılıklar kırsal bölgelerde internet altyapısının yetersizliği, Covid-19 sürecinde eğitimde fırsat eşitsizliğini daha da artırmıştır. Gündoğdu ve Yıldırım (2021) araştırmalarında kırsal bölgelerde yaşayan öğrencilerin derslere düzenli katılım oranlarının düşük olduğunu ve donanım yetersizlikleriyle birlikte motivasyon kaybı yaşadıklarını bulmuştur. Merkezi şehirler ve taşra bölgeleri arasındaki eğitim fırsatlarında metropol şehirlerde daha güçlü teknolojik altyapı bulunmasına rağmen, taşra bölgelerinde eğitim kurumlarının dijital dönüşüme daha yavaş uyum sağladığı gözlenmiştir. Warschauer (2003), dijital uçurumun yalnızca bireysel değil, kurumsal düzeyde de farklılıklar yarattığını, okulların donanım ve dijital içerik üretim kapasitelerindeki eşitsizliklerin öğrencilerin öğrenme çıktılarını doğrudan etkilediğini savunmaktadır. İnternet altyapısı ve erişim sorunlarında Türkiye'deki bölgesel internet erişim farkları, dijital uçurumun en temel göstergelerinden biridir. Özellikle Doğu ve Güneydoğu Anadolu bölgelerinde altyapı sorunları, öğrencilerin uzaktan eğitime aktif katılımını ciddi biçimde engellemiştir (TEDMEM, 2021).

COVID-19 sürecindeki dijital derinleşme, eğitimde dijital uçurumu en görünür hâle getiren dönem olmuştur. UNESCO (2020), pandemi nedeniyle dünya genelinde 1,5 milyardan fazla öğrencinin uzaktan eğitime geçtiğini, ancak özellikle düşük gelirli ülkelerde öğrencilerin yarısından fazlasının eğitime hiç erişemediğini raporlamıştır. EBA (Eğitim Bilişim Ağı) erişim sorunları Türkiye'de Millî Eğitim Bakanlığı tarafından geliştirilen EBA platformu, tüm öğrencilere eşit eğitim imkânı sunmayı hedeflemiş olsa da, internet bağlantısı ve donanım eksikliği nedeniyle özellikle dezavantajlı bölgelerde bu platformdan yararlanma oranları oldukça düşük kalmıştır (TEDMEM, 2021). Donanım, internet ve yazılım eşitsizliklerinde öğrenciler arasındaki donanım paylaşımı, internet kotalarının yetersizliği ve uygun dijital içeriklere erişimde yaşanan sıkıntılar, öğrenme çıktılarını olumsuz etkilemiştir (Livingstone ve Helsper, 2007). Bu durum, eğitimin niteliğinde bölgesel ve sınıfsal farklılıkların daha da derinleşmesine yol açmıştır.

Araştırmanın sonuçları bağlamında dijital okuryazarlık ve kullanım becerileri, her öğrencinin teknolojiye erişimi olsa bile dijital becerilerindeki farklılıklar, öğrenme fırsatlarını doğrudan etkilemektedir. Van Dijk (2020), dijital uçurumun "ikinci düzey" eşitsizlik olarak tanımladığı bu boyutun, öğrencilerin çevrimiçi öğrenmeden ne derece faydalanabildiğini belirlediğini vurgulamaktadır. Öğretmenlerin dijital pedagojik yeterliklerinde öğretmenlerin çevrimiçi öğretim materyalleri hazırlama, dijital sınıf yönetimi ve pedagojik uyarlama becerilerindeki eksiklikler, uzaktan eğitimin niteliğini belirleyen kritik unsurlar olmuştur (Selwyn, 2016). Eğitimde dijital uçurum, bu bağlamda yalnızca öğrenciler değil öğretmenler için de bir beceri sorunu olarak kendini göstermiştir. Çevrimiçi eğitim sürecinde ailelerin çocukların öğrenme süreçlerine katılımı, özellikle ilkokul düzeyinde büyük önem taşımaktadır. Ancak ailelerin dijital beceri eksiklikleri ve eğitim sürecine yeterince dâhil olamamaları, öğrencilerin akademik performansını olumsuz etkilemiştir (Livingstone ve Helsper, 2007).

Araştırmanın sonuçları bağlamında alanyazında Türkiye'de yapılan araştırmalar, özellikle COVID-19 sürecinde bu uçurumun görünür hale geldiğini göstermektedir. Eğitim Reformu Girişimi'nin (ERG, 2021) raporuna göre, uzaktan eğitim döneminde öğrencilerin yaklaşık %40'ının bilgisayara veya tablete erişimi olmamış, %20'sinin ise düzenli internet bağlantısı bulunmamıştır. Kırsal bölgelerde yaşayan ve düşük gelirli hanelere mensup öğrenciler, eğitimden en fazla dışlanan gruplar arasında yer almıştır.

Dezavantajlı topluluklar (Suriyeli mülteciler, kırsal kesimdeki öğrenciler, mevsimlik tarım işçilerinin çocukları, engelli öğrenciler) dijital eğitim süreçlerinde nitelikli içeriklere ulaşmakta ve eğitimsel destek almakta ciddi sorunlarla karşılaşmıştır (UNICEF, 2022). Bu eşitsizlik, yalnızca akademik başarı farklarını değil; aynı zamanda uzun vadede toplumsal katılım, istihdam ve sosyal uyum süreçlerini de derinleştiren bir etki yaratmaktadır. Türkiye'de eğitimde dijitalleşme çabaları (EBA-Eğitim Bilişim Ağı, Fatih Projesi vb.) önemli bir adım olarak görülse de, bu projelerin altyapı eksiklikleri, sürdürülebilirlik sorunları ve bölgesel farklılıklar nedeniyle eşitsizlikleri azaltmaktan çok, zaman zaman daha görünür kıldığı eleştirileri yapılmaktadır (Gür ve Koç, 2022).

Sonuç olarak, nitelikli eğitime erişimde derinleşen eşitsizlikler dijital çağda yalnızca mekânsal ya da ekonomik sınırlardan değil, aynı zamanda teknolojik imkânların adil dağıtılmamasından da kaynaklanmaktadır. Bu nedenle, dijital uçurumun yalnızca teknik bir problem değil; sosyal, ekonomik ve kültürel boyutları olan yapısal bir sorun olarak değerlendirilmesi gerekmektedir.

Teşekkür

Bu çalışma TÜBİTAK 2224-B Yurt İçi Bilimsel Etkinliklere Katılım Desteği Programı tarafından desteklenmiştir.

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Dijital Eğitim Tercihlerinde Tasarimin Etkisi: Çalişanlarin LMS Tabanli Eğitimlerde Çoklu Ortam İlkelerine Göre Hazirlanmiş İçeriklere Yönelimi Üzerine Nitel Bir Vaka Analizi

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Özet

Bu araştırma, dijital eğitim içeriklerinin tasarımında çoklu ortam ilkelerinin yetişkin kullanıcı tercihleri üzerindeki etkisini incelemektedir. Günümüzde dijital ortamda tasarlanan eğitimlerden yalnızca akademik boyutta değil, aynı zamanda kurumsal eğitim boyutunda da yararlanılmaktadır. Ancak eğitimlerin verimli ve etkin olmasında eğitim tasarımının rolünün etkisi dikkat çekmektedir.

Bu çalışma sayesinde, Mayer'in Çoklu Ortam İlkelerinin eğitim tasarımı aşamasında, geleneksel metin tabanlı içeriklere kıyasla öğrenmeyi daha etkili kılıp kılmadığını görmek amaçlanmaktadır. Çalışmada nitel araştırma yöntemlerinden vaka analizi deseni tercih edilmiş olup, araştırma İstanbul'da faaliyet gösteren ve 500 üzeri çalışana sahip kurumsal bir firmada görev yapan altı katılımcı ile yapılandırılmış görüşmeler üzerinden gerçekleştirilmiştir. Katılımcılar, çoklu ortam ilkelerine göre tasarlanmış dijital içerikler ile geleneksel yaklaşımla tasarlanmış içerikleri deneyimlemiş ve bu deneyimlere yönelik algıları analiz edilmiştir. Analiz sonucunda 334 kod, 38 kategori ve 6 tema ortaya çıkmıştır.

Araştırma sonuçları, kullanıcıların özellikle görsel-işitsel bütünlük, tutarlılık, bireysel farklılıklar ve bilişsel yük açısından çoklu ortam ilkelerine uygun içerikleri daha etkili, anlaşılır ve ilgi çekici bulduğunu ortaya koymuştur. Geleneksel tabanlı metin içerikli eğitimlerin ise monoton, takip açısından zorlayıcı ve bilişsel bir yük oluşturduğu yönünde sonuçlar elde edilmiştir.

Çalışma, kurumların dijital eğitim tasarımlarını yaparken çoklu ortam ilkelerini dikkate almalarının ve çalışan merkezli yaklaşımlara yönelmesinin önemini vurgulamakta ve eğitim teknolojileri alanına kullanıcı deneyimine dayalı özgün katkılar sunmaktadır.

Anahtar Kelimeler: *dijital öğrenme, çoklu ortam ilkeleri, öğrenme yönetim sistemi (LMS), yetişkin eğitimi*

The Impact Of Multimedia Design On Digital Training Preferences: A Qualitative Case Study On Employees' Orientation Toward LMS-Based Content

Abstract

This study examines the influence of multimedia principles on adult learners' preferences in the design of digital training content. Today, digital training is utilized not only in academic contexts but also in corporate settings. However, the effectiveness and efficiency of such training largely depend on the role of instructional design. The purpose of this study is to explore whether the application of Mayer's Multimedia Principles in instructional design provides a more effective learning experience compared to traditional text-based content.

The research employed a qualitative case study design and was conducted with six employees working at a corporate company in Istanbul, Turkey, with more than 500 staff members. Data were collected through structured interviews. Participants experienced digital training materials designed according to multimedia principles as well as traditional, text-based content, and their perceptions of these experiences were analyzed. The analysis produced 334 codes, 38 categories, and 6 themes.

The findings indicated that users perceived multimedia-based content as more effective, clear, and engaging, particularly in terms of audiovisual integration, coherence, accommodation of individual differences, and reduction of cognitive load. In contrast, traditional text-based training materials were described as monotonous, difficult to follow, and cognitively demanding.

The study highlights the importance of incorporating multimedia principles into corporate digital training design and emphasizes the need for learner-centered approaches. It also provides an original, user experience-based contribution to the field of educational technologies.

Keywords: *digital learning, multimedia principles, learning management system (LMS), adult education*

Giriş

Günümüzün sürekli öğrenme ortamında eğitim, yalnızca fiziksel ortamlarda sınırlı kalmayıp, teknolojinin sunduğu tüm olanakları ele alarak her an, her yerden erişilebilen bir deneyime dönüşmüştür. Bu deneyim dönüşümü sürecinde, öğrenme yönetim sistemleri (LMS) gibi dijital platformlar, yalnızca akademik kurumlarda değil, bir yandan da kurumsal hayatın da içinde yetişkin eğitiminin temel araçları arasında yer bulmaya başlamıştır. Ancak bu sistemlerin başarısı teknik altyapıyla da sınırlı kalmayıp, içeriklerin de etkin tasarımına bağlı olarak ilerlemektedir. Özellikle yetişkin bireylerin kendilerine yönelik öğrenme alanları, bireysel farklılıkları, öğrenmeye yönelik motivasyonları ve deneyimleri göz önüne alındığında, içerik tasarımında önem verilmesi gereken birçok etken olduğu ortaya çıkmaktadır.

Bu bağlamda, Mayer'in Çoklu Ortam Öğrenme Kuramı çerçevesinde hazırlanan eğitim materyallerinin, öğrenme sürecine katkı sağlayıp sağlamadığı, kullanıcı deneyimleri üzerinden değerlendirilmeye değer bir yaklaşımdır. Nitel bir vaka analizi üzerinden gerçekleştirilen bu araştırma, İstanbul'da faaliyet gösteren kurumsal bir firmada çalışan bireylerin dijital eğitim içeriklerine yönelik algı ve tercihlerini ortaya koymayı amaçlamaktadır. Araştırmanın temel amacı, çoklu ortam ilkelerine göre hazırlanmış içeriklerin, geleneksel içeriklerle kıyaslandığında kullanıcılar üzerindeki etkisini derinlemesine incelemektir.

Araştırmanın Yöntemi

Bu araştırma, nitel araştırma yöntemlerinden biri olan vaka analizi (case study) deseni ile yürütülmüştür. Vaka analizi, belirli bir durumun ya da olayın derinlemesine ve çok boyutlu olarak incelenmesine olanak sağlayan bir yaklaşımdır (Yin, 2018). Bu çalışmada vaka olarak, İstanbul'da faaliyet gösteren ve 500'ü aşkın çalışana sahip bir kurumsal firmanın çalışanları tarafından deneyimlenen iki farklı türde dijital eğitim içeriği (çoklu ortam ilkelerine göre tasarlanmış içerik ve geleneksel içerik) seçilmiştir.

Vaka analizi deseninin tercih edilmesinin temel nedeni; araştırmanın amacının, katılımcıların iki farklı dijital eğitim içeriğine yönelik deneyimlerini, algılarını ve tercih nedenlerini kendi bağlamsal koşulları içinde anlamak olmasıdır. Ayrıca bu yöntem, çoklu veri kaynakları kullanılarak veri çeşitliliği sağlanmasına ve araştırma sorularına daha derinlemesine yanıtlar bulunmasına olanak tanımaktadır.

Araştırmada kullanılan yaklaşım, betimsel bir nitel durum çalışması olup, örnek olay olarak seçilen kurumsal firmada çalışan bireylerin eğitim deneyimlerine odaklanılmıştır. Araştırma sürecinde katılımcılara her iki türde içerik deneyimletilmiş; sonrasında bire bir görüşmeler ile derinlemesine veri toplanmıştır. Elde edilen veriler, içerik analizi yöntemi ile değerlendirilmiştir.

Bu yöntemin seçilmesindeki bir diğer önemli neden, gerçek yaşam bağlamında dijital eğitim içeriklerinin etkilerini anlamak ve kullanıcı temelli çıkarımlar yapabilmektir. Yıldırım ve Şimşek (2016) vaka analizinin, bireylerin kendi sosyal ve örgütsel bağlamlarında yaşadıkları deneyimleri anlamak için etkili bir yöntem olduğunu vurgulamaktadır. Bu bağlamda araştırma, hem içerik tasarımı ile öğrenen algısı arasındaki ilişkiyi açığa çıkarmayı hem de kurumsal dijital eğitim politikalarına katkı sunacak öneriler geliştirmeyi hedeflemektedir.

Bu araştırmanın çalışma grubu, İstanbul'da faaliyet gösteren özel bir kurumsal firmada görev yapan, farklı birimlerde çalışan yetişkin bireylerden oluşmaktadır. Katılımcılar, amaçlı örnekleme yöntemi ile seçilmiştir. Amaçlı örnekleme, araştırma amacına doğrudan katkı sağlayabilecek nitelikte bireylerin bilinçli olarak seçildiği bir örnekleme türüdür (Çoban & Oral, 2020). Bu bağlamda, dijital eğitim deneyimi olan çalışanların derinlemesine görüşleriyle içerik tasarımı üzerine anlamlı veriler sunacağı düşünülerek örneklem oluşturulmuştur.

Araştırmaya katılan bireylerin seçiminde aşağıdaki ölçütler dikkate alınmıştır:

- En az 5 yıl kurumsal iş deneyimine sahip olmaları,
- Çalıştıkları firma ya da daha önceki firmalarında LMS (e-öğrenme platformu) kullanmış olmaları,
- E-öğrenme içeriklerini aktif şekilde deneyimlemiş olmaları,
- Farklı departmanlarda görev alarak çeşitlilik sağlamaları.

Bu ölçütler doğrultusunda, araştırma grubuna 3 farklı departmandan 6 kişi dahil edilmiştir. Cinsiyet ve yaş gibi demografik faktörlere göre bir sınırlama getirilmemiş, veri çeşitliliğini sağlamak amacıyla heterojen bir yapı tercih

edilmiştir. Katılımcılar, etik kurallar doğrultusunda anonimleştirilmiş, her biri "K" harfi ve bir sıra numarası ile kodlanmıştır (örneğin: K1, K2...).

Veri Toplama Araçları

Bu araştırmada nitel veri toplama yöntemleri çerçevesinde, temel veri toplama aracı olarak yapılandırılmış görüşmeler tercih edilmiştir. Nitel araştırmalarda, araştırmacı aynı zamanda sürecin önemli bir parçasıdır ve veri toplama, yorumlama, analiz etme işlevlerini doğrudan yerine getirir. Bu bağlamda, araştırmacının kendisi de sürece doğrudan katkı sağlayan bir unsur olarak değerlendirilir (Tekindal & Arsu, 2020).

Araştırma deseni olarak kullanılan vaka analizi, belirli bir bağlamda yaşanan olguları derinlemesine anlamayı hedefler. Bu nedenle görüşme tekniği, karmaşık sosyal olguların çok yönlü olarak incelenmesi için uygun bir yöntem olarak seçilmiştir. Vaka analizlerinde, veri çeşitliliğini sağlamak ve olgunun çok boyutlu yapısını yakalayabilmek adına görüşmeler sıkça başvurulan bir araçtır (Yin, 2018).

Bu çalışmada, katılımcılarla bire bir yapılan yapılandırılmış görüşmeler, dijital eğitim içeriklerine dair algılarını ve öğrenme deneyimlerini ortaya koymayı amaçlamıştır. Görüşme formu, çoklu ortam ilkelerine göre tasarlanmış içerikler ile geleneksel içerikler karşılaştırılarak katılımcıların düşünce ve deneyimlerini anlamaya yönelik sorular içermektedir. Görüşmelerin sonucu yazılı transcripte dökülmüş ve içerik analizine uygun veri elde edilmiştir.

Ayrıca, nitel verilerin yanında destekleyici olarak, araştırmanın yürütüldüğü kurumun LMS (Learning Management System) sisteminden alınan kullanım raporları da analizde kullanılmıştır. Bu veriler, görüşmelerde dile getirilen tutum, davranış ve tercihlerin sistemsel verilerle ilişkilendirilmesine olanak sağlamıştır.

Veri Toplama ve Çalışma Süreci

Bu araştırmada veri toplama süreci, yapılandırılmış görüşmeler ve destekleyici doküman analizlerinden oluşmaktadır. Katılımcılarla bire bir görüşmeler gerçekleştirilmiş ve görüşme soruları, araştırmanın amacı doğrultusunda önceden yapılandırılmış açık ve kapalı uçlu sorularla hazırlanmıştır. Görüşme formunda, özellikle çoklu ortam ilkelerine göre hazırlanmış ve geleneksel olarak tasarlanmış dijital içeriklere dair kullanıcı deneyimi, algı, tercih nedenleri ve öneriler yer almıştır.

Katılımcıların rahat bir iletişim ortamı içerisinde görüşme sürecine dahil olabilmeleri için esnek bir zaman planlaması yapılmıştır. Katılımcılar, kendileri için en uygun zaman ve mekânda görüşmeye katılmışlardır. Bu durum, nitel araştırmalarda veri kalitesini artırmak adına önemli bir etik ve metodolojik yaklaşımdır. Her bir görüşme araştırmacı tarafından birebir transkripte edilmiştir.

Veri toplama süreci, araştırmanın nitel vaka analizine dayalı yapısına uygun olarak yürütülmüş, bireysel deneyimlerin bağlamsal olarak anlaşılması ve yorumlanması esas alınmıştır. Görüşme sürecinde etik kurallara tam uyum sağlanmış, katılımcıların gizliliği ve gönüllü katılım ilkeleri titizlikle gözetilmiştir.

Veri toplama sürecinde yapılandırılmış görüşmeler üzerinden ilerlenen sorular şunlardır;

1. Size sunulan iki farklı eğitim içeriğinden hangisini daha etkili buldunuz? Neden?
2. Hangi içerik öğrenmenizi daha çok destekledi? Ne gibi farklar hissettiniz?
3. Görsel, sesli veya animasyonlu unsurlar sizin için ne kadar dikkat çekiciydi?
4. Eğitim içeriklerinin sizin öğrenme motivasyonunuza etkisi oldu mu?
5. Eğitimleri tamamlama sürecinizde sizi teşvik eden veya zorlayan unsurlar nelerdi?
6. Anlamadığınız ya da zorlandığınız bir nokta olduysa, bunu neyle ilişkilendirirsiniz?
7. Tasarım açısından içerikler arasında dikkatinizi çeken farklar oldu mu?
8. İçerikteki metin-görsel dengesi sizce yerinde miydi?
9. Sesli anlatımın olması veya olmaması öğrenmenizi nasıl etkiledi?
10. Kurumunuz bu içeriklerden hangisini yaygınlaştırmalı sizce? Neden?
11. Eğitim içerikleri size daha kişisel, daha ilgili veya daha uzak geldi mi?
12. Önümüzdeki süreçte dijital içeriklerin nasıl olmasını istersiniz?

Veri Analizi

Bu çalışmadaki araştırma verilerini katılımcılarla yapılan bire bir görüşmeler oluşturmaktadır.

Veri analizi sonucunda 6 Tema, 38 Kategori ve 334 Kod oluşmuştur. Her bir Kod için katılımcıların ifadeleri birebir alınmış, veri analizi içine eklenmiştir. Kodların belirlenmesi aşamasında ise birinci ve ikinci eğitime yönelik cevaplar ayrılmış, her bir cevap, negatif (-) ve pozitif (+) ifadeleri içerecek şekilde ayrıca ayrılmıştır. Katılımcıların 12 soru için verdikleri yanıtlar içinde negatif ve pozitif ifadeler söylemlere bölünerek kodlar oluşturulmuştur.

Kodlar, öncelikle açık kodlama ile tamamen hiçbir değişiklik yapılmadan katılımcıların ifadelerini bire bir alarak ilerlenmiştir. Bu, bazen bir kelime bazen de bir kelime topluluğu, kısa cümle olarak yazılmıştır. Daha sonra, katılımcıların ifade etmek istedikleri kavramlardan ortak çağrışım oluşturan kodlar bir araya getirilmiş ve kategoriler oluşturulmuştur. Kodlama da kategori de tamamen araştırmacının herhangi bir yazılım programı kullanmadan manuel ilerlemesi ile elde edilmiştir. Kodlar, katılımcıların ifadelerinden ham veri olarak alınmış ve ortak çerçevede kategori içine yerleştirilmiş olup, bu işlem ham kodların tekrar ve tekrar okunması ve tam anlamı ortaya çıkarabilmek için trancripte dönüp ham kodun geçtiği cümlenin tekrar okunması ile belirlenmiştir.

Oluşturulan kategorilerden 6 tema belirlenmiş ve kod-kategori-tema üçlüsü farklı bir uzmana da sorularak görüşü alınmıştır. Temalar birinci ve ikinci eğitim içeriği dikkate alınarak katılımcıların vermiş oldukları eğitimlere yönelik cevapları ile eşleştirilerek her alanda 2 tema olmak üzere 3 ana alanda oluşturulmuştur. Bu alanlar; birinciye eğitime yönelik cevaplardan oluşan kod/kategori/tema; ikinci eğitime yönelik cevaplardan oluşan kod/kategori/tema; her iki eğitimden de bahsetmeden genel verilen cevaplardan oluşan kod/kategori/tema üçlüsüdür. Bu 6 temadan da üç alana yönelik 3 çıkarım elde edilmiştir.

Geçerlik, Güvenirlik ve Etik

Bu araştırmada içerik geçerliğini sağlamak amacıyla yapılandırılmış görüşme formu alanyazın ve araştırmanın amaçları doğrultusunda geliştirilmiştir. Görüşme soruları hazırlanırken, Mayer'in Çoklu Ortam İlkeleri dikkate alınmış, katılımcıların dijital eğitim içeriklerine yönelik deneyim ve algılarını derinlemesine yansıtabilecek şekilde tasarlanmıştır. Ayrıca uzman görüşleri dikkate alınmış ve görüşme formundaki bilgiler değerlendirilerek gerekli yerlerde düzenlemeler yapılmıştır. Bu sayede verilerin araştırma sorularını karşılamadaki yeterliliği artırılmıştır. Departman farklılıkları ve katılımcı deneyimleri gözetilerek çeşitlilik sağlanmaya ve bu doğrultuda verilerde bağlamsal geçerliliği desteklenmeye çalışılmıştır.

Doğru bilgiye ulaşma konusunda gereken önlemlerin alınması (geçerlik) ve araştırma sürecinin ve verilerinin açık ve ayrıntılı bir şekilde yani bir başka araştırmacının değerlendirmesine imkân verecek şekilde tanımlanması (güvenirlik), nitel araştırmacının karşılaması gereken önemli beklentilerdir (Yıldırım & Şimşek, 2016). Nitel araştırmalarda güvenirlik, araştırmacının verileri doğru toplaması, analiz etmesi ve yorumlaması ile doğrudan ilişkilidir. Bu çalışmada verilerin güvenirliğini sağlamak için görüşmeler yüz yüze yapılmış, görüşme sonuçları transkript edilmiş ve her bir katılımcının onayına sunularak teyitleri alınmıştır. Veriler içerik analizi yöntemi ile sistematik şekilde kod ve temalara dönüştürülmüştür. Kod ve tema oluşturma sürecinde ikinci bir araştırmacıdan kontrol alınarak kodlar arası tutarlılık sağlanmıştır. Bu sayede yorumların subjektif yargılardan uzaklaştırılması sağlanmıştır.

Araştırma etik açından bilimsel gerekliliklere uygun olarak yürütülmüş ve tüm katılımcılar gönüllülük esasına göre araştırmaya dahil edilmiştir. Katılımcılara araştırmanın amacı, içeriği ve süreç hakkında açık ve net bir şekilde bilgilendirme yapılmış, görüşmeler öncesinde katılımcıların onayı alınmıştır. Katılımcıların kimliklerine açık şekilde yer verilmemiş ve kodlar (K1, K2, K3 vb.) ile tanımlanarak kimlik bilgileri gizli tutulmuştur. Elde edilen veriler yalnızca bilimsel amaçla kullanılmış olup üçüncü kişilerle paylaşılmamıştır.

Varsayımlar ve Sınırlılıklar

Yapılan bu nitel vaka analizinde temel alınan varsayımlar şunlardır;

- Katılımcıların yapılandırılmış görüşmelerde verdikleri yanıtların içten ve gerçeği yansıttığı kabul edilmiştir.
- Katılımcıların hem çoklu ortam ilkelerine göre tasarlanmış hem de geleneksel içerikleri deneyimledikleri süreçte, içeriğe dikkatle odaklandıkları ve sürece aktif katılım sağladıkları varsayılmıştır.
- Görüşme formunda yer alan soruların, katılımcıların dijital eğitim içeriklerine yönelik algı ve deneyimlerini etkili biçimde yansıtabileceği varsayılmıştır.

Araştırmanın bulgularının değerlendirilmesinde dikkate alınması gereken bazı sınırlılıklar bulunmaktadır;

- Araştırma yalnızca İstanbul'da faaliyet gösteren ve 500'den fazla çalışana sahip tek bir kurumsal firmada gerçekleştirilmiş olup, elde edilen sonuçların farklı kurumlara doğrudan genellenmesi sınırlıdır.
- Katılımcı sayısı altı bireyle sınırlı tutulmuştur; bu sayı nitel veri derinliği açısından yeterli olmakla birlikte geniş bir popülasyonun temsili açısından sınırlayıcıdır.
- Araştırmada sadece LMS tabanlı dijital eğitim içerikleri analiz edilmiştir. Diğer dijital öğrenme yöntemleri (canlı dersler, mobil uygulamalar vb.) kapsam dışında bırakılmıştır.
- Bulgular, katılımcıların bireysel görüşlerine dayandığı için nesnel ölçümlerle desteklenmemiştir.
- Veriler, belirli bir zaman diliminde toplanmıştır ve katılımcıların zamanla değişebilecek tutum ve algılarını kapsamamaktadır.

Bulgular ve Tartışma

Araştırma, İstanbul'da faaliyet gösteren özel bir kurumsal firmada çalışan yetişkin bireylerin izledikleri iki farklı dijital eğitim içeriklerine yönelik algılarını değerlendirmek için yapılandırılmış görüşme ile kendilerinden alınan yanıtların sonuçları ile yapılmıştır.

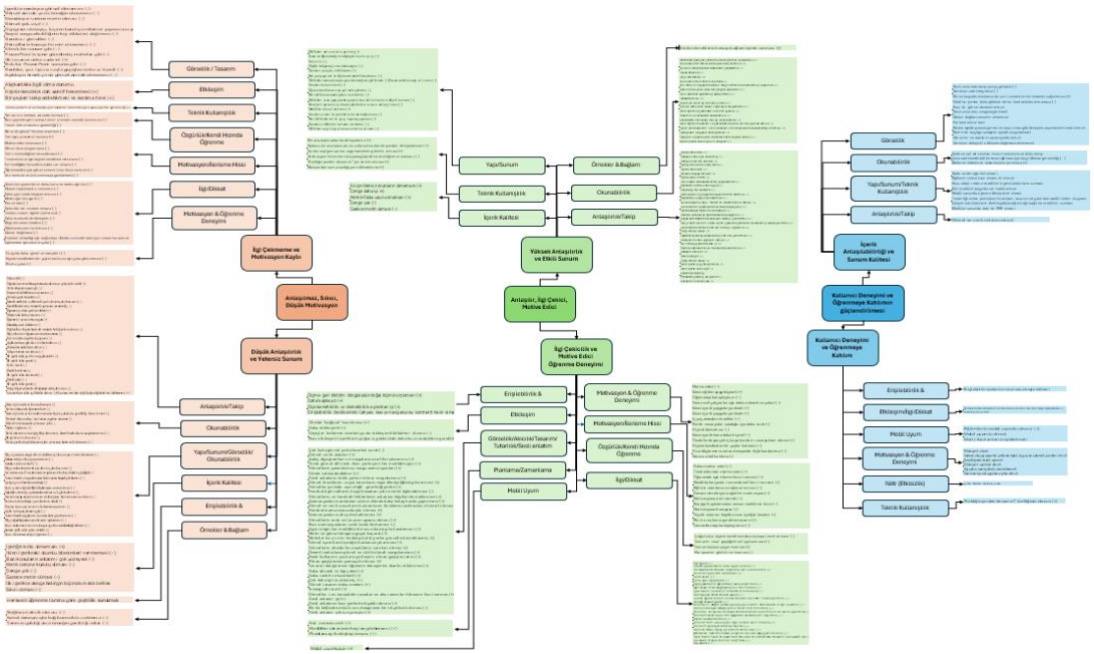
Çalışmada elde edilen kod, kategori ve temalar, bir kavram haritası üzerinde şekillendirilmiş ve bütünsel bir görsel ile Şekil 1'de gösterilmiştir. Bu çalışma sonucunda 3 farklı çıkarım elde edilmiş ve 6 tema, 38 Kategori ve 334 Kod elde edilmiştir. 3 çıkarım ve 6 tema şunlardır;

Çıkarımlar ve temaları;

- Anlaşılmaz, Sıkıcı, Düşük Motivasyon
  - İlgi Çekmeme ve Motivasyon Kaybı
  - Düşük Anlaşılırlık ve Yetersiz Sunum

- Anlaşılır, İlgi Çekici, Motive Edici
  - Yüksek Anlaşılırlık ve Etkili Sunum
  - İlgi Çekicilik ve Motive Edici Öğrenme Deneyimi

- Kullanıcı Deneyimi ve Öğrenmeye Katılımın güçlendirilmesi
  - İçerik Anlaşılabilirliği ve Sunum Kalitesi
  - Kullanıcı Deneyimi ve Öğrenmeye Katılım

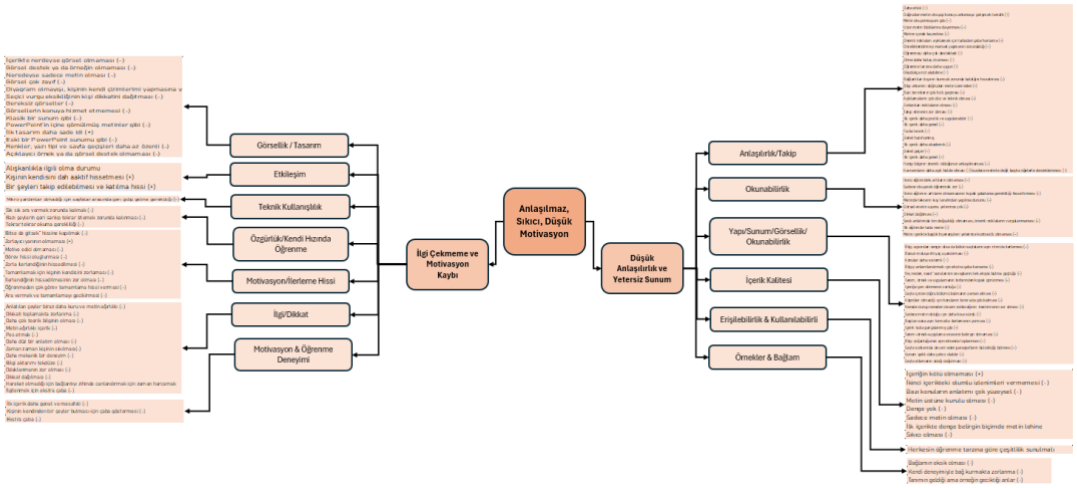


Şekil 1. Kod/Kategori/Tema Kavram Haritası

Kavram haritasından da görüldüğü üzere üç farklı renklendirme mevcuttur. Bu renklerin kavram haritası üzerindeki okuma koduna göre; turuncu renkli alanlar katılımcıların sorular karşısından ilk eğitime yönelik olan yanıtları, yeşil renkli alanlar katılımcıların sorular karşısından ikinci eğitime yönelik olan yanıtları, mavi renkli alanlar ise katılımcıların sorular karşısından ne ilk eğitim ne de ikinci eğitime yönelik spesifik olmayan yanıtlarıdır.

Katılımcıların İlk Eğitime Yönelik Algıları

Araştırmada katılımcılarla yapılan görüşmeler sonucunda katılımcıların yanıtlarının ilk eğitime yönelik negatif (-) ağırlıklı olduğu gözlemlenmiştir. Şekil 2'de görüldüğü üzere katılımcıların verdiği yanıtlarda "İlgi Çekmeme ve Motivasyon Kaybı" teması altında görsellik/tasarım, etkileşim, teknik kullanışlılık, özgürlük/kendi hızında öğrenme, motivasyon/ilerleme hissi, ilgi/dikkat ve motivasyon & öğrenme deneyimi kategorilerine ayrılmış olan kodlarda negatif (-) ifadeler yer almaktadır. "Düşük Anlaşılırlık ve Yetersiz Sunum" teması altında yer alan anlaşılırlık/takip, okunabilirlik, yapı/sunum/görsellik/okunabilirlik, içerik kalitesi, erişilebilirlik & kullanılabilirlik, örnekler & bağlam kategorilerini oluşturan kodlar da aynı şekilde çoğunlukla negatif (-) ifadelerden oluşmaktadır.



Şekil 2. Birinci Eğitime Yönelik Yanıtların Kod/Kategori/Tema Kavram Haritası

Katılımcıların birinci eğitime yönelik vermiş oldukları yanıtlara örnek içerikler aşağıdaki gibidir;

Soru : Size sunulan iki farklı eğitim içeriğinden hangisini daha etkili buldunuz? Neden?

K3: ilk içerikte bir şeyler anlatılıyor ama sanki bir metin okuyormuşum gibi geldi. Dikkatimi toplamakta zorlandım çünkü sürekli okumam gerekiyordu ve anlatım çok düz ilerliyordu.

K4: İlk içerik uzun metin bloklarına dayandığı için bir süre sonra metnin içinde kaybolduğumu hissettim ve önemli noktaları ayıklamak için fazladan çaba harcadım.

Soru: Hangi içerik öğrenmenizi daha çok destekledi? Ne gibi farklar hissettiniz?

K1: Bazı kavramlar vardı ki, ilk içerikte anlamakta zorlandım.

K5: Metin ağırlıklı ilk içerikte geri dönmek daha zahmetliydi; sayfa içinde doğru bölümü bulmak zaman aldı ve bazen pes ettim.

Soru: Eğitim içeriklerinin sizin öğrenme motivasyonunuza etkisi oldu mu?

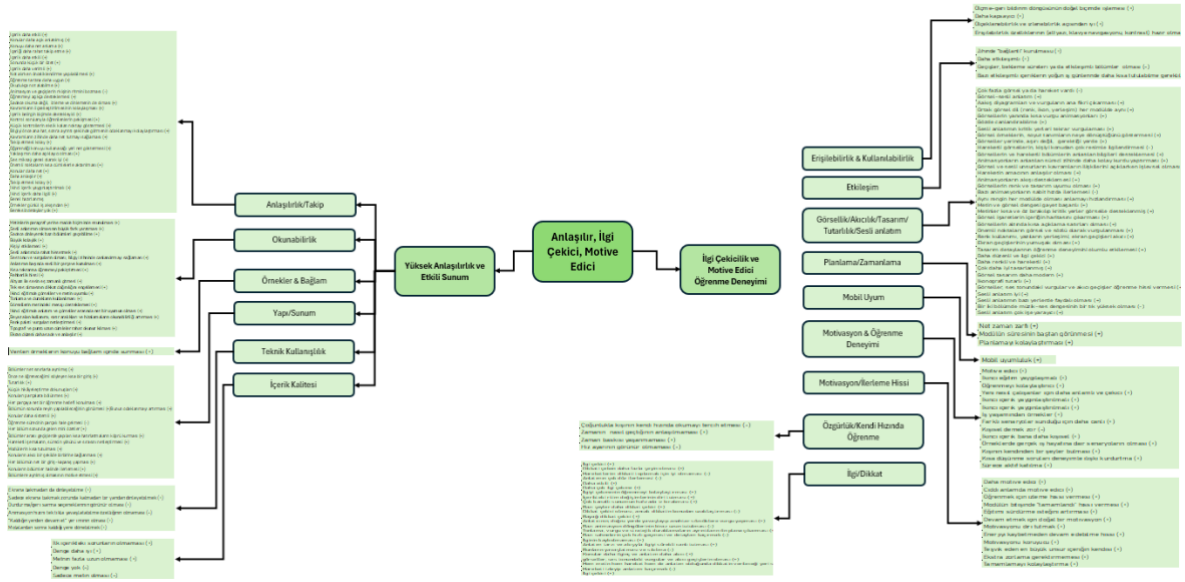
K1: İlk eğitimde ise "bitse de gitsek" hissine kapıldım. Zorlayıcı bir yanı yoktu ama motive edici de değildi. Daha görev gibi yaklaştım.

K3: İlk içerikte ise baştan sona aynı formatta ilerlemek bir süre sonra yordu. O nedenle sık sık ara vermek zorunda kaldım. Aslında içerik kötü değildi ama sunum şekli daha çekici olabilirdi

Katılımcıların İkinci Eğitime Yönelik Algıları

Araştırmada yer alan katılımcıların 12 soru üzerinden verdikleri yanıtlarda ikinci eğitimi dikkate alan ifadeleri pozitif (+) ağırlıklıdır. "Yüksek Anlaşılırlık ve Etkili Sunum" teması altında 6 kategori oluşturulmuş (anlaşılırlık/takip, okunabilirlik, örnekler & bağlam, yapı/sunum, teknik kullanışlılık, içerik kalitesi) ve katılımcıların birinci eğitim özelinde verdikleri yanıtlar ile ikinci eğitim özelinde verdikleri yanıtlarla aynı kategoriyi oluşturan farklı kodlar arasındaki fark, Şekil 3'de de görüldüğü üzere pozitif (+) ağırlıklı ifadelerdir.

"İlgi Çekicilik ve Motive Edici Öğrenme Deneyimi" teması altında ise 9 kategori oluşturulmuştur. Bu kategoriler; erişilebilirlik & kullanılabilirlik, etkileşim, görsellik/akıcılık/tasarım/tutarlılık/ sesli anlatım, planlama/zamanlama, mobil uyum, motivasyon & öğrenme deneyimi, motivasyon/ilerleme hissi, özgürlük/kendi hızında öğrenme ve ilgi/dikkat kategorileridir (Şekil 3).



Şekil 3. İkinci Eğitime Yönelik Yanıtların Kod/Kategori/Tema Kavram Haritası

Katılımcıların ikinci eğitime yönelik vermiş oldukları yanıtlara örnek içerikler aşağıdaki gibidir;

Soru: Eğitimleri tamamlama sürecinizde sizi teşvik eden veya zorlayan unsurlar nelerdi?

K1: Teşvik eden en büyük unsur içeriğin kendisiydi. Eğer içerik beni içine çekiyorsa zaten tamamlamak için ekstra bir zorlama gerekmiyor. İkinci eğitimde bu konuda hiç sıkıntı yaşamadım.

K6: İkinci içerikte "Kaldığın yerden devam et" ve yer imi ekleme özellikleri, eğitimi tamamlama sürecimde büyük kolaylık sağladı. Molalardan sonra kaldığım noktaya dönmek, hem zaman hem de dikkat açısından verimliydi.

Soru: Tasarım açısından içerikler arasında dikkatinizi çeken farklar oldu mu?

K2: Evet, ikinci içerik daha renkli ve hareketliydi.

K3: Evet, ikinci içerik çok daha iyi tasarlanmıştı. Hem ekran düzeni daha sade ve anlaşılırdı, hem de görsel tasarım daha moderndi.

Soru: İçerikteki metin-görsel dengesi sizce yerinde miydi?

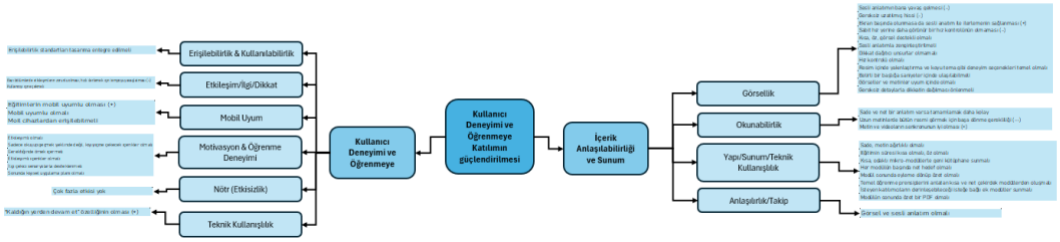
K4: Sesli anlatım, özellikle gün içinde ekran başında olamadığım anlarda bile ilerlememi sağladı; kulaklıkla yürürken bile modül bitirdim. Anlatıcının kritik kavramlarda tempoyu düşürmesi odaklanmama yardımcı oldu.

K5: Anlatımın başında sesli bir çerçeve kurulması çok işe yaradı.

Katılımcıların Eğitim Belirtmeksizin Sürece Yönelik Algıları

Katılımcılarla gerçekleştirilen yapılandırılmış görüşmelerde, özellikle yanıtlarının spesifik olarak birinci ya da ikinci eğitim ile ilgili olmaması durumu analiz edilmiş ve "Kullanıcı Deneyimi ve Öğrenmeye Katılım" teması altında erişilebilirlik & kullanılabilirlik, etkileşim/ilgi/dikkat, mobil uyum, motivasyon & öğrenme deneyimi, nötr

(etkisizlik), teknik kullanışlılık olmak üzere 6 kategori oluşturulmuştur. Ayrıca görsellik, okunabilirlik, yapı/sunum/teknik kullanışlılık, anlaşılırlık/takip kategorileri de "İçerik Anlaşılabilirliği ve Sunum Kalitesi" teması altında oluşturulmuştur (Şekil 4.).



Şekil 4. Genel Değerlendirmeye Yönelik Kod/Kategori/Tema Kavram Haritası

Katılımcıların genel olarak içeriklere ve sürece verdiği yanıtlardan örnekler şöyledir;

Soru : Kurumunuz bu içeriklerden hangisini yaygınlaştırmalı sizce? Neden?

K1: Kesinlikle ikinci eğitimi yaygınlaştırmalı. Çünkü daha anlaşılır, takip etmesi kolay ve motive edici. İnsanların gerçekten bir şey öğrenmesini istiyorsak bu tarz içeriklerin etkili olduğunu düşünüyorum.

K3: Bence ikinci içerik yaygınlaştırılmalı. Çünkü çalışanların hem ilgisini çekiyor hem de öğrenmeyi kolaylaştırıyor. Özellikle yeni nesil çalışanlar için bu tarz içerikler çok daha anlamlı ve çekici olacaktır. Öğrenmenin sadece bilgi aktarımı değil, aynı zamanda bir deneyim olduğunu unutmamak gerek.

Soru: Önümüzdeki süreçte dijital içeriklerin nasıl olmasını istersiniz?

K1: Kısa, öz, görsel destekli, sesli anlatımla zenginleştirilmiş ve mümkünse etkileşimli. Sadece okuyup geçeceğim değil, beni içine çekecek içerikler olmalı.

K3: Görselliği ve sesli anlatımı olan, mümkünse kullanıcıyı içine çeken, etkileşimli içerikler olmalı. Eğitimin süresi kısa tutulmalı ama öz olmalı. İlgimi çekecek senaryolarla desteklenirse çok daha iyi olur. Bir de mobil uyumlu olursa gün içinde rahatça erişebilirim.

K6: Dijital içeriklerde en baştan erişilebilirlik standartlarının tasarıma entegre edilmesini önemli buluyorum. Her modülün sonunda özet bir PDF ve indirilebilir çalışma sayfası bulunması, bilgiyi pekiştirmeyi kolaylaştırır. Ayrıca eğitim sonunda kişisel bir uygulama planı oluşturup bunu e-posta ile kendime gönderebilmek, öğrendiklerimi iş hayatına daha hızlı taşımamı sağlar.

Sonuç ve Öneriler

Bu araştırmada, İstanbul'da faaliyet gösteren bir kurumsal firmada farklı birimlerde çalışan altı katılımcının, Mayer'in çoklu ortam ilkelerine göre tasarlanmış dijital eğitim içerikleri ile Mayer'i ilkeleri dikkate alınmadan geleneksel metin ağırlıklı olarak hazırlanmış içeriğe yönelik algı ve tercihleri incelenmiştir. Veriler nitel vaka analizi üzerinden yapılandırılmış görüşmelerle elde edilmiştir. Tüm veriler incelendiğinde 334 Kod, 38 Kategori ve 6 Tema ortaya çıkmış ve araştırmanın sonucunda üç farklı çıkarım elde edilmiştir.

Katılımcıların sorulara yönelik vermiş oldukları yanıtların birinci eğitimi kapsamasından kaynaklı 111 adet kod üretilmiş ve bu kodların 91 tanesi negatif (-) ifadelerden oluşurken, 15 tanesi pozitif (+) ifadelerden oluşmuş ve 5 tanesi nötr kalmıştır.

Aynı şekilde katılımcıların sorulara yönelik vermiş oldukları yanıtların ikinci eğitimi kapsamasından kaynaklı 185 adet kod üretilmiş ve bu kodların 162 tanesi pozitif (+), 22 tanesi negatif (-) ifadelerden oluşurken sadece 1 tanesi nötr kalmıştır.

Katılımcılar, geleneksel metin tabanlı eğitim içeriklerini genellikle "sıkıcı", "takip edilmesi zor" ve "motivasyonu düşüren" nitelikte tanımlamışlardır. Kodlamalarda, "uzun metin blokları (-)", "dikkati toplamakta zorlanma (-)", "öğrenme sürecinde kaybolma (-)" gibi ifadeler sıkça yer almıştır. Bu durum, metin ağırlıklı içeriklerin bilişsel yükü artırdığı ve öğrenme motivasyonunu azalttığını göstermektedir.

Mayer'in çoklu ortam ilkelerine göre tasarlanmış olan ikinci eğitim ise, katılımcılar tarafından daha anlaşılır, ilgi çekici ve motive edici bulunmuştur. Bu tip içeriklerden oluşan eğitim için "daha etkili (+)", "konular açık anlatılmış (+)", "daha rahat takip edilebiliyor (+)", "özet sunulması öğrenmeyi kolaylaştırıyor (+)" gibi ifadelerin öne çıktığı gözlenmiştir. Bu bulgu, Mayer'in çoklu ortam kuramını destekler biçimde, görsel-işitsel bütünlüğün öğrenme sürecine katkısını ortaya koymaktadır.

Katılımcıların geleneksel içerikli ya da çoklu ortam ilkelerine göre tasarlanmış içerikli bir eğitim olmasından bağımsız genel değerlendirmelerinde ise, içeriklerin erişilebilirliği, mobil uyumu, görsel tasarımı ve sesli anlatım unsurları, öğrenme sürecinde önemli etkenler olduğu yönde algıları tespit edilmiştir. Bu sonuçtan hareketle kullanıcı deneyiminin öğrenmeye katılımı artırdığı söylenebilir.

Öneriler

Araştırmanın sonucunda şu öneriler verilebilir;

- Kurumlarda yetişkinler için tasarlanan eğitim içeriklerinde metin yoğunluğundan kaçınılması, görseller, animasyonlar, sesli anlatımlar ve etkileşimli ögelerle öğrenmenin desteklenmesi önerilir.
- İçeriklerin kısa ve anlaşılır şekilde tasarlanması, özet bölümler, anahtar noktalar ve aşamalı ilerleme imkânı ile katılımcıların öğrenmesini desteklemesi önerilir.
- Çalışanların motivasyonunu artırmaya yönelik kişiselleştirilebilir öğrenme hızları, erişilebilirlik, platformun mobil uyumlu olması ve etkileşimli özelliklerin yer alması önerilir.
- Eğitim tasarımcılarının içerikleri tasarlarken Mayer'in Çoklu Ortam İlkeleri ile andragoji yaklaşımını bütünleştirmesi ve bu sayede çalışanların öğrenme sürecine aktif katılımını sağlanması önerilir.

Özetle, kurumsal firmalarda yetişkin öğrenimine yönelik eğitim tasarımında çoklu ortam ilkelerinin öncelikli ve kullanıcı deneyimi odaklı olması ve böylece bilişsel yükün azaltılması ile öğrenme sürecinin desteklenmesi önerilir.

Gelecek araştırmalara öneri:
Bu nitel araştırma altı katılımcı ile sınırlı olup; daha geniş örneklemler ele alınarak nicel verilerle desteklenmiş araştırmalar yapılması, sonuçların genellenebilirliğini artırabilir. Bu çalışma tek bir sektör özelinde yapılmış olup farklı sektörlerde de yapılması, Mayer'in çoklu ortam ilkelerinin sektörel anlamda çalışanların öğrenme deneyimi üzerinde etkileri olup olmadığı incelenebilir. Ayrıca bu çalışma, çalışanların kısa dönemdeki izledikleri eğitimlerin yapılandırılmış sorularla algıları gözlenmiş olup, uzun dönemdeki takip çalışmaları ile çoklu ortam tasarımlı içeriklerin, çalışanlar üzerindeki öğrenme kalıcılığı ve performansa etkileri ölçülebilir.

Teşekkür

Arife Ceren Gürsoy, değerli rehberlik ve destekleri için Bahçeşehir Üniversitesi Eğitim Teknolojisi Doktora Programı hocalarına, ayrıca katkılarından dolayı özellikle Bahçeşehir Üniversitesi Dr. Öğr. Üyesi Zeynep CÖMERT'e teşekkür eder.

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Dünya'dan Örneklerle Türkiye'de Okul Öncesi Eğitimde Yapay Zekâ Uygulamalarının Kullanımının Değerlendirilmesi

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Özet

Bu çalışma, Türkiye'de okul öncesi öğretmenlerinin yapay zekâ (YZ) teknolojileri hakkındaki görüşlerini belirlemek ve kullanım amaçlarını araştırmak amacıyla yürütülmüştür. Araştırma, nitel araştırma yöntemlerinden durum çalışması deseniyle tasarlanmıştır. Amaçlı örnekleme ile belirlenen ve Millî Eğitim Bakanlığı'na bağlı anasınıfı ile anaokullarında çalışan toplam 23 öğretmenle yarı yapılandırılmış görüşmeler yapılmıştır. Veriler, betimsel ve içerik analizi teknikleri kullanılarak çözümlenmiştir. Analiz sonucunda, öğretmenlerin YZ'yi hayatı kolaylaştırma, insanı taklit etme, teknik işlev gibi temalarla açıkladıkları görülmüştür. Katılımcılar en çok ChatGPT, Google Gemini ve Siri gibi YZ uygulamalarını bildiklerini belirtmişlerdir. YZ kullanım amaçları arasında eğitimsel planlama, bilgiye erişim, günlük yaşam kolaylığı ve dijital içerik desteği ön plana çıkarken; bazı öğretmenler bu uygulamaları hiç kullanmadıklarını belirtmiştir. Öğretmenlerin görüşleri işlevsel fayda, koşullu kabul, olumsuz-kararsız yaklaşım ve gelecek potansiyeli gibi temalar altında toplanmıştır. Yapay zekânın özellikle bilişsel etkinliklerde, içerik geliştirme ve yaratıcılık gerektiren uygulamalarda kullanılabileceği ifade edilmiştir. Sonuç olarak öğretmenlerin yapay zekâya yönelik genel olarak olumlu ancak temkinli bir yaklaşıma sahip oldukları, kullanım düzeylerinin ise sınırlı olduğu görülmüştür. Çalışma, YZ teknolojilerinin okul öncesi eğitimde etkili ve bilinçli kullanımı için öğretmen eğitimlerinin artırılması ve destekleyici politikalar geliştirilmesi gerektiğini önermektedir.

Anahtar Kelimeler: Yapay zekâ, eğitimde yapay zekâ, öğretmen görüşleri, okul öncesi eğitim

Evaluation of the Use of Artificial Intelligence Applications in Preschool Education in Türkiye with Examples from Around the World

Abstract

This study was conducted to identify the opinions of preschool teachers in Türkiye regarding artificial intelligence (AI) technologies and to examine their purposes of use. The research was designed using a case study pattern, one of the qualitative research methods. Semi-structured interviews were conducted with a total of 23 teachers, selected through purposive sampling, who work in kindergartens and preschools affiliated with the Ministry of National Education. The data were analyzed using descriptive and content analysis techniques. The analysis revealed that teachers explained AI through themes such as facilitating life, imitating humans and technical function. Participants stated that they were most familiar with AI applications such as ChatGPT, Google Gemini and Siri. Among the purposes of AI use, educational planning, access to information, facilitation of daily life and digital content support came to the forefront, while some teachers indicated that they did not use these applications at all. Teachers' views were grouped under themes such as functional benefit, conditional acceptance, negative–indecisive approach and future potential. It was noted that AI could particularly be used in cognitive activities, content development and applications requiring creativity. In conclusion, it has been observed that teachers generally have a positive but careful attitude about AI and their usage levels are restricted. The study suggests that in order to ensure the effective and conscious use of AI technologies in preschool education, teacher training should be increased and supportive policies should be developed.

Keywords: Artificial intelligence, artificial intelligence in education, teachers' opinions, preschool education

Giriş

Yapay zekâ, McCarthy (2004) tarafından, "İnsan benzeri zeki makineler özellikle de zeki bilgisayar programları yapma bilimi ve mühendisliği" şeklinde ifade edilmektedir. Yapay zekânın gelişimi, pek çok farklı alanda olduğu gibi, eğitim alanında da köklü değişimlerin başlangıcı olmuştur. Eğitimde yapay zekâ, eğitim ve öğretimde sağladığı kolaylıklar açısından son yıllarda giderek yaygınlaşan ve eğitimcilerin ve araştırmacıların gün geçtikçe daha fazla ilgi duyduğu bir alan haline gelmiştir (Su & Yang, 2022).

21. yüzyılda yetişen kuşağın, teknolojinin merkezinde büyümesi nedeniyle, geleneksel öğretim yöntemlerinin ötesine geçilerek daha yenilikçi ve teknoloji odaklı yaklaşımlara ihtiyaç duyulmaktadır (Chen vd., 2020). Bazı gelişmiş ülkelerde çocuklara yönelik yapay zekâ eğitimi artık uygulamaya geçmiş, küresel rekabet artmıştır (Changmeng, 2024). Çin, Amerika Birleşik Devletleri (ABD), Kanada, Güney Kore ve Singapur'da yapay zekâ eğitimi ile ilgili okul öncesinden itibaren özellikle de ilk ve ortaokul kademelerinde yapay zekanın dâhil edildiği okul müfredatları tasarlanması ve uygulanması amacıyla plan ve projeler geliştirilmiştir (Asia Pacific Foundation of Canada Korea Al Ethics Association, 2021; Chiu & Chai, 2020; Smart Nation and Digital Government Office, 2019). Ayrıca Türkiye dahil olmak üzere ABD, Birleşik Krallık, Avrupa Birliği ve Çin'de, yapay zekânın eğitimde kullanılmasına yönelik çeşitli politika belgeleri yayımlanmıştır (Changmeng, 2024; MEB, 2025). Okul öncesinde yapay zekâ eğitimi ile ilgili olarak ise Çin'de Keeko, Güney Kore'de Alpha Mini adlı fiziksel beceriler sergileyebilen ve sesli etkileşimlere girebilen robotların pilot proje kapsamında uygulamaları yapılmıştır (Seoul Metropolitan Government, 2021; Wang, Liu, & Zheng, 2020). Singapur'da da yine bir pilot proje kapsamında okul öncesi çağdaki çocuklara yaratıcı düşünme becerisi ve dijital okuryazarlık kazandırmak amacıyla EdGPT adlı yapay zekâ destekli bir sohbet aracı geliştirilmiş ve çocukların kullanımına sunulmuştur (The Straits Times, 2023). ABD'de ise erken çocukluk eğitimi için yapay zekâ temelli bir müfredat tasarlamak amacıyla PopBots ve Zhorai adlı iki yapay zekâ aracı kullanılmış; bu araçlar, küçük çocukların yapay zekâ ve makine öğrenimi kavramlarını daha kolay kavramalarına yardımcı olmuştur. (Lin vd., 2020; Williams, Park, & Breazeal, 2019; akt. Su ve Yang, 2022). Ek olarak bazı ülkelerde okul öncesi eğitimde yapay zekâ konulu ortak projeler gerçekleştirilmiştir. Örneğin; Almanya, İtalya, Danimarka ve Litvanya'dan eğitim uzmanları ve araştırmacılar tarafından düzenlenen "I'm Not a Robot" adlı Avrupa projesi çerçevesinde, öğretmenlere yönelik dijital setler ve çevirim içi öğrenme platformları geliştirilmiş; böylece çocukların yapay zekâ ile etkileşimli öğrenme deneyimleri kazanmaları desteklenmiştir (Klax Berlin gGmbH, 2023). Dünya'da okul öncesi eğitimde yapay zekâ kullanım örnekleri sadece bunlarla sınırlı kalmamakta, daha da çeşitlendirilebilmektedir. UNESCO'nun "Eğitimde 2030" hedefi doğrultusunda yapay zekâ teknolojileri gündemi, sürdürülebilir kalkınma hedeflerine katkı sağlayan eğitim uygulamalarını teşvik etmeyi amaçlamaktadır (Pedro vd., 2019). Bu gelişmeler göz önüne alındığında yapay zekânın ilerleyen yıllarda eğitim alanındaki kapsamının genişleyeceği beklenmektedir.

Yapay zekâ, eğitim sektöründeki yenilikçi etkisiyle özellikle çocukların temel eğitim aldığı okul öncesi dönemde, öğretmenler için yeni ve heyecan verici fırsatlar yaratma potansiyeline sahiptir (Küçükkara vd., 2024). Erken çocukluk dönemi yapay zekâ eğitimi, bu yaş grubunun ihtiyaçlarıyla yapay zekâ teknolojisinin uyumlu bir şekilde birleştirilmesini gerektirdiğinden, öğretmenlerin, yapay zekâ araçlarını ders tasarımına nasıl entegre edeceklerini bilmeleri ve çocukların gelişim düzeyine uygun teknolojileri seçip değerlendirebilmeleri eğitimin niteliği açısından önem taşımaktadır (Changmeng, 2024). Yapay zekâ uygulamaları içinde yaygın olarak kullanılan ve üretken yapay zekâ için tipik bir eğitsel araç olan ChatGPT, öğretmenlerin ve öğrencilerin yapay zekâ temelli öğretim ve öğrenimi anlama ve uygulama yeteneklerini geliştirmektedir. Aynı zamanda sanal bir koç görevi üstlenerek, erken çocukluk öğretmenlerinin öğretim uygulamalarını geliştirmelerine ve küçük çocukların öğrenme sonuçlarını iyileştirmelerine yardımcı olabilir. Bu kapsamda, öğretmene eleştirel düşünmeyi teşvik etmek için açık uçlu soru kullanımına dair bilgi sağlayabilir ve ilerleyen süreçte uygulayabileceği etkinlik önerileri sunabilmektedir (Su & Yang, 2023). Nan'a (2020) göre, öğretmenler, yapay zekâ temelli teknolojileri öğrenmeye önem verip bu teknolojileri doğru bir şekilde kavradıklarında, günlük uygulamalarında daha etkili kullanabilmekte ve bu sayede öğretimin kalitesi ve verimliliği artabilmektedir. Ancak, öğretmenlerin yapay zekâ konusundaki algısını değerlendiren çalışmalar, çoğunun yapay zekâ hakkında genel bir fikir sahibi olduğunu, ancak bu farkındalığın genellikle medyadan edinilen bilgilerle sınırlı kaldığını göstermektedir (Chounta 2022; Kölemen ve Yıldırım, 2025; Küçükkara vd, 2024; Lindner ve Romeike, 2019). Öğretmenler yapay zekâyı çoğunlukla makine öğrenmesi, dil işleme ve veri analizi gibi alanlarla ilişkilendirmektedir. Bu da yapay zekânın kapsamı ve temel prensipleri konusunda yeterli bilgiye sahip olmadıklarını göstermektedir. Bu çalışmalardan anlaşıldığı üzere Dünyada yaygınlaşmaya başlayan yapay zekâ uygulamalarının Türkiye'deki okul öncesi öğretmenler tarafından kullanımına yönelik araştırmalar sınırlıdır. Bu nedenle bu çalışmanın amacı, dünya genelinde kullanılan yapay zekâ uygulamaları hakkında okul öncesi öğretmenlerinin görüşlerini belirlemek ve bu uygulamaları kullanım amaçlarını araştırmaktır.

Yöntem

Araştırmanın Modeli

Araştırma nitel araştırma yaklaşımıyla yürütülmüş olup durum çalışması (case study) deseni kullanılmıştır. Desen olarak **t**anımlayıcı durum çalışması tercih edilmiştir. Durum çalışması deseni, belirli bir olgunun, kendi gerçek yaşam bağlamı içerisinde ayrıntılı bir biçimde incelenmesine olanak sağlar (Yin, 2018). Bu çalışmada da amaç, okul öncesi öğretmenlerinin, yapay zekâ uygulamalarını eğitimde kullanımına ilişkin görüşlerini mevcut durumlarıyla birlikte ayrıntılı bir şekilde betimlemektir.

Çalışma Grubu

Çalışma grubu, amaçlı örnekleme yönteminin kolay ulaşılabilir örnekleme alt türü ile belirlenmiştir. Bu doğrultuda çalışma, MEB'e bağlı resmi anasınıfı ve anaokullarında görev yapan, yaşları 25 ile 45 arasında değişen 3'ü erkek ve 20'si kadın olmak üzere toplam 23 okul öncesi öğretmeni ile yürütülmüştür.

Veri Toplama Araçları ve Verilerin Toplanması

Okul öncesi öğretmenleriyle, araştırmacılar tarafından hazırlanmış yarı yapılandırılmış görüşme formu aracılığıyla yüz yüze görüşmeler yapılmıştır. Form, uzman görüşü doğrultusunda hazırlanmıştır. Öğretmenlere, yapay zekâya ilişkin kullandıkları uygulamalar, kullanım amaçları ile avantaj ve sınırlılıklarını belirlemeye yönelik sorular yöneltilmiştir. Katılımcılardan görüşme öncesinde gönüllü onamları alınmış, kişisel bilgileri gizlilik ilkesi ile korunmuştur. Veri toplama süreci, veri doygunluğuna ulaşılana kadar devam edilmiş, öğretmenlerin benzer temaları tekrar etmeye başlaması üzerine görüşmeler sonlandırılmıştır.

Verilerin Analizi

Verilerin analizinde, betimsel ve içerik analizi kullanılmıştır. Verileri, öğretmen görüşlerinin tematik olarak sunulması için betimsel analizle; verilerde tekrar eden ve benzer olan kavramların kodlanarak temalar oluşturulması sürecinde ise içerik analiziyle incelenmiştir. Kodlama süreci iki araştırmacı tarafından ayrı ayrı yapılmış, elde edilen kodlar karşılaştırılarak görüş birliğine varılmıştır.

Geçerlik ve Güvenilirlik

Uzman görüşü ile veri toplama aracının kapsam geçerliği sağlanmıştır.

Bulgular

Bu bölümde, okul öncesi öğretmenlerinin yapay zekâ uygulamalarını eğitimde kullanımına ilişkin görüşlerini ortaya koymaya yönelik sorularla elde edilen verilerin analizine dayalı bulgulara yer verilmiştir.

Tablo 1. Okul Öncesi Öğretmenlerinin Yapay Zekâ 'ya Yönelik Genel Görüşleri

Tema	Örnek İfadeler	Frekans (f)
Hayatı kolaylaştırma/pratiklik	Ö12: "İşlerimi kolaylaştırır" Ö8:"Her bilgiyi kolayca aktaran"	10
İnsanı taklit etme	Ö18:"İnsan zekâsını taklit eden bilgisayar" Ö16:"Makinaların düşünebilmesi"	6
Teknik işlev	Ö1:"Bilgilerin kısa sürede bir havuzda toplanıp sunulması olayıdır" Ö22:"İnsanlar tarafından oluşturulan görsel oluşturup sorulara yanıt bulabilen bir yazılım"	4
Eleştirel yaklaşım	Ö4:"Kontrollü kullanılırsa hayatı kolaylaştırır, yoksa hayatı sıkıntıya sokabilir" Ö20:"Tembelliğe sevk ediş",	3
Hayal Gücünün Somutlaşması	Ö23:"Hayallerin gerçeğe dönüşmesi"	1

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 1'de öğretmenlerin yapay zekâyı nasıl tanımladıkları "Hayatı kolaylaştırma/pratiklik", "İnsanı taklit etme", "Eleştirel yaklaşım", "Teknik işlev", Hayal gücünün somutlaşması" şeklinde 5 farklı ana tema altında incelenmiştir. Yapay zekânın yaşamı kolaylaştırıcı etkisinin birçok öğretmen tarafından (f=10) vurgulandığı görülmektedir. Öğretmenlerin bir bölümü (f=6) yapay zekâyı insan zihni ya da zekâsıyla ilişkilendirerek bir bölümü ise (f=4) yapay zekâyı teknik ve işlevsel özellikleri üzerinden tanımlamıştır. Bazı öğretmenler ise (f=3) yapay zekânın olası olumsuz etkilerine dikkat çekmişler ve bazı risklerin olduğunu vurgulamışlardır. Bir öğretmen yapay zekâyı, "Hayallerin gerçeğe dönüşmesi" olarak tanımlayarak yapay zekanın soyut boyutuna dikkat çekmiştir. Bir öğretmen ise yapay zekâ hakkında bilgi sahibi olmadığını ve hiç kullanmadığını açıkça ifade etmiştir.

Tablo 2. Okul Öncesi Öğretmenlerinin Bildiği Yapay Zekâ Uygulamaları: Frekans Dağılımı

Yapay Zekâ Uygulaması	Frekans (f)
ChatGPT	16
Google Gemini	7
Apple Siri	5
Google Assistant	4
Microsoft Copilot	2
Deepseek	2

Capcut	1
Bilmeyenler	4

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 2'de öğretmenlerin hangi yapay zekâ uygulamalarını bildiklerine yönelik bulgular değerlendirildiğinde öğretmenlerin en sık belirttiği yapay zekâ aracı ChatGPT (f=16) olmuştur. Bunun dışında birkaç öğretmen Google Gemini, Deepseek, Apple Siri, Microsoft Copilot, Google Assistant gibi diğer uygulamalardan da söz etmiştir. Ancak bu uygulamalar daha az sayıda yanıt içinde yer almaktadır. Bu yanıtlara ek olarak 4 öğretmen ise hiçbir yapay zekâ uygulaması bilmediğini ifade etmiştir. Dünya'da okul öncesi eğitim alanında kullanılan yapay zekâ uygulamalarına somut örnek gösteren bir öğretmen olmamıştır.

Tablo 3. Okul Öncesi Öğretmenlerinin Etkinlik Planlayıp Uygulama Sürecinde Yapay Zekâ Kullanım Amaçları

Tema	**Örnek İfadeler**	**Frekans (f)**
Eğitimsel planlama ve içerik üretimi	Ö12:"Plan hazırlama, proje oluşturma" Ö20:"Etkinlik fikirleri"	7
Bilgiye erişim / araştırma	Ö22:"Merak ettiğim şeyleri araştırmak" Ö11:"Aramak istediğim şeyler olduğunda onlara ulaşmak"	6
Günlük yaşamda kolaylık	Ö21:"Yol tarifi, hatırlatıcı" Ö8:"Telefon kullanımını kolaylaştırma"	5
Görsel ve dijital içerik desteği	Ö16:"Animasyon hazırlamak" Ö7:"Görsel düzenleme"	2
Kullanmayanlar	Ö4:"Hiç kullanmadım" Ö13:"Daha önce kullanmadım"	9

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 3 incelendiğinde, okul öncesi öğretmenlerinin etkinlik planlayıp uygulama sürecinde yapay zekâyı farklı amaçlarla kullandıkları görülmektedir. En yüksek frekansa sahip grup, yapay zekâyı kullanmayanlar (f=9) olarak belirlenmiştir. Bu gruptaki öğretmenler, daha önce yapay zekâ kullanmadıklarını ifade etmiştir. Eğitimsel planlama ve içerik üretimi (f=7) teması kapsamında, öğretmenler yapay zekâyı plan hazırlama ve etkinlik fikirleri geliştirme amacıyla kullandıklarını belirtmiştir. Bilgiye erişim/araştırma teması (f=6), merak edilen konuların araştırılması şeklinde ifade edilmiştir. Günlük yaşamda kolaylık (f=5) teması altında ise yol tarifi alma, hatırlatıcı kullanma ve telefonla ilgili kolaylıklar örnek olarak verilmiştir. Görsel ve dijital içerik desteği (f=2) teması, animasyon hazırlama ve görsel düzenleme gibi amaçlarla ilişkilendirilmiştir.

Tablo 4. Okul Öncesi Öğretmenlerinin, Okul Öncesi Eğitimde Yapay Zekâ Kullanımına İlişkin Görüşlerine Ait Temalar ve Frekanslar.

Tema	**Örnek İfadeler**	**(f)**
İşlevsel Faydalar	Ö12:"Alışılmışın dışında etkinlikler yapmada faydalı olduğunu düşünüyorum. İşimi kolaylaştırıyor." Ö16:"Önemli günlere hazırladığım sanat etkinliklerinde faydasını oldukça görüyorum."	9
Koşullu Kabul / Bilinçli Kullanım Gerekliliği	Ö19:"Şu an için pek kullanmadım ama her şey gibi bilinçli kullanımda ekonomiklik, zaman vs. açısından faydalı olabilir." Ö6: "Sınıf ortamı müsaitse, öğretmenin bilgisi varsa ve ulaşılabilirliği kolaysa kullanılmasını faydalı buluyorum."	5
Olumsuz / Kararsız Yaklaşım	Ö3:"Çok gerekli olduğunu düşünmüyorum." Ö14:"Fikrim yok"	5
Potansiyel / Gelecek Vurgusu	Ö1:"Yaygınlaştırılıp sınıflara da entegre edilirse öğretmene ve çocuklara çok büyük katkısının olacağını düşünüyorum."	4
Öğrenciye Katkı	Ö21:"Görsel ve işitsel olarak çocukların ilgisini çekme başarısı göz önünde bulundurulduğunda kesinlikle faydalı olduğunu düşünüyorum." Ö11:"Çocuklara göre geliştirilen oyun arkadaşı niteliğindeki yapay zekâ uygulamalarıyla öğrenilenlerin sınıf içinde pekiştirmesine çok katkı sağlar."	3

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 4 incelendiğinde öğretmenlerin yapay zekânın okul öncesi eğitimde kullanımına ilişkin görüşleri arasında en yüksek frekansa (f=8) sahip olan "İşlevsel Faydalar" teması kapsamında öğretmenler, yapay zekânın özellikle etkinlik planlama, materyal hazırlama, bireysel çalışma ve özel gereksinimli çocuklarla yapılan çalışmalarda öğretmene büyük kolaylık sağladığını belirtmiş, zaman tasarrufu ve hızlı erişim gibi faydalı yönlerine de dikkat çekmişlerdir. Verdikleri cevaplarla "Koşullu Kabul / Bilinçli Kullanım Gerekliliği" temasına dahil olan öğretmenler (f=5), yapay zekânın eğitimde fayda sağlayabileceğini ancak bu faydanın bilinçli kullanımına dair temkinli bir yaklaşım sergilemişlerdir. "Olumsuz / Kararsız Yaklaşım" teması altında yer alan öğretmenler (f=5), yapay zekânın eğitim için çok gerekli olmadığını düşündüklerini ya da konu hakkında fikir sahibi olmadıklarını belirtmişlerdir. Öğretmenlerden bazıları (f=4) "Potansiyel / Gelecek Vurgusu" teması kapsamında belirttiği görüşler, yapay zekanın henüz yaygın olarak kullanılmadığını ancak ilerleyen süreçte öğretmenler tarafından daha etkin biçimde entegre edilmesi halinde eğitime önemli katkılar sunabileceğini vurgulamaktadır. "Öğrenciye Katkı" temasında (f=3), yapay zekânın öğrencilerin dikkatini çekme, görsel-işitsel öğrenmeyi destekleme ve etkinlik verimliliğini artırma yönü öne çıkmıştır. "Öğretmene Katkı" temasında (f=2), yapay zekâ öğretmenin iş yükünü azaltan ve süreci kolaylaştıran bir araç olarak tanımlanmıştır.

Tablo 5. Okul Öncesi Öğretmenlerinin Yapay Zekâ Uygulamalarını Okul Öncesi Eğitim Etkinliklerinde Kullanım Alanları

Tema	Örnek İfadeler	Frekans (f)
Bilişsel ve Akademik Etkinlikler	Ö6:"Fen ve doğa etkinlikleri" Ö4: "Analitik düşünme, kodlama"	14
Yaratıcılık ve Sanat Etkinlikleri	Ö12:"Drama, sanat, etkinlikleri" Ö7:"Eğlenceli, ilgi çekici etkinlik tasarımı"	7
Eğitsel İçerik Geliştirme ve Uyarlama	Ö10:"Sınıf düzeyine ve şartlarına uygun etkinlik planlarken" Ö8:"Akıllı tahtaya entegre içerikler"	5
Oyun Etkinlikleri	Ö9:"Oyun" Ö3:"Oyun planlama"	3
Gezi Planlamaları	Ö9:"Sistemli ve verimli gezi etkinlik planlaması"	1
Tüm Etkinliklerde Kullanım	Ö18:"Tüm etkinliklerde kullanılabilir." Ö20:"Her etkinlik ve uygulamada kullanılabilir."	3
Belirsiz / Olumsuz Görüşler	Ö13:"Kullanmıyorum" Ö14:"Bilmiyorum."	2

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 5'te yapay zekânın okul öncesi eğitim etkinliklerinde kullanım alanları incelendiğinde öğretmenlerin yapay zekânın okul öncesi eğitimde özellikle bilişsel ve akademik alanlarda daha fazla kullanılabileceğini düşündükleri görülmektedir (f = 14). Ayrıca, yapay zekânın oyun planlama, sınıf şartlarına uygun etkinlik geliştirme ve akıllı tahtaya entegre içerikler hazırlama gibi içerik üretim süreçlerinde katkı sağlayabileceği belirtilmiştir (f = 7). Drama, sanat ve müzik gibi yaratıcı alanlarda eğlenceli içerikler üretmede yapay zekânın kullanımı da dikkat çekmektedir. Bazı öğretmenler (f=3), yapay zekânın oyun temelli öğrenme süreçlerinde kullanılması gerektiğini belirtmiştir. Gezi Planlaması teması (f=1) en az dile getirilen tema olup yapay zekânın gezi etkinliklerinin daha sistemli ve etkili planlanmasında kullanılması önerilmiştir. Bazı öğretmenler (f=3) yapay zekânın tüm etkinliklerde genel olarak faydalı olabileceğini belirtmiştir. 2 öğretmen ise ya yapay zekâyı kullanmadığını ya da bu konuda bilgisi olmadığını ifade etmiştir.

Tablo 6. Okul Öncesi Öğretmenlerinin Yapay Zekânın Eğitimdeki Avantajlarına İlişkin Görüşleri

Tema	Örnek İfadeler	(f)
Zaman ve Kaynak Tasarrufu	Ö4:"Zamandan tasarruf" Ö23:"Kağıt israfı önlenebilir"	8
Bilgiye Kolay Erişim ve İş Yükünün Azalması	Ö1:"Birçok bilgiyi aynı anda farklı kaynaklardan ulaşabilme avantajları" Ö20:"İşleri daha hızlı ve pratikleştirir."	8
Etkinlik Çeşitliliği ve Görsel-İşitsel Destek	Ö7:"Çok faydalı, tekdüzelikten kurtarıyor." Ö8:"Renkli, sesli ve ilgi çekici içerikler sağlıyor."	5
Mesleki Gelişim	Ö21:"Öğretmen kendini geliştirebilir"	3

Öğrenmeyi Kolaylaştırma ve Seviyeye Uygunluk	Ö6:"Öğretmenin çocukların yaş düzeyine inmesini kolaylaştırabilir."	2
Olumlu Genel Görüşler	Ö15:"Kesinlikle öğretmene katkısı çok" Ö3:"Doğru şekilde kullanımında birçok fayda sağlayacağını düşünüyorum."	3
Belirsiz / Olumsuz Görüşler	Ö13:"Kullanmadığım için fikir sahibi değilim"	3

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 6 incelendiğinde, okul öncesi öğretmenlerinin yapay zekânın eğitimdeki avantajlarına ilişkin görüşleri kapsamında en çok vurgulanan temalar zaman ve kaynak tasarrufu (f = 8) ve bilgiye kolay erişim ile iş yükünün azalması (f = 8) olmuştur. Öğretmenler, özellikle planlama, içerik üretimi ve evrak işleri gibi görevlerde yapay zekâ kullanımının işlerini kolaylaştırdığını ve zaman kazandırdığını belirtmiştir. Bunu etkinlik çeşitliliği ve görsel-işitsel destek (f=5) teması takip etmekte olup, öğretmenler bu teknolojinin dersleri daha renkli, ilgi çekici ve etkileşimli hâle getirdiğini ifade etmiştir. Bazı öğretmenler, yapay zekânın öğrenmeyi kolaylaştırıp, öğretmenin çocukların yaş düzeyine uygun içerikler üretmesine yardımcı olduğunu (f = 2) belirtmişlerdir. Mesleki gelişim (f = 3) açısından da öğretmenlerin, yapay zekânın kendilerini geliştirmelerine olanak sağladığını düşündükleri görülmektedir. Bununla birlikte, 3 öğretmen olumlu genel görüşlerini bildirirken 3 öğretmen de kullanmadıklarını veya konu hakkında bilgi sahibi olmadıklarını ifade etmişlerdir.

Tablo 7. Okul Öncesi Öğretmenlerinin Yapay Zekânın Eğitimdeki Dezavantaj ve Sınırlılıklarına İlişkin Görüşleri

Tema	**Örnek İfadeler**	**(f)**
Psikososyal ve Duygusal Gelişime Etkisi	Ö3:"Hayal gücünü kısıtlayabilir." Ö2:"Ekran bağımlılığı ve kısıtlı düşünmeye yol açabilir."	6
Erişim ve Fırsat Eşitsizliği	Ö20:"Teknolojiye ulaşma ve fırsat eşitliği gibi konular sınırlılık içinde yer alabilir." Ö19:"Her yerde uygulanabilirliği açısından sınırlılıkları vardır."	6
Yaş ve İçerik Uygunluğu	Ö6:"Çocukların yaşına hitap etmeyebilir." Ö22:"Görsel oluştururken çocukların gerçeklik algısını ve kafasını karistirabilir."	5
Bilinçli Kullanım Gerekliliği	Ö21:"Yapay zekâ kullanımı ebeveyn kontrolünde olmalı." Ö19:"Bilinçli kullanım gerektirir ve her yerde uygulanabilirliği açısından sınırlılıkları vardır."	4
Çaba ve Motivasyonun Azalması	Ö1:"Bilgiye kolay erişildiğinden dolayı çaba ve gayret azalabilir." Ö2:"Öğretmeni tembelliğe yönlendirebilir."	2
Belirsiz / Olumsuz Görüşler	Ö13:"Fikir sahibi değilim." Ö17:"Bilemedim"	3

Not: Birden fazla katılımcı birden fazla temaya değindiği için frekans değeri toplam katılımcı sayısını aşmaktadır.

Tablo 7 incelendiğinde, okul öncesi öğretmenlerinin yapay zekânın eğitimdeki dezavantajlarına ilişkin çeşitli görüşleri arasında en yüksek frekansa sahip temalardan biri olan psikososyal ve duygusal gelişime etkisi (f=6) temasında çocukların sosyal etkileşim ihtiyacı, hayal gücünün sınırlanması, pasiflik, ekran bağımlılığı ve kısıtlı düşünme gibi ifadeler yer almaktadır. Aynı frekansa sahip (f=6) erişim ve fırsat eşitsizliği teması ise okullar arası donanım farkı, ailelerin bilgi yetersizliği, program azlığı ve yüksek maliyet unsuru ile ilişkilendirilmiştir. Yaş ve içerik uygunluğu teması (f=5) altında, yapay zekâ uygulamalarının yaş grubuna uygun olmaması ve görsel gerçeklik algısına etkisi dile getirilmiştir. Bilinçli kullanım gerekliliği (f=4) temasında, kullanımın ebeveyn denetiminde ve sınırlı olması gerektiği belirtilmiştir. Çaba ve motivasyonun azalması (f=2) teması kapsamında, bilgiye kolay erişimin gayret düzeyini düşürebileceği görüşü ifade edilmiştir. Son olarak, olumsuz veya belirsiz görüşler (f=3) temasında, bazı öğretmenlerin dezavantaj olmadığını düşündüğü veya konu hakkında fikrinin olmadığı görülmektedir.

Sonuç ve Öneriler

Bu çalışma, Türkiye'deki okul öncesi öğretmenlerinin yapay zekâ uygulamalarına ilişkin görüşlerini ve bu uygulamaları hangi amaçlarla kullandıklarını belirlemek amacıyla gerçekleştirilmiştir. Araştırma sonuçları, öğretmenlerin büyük çoğunluğunun yapay zekâyı yaşamı kolaylaştıran, bilgiye erişimi hızlandıran ve öğretim

süreçlerini destekleyen bir araç olarak tanımladığını ortaya koymuştur. Ancak katılımcılar arasında yapay zekâ kullanımına tamamen yabancı olan veya bilgi sahibi olmayan öğretmenlerin de bulunduğu görülmüştür. Öğretmenlerin en fazla bildiği yapay zekâ uygulamalarının ChatGPT, Google Gemini ve Siri olduğu belirlenmiştir. Dünya'da okul öncesi eğitim alanında kullanılan yapay zekâ uygulamalarına somut örnek verebilen herhangi bir öğretmen bulunmamıştır; bu durum, öğretmenlerin konuya ilişkin bilgi ve farkındalık düzeylerinin sınırlı olabileceğini göstermektedir. Öğretmenlerin yapay zekâ uygulamalarını kullanım amaçları arasında en sık belirtilenler eğitimsel planlama, içerik üretimi ve bilgiye erişim olurken, bazı öğretmenlerin günlük yaşamda kolaylık sağlama gibi bireysel amaçlarla da yapay zekâdan faydalandığı görülmüştür. Öğretmenlerin yapay zekaya yönelik algıları genel olarak işlevsel faydalar, koşullu kabul ve geleceğe yönelik beklentiler çerçevesinde şekillenmiştir. Ancak, teknolojinin bilinçsiz kullanımına dair endişeler ve fırsat eşitsizliği gibi dezavantajlara da dikkat çekilmiştir. Özellikle, bazı öğretmenler teknolojinin psikososyal gelişime olumsuz etkiler doğurabileceğini vurgulamıştır. Bu bulgu, Lindner ve Romeike (2019) çalışmasında da vurgulanan, öğretmenlerin yapay zekaya yönelik temkinli yaklaşımı ile örtüşmektedir. Etkinlik türleri açısından yapay zekânın en çok bilişsel ve akademik etkinliklerde kullanılabileceği belirtilmiştir. Bu sonuç, yapay zekânın okul öncesi dönemde özellikle analitik düşünme, fen, matematik ve okuma-yazma hazırlığı gibi alanlara entegre edilebileceğini göstermektedir. Benzer şekilde, yaratıcı etkinlikler, içerik geliştirme ve oyun planlaması gibi alanlarda da yapay zekanın destekleyici rol üstlenebileceği ifade edilmiştir. Avantajlar açısından öğretmenler en çok zaman tasarrufu, iş yükünün azalması, içerik çeşitliliği ve görsel-işitsel destek gibi unsurları öne çıkarmıştır. Bu, yapay zekanın öğretim süreçlerini kolaylaştırıcı rolünü pekiştirmektedir. Ancak, yaşa uygunluk sorunları, bilinçli kullanım gerekliliği ve fırsat eşitsizliği gibi sınırlayıcı unsurlar da dikkat çekmiştir. Bu çalışmada elde edilen bulgular, literatürde yer alan bazı çalışmalarda (Örneğin, Kölemen & Yıldırım, 2025; Chiu & Chai, 2020) vurgulandığı gibi, öğretmenlerin yapay zekâ içeriği, uygulamaları, okuryazarlığı ve pedagojisine ilişkin bilgi ve becerilerinin geliştirilmesinin önemli olduğuna dikkat çekmektedir. Bu doğrultuda, yapay zekâ teknolojilerinin okul öncesi eğitimde daha etkili ve bilinçli şekilde kullanılabilmesine yönelik aşağıdaki çeşitli öneriler geliştirilmiştir:

- Öğretmenlerin yapay zekâ araçlarını etkili kullanabilmeleri için hizmet içi eğitimler yaygınlaştırılabilir.
- MEB tarafından okul öncesi öğretmenlerine yönelik yapay zekâ destekli ders materyalleri ve etkinlik örnekleri içeren rehber kitapçıklar hazırlanabilir.
- Yapay zekâ uygulamalarının aktif kullanımı için donanım desteği (tablet, akıllı tahta, internet altyapısı vb.) sağlanabilir.

Bu çalışma, Türkiye'de okul öncesi öğretmenlerinin yapay zekâ uygulamaları hakkındaki görüşlerini ortaya koyması açısından literatüre önemli katkı sunmaktadır. Ancak literatürde, daha çok katılımcı sayısıyla ve nicel verilerle desteklenen daha geniş kapsamlı çalışmalara ihtiyaç duyulmaktadır.

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Mikroalg Tabanlı Biyoreaktör ve Dijital Gözlem Sistemi Geliştirilmesi: Sürdürülebilir Karbon Yönetimine Yönelik Bir Yaklaşım

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Özet

Küresel iklim değişikliği, doğal süreçlerin ötesinde insan faaliyetlerinin etkisiyle atmosferin bileşiminde meydana gelen değişikliklerle hız kazanmakta; bu durum çevresel, ekonomik ve toplumsal riskleri derinleştirmektedir. Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi (BMİDÇS), iklim değişikliğini "uzun dönemli doğal değişimlere ek olarak, insan etkisiyle atmosferin kompozisyonunda oluşan bozulmalar" olarak tanımlamaktadır. Bu bağlamda, küresel ısınmanın 1.5 °C ile sınırlandırılması amacı doğrultusunda 2050 yılına kadar "sıfır karbon" hedefine ulaşılması kritik öneme sahiptir. Karbon salımlarını azaltmaya yönelik yöntemlerden biri de mikroorganizmaların karbondioksit yakalama özelliğinden faydalanılmasıdır. Siyanobakteriler ve mikroalgler gibi bazı mikroorganizmaların karbondioksit yakalama ve oksijen üretme özelliklerinden faydalanılarak sera gazı emisyonunun azaltılmasına katkı sunabilecek sürdürülebilir teknolojilerin başında biyoreaktörler gelmektedir. Bu çalışmanın amacı mikroalg tabanlı biyoreaktör ve optimum şartların kontrol edilmesi için dijital gözlem sistemi geliştirilmesidir. Çalışmada, Spirulina platensis türü mikroalg kullanılarak, sera gazı emisyonlarının azaltılmasına katkı sunacak bir biyoreaktör sistemi geliştirilmiş ve bu sisteme entegre bir dijital gözlem mekanizması tasarlanmıştır. Geliştirilen sistemin temel amacı, mikroalglerin metabolik tepkilerini farklı çevresel parametreler altında eş zamanlı olarak gözlemleyerek optimum üretim koşullarını sağlamaktır. Sistem; CO_2, O_2, pH, toplam çözünmüş madde miktarı (TDS), bulanıklık ve sıcaklık gibi çoklu çevresel parametreleri aynı anda izleyebilmektedir. Bu sayede mikroalglerin çevresel değişkenlere karşı duyarlılığı anlık olarak değerlendirilmekte, biyokütle üretiminin verimliliği ve karbon sekestrasyon kapasitesi artırılabilmektedir. Deneysel çalışmalar sonucunda, Spirulina mikroalg türünün full-spectrum (tam spektrumlu) ışık koşulları altında oksijen üretiminde en yüksek performansı gösterdiği tespit edilmiştir. Ayrıca ortam CO_2 düzeyinin 7000–10000 ppm aralığına çıkarılmasıyla oksijen üretiminin %20.5'ten %22.1'e yükseldiği belirlenmiştir. Bu bulgular, mikroalglerin hem karbon emiliminde hem de oksijen üretiminde yüksek potansiyele sahip olduğunu ortaya koymaktadır. Sonuç olarak, bu çalışma ile mikroalg tabanlı biyoreaktörlerin dijital sistemlerle desteklenerek çevresel koşullara hızlı uyum sağlayabilen ve sürdürülebilir biyolojik üretimi mümkün kılan bir yapıya dönüştürülebileceği gösterilmiştir. Bu yaklaşım, iklim değişikliğiyle mücadelede çevresel teknolojilerin gelişimine katkı sunacak niteliktedir.

Anahtar Kelimeler: Dijital gözlem sistemi, mikroalg, biyoreaktör, karbon sekestrasyonu, iklim değişikliği.

Development of a Microalgae-Based Bioreactor and Digital Monitoring System: An Approach to Sustainable Carbon Management

Abstract

Global climate change is accelerating due to the effect of human activities beyond natural processes on the atmosphere's composition, thereby deepening environmental, economic, and social risks. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." In this context, achieving the "net-zero carbon" target by 2050 is critical for limiting global warming to 1.5^0C. One of the methods for reducing carbon emissions is utilizing the carbon dioxide capture capability of microorganisms. Bioreactors are at the forefront of sustainable technologies that can contribute to the reduction of greenhouse gas emissions by leveraging the CO_2 capture and oxygen production properties of certain microorganisms like cyanobacteria and microalgae.

The aim of this study is to develop a microalgae-based bioreactor and a digital monitoring system for controlling optimum conditions. In this research, a bioreactor system utilizing the *Spirulina platensis* microalgae species was developed to contribute to the reduction of greenhouse gas emissions, and an integrated digital monitoring mechanism was designed for this system. The primary goal of the developed system is to provide optimal production conditions by simultaneously observing the metabolic responses of microalgae under various environmental parameters. The system is capable of simultaneously monitoring multiple environmental parameters such as CO_2, O_2, pH, Total Dissolved Solids (TDS), turbidity, and temperature. This real-time assessment of microalgae's sensitivity to environmental variables allows for increased efficiency in biomass production and carbon sequestration capacity. Experimental results determined that the *Spirulina* microalgae species exhibited the highest performance in oxygen production under full-spectrum light conditions. Furthermore, it was found that increasing the ambient CO_2 level to the range of 7000-1000ppm elevated oxygen production from 20.5% to 22.1%. These findings demonstrate the high potential of microalgae for both carbon assimilation and oxygen generation. In conclusion, this study demonstrates that microalgae-based bioreactors, when supported by digital systems, can be transformed into structures capable of rapid adaptation to environmental conditions and enabling sustainable biological production. This approach is poised to contribute to the development of environmental technologies in the fight against climate change.

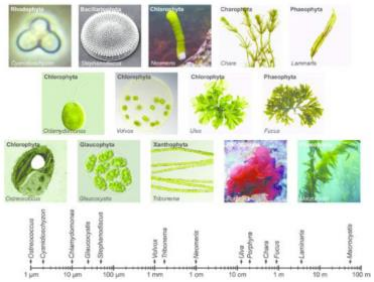
Keywords: Digital monitoring system, microalgae, bioreactor, carbon sequestration, climate change.

Giriş

İnsanlık; iklim değişikliği, kuraklık ve kıtlık gibi nedenlerden dolayı Dünya kaynaklarını etkin biçimde kullanamamaktadır. Atmosfere salınan zararlı gazlar oksijen seviyesinin düşmesine ve karbondioksit gazı oranının artmasına sebebiyet vermektedir. Bu durum canlı sağlığı üzerinde olumsuz etki oluşturup canlı yaşamını tehdit etmektedir.

İlk kez 1771 yılında Joseph Priestley, bitkiler tarafından dışarıya verilen oksijenin diğer canlılar tarafından karbondioksite dönüştürülen havayı dönüştürdüğü fikrini ortaya atmıştır. 1782 yılında ise Senebier, yeşil bitkilerin havaya O_2 vermesinin CO_2 almalarına ve bitkiler tarafından meydana getirilen O_2 miktarının tamamen ortamda var olan CO_2 miktarına bağlı olduğunu göstermiştir (OMÜ-Akademik Veri Yönetim Sistemi, 2019).

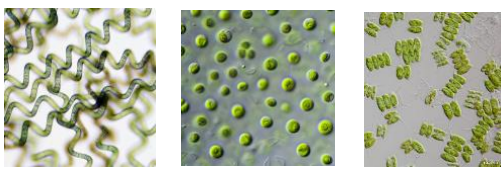
Yunanca fito (bitki), plankton (dolaşmak veya sürüklenmek) kelimelerinden oluşan fitoplankton, tuzlu ve tatlı su ortamlarında yaşayan mikroskobik organizmadır. Bu organizmaların bir kısmı bakteri, bir kısmı protist, ancak çoğu tek hücreli ökaryot canlılardan oluşur (Şekil 1). Bentik algler, sucul ekosistemlerde besin üretimi ve biyolojik çeşitlilik açısından kritik bir role sahiptir (Akköz, 2017).



Şekil 1: Alg türlerinin boyutları (Hallman, 2015).

Algler, endüstride geniş bir kullanım alanına sahiptir. Özellikle mikroalgler, biyoyakıt üretiminden gıda ve kimyasal üretime, gübre endüstrisinden su arıtımına kadar birçok alanda önemli bir kaynak potansiyeli olarak değerlendirilmektedir (Metin & Altınbaş, 2018). Bunun yanı sıra karbon emisyonlarını azaltmada önemli bir role sahiptirler.

Çalışmada; hızlı üremesi, çeşitli ortamlara uyum sağlaması ve yoğun çoğalma gösterebilmesinden dolayı spirulina, scenedemus ve chlorella olmak üzere 3 farklı alg türü incelenmiştir (Şekil 2).



Şekil 2: a) Spirulina, b) Chlorella, c) Scenedesmus

Chlorella vulgaris, ilk kez 1890 yılında Beijerinck tarafından Delft (Hollanda) Gölü'nden izole edilerek tanımlanmıştır. Hem tatlı hem de deniz suyunda bulunan bir tek hücreli yeşil mikroalg türüdür (Krienitz, Huss, & Bock, 2015).

Scenedesmus, biyoyakıt üretiminde yüksek lipid içeriği ve uygun yağ asidi profilleri nedeniyle dikkat çeken bir mikroalg türüdür (Singh, 2023; Kumar ve diğerleri, 2021).

Spirulina, uzun yıllardır çeşitli popülasyonlar tarafından besin kaynağı olarak kullanılan, mavi yeşil algler sınıfında yer alan bir siyanobakteridir. Yüksek besin değeri nedeniyle Dünya Sağlık Örgütü tarafından "en iyi sağlık ürünü," UNESCO tarafından ise "geleceğin en iyi besini" olarak tanımlanmıştır. Ayrıca Avrupa Uzay Ajansı (ESA) ve NASA tarafından uzun süreli uzay yolculuklarında yetiştirilebilecek başlıca besinlerden biri olarak değerlendirilmiştir (Nurko, Nakilcioğlu, & Ötleş, 2023).

Fosil yakıt kullanımına bağlı artan sorunlar, yenilenebilir biyoyakıtların çözüm olarak öne çıkmasına neden olmuştur. Yağ bitkileri ve atık yağlardan üretilen biyoyakıtlar mevcut talebi karşılamada yetersiz kalsa da mikroalgler daha umut verici bir hammadde seçeneği olarak değerlendirilmektedir (Chisti, 2007; Chisti, 2008). Mikroalglerin üretimi ve hasadındaki engellerin aşılması, atık su arıtımı ile biyoyakıt ve biyoürün üretiminde önemli katkılar sağlayabilir (Christenson & Sims, 2011). İncelenen çalışmalar, mikroalglerin gelecekte alternatif bir kaynak olarak daha fazla önem kazanacağını göstermektedir.

Mikroalg Yetiştirme Ortamları

Alg yetiştirmek için farklı yöntemler bulunmaktadır. Raceway (kanal) tipi havuz, tübüler fotobiyoreaktör, düz plaka fotobiyoreaktör, hava kaldırmalı fotobiyoreaktör gibi farklı tip üretim sistemleri mikroalg üretiminde kullanılmaktadır. Bu çalışmada biyoreaktör geliştirmek amaçlanmıştır. Geliştirilen biyoreaktör sıcaklık ve nem, ışık renkleri, pH, O_2, CO_2, pH, bulanıklık, azot parametrelerinde incelenmiştir. İncelenen parametreler doğrultusunda hava kaldırmalı fotobiyoreaktör uygun görülmüştür. O_2 üretimi verimliliğinin arttırılması için optimum üretim şartlarının sağlanması dikkate alınmıştır. Tablo 1'de mikroalglerin optimum üretim şartları verilmiştir.

Tablo 1: Mikroalglerin Üretim Şartları (Eliçin, 2017; Eliçin, Koç, Gezici, & Gürhan, 2013)

Parametreler	Sınır değerleri	Optimum şartlar
Sıcaklık	16-40	18-24
Tuzluluk	12-40	20-24
Işık Yoğunluğu	1000-10000	2500-5000
Işıklanma Süresi	-	16:8 minimum 24:0 Maksimum
pH	7-9	8,2-8,7

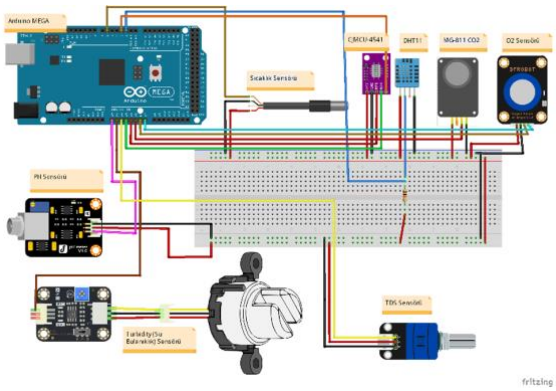
Bu çalışmada barındırdığı potansiyel faydalar nedeniyle algler hakkında daha fazla bilgi edinebilmek için bir gözlem ve deneysel amaçlı biyoreaktör sistemi geliştirilmiştir. Ayrıca biyoreaktörlerdeki CO_2, O_2, pH, suda çözünmüş O_2, TDS ve iletkenlik değerlerini düzenli ölçebilecek bir elektronik sistem geliştirilmiştir. Sistemde Spirulina, Chlorella ve Scenedesmus olmak üzere 3 farklı alg türünün verileri toplanarak analiz edilmiştir.

Yöntem

Test sistemin geliştirilmesinde (Hynes, 2011) tarafından geliştirilen "Mühendislik Tasarım Süreci" kullanılmıştır. Süreç; ihtiyacın belirlenmesi, ihtiyaçların araştırılması, olası çözümlerin tespit edilmesi, en uygun çözümün belirlenmesi, prototip tasarımı, çözümün test edilmesi ve değerlendirilmesi, çözümün paylaşılması, yeniden tasarım ve tasarımın sonlandırılması olmak üzere dokuz basamaktan oluşmaktadır. Süreç boyunca basamaklar arasında geçişler yapılabilmektedir. İhtiyaç halinde geriye dönülebilir bir yapıya sahip olması bu süreci esnek kılmaktadır. Bu esnek yapı sayesinde sistem sürekli olarak kendini yenilemektedir (Bozkurt- Altan, 2016).

Dijital Gözlem Sistemi

Test sisteminde ortam verilerinin analiz edilmesi için Arduino Mega 2560 kartı kullanılmıştır. Ortam sıcaklığını ölçmek için DHT11, sıvı sıcaklığını ölçmek için DS1820 sıcaklık sensörü kullanılmıştır. Biyoreaktördeki gaz çıkışını ölçümlemek için ise Karbondioksit (MG-811), Elektrokimyasal Oksijen sensörü ve CO, NO_2, C_2H_5OH, H_2, NH_3, CH_4 CJMCU-4541 gaz sensörleri tercih edilmiştir (Şekil 3).



Şekil 3: Devre tasarımı

Hazırlanan devrenin çalışması için gerekli kod Arduino IDE ile yazılmıştır. Sensörlerin bilgi sayfalarından elde edilen katsayı ve dönüştürme formülleri ile okunan değerler istenen birimlere çevrilmiştir. Arduino IDE ile gözlenen sistemin verilerini görselleştirmek ve daha hızlı yorumlayabilmek amacıyla Python programlama dili kullanılarak bir arayüz (user interface) geliştirilmiştir (Şekil 4). Arduino'nun seri portundan gelen sensör verileri tarih ve saat bilgileri ile bir tablo üzerinde gösterilmiştir. Tablodaki veriler daha çok veri bilimlerinde kullanılan Mathplotlib kütüphanesi ile grafiğe dönüştürülmüştür.

Şekil 4: Biyoreaktörler için geliştirilen test sistemi arayüzü

Aydınlatma

İncelenen kaynaklar (Eliçin, Koç, Gezici, & Gürhan, 2013) doğrultusunda dört farklı ışık kaynağının etkisinin araştırılmasına karar verilmiştir. Bitki büyütme ışığı (full spectrum), mavi, kırmızı ve gün ışığı ledler biyoreaktörlerin ortasında pleksi boruların içinde olacak şekilde yerleştirilmiştir (Şekil 5). Ledler 100 cm uzunlukta olup 23 watt enerji harcamaktadır. Ortalama 1000-1800 lümen parlaklık veren ledler 12V ile beslenmektedir.

Şekil 5: Full spectrum, mavi, kırmızı ve gün ışığı ledler

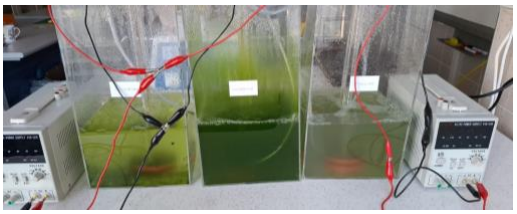
Havalandırma

Biyoreaktörlerin içerisinde alglerin ihtiyaç duyduğu havalandırmayı sağlamak amacıyla dakikada 1,75 litre verebilen RS082 hava motoru kullanılmıştır. Verilen havanın eşit dağılımı amacıyla 12,5cm çapa sahip silindir havalandırma taşlarından yararlanılmıştır.

Alg Türleri

Biyoreaktör için cam malzemeye göre daha avantajlı olan pleksi malzeme tercih edilmiştir. İncelenen üç alg türünden Chlorella sp., Scenedesmus_sp. Ondokuz Mayıs Üniversitesi Fen Fakültesi ve Spirulina Çukurova Üniversitesi Su Ürünleri Fakültesi'nden saf stok olarak temin edilmiştir. Algal kültürün gelişimi, test tüplerindeki kültürün kalitesinden doğrudan etkilenmektedir. Sağlıklı bir alg kültürü için saf stok ürün kullanılması önem

taşımaktadır. Nitelikli ve saf alg stok kültürü elde etmenin yolları ya izolasyon teknikleri kullanılması ya da laboratuvar ortamında üretilmiş orijinal stok kültür kullanılması çalışmanın niteliği açısından kritiktir. Bu sebeple üniversitelerde üretimi yapılan saf stok kültürlerin kullanılması uygun görülmüştür. Alg kültürü yetiştirmede iki aşamadan oluşan prosedür uygulanmaktadır. Birinci aşama kapalı ortamda küçük ölçeklerde tam kontrollü üretim, ikinci aşama büyük ölçekli üretim (Alpbaz, 2024). Çalışmada literatüre bağlı olarak öncelikle test tüpünde bir süre alg kültürlerinin gelişimi sağlanmış ardından 2 litre olan içerisinde çözeltiler bulunan şişelere alınmıştır (Şekil 6).



Şekil 6: Chlorella sp., Scenedesmus_sp. ve Spirulina kültürü için kurulan biyoreaktörler

Bulgular

Geliştirilen elektronik gözlem sistemi, mikroalglerin büyüme ve metabolik parametrelerinin gerçek zamanlı olarak izlenmesini sağlayarak, verilerin toplanmasını ve sistemin kontrolünü önemli ölçüde kolaylaştırmıştır. Sistem, O_2, CO_2, pH, TDS, bulanıklık gibi çevresel parametreleri hassas bir şekilde ölçerek, biyoreaktördeki alglerin çevresel koşullara verdikleri tepkileri sürekli olarak takip edebilmiştir. Ayrıca, sistemdeki sensörlerin doğruluğu ve hassasiyeti, verilerin güvenilirliğini artırmış ve alglerin büyüme dinamiklerinin doğru bir şekilde analiz edilmesini sağlamıştır.

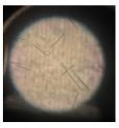
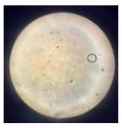
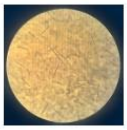
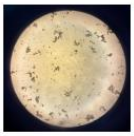
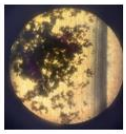
Veri toplama süreci, kullanıcı dostu bir arayüz üzerinden yapılabilmiş, böylece sistemin izlemesi ve yönetilmesi daha pratik hale gelmiştir. Mikroalglerin çevresel değişkenlere nasıl tepki verdiğini daha hızlı ve doğru bir şekilde gözlemlemeyi mümkün kılmıştır. Ayrıca, kullanıcıya sistemin parametrelerini anlık olarak değiştirme ve optimize etme imkânı sunmaktadır. Geliştirilen bu sistem, mikroalglerin biyoreaktörlerde daha verimli bir şekilde yetiştirilmesi ve sistem yönetiminin kolaylaştırılması açısından büyük bir potansiyel taşımaktadır.

CO_2 besleme koşulları altında yapılan gözlemler, biyoreaktördeki oksijen seviyelerinin CO_2 konsantrasyonu ile doğrudan ilişkilendirilebileceğini ortaya koymuştur. 7000-10000 ppm arasında CO_2 verildiğinde, biyoreaktördeki oksijen miktarının %20,5'ten %22,1'e kadar arttığı gözlemlenmiştir. Bu sonuç, CO_2'nin fotosentez hızını artırarak oksijen üretimini teşvik ettiğini ve alglerin verimli bir şekilde CO_2 tüketerek oksijen saldığını göstermektedir.

Farklı alg türleri arasında yapılan karşılaştırmalarda, Spirulina türü en hızlı ve olumlu tepki veren tür olarak belirlenmiştir. Bu tür, özellikle ışık ve CO_2 seviyelerinde yapılan değişikliklere hızlı bir şekilde uyum sağlamış ve yüksek verimlilikle oksijen üretimi gerçekleştirmiştir. Hücre sayımında da benzer şekilde, Spirulina türünün büyüme hızının yüksek olduğu ve sistemde gözlemlenen alg sayısının artışıyla bu gözlemlerin desteklendiği görülmüştür.

Verilen grafikte, CO_2 beslemesi sonrası gözlemlenen değerler, alglerin büyüme dinamiklerinin, çevresel faktörlere duyarlı olduğunu ve CO_2 ile besleme koşullarında oksijen üretiminde önemli bir artış sağladığını göstermektedir. Bu veriler, alglerin sürdürülebilir enerji üretimi ve atmosferik CO_2 dönüşümü gibi biyoteknolojik uygulamalar için potansiyelini ortaya koymaktadır.

Tablo 2: Mikroalglerin CO_2 uygulanmadan önceki ve sonraki mikroskop görüntüleri.

	Spirulina	Chorella	Shanedesmus
CO_2 öncesi			
CO_2 sonrası			

Sonuçlar

Elde edilen veriler, mikroalglerin farklı ışık ve CO_2 seviyelerine karşı duyarlı olduğunu ve bu koşulların biyoreaktörlerde alg üretimi üzerinde büyük etki sağladığını göstermektedir. Bu sonuçlar, mikroalglerin çevresel sürdürülebilirlik projelerinde, özellikle CO_2 emisyonlarının azaltılması ve oksijen üretimi gibi biyoteknolojik uygulamalarda potansiyelinin yüksek olduğunu ortaya koymuştur. Sonuç olarak, bu çalışma, mikroalglerin ekstrem çevre koşullarında biyokatalitik potansiyelinin değerlendirilmesinde önemli bir adım olmuştur ve geliştirilen sistemin biyoreaktör yönetimindeki katkıları, alglerin daha verimli bir şekilde yetiştirilmesi ve çevresel sürdürülebilirlik projelerinde kullanılmasını mümkün kılmaktadır. Gelecek çalışmalarda, daha geniş CO_2 aralıklarında ve farklı ışık koşullarında yapılacak deneylerle bu bulguların daha da derinleştirilmesi, alglerin potansiyelini en üst düzeye çıkaracak biyoteknolojik uygulamalara olanak sağlayacaktır.

Teşekkür

Ondokuz Mayıs Üniversitesi'nden Doç. Dr. Özgür Baytut'a ve Çukurova Üniversitesi'nden Prof.Dr. Oya Işık'a saf alg kültürlerinin sağlanmasındaki katkıları için teşekkür ederiz. Elektronik gözlem sisteminin geliştirilmesindeki katkılarından dolayı Ebabil Teknoloji Derneğine teşekkür ediyor ve onursal başkanı Ecem Sultan Çamlı'yı rahmetle anıyoruz.

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Öğretim Görevleri için ChatGPT'nin Kullanılabilirlik Değerlendirmesi: Tıklama Sayılarının Betimleyici Çözümlemesi

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Özet

Yapay zekâ teknolojilerinin eğitimle bütünleştirilmesinde beklentiler yeterince karşılanamamakta ve bazı güçlüklerle karşılaşılmaktadır. Söz konusu güçlüklerden birisi olarak, önceki araştırmalar, ChatGPT gibi üretken yapay zekâ teknolojilerinin kullanılabilirliğinin öğretmenler için yeterince yüksek olmadığını ortaya koyulmuştur. Diğer işlev ve kullanım amaçlarına ek olarak, ChatGPT, aynı zamanda bir çevrimiçi öğrenme ortamıdır. Çevrimiçi ortamların kullanılabilirliğini değerlendirmenin bir yolu da tıklama sayılarının incelenmesidir. Dolayısıyla bu araştırmada tıklama sayılarının betimleyici çözümlemesi yolu ile öğretim görevleri için ChatGPT'nin kullanılabilirliğinin değerlendirilmesi amaçlanmıştır. Millî Eğitim Bakanlığına bağlı okullarda görev yapmakta olup çalışmaya katılmaya gönüllü olan 12 öğretmen, araştırmanın örneklemini oluşturmuştur (N=12). Öğretmenlerden dokuz öğretimsel görevi yerine getirmesi istenmiş ve görevleri yerine getirmeleri sırasındaki toplam tıklama sayıları kaydedilmiştir. Ek olarak kişisel bilgi formu ile öğretmenlerin yaş, cinsiyet, öğretmenlik alanı ve hizmet yılı bilgileri edinilmiştir. Veriler betimleyici istatistiksel tekniklerle incelenmiştir. Yaşları 35 ve 56 arasında ($\bar{x}$=46,08), hizmet yılları 10 ve 32 arasında ($\bar{x}$=22,67) değişmekte olup 6 değişik alandan olan öğretmenler görevleri tamamlamıştır. Öğretmenler görevleri aritmetik ortalamalara göre 4,111 ile 9,667 arasındaki tıklama sayıları ile ($\bar{x}$=6,148); geometrik ortalamalara göre ise 2,786 ile 5,522 arasındaki tıklama sayıları ile ($\bar{x}$=4,041) bitirmiştir. Toplam tıklama sayılarına göre ise öğretmenler görevleri 37 ile 87 arasında tıklama ile bitirmiştir ($\bar{x}$=55,33). Ek olarak uygulanan çıkarsamalı istatistiksel çözümlemelerin sonuçları, tıklama sayılarının cinsiyete ve öğretmenlik alanına göre anlamlı bir değişiklik göstermediği gibi yaşla ya da hizmet süresiyle de ilişkili olmadığını göstermiştir. Bu bağlamda tıklama sayılarının yalnızca görevin kendisinden ve ChatGPT'nin tasarımından kaynaklandığını anlaşılmıştır. Bulgular tartışılmış ve önerilerde bulunulmuştur.

Anahtar Kelimeler: ChatGPT, çevrimiçi öğrenme ortamı, e-öğrenme, kullanılabilirlik, tıklama sayısı.

Giriş

İnsan beyninin işleyişini model alan yapay zekâ; akıllı telefon uygulamaları, otonom arabalar, akıllı ev ve ev aletleri gibi teknolojik ürünlerde yer alarak günlük yaşamın vazgeçilmez bileşenlerinden biri haline gelmiştir (İşler ve Kılıç, 2021; Stolpe ve Hallström, 2024). Üstelik üretkenliği artırmak, bilimsel araştırmaları hızlandırmak, sürdürülebilir çevre anlayışını yaygınlaştırmak, insan haklarını korumak, sağlık sistemlerinin iyileştirmek ve eğitimde etkili sonuçlara ulaşmak için yapay zekâ sistemlerini kullanma ve geliştirme zorunluluğu her geçen gün artmaktadır (OECD, 2024). Makine öğrenmesindeki gelişmelerden de yararlanmak için eğitimsel dijital içerik geliştirmede, üretken yapay zekâ gibi daha yenilikçi teknolojilere geçilmiştir (Hu, 2022). Üretken yapay zekanın, özellikle ChatGPT'nin hızlı yükselişi, yapay zekanın eğitime dahil edilmesi yönünde yapılan çalışmaları hızlandırmaktadır (Wang, 2023). Eğitim programlarında yapay zekâ teknolojisini ve uygulamalarını geliştirmeye çalışan ülkeler, çeşitli politikalar ve stratejiler üreten çalışmalara destek sağlamaktadırlar (Cheng ve Wang, 2023; Gürlek vd., 2023; Xia vd., 2022; Chiu, 2021; Office for Artificial Intelligence, 2021; National Science and Technology Council, 2019). Ancak araştırmalar yapay zekanın eğitim sistemleriyle bütünleştirilmesi ve kullanılmasında beklentilerin karşılanamadığını ve bazı güçlüklerle karşılaşıldığını ortaya çıkarmıştır (Atabek, 2019; Chiu vd., 2023; Wang ve Cheng, 2021). Bu güçlüklere örnek olarak; eğitim programlarının uyumsuzluğu, yapay zekâ kullanımıyla ilgili yönerge eksiklikleri, okul yöneticilerinin düşük farkındalığı, öğrenci ve öğretmenlerin yapay zekayla ilgili yeterlilik düzeyleri ve öğretmenlerin genel olarak eğitim teknolojisi alanındaki yetersizlikleri gösterilmektedir (UNESCO, 2019).

Bu güçlükler; eğitim sistemleri ile yapay zekanın bütünleştirilmesinin önündeki dış ve iç kaynaklı engeller olarak gruplandırılmaktadır (Wang ve Cheng, 2021). Eğitim programları ve okulun teknolojik yapısı gibi engeller, dış kaynaklı olup, program yenileme çalışmaları, eksik yönergelerin tamamlanması, okulun teknolojik alt yapısının hazırlanması ve okul donanımının iyileştirilmesi çalışmaları ile çözülebilmektedir. Ancak teknolojinin eğitimle bütünleştirilmesi yalnızca var olan bilgisayar sayılarını arttırmak ya da dersliklerdeki bilgisayarları güncellemek ile gerçekleştirilememektedir (Ertmer, 1999). Çünkü eğitim programlarının asıl uygulayıcısı olan öğretmenlerden kaynaklı içsel nedenlerin de öncelikle çözümlenmesi gerekmektedir (Atabek, 2020). Araştırmalar öğretmenlerin yapay zekâ teknolojilerinin hızlı gelişimine uyum sağlayamadıkları için yapay zekayı, öğretimde uygulama

konusunda isteksiz olduklarını göstermektedir (Cheng ve Wang, 2023). Özellikle teknolojiye yatkın olmayan öğretmenlerin öğretim uygulamalarında harcadıkları fazladan zaman ve enerji bu isteksizliğin nedenleri olarak gösterilmektedir (Wang, 2017; Neyland, 2011). Bazı öğretmenlerin, yapay zekâ teknolojilerinin nasıl çalıştığına dair bir anlayışa sahip olmadıkları rapor edilmiştir (Chiu vd., 2023; Wood vd., 2021; Haseski, 2019). Hatta bazı öğretmenlerin yeterince yapay zekâ eğitimi almadıkları sonucuna varılmıştır (Cheng ve Wang, 2023). Öğretim uygulamalarında yapay zekâ sistemlerini kullanan öğretmenler ise sistemlerin kötü performans göstermesinden, sağlanan içeriklerin tek bir biçimle sınırlı olmasından, çeşitli yaş gruplarına uygun olmamasından, görsel ilgi çekiciliğinin düşük olmasından, çeşitli öğretim yöntemlerinin kullanımına izin vermemesinden yakınmışlardır (Chiu vd., 2023; Kahn ve Winters, 2021; Nabiye vd., 2019; Holstein vd., 2019). Üstelik yapay zekâ sistemleri verilen görevlerin nedenlerini ve çalışma mekanizmalarını açıklayamamaktadır (Holstein vd., 2019). Bu bulgular; yapay zekâ ile tasarlanan uygulamaların, öğretmenler için kullanılabilirliği yüksek tasarımlar olmadığına bağlamaktadır (Chiu vd., 2023).

Yapay zekanın eğitimde kullanılabilirliği, öğretmenlerin ilk defa karşılaştıkları görevleri etkili, verimli ve memnuniyet duyguları ile yerine getirmesinin ölçüsüdür (International Organization for Standardization [ISO], 1998). Bu nedenle, kişiselleştirilmiş ve uyarlanabilir öğrenmeye olanak sağlayan yapay zekâ teknolojilerinin nasıl kullanılacağı ve nasıl daha iyi tasarlanabileceğine yönelik yapılacak, kullanılabilirlik araştırmalarına gereksinim duyulmaktadır (Long ve Magerko, 2020; Luckin ve Çukurova, 2019). Ancak yapay zekanın, eğitimde kullanılabilirliğini ölçmeye yönelik çalışmalar oldukça sınırlı kalmıştır (Chiu vd., 2023; Luckin ve Çukurova, 2019; Kayabaş, 2010). Bu bağlamda, eğitimde kullanılabilecek yapay zekâ uygulamalarının kullanılabilirliğinin incelenmesi; sistemlerin doğrulanmasını ya da zayıflıkların tanımlanmasını sağlayabilir. Kullanıcıların uygulamalar sırasında gerçekte zorluk yaşadığı yerler vurgulanırken, elde edilen sonuçlara göre yeniden geliştirilecek olan sistemlerin; öğrenme kolaylığı, kullanım kolaylığı, içerik kalitesi ve kapsamlılığının artması, teknolojinin eğitimle bütünleştirilmesi ile birlikte eğitim sistemlerinin kaliteli ve verimli olmasına katkıda bulunabilir (Granic, Glavinic ve Stankov, 2004; Shaikh vd., 2023). ChatGPT, yapay zekâ uygulamaları arasındaki en gelişmiş ve en yaygın olanıdır (Gill vd., 2024; Shaikh vd., 2023; Koçyiğit ve Darı, 2023; Zhai, 2022). Dolayısıyla bu araştırmada tıklama sayılarının betimleyici çözümlemesi yolu ile öğretim görevleri için ChatGPT'nin kullanılabilirliğinin değerlendirilmesi amaçlanmıştır.

Yöntem

Bu araştırmada nicel araştırma yöntemleri kullanılmıştır. Öğretmenlerin görevleri tamamlarken gerçekleştirdikleri tıklama sayıları betimsel olarak incelenmiş, daha sonra tıklama sayıları ile görev tamamlama süresi ve görev başarısı arasındaki ilişkiler değerlendirilmiştir. Betimsel araştırmalarda olaylar, olgular, nesneler, kurumlar ya da gruplar, olduğu şekliyle ortaya konulmakta, tanımlanmakta ve açıklanmaktadır (Karasar, 2021). İlişkisel araştırmalarda ise iki ya da daha çok değişken arasındaki ilişki düzeyini belirlemek ve bu değişkenler arasındaki ilişkileri ortaya koymak amaçlanmaktadır (Fraenkel vd., 2023).

Katılımcılar

Araştırmanın örneklemi, Isparta ilindeki Millî Eğitim Bakanlığına bağlı okullarda görev yapmakta olup çalışmaya katılmaya gönüllü olan daha önce hiç ChatGPT kullanmamış 6'sı kadın, 6'sı erkek olmak üzere toplam 12 öğretmenden oluşmaktadır. Örneklem seçiminde, ulaşılabilir olmaları nedeniyle amaçlı örnekleme yöntemlerinden elverişlilik örneklemesi yöntemi kullanılmıştır. Elverişlilik örneklemesi, araştırmacının kolayca ulaşabildiği ve araştırmaya katılmayı isteyen bireylerden oluşan örnekleme yöntemidir (Fraenkel vd., 2023).

Verilerin Toplaması

Araştırmada veriler, kişisel bilgi formu ve video kayıt yapılarak toplanmıştır. Verilerin kayıt altına alınabilmesi için tüm katılımcılardan izin alınmıştır. Katılımcıların gerçekleştirdiği öğretim görevlerini bilgisayara kurulmuş olan OBS Studio uygulaması (https://obsproject.com/) ile arka planda kaydedilmiştir. Bu uygulama, katılımcılar öğretim görevlerini gerçekleştirirken sayfadaki tüm hareketlerin (tıklama, sürükleme, yazma, seçme vb.) ve sesini bir kamera gibi kaydetmektedir. Katılımcıların; yaş, cinsiyet, öğretmenlik alanı, hizmet yılı bilgilerini edinmek üzere 4 sorudan oluşan kişisel bilgi formu, araştırmacı tarafından hazırlanmıştır.

İşlem

ChatGPT'nin kullanılabilirliğinin incelenebilmesi için belirlenen öğretmenler tarafından gerçekleştirmesi beklenen 9'ar görev belirlenmiştir. Görevler daha önce hiç ChatGPT kullanmamış öğretmenlerin yapay zekayı hem tanıması hem de eğitim için kullanması üzerine tasarlanmıştır. Ayrıca görevlerin tasarlanmasında,

ChatGPT'nin, öğretmenlerin anlatmakta, öğrencilerin ise anlamakta zorlandıkları derslerin konularına yönelik, öğretimi destekleyici yönünün kullanılabilirliği temel olarak alınmıştır. Katılımcılara her bir görevin tamamlanması için 5 dakikalık süre verilmiştir. Katılımcıların süre değişkeninden en az şekilde etkilenmesi için görevler arasında 2-3 dakikalık aralar verilmiştir. Belirlenen bir bilgisayarda sırayla katılımcılar tarafından gerçekleştirilen bu görev performansları, araştırmacı gözetiminde video kaydına almıştır. Aşağıda Tablo 1'de katılımcı olan öğretmenlerin gerçekleştirmesi beklenen görevler verilmiştir.

Tablo1. Öğretim görevleri.

Görev	Görevin İçeriği
1. Görev	ChatGPT web sitesine giriş yapınız.
2. Görev	ChatGPT'ye ücretsiz üye olunuz.
3. Görev	ChatGPT'nin arayüzündeki menülerde inceleyerek dolaşınız.
4. Görev	ChatGPT ile kısaca genel olarak sohbet ediniz (Birkaç tane soru sorabilirsiniz).
5. Görev	Alanınız ile ilgili öğrencilerin zorlandıkları bir konu ya da kazanımda yapay zekâ ile hazırlanmış etkileşimli bir öğretim materyallerini araştırmak için ChatBot ile bir sohbet başlatınız.
6. Görev	ChatGPT ile söz konusu materyalin etkililiğinin nasıl ölçüleceğini tartışınız.
7. Görev	ChatGPT'den, ilgili materyalin etkililiğini ölçmek için yapay zekâ kullanılarak hazırlanmış bir ölçme-değerlendirme aracı isteyiniz.
8. Görev	ChatGPT'ye, ilgili konu ya da kazanım için önerilen materyal ve ölçme araçlarından, seçtiklerinizin kullanılabildiği bir öğretim tasarımı (ders planı) yazdırınız.
9. Görev	Geliştirilen öğretim tasarımı ya da ders planını bilgisayarınıza indiriniz

Verilerin Çözümlenmesi

Toplanan veriler, SPSS programı kullanılarak çözümlenecektir (IBM SPSS Statistics Version 27). Verilerin çözümlenmesinde betimleyici istatistiksel teknikler kapsamında geometrik ortalama kullanılmıştır (Sauro & Lewis, 2010).

Bulgular

Araştırmada öğretmenlerin ChatGPT kullanımına yönelik gerçekleştirdikleri öğretim görevlerindeki tıklama sayıları incelenmiştir. Bulgular tıklama sayıları, demografik değişkenlerle ilişkiler ve görev bazlı ortalama tıklama sayıları olmak üzere üç bölümde değerlendirilmiştir. Öğretmenlerin toplam tıklama sayıları incelendiğinde en düşük tıklama sayısının 37 ile Bilişim Teknolojileri branşında, en yüksek tıklama sayısının ise 87 ile İlköğretim Matematik branşında görev yapan öğretmende olduğu görülmektedir (Tablo 1).

Tablo 1. Öğretmenlerin Branşlarına Göre Tıklama Sayıları

ID	C	Yas	Yıl	Brans	Toplam	TSG1	TSG2	TSG3	TSG4	TSG5	TSG6	TSG7	TSG8	TSG9	ArOr	SS	GeOrt	GeSS
K01	E	50	25	Matematik	42	3	6	2	5	2	3	1	1	19	4.667	5.635	3.014	7.624
K02	E	56	32	Türkçe	53	4	7	12	7	6	1	3	1	12	5.889	4.137	4.305	11.031
K05	E	44	20	Bilişim	37	5	9	9	5	1	1	1	1	5	4.111	3.333	2.786	7.563
K10	E	43	19	İlköğretim	87	4	10	17	30	13	2	1	1	9	9.667	9.487	5.522	19.204
K11	E	53	32	İlköğretim	50	7	8	3	12	2	2	2	1	13	5.556	4.613	3.902	9.830
K15	E	49	26	Beden	43	5	8	12	4	2	2	4	2	4	4.778	3.308	3.971	7.459
K04	K	35	12	Türkçe	58	4	5	22	5	2	3	2	2	13	6.444	6.766	4.452	10.443
K06	K	51	28	Teknoloji ve	59	5	7	16	7	2	2	2	1	17	6.556	6.064	4.328	11.764
K07	K	51	27	Teknoloji ve	44	3	6	3	7	5	1	1	2	16	4.889	4.676	3.399	8.487
K08	K	40	17	İngilizce	58	5	5	6	4	2	2	2	2	30	6.444	8.974	4.042	9.779

K12	K	46	24	İngilizce	69	4	8	3	4	4	7	2	2	35	7.667	10.452	4.857	11.717
K14	K	35	10	İlköğretim	64	2	11	25	6	6	1	1	1	11	7.111	7.833	3.918	13.319

Tıklama sayıları ile cinsiyet, öğretmenlik alanı, yaş ve hizmet süresi arasındaki ilişki incelenmiş, ancak anlamlı bir farklılık bulunmamıştır (Tablo 2).

Tablo 2. Öğretmenlerin Demografik Özelliklerine Göre Tıklama Sayıları İlişkisi

Değişken	Sonuç
Cinsiyet	$p > 0,05$
Öğretmenlik alanı	$p > 0,05$
Yaş	$p > 0,05$
Hizmet süresi	$p > 0,05$

Tablo 2'ye göre tüm değişkenler için anlamlılık düzeyi 0,05'in üzerindedir. Buna göre tıklama sayıları ile cinsiyet, öğretmenlik alanı, yaş ve hizmet süresi değişkenleri arasında anlamlı bir ilişki bulunmamaktadır. Bu bulguya göre öğretmenlerin tıklama sayılarının demografik özelliklerden bağımsız olduğu söylenebilir. Öğretim görevlerinin ortalama tıklama sayıları incelendiğinde ise en yüksek ortalamanın "Geliştirilen öğretim tasarımını ya da ders planını bilgisayarınıza indiriniz" (G9, $\bar{x} = 15.33$) görevindedir. Bunu sırasıyla "ChatGPT'nin arayüzündeki menülerde inceleyerek dolaşınız" (G3, $\bar{x} = 10.83$) ve "ChatGPT ile kısaca genel olarak sohbet ediniz" (G4, $\bar{x} = 8.00$) görevleri takip etmektedir. En düşük ortalama ise "ChatGPT'ye ders planı yazdırınız" (G8, $\bar{x} = 1.42$) görevinde gözlenmiştir (Tablo 3).

Tablo 3. Öğretmenlerin Öğretim Görevlerinin Ortalama Tıklama Sayıları

Görev Kodu	$\bar{x}$	Görev Açıklaması
G9	15.33	Geliştirilen öğretim tasarımını ya da ders planını bilgisayarınıza indiriniz.
G3	10.83	ChatGPT'nin arayüzündeki menülerde inceleyerek dolaşınız.
G4	8.00	ChatGPT ile kısaca genel olarak sohbet ediniz.
G2	7.50	ChatGPT'ye ücretsiz üye olunuz.
G1	4.25	ChatGPT web sitesine giriş yapınız.
G5	3.92	Alanınızla ilgili öğrencilerin zorlandıkları bir konu için ChatBot ile sohbet başlatınız.
G6	2.25	ChatGPT ile materyalin etkililiğinin nasıl ölçüleceğini tartışınız.
G7	1.83	ChatGPT'den ölçme-değerlendirme aracı isteyiniz.
G8	1.42	ChatGPT'ye ders planı yazdırınız.

Sonuç

Bu çalışmada öğretmenlerin ChatGPT kullanımına yönelik gerçekleştirdikleri öğretim görevlerinin tıklama sayıları incelenmiştir. Bulgulara göre tıklama sayıları cinsiyet, öğretmenlik alanı, yaş ya da hizmet süresiyle ilişkili değildir. Bu bağlamda tıklama sayılarının yalnızca görevin kendisinden ve ChatGPT'nin tasarımından kaynaklandığını anlaşılmıştır. Bu bulgular doğrultusunda ChatGPT'nin eğitimde kullanılabilirliğinin artırılması için tasarımı öğretim görevlerine uygun olmalıdır. Öğretim görevlerinin mevcut ChatGPT tasarımına uyarlanması her zaman beklenen yararı sağlamayabilir. Bunun yerine, ChatGPT'nin öğretim gereksinimlerine göre yeniden düzenlenmesi, öğretmenlerin bu teknolojiyi daha verimli kullanmalarına katkı sağlayacaktır. Sonuç olarak, her yaş ve branştan öğretmenin ChatGPT aracılığıyla öğretim görevlerini gerçekleştirebilmesi, yapay zekâ teknolojilerinin öğretimle bütünleştirilmesine olanak sunmaktadır.

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Yapay Zekânın Bireysel Karar Alma Süreçleri Üzerine Etkileri

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Özet

Yapay zekâ teknolojilerinin gelişimiyle birlikte, bireylerin karar alma süreçlerinde bu sistemlere başvurma eğilimi dikkat çekici biçimde artmıştır. Sadece teknik veya profesyonel alanlarla sınırlı kalmayan bu eğilim, bireylerin sosyal ilişkilerden psikolojik durum değerlendirmelerine, yaşam tarzı tercihlerinden kariyer planlamasına kadar uzanan geniş bir yelpazede yapay zekâ tabanlı araçlardan danışmanlık hizmeti almasına yol açmaktadır. Kullanıcılar, özel konuşmalarını, duygu durumlarını ya da sosyal etkileşimlerini yapay zekâ sistemlerine aktararak, bu sistemlerin sunduğu analiz ve öneriler doğrultusunda kararlarını şekillendirmektedir. Bireylerin gündelik yaşamda yapay zekâya danışma pratikleri ve bu pratiklerin karar alma mekanizmaları üzerindeki etkilerinin incelendiği bu çalışmada nitel içerik analizi gerçekleştirilmiştir. Sosyal medya içerikleri ve kullanıcı yorumları üzerinden yürütülen araştırmada, yapay zekânın gayri resmî bir danışman, rehber ya da psikolojik destek unsuru olarak kullanıldığı gözlemlenmiştir. Bireylerin yaşadıkları sosyal ve duygusal karmaşalarda, profesyonel yardım yerine yapay zekâ önerilerine yönelmeleri; güven, hız ve mahremiyet gibi etkenlerle ilişkilendirilmekte, fakat aynı zamanda bireysel özerklik, dijital bağımlılık ve etik sınırlar bağlamında yeni tartışma alanları da doğurmaktadır. Yapay zekâ tabanlı sistemlerin bireylerin içsel düşünme süreçlerinin dışsal bir uzantısına dönüşmesi, teknoloji-insan etkileşimini yeniden tanımlamakta ve çağdaş karar alma dinamiklerini köklü biçimde dönüştürmektedir. Bu dönüşüm, disiplinler arası yaklaşımlarla ele alınması gereken sosyoteknolojik bir olgu haline gelmiştir.

Anahtar Kelimeler: yapay zekâ, karar alma süreçleri, teknoloji.

Abstract

With the development of artificial intelligence technologies, individuals' tendency to refer to these systems in their decision-making processes has increased significantly. This trend, which is not limited to technical or professional fields, has led individuals to seek advisory services from artificial intelligence-based tools in a wide range of areas, from social relationships to psychological assessments, lifestyle choices, and career planning. Users share their private conversations, emotional states, or social interactions with AI systems and shape their decisions based on the analyses and recommendations provided by these systems. This study, which examines individuals' practices of consulting artificial intelligence in their daily lives and the effects of these practices on decision-making mechanisms, employs qualitative content analysis. The research, conducted through social media content and user comments, observed that artificial intelligence is used as an informal advisor, guide, or psychological support element. Individuals' tendency to turn to AI recommendations instead of professional help in their social and emotional turmoil is associated with factors such as trust, speed, and privacy, but it also raises new areas of debate in the context of individual autonomy, digital addiction, and ethical boundaries. The transformation of AI-based systems into an external extension of individuals' internal thought processes is redefining technology-human interaction and fundamentally transforming contemporary decision-making dynamics. This transformation has become a socio-technological phenomenon that requires an interdisciplinary approach.

Keywords: artificial intelligence, decision-making processes, technology.

Giriş

Yapay zekâ teknolojilerinin hızlı gelişimi, bireylerin gündelik yaşamlarında karar alma süreçlerini köklü biçimde dönüştürmektedir. Geleneksel olarak bilişsel, duygusal ve çevresel faktörlerin etkileşimiyle şekillenen karar alma süreci (Simon, 1997), günümüzde yapay zekâ tabanlı sistemlerin sunduğu öneri ve yönlendirmelerle desteklenmektedir. Bu sistemler, yalnızca bilgiye erişimi hızlandırmakla kalmamakta; aynı zamanda alternatif üretme, seçenekleri karşılaştırma ve risk analizi yapma gibi işlevlerle bireylerin karar öncesi bilişsel yükünü azaltmaktadır (Brynjolfsson and McAfee, 2017).

Bu dönüşümün önemi, yapay zekânın yalnızca teknik ya da profesyonel alanlarla sınırlı kalmayıp; sosyal ilişkiler, psikolojik danışma, sağlık yönetimi, finansal tercihler ve tüketici davranışları gibi geniş bir yelpazede bireylerin kararlarını etkilemesinden kaynaklanmaktadır (Rahwan et al., 2019). Özellikle hız, erişilebilirlik ve mahremiyet faktörleri, bireylerin profesyonel yardım yerine yapay zekâ önerilerine yönelmesini teşvik etmektedir. Bununla

birlikte, aşırı bağımlılık, özerklik kaybı ve etik sınırlar gibi konular, yapay zekâ destekli karar verme pratiklerinin tartışmalı yönleri olarak öne çıkmaktadır (Floridi and Cowls, 2019).

Mevcut literatürde yapay zekânın iş yaşamı, sağlık sektörü ya da büyük ölçekli organizasyonlarda karar alma süreçlerine entegrasyonu üzerine geniş bir araştırma ağı bulunmakla birlikte bireysel karar alma dinamiklerine ilişkin çalışmaların sınırlı olduğu görülmektedir (Makridakis, 2017; Davenport and Ronanki, 2018). Özellikle gündelik hayatta bireylerin kişisel ve sosyal kararlarını şekillendirmede yapay zekânın oynadığı rol, çoğunlukla psikolojik danışmanlık ya da tüketici davranışları bağlamında ele alınmış; fakat bu deneyimlerin bütüncül ve disiplinler arası bir çerçevede incelenmesine yeterince odaklanılmamıştır. Dolayısıyla, bireylerin yapay zekâ ile kurdukları etkileşimlerin karar verme süreçlerinde nasıl bir dönüşüm yarattığını anlamak hem teorik hem de pratik düzeyde kritik bir araştırma boşluğuna işaret etmektedir.

Bu bağlamda araştırmanın amacı bireylerin gündelik yaşamda yapay zekâya danışma pratikleri ve bu pratiklerin karar alma mekanizmaları üzerindeki etkilerinin incelemektir. Bu amaç doğrultusunda aşağıdaki sorulara yanıt aranmıştır:

1) Yapay zekâ gündelik yaşamda hangi amaçlarla kullanılmaktadır?
2) Bireysel karar alma süreçlerinde yapay zekânın etkileri nelerdir?

Yöntem

Bu çalışma, yapay zekânın bireysel karar alma süreçlerine etkisini inceleyen nitel bir çalışma olup fenomenoloji deseniyle yürütülmüştür. Youtube, Instagram ve X sosyal medya platformlarından amaçlı seçilen 27 paylaşım üzerinden içerik analizi yapılarak verilere erişilmiştir. Elde edilen veriler içerik analiziyle çözümlenmiş; kod, kategori ve temalar oluşturulmuş, bulgular yorumlanarak analiz tamamlanmıştır (Yıldırım & Şimşek, 2021).

Bulgular

Youtube, X ve Instagram sosyal medya platformlarından amaçlı olarak seçilen 27 paylaşım üzerinden elde edilen veriler içerik analiziyle analiz edilmiştir. Çeşitli alıntılarla desteklenen bulgular aşağıda belirtilmiştir.

Bilişsel Destek ve Yaratıcılık

Bilişsel destek ve yaratıcılık kategorisi için "Fikir üretimi ve yaratıcı yazma", "Alternatifleri listeleme", "Hızlı bilgi sentezi", "Öz-düşünmeyi tetikleyen sorular", "Kişisel ifade ve üretkenlik" temaları belirlenmiştir. Temalar üzerinden gerçekleştirilen analiz sonucu bireysel karar alma süreçlerinde yapay zekânın seçenek üretme ve kısa sürede içerik oluşturma işleviyle bireyin karar öncesi keşif uzayını genişlettiği gözlenmektedir. Bu durum, bilişsel yükü azaltırken, kullanıcıyı alternatifleri daha sistematik tartmaya teşvik eder.

> *"Slm. Kız çocuğumuz oldu önerebileceğin isimler neler?" [V3]*
>
> *"Her şeyi ama her şeyi önce ona sonra birbirimize soruyoruz." [V3]*
>
> *"I used ChatGPT to create a training plan to run a 250 mile race and I finished it, in 124 hours. (250 mil koşacağım bir yarış için bir antrenman planı oluşturmak üzere ChatGPT'yi kullandım ve 124 saat içinde bitirdim.)" [V2]*

Erişilebilirlik ve Engelleri Azaltma

Erişilebilirlik ve Engelleri Azaltma kategorisi için belirlenen "Görme/işitme engeline destek", "Basitleştirilmiş dil ve özetler", "Arayüz üzerinden yardım", "Gündelik görevlerde destek", "Dijital uçurumu azaltma" temaları incelendiğinde engelli bireylerin gündelik yaşamda yapay zekâ destekli betimlemelerden yararlandığı görülmekte, böylelikle bilgiye erişim boyutunda sağlanan eşitlik ile kararların dengelendiği gözlenmektedir.

> *"Eşeğim kaçtı nasıl tutabilirim?" [V4]*
>
> *"Kızım ChatGPT'yi kullanıyordu ben de ondan öğrendim." [V15]*
>
> *"Dolabımda olan malzemeleri ChatGPT'ye söylüyorum bana ne yemek yapacağımı söylüyor." [V15]*
>
> *"Teknoloji ilerledikçe biz engellilerin hayatı kolaylaşıyor." [V16]*

Sağlık ve Psikolojik Danışma

Sağlıkla ilgili durumlarda ve hatta psikolojik anlamda bireysel olarak karar alma süreçlerinde yapay zekâdan destek alındığı görülmüştür. "Duygusal destek ve anlık danışma", "Kaygı azaltma/duygu düzenleme",

"Psikoeğitim ve öz-bakım önerileri", "Terapötik müdahalelere tamamlayıcılık", "Sınırlar ve riskler" temaları üzerinden yapılan analizde kişisel sağlık sorunlarına uzman desteği almadan önce başvurulduğu ve yönlendirme talep edildiği gözlenmiştir.

> *"ChatGPT has actually been incredibly supportive and emotionally comforting to me (ChatGPT aslında bana inanılmaz destek oldu ve duygusal olarak rahatlattı." [V7]*
>
> *"Ben de şu an chatgpt ile kilo veriyorum 145'den 130'a düştüm cebimde sürekli bir diyetisyen taşıyorum." [V11]*
>
> *"Sağlık konusunda kesinlikle çok başarılı." [V11]*
>
> *"Çin'de yapılan bir çalışmada yapay zekânın kalp grafisini doktorlardan daha iyi okuyarak ölüm oranlarını %33 azalttığı görüldü." [V12]*

Finansal ve Tüketici Kararları

Farklı alanlarda yapay zekâya başvurulduğu ve karar alma süreçlerinde önceliklendiği görülmektedir. Bunlardan biri olan finansal durumlar ve tüketici kararlarıdır. "Bütçe/harcama önerileri", "Yatırım/finans bilgisi", "Ürün karşılaştırma ve yorum tarama", "Fiyat/performans analizleri", "Kişiselleştirilmiş satın alma rehberi" temalarına bakıldığında yatırım ve alışveriş kararlarında bilgi derleme ve karşılaştırma gücü öne çıkmaktadır. Ancak güvenilirlik, risk ve kaynak şeffaflığı kritik sınırlılıklar olarak öne çıkmaktadır.

> *"Heyecanla bu şirkete yatırım yapılıp yapılmayacağına vereceği kararı bekliyorum."* [V23]

Etik, Güven, Özerklik

"Şeffaflık ve kaynak belirtme", "Veri gizliliği ve mahremiyet", "Önyargı ve adil olma", "Aşırı bağımlılık ve karar sorumluluğu", "İnsan-denetimli kullanım ilkeleri" temaları ile incelenen etik, güven ve özerklik kategorisinde kullanıcıların aşırı bağımlılık riskinin mevcut olduğu gözlenmektedir. Karar sorumluluğunu kişilerin almaları ve son kararın verilmesinde sorumlu olduklarını bilmelerinin önemi ortaya çıkmaktadır. Bu durumda çıktıların gerekçelendirilmesi ve kişisel verilerin korunması, özerk kararın sürdürülmesi için temel koşullar olmalıdır.

> *"Artık saatlerce kod yazmıyorum. ChatGPT'ye promptu veriyorum. Kodu kendisi yazıyor. Ben sadece eksik varmı yok mu diye kontrol ediyorum. %90 doğru çıkıyor."* [V26]

Sonuç ve Öneriler

Bu çalışma nitel olarak fenomonoloji ile desenlenmiştir. Youtube, X, Instagram sosyal medya platformlarından amaçlı olarak seçilmiş 27 paylaşım üzerinden elde edilen veriler içerik analizi yapılarak yorumlanmıştır. Elde edilen bulgular bireysel karar verme süreçlerinde yapay zekânın rolünü anlamak açısından önemli göstergeler sunmaktadır. Yapay zekâ destekli öneri sistemlerinin bireylerin kararlarında bilişsel ve duygusal açıdan etkiler oluşturduğu görülmektedir. Bireysel karar alma süreçlerinde ilk başvuru alanı olarak görülen yapay zekâ dolaylı ya da doğrudan etkiler oluşturmaktadır. Kriz yönetiminde, sağlıkla ilgili yönlendirmelerde, finansal açıdan planlamalar yaparken öneri almak için ilk başvuru yapay zekâya yapılmaktadır. Öneriler doğrultusunda uzman görüşüne ihtiyaç duyulduğu belirlenmektedir. Bu bağlamda yapay zekâ, bireylerin alternatifleri karşılaştırma, risk analizi yapma ve en uygun seçeneği belirlemede güçlü bir araç haline gelmektedir. Bununla birlikte ilerleyen süreçte yapay zekânın karar alma süreçlerinde kişiselleştirilmiş ve öngörüye dayalı öneriler sunma kapasitesinin artması beklenmektedir.

Bulgular, yapay zekâ tabanlı sistemlerin bireylerin yalnızca gündelik ve pratik kararlarında değil, aynı zamanda özel yaşamlarına ilişkin duygusal ve sosyal süreçlerde de etkili biçimde başvurulan bir kaynak haline geldiğini göstermektedir. Özellikle ilişkilerde yaşanan belirsizlik, iletişim sorunları ya da duygusal kararsızlık anlarında, bazı katılımcıların yapay zekâdan aldıkları yorum ve önerileri dikkate alarak kendi yönelimlerini ve tutumlarını yeniden değerlendirdikleri görülmüştür. Bu durum, yapay zekânın yalnızca bilgi sağlayıcı ya da teknik bir destek aracı olmanın ötesine geçerek, bireylerin içsel düşünme süreçlerine dâhil olduğunu ve zaman zaman kişisel değerlendirmelerin yerine geçtiğini ortaya koymaktadır. Böylece bireyler, kendi duygusal deneyimlerini üçüncü bir gözden okumak ya da dışsal bir teyit almak amacıyla yapay zekâya yönelmekte; bu süreç ise kararların alınış biçiminde güven, hız ve mahremiyet gibi unsurların öne çıkmasına yol açmaktadır.

Bununla birlikte, bu eğilim bireysel özerklik, etik sorumluluk ve kişisel verilerin kullanımı bağlamında dikkatle tartışılması gereken yeni boyutlar açığa çıkarmaktadır. Bu bağlamda sürecin dikkatle yönetilmesi adına; karar öncesi birden fazla kaynaktan doğrulama yapılması, gizlilik ayarlarının önemsenmesi, paylaşılan bilgilere dikkat edilmesi, elde edilen önerilerin gerekçelerinin talep edilmesi yerinde olacaktır. Yapay zekânın bir uzmanın yerini alamayacağını sadece destekleyici bir unsur olduğunu göz önünde bulundurarak etkili kullanılması gerekmektedir.

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Eğitimde Yapay Zekânın Dönüştürücü Rolü: Teoriden Pratiğe

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Özet

Teknolojideki hızlı gelişmeler, eğitim alanını da derinden etkilemiş ve yapay zekâ teknolojileri eğitim sistemlerine entegre edilmeye başlanmıştır. Öğrenme süreçlerini kişiselleştirme, öğretim materyallerini çeşitlendirme, değerlendirme sistemlerini dönüştürme gibi çeşitli alanlarda sunduğu olanaklarla yapay zekâ, eğitimin niteliğini artırma potansiyeline sahiptir. Ancak bu teknolojilerin eğitim ortamlarında ne ölçüde ve nasıl kullanıldığı, özellikle öğretmenlerin bu sürece yaklaşımları, uygulamaları ve deneyimleri büyük önem taşımaktadır. Günümüzde öğretmenlerin sınıf içi uygulamalarda yapay zekâ teknolojilerini kullanma durumu, bu araçların etkili kullanımına yönelik bilgi düzeyleri ve teknolojilere bakış açıları, eğitim politikalarının yönünü belirlemede temel bir veri kaynağı niteliğindedir. Eğitimde yapay zekâ uygulamalarının başarılı bir şekilde entegre edilmesi için öğretmenlerin bu teknolojilere olan farkındalığı, hazır bulunuşluk düzeyleri ve destek ihtiyaçlarının anlaşılması gerekmektedir. Bu araştırmanın amacı, öğretmenlerin yapay zekâ teknolojilerine yönelik farkındalıklarını, kullanım durumlarını ve bu teknolojilerin eğitimdeki rolüne ilişkin görüşlerini ortaya koymaktır. Nitel araştırma desenlerinden fenomenoloji yöntemiyle yürütülen çalışmada, farklı branşlardan 12 öğretmenle yazılı görüşmeler gerçekleştirilmiştir. Veriler, yapılandırılmış görüşme formu aracılığıyla Google Form üzerinden toplanmış ve içerik analiziyle çözümlenmiştir. Elde edilen bulgulara göre öğretmenler yapay zekâyı yaratıcı, kolaylaştırıcı ve bilgiye hızlı erişim sağlayan bir araç olarak görmektedir. Bununla birlikte etik, güvenlik, mahremiyet gibi çeşitli risklere de dikkat çekilmektedir. Katılımcıların önemli bir kısmı yapay zekâ araçlarını öğretimde kullanmadıklarını ifade etmiş; kullanımın önündeki engeller arasında bilgi eksikliği, internet erişimi, güvenilirlik sorunları yer almıştır. Ayrıca öğretmenler, yapay zekâ teknolojilerini daha etkili kullanabilmek için özellikle eğitim ve teknolojik destek ihtiyaçlarını dile getirmiştir. Çalışma, öğretmenlerin genel olarak yapay zekânın eğitimdeki yerini kabul ettiklerini ancak bu entegrasyonun sağlıklı işlemesi için altyapı ve hizmet içi eğitime ihtiyaç olduğunu ortaya koymuştur.

Anahtar Kelimeler: yapay zekâ, eğitim, teknoloji

Abstract

Rapid advances in technology have profoundly impacted the field of education, and artificial intelligence technologies have begun to be integrated into education systems. With the opportunities it offers in various areas such as personalizing learning processes, diversifying teaching materials, and transforming assessment systems, artificial intelligence has the potential to improve the quality of education. However, the extent to which these technologies are used in educational environments, especially teachers' approaches, practices, and experiences in this process, are of great importance. Today, teachers' use of artificial intelligence technologies in classroom applications, their level of knowledge regarding the effective use of these tools, and their perspectives on these technologies constitute a fundamental source of data in determining the direction of education policies. In order to successfully integrate artificial intelligence applications in education, it is necessary to understand teachers' awareness of these technologies, their level of readiness, and their support needs. The purpose of this study is to reveal teachers' awareness of artificial intelligence technologies, their usage situations, and their views on the role of these technologies in education. Conducted using the phenomenology method, one of the qualitative research designs, the study involved written interviews with 12 teachers from different disciplines. Data were collected through a semi-structured interview form via Google Forms and analyzed using content analysis. According to the findings, teachers view artificial intelligence as a creative, facilitating tool that provides quick access to information. However, they also highlight various risks such as ethics, security, and privacy. A significant portion of the participants stated that they do not use artificial intelligence tools in teaching; among the obstacles to use are lack of knowledge, internet access, and reliability issues. Additionally, teachers expressed the need for educational and technological support to use artificial intelligence technologies more effectively. The study revealed that teachers generally accept the role of artificial intelligence in education, but that infrastructure and in-service training are needed for this integration to function effectively.

Keywords: artificial intelligence, education, technology

Giriş

21. yüzyıldaki dijital gelişmeler, eğitim sistemlerini derinden dönüştürmüş; bu dönüşümün en dikkat çekici boyutlarından biri yapay zekâ teknolojilerinin hızla eğitim ortamlarına entegre edilmesi olmuştur. Yapay zekâ; öğrenme analitiği, bireyselleştirilmiş öğretim ve otomatik değerlendirme gibi alanlarda yenilikçi çözümler sunarken (Luckin et al., 2016), öğretmenlerin bu teknolojilere yönelik bilgi, algı ve uygulamaları sürecin başarısında kritik rol oynamaktadır (Koehler & Mishra, 2009; Zawacki-Richter et al., 2019).

Eğitimde yapay zekâ bir yandan kişiselleştirilmiş öğrenme ve veri temelli öğretim gibi fırsatlar sunarken, diğer yandan etik, mahremiyet ve algoritmik önyargılar gibi riskler barındırmaktadır (Selwyn, 2019). Bu nedenle entegrasyonun pedagojik, teknik ve etik boyutlarıyla ele alınması gerekmektedir. Literatür, yapay zekânın öğrencilerin ihtiyaçlarına uygun içerikler sunarak başarıyı artırabileceğini ve öğretmenleri destekleyici bir araç olabileceğini vurgulamaktadır (Holmes et al., 2019; Luckin et al., 2016). Ancak öğretmenlerin farkındalıklarının sınırlı olması, teknik bilgi eksiklikleri ve altyapı sorunları uygulamayı güçleştirmektedir (Zawacki-Richter et al., 2019).

Türkiye'de yapılan araştırmalar, öğretmenlerin yapay zekâya ilgi duyduklarını fakat kullanım düzeylerinin düşük olduğunu göstermektedir. Bu durum, bilgi eksikliği ve güvenlik kaygılarıyla ilişkilidir. Ayrıca öğretmenler arasında yapay zekâya yönelik algılar farklılık göstermektedir; kimi öğretmenler bunu yenilikçi bir araç olarak görürken, kimileri tehdit unsuru olarak değerlendirmektedir (Selwyn, 2019).

Bu araştırma, öğretmenlerin yapay zekâya yönelik farkındalık, bilgi, kullanım durumları ve görüşlerini ortaya koymayı amaçlamakta; elde edilecek bulguların öğretmenlere yönelik destek mekanizmalarının geliştirilmesine ve eğitim politikalarının şekillendirilmesine katkı sağlaması hedeflenmektedir. Bu doğrultuda aşağıdaki sorulara yanıt aranmıştır:

1. Yapay zekâ öğretmenler tarafından kullanılıyor mu?
2. Öğretmenlerin bakış açısıyla yapay zekânın eğitimdeki rolü nedir?

Yöntem

Bu araştırma, eğitimde yapay zekâ kullanımını inceleyen nitel bir çalışma olup fenomenoloji deseniyle yürütülmüştür. Çalışma grubu, amaçlı örnekleme yöntemiyle seçilen farklı branşlardan 12 öğretmenden (8 kadın, 4 erkek) oluşmaktadır. Veriler, yapılandırılmış görüşme formu aracılığıyla Google Form üzerinden yazılı olarak toplanmıştır. Katılımcılar bilgilendirilmiş, gönüllülük ve gizlilik esas alınarak onamları alınmıştır. Elde edilen veriler içerik analiziyle çözümlenmiş; kod, kategori ve temalar oluşturularak alıntılarla desteklenmiştir (Yıldırım & Şimşek, 2021).

Bulgular ve Tartışma

Yapay Zekâ Kavramı

Katılımcıların yapay zekâ kavramına ilişkin algıları çeşitlilik göstermektedir. Bunlardan bazılarının yaratıcı düşünme, taklit, kolaylık, tehlike kavramları olduğu gözlenmektedir. Bazı öğretmenler yapay zekâyı yaratıcılık ile ilişkilendirerek bu teknolojilerin özgün içerikler oluşturabilme yetisine vurgu yapmıştır. Bazı katılımcılar ise yapay zekânın insan davranışlarını taklit etme özelliğine dikkat çekmiştir. Yapay zekânın bilgiye sınırsız erişim sunduğu görüşü öğretmenlerin bu teknolojileri sonsuz bilgi kaynağı olarak değerlendirdiklerini göstermektedir. Bazı öğretmenlere göre yapay zekâ kullanım pratikliği sağlarken diğerleri tarafından muhtemel olumsuz etkiler oluşturabileceği düşüncesi belirtilmiştir. Bu bulgular, öğretmenlerin yapay zekâya yönelik algılarında hem fırsat hem de risk odaklı bir çeşitliliğin olduğunu göstermektedir.

> *"Bana insanın özelliklerinin taklidi gibi geliyor." [Ö2]*
>
> *"Herhangi bir konu hakkında birisinin görüşünü almak gibi kolayca ekstra ikinci bir fikir sahibi olmayı çağrıştırıyor." [Ö6]*

Yapay zekâ kavramının öğretmenlerde oluşturduğu çağrışımlar çok yönlü ve duygusal çeşitlilik içermektedir. Bazı katılımcılar merak, hayranlık, heyecan, yeni bir başlangıç duygusunu ifade etmiştir. Akıllı, analiz yapabilen, mantıklı ve yardımcı gibi tanımlamalar yapay zekânın işlevselliğine ve rasyonel yönüne vurgu yapmaktadır. Bazı öğretmenler ise yapay zekâyı geleceğin teknolojisi olarak görmektedir. Ayrıca zaman kazandırma, güç, kazanç gibi tanımlamalar, yapay zekânın öğretmenlerin iş yükünü azaltma ve verimlilik sağlama potansiyelini yansıtmaktadır.

Tablo 1. "Öğretimde Kullanılan Yapay Zekâ Araçları" kategorisine ilişkin bulgular

Kodlar	Katılımcılar
ChatGPT	Ö1, Ö5
Copilot	Ö1
Deepseek	Ö1
Google Scholar	Ö1
Final IA	Ö7, Ö8
Kullanmadım	Ö2, Ö3, Ö4, Ö6, Ö9, Ö10, Ö11, Ö12

Yapay zekâ araçlarının öğretim süreçlerinde kullanımına yönelik bulgular, bu teknolojilerin öğretmenler tarafından sınırlı düzeyde kullanıldığını göstermektedir. Yalnızca birkaç öğretmen ChatGPT'yi aktif olarak kullanmakta; bir katılımcı ayrıca Copilot, Deepseek ve Google Scholar gibi farklı yapay zekâ araçlarını da öğretim süreçlerinde değerlendirmektedir. Ancak, büyük bir çoğunluk herhangi bir yapay zekâ aracı kullanmadığını ifade etmiştir. Bu durum, yapay zekâ araçlarının potansiyeline rağmen öğretmenler arasında kullanımının henüz yaygınlaşmadığını ve bu araçlara erişim, bilgi düzeyi ya da motivasyon gibi etkenlerin kullanım davranışlarını sınırladığını göstermektedir (Tablo 1).

"Chatgbt, zaman zaman okul işlerinde rapor vs. düzenlerken kullanıyorum." [Ö5]

Katılımcıların ifadelerine göre, yapay zekâ araçlarının kullanımında çeşitli engeller bulunmaktadır. Katılımcılar yapay zekâ araçların kullanımında uyum sorunları yaşadıklarını belirtirken, yanıltıcı bilgi üretimi konusu da öğretmenler açısından ciddi bir risk olarak değerlendirilmiştir. İnternet erişimi eksikliği yapay zekâ kullanımının teknik altyapıya bağımlı olduğunu göstermektedir. Bazı öğretmenler araçlara ilişkin bilgi eksikliği nedeniyle bu teknolojilerden yeterince yararlanamadıklarını ifade etmiştir. Bu faktörler, yapay zekâ teknolojilerinin eğitime entegrasyonunda yalnızca teknolojik erişimin değil, aynı zamanda kullanıcıya uygun tasarım, doğruluk ve güvenilirlik gibi unsurların da belirleyici rol oynadığını göstermektedir (Tablo 4).

"Benim için yeni bir platform olduğu için açıkçası hangi alanlarda etkili kullanabilmem gerektiği konusunda kendimi yetersiz hissediyorum. Belki de bizler için de tanıtıcı bir eğitim verildiği taktirde hayatımızda ve mesleğimizde yapay zekayı daha etkin ve verimli bir şekilde kullanabiliriz." [Ö5]

Eğitim ve Yapay Zekâ

Katılımcı öğretmenlerin yapay zekâ uygulamaları konusundaki bilgi düzeyleri incelendiğinde, çoğunluğun bu alanda yeterli bilgiye sahip olmadığı görülmektedir. Bu durum, öğretmenlerin yapay zekâ teknolojilerini etkili bir biçimde kullanabilmeleri için bilgi düzeylerinin artırılmasına yönelik eğitim ve destek programlarına ihtiyaç duyulduğunu ortaya koymaktadır.

"Kurumsal işlerimizi kolaylaştırma açısından profesyonel olmamakla birlikte zaman zaman kullandığımız çeşitli platformlar var. Temel düzeyde bilgi sahibiyim diyebilirim." [Ö5]

Birkaç uygulama dışında eğitimde yapay zekâ kullanımım sınırlı." [Ö12]

Tablo 2. "Öğretmenlerin İhtiyaç Duydukları Destekler" kategorisine ilişkin bulgular

Kodlar	Katılımcılar
Eğitim	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö9, Ö10, Ö11
Teknoloji Desteği	Ö6, Ö7, Ö8

Öğretmenlerin yapay zekâ temelli uygulamaları kullanabilmeleri için en çok ihtiyaç duydukları destek türleri incelendiğinde, öncelikli olarak eğitim desteği öne çıkmaktadır. Bununla birlikte teknolojik altyapı ve donanım desteğine duyulan gereksinim de belirtilmiştir. Bu bulgu, öğretmenlerin hem bireysel gelişimlerine yönelik hem de kurumsal anlamda desteklenmeleri gerektiğini göstermektedir (Tablo 2).

"Öğretmenlerin bu konuda eğitim almaları gerekir." [Ö2]

"Seminerler yapışmalı bu konuda okulda teknolojik aletler artmalı." [Ö6]

Katılımcılar, yapay zekâ teknolojilerinin eğitimde kullanımına yönelik çeşitli risk alanlarına dikkat çekmiştir. Etik, mahremiyet, güvenlik endişeleri, algoritma karmaşıklığı, düzey uygunluğu ve gizlilik ihlalleri vurgulanmıştır. Bu durum, yapay zekâ uygulamalarının öğrenci verilerini işlerken şeffaflık, güvenilirlik ve sorumluluk ilkeleri çerçevesinde ele alınması gerektiğini göstermektedir. Bu durum, yapay zekânın eğitim sistemine entegre edilmesi sürecinde etik, hukuki ve pedagojik çerçevelerin netleştirilmesi gerektiğini ortaya koymaktadır.

"Yanlış programlandığında toplum düzenine zarar verebilir" [Ö2]

"Tüm kişisel bilgilere erişim sağlanması durumunda riskli olabilir." [Ö4]

"Öğrencilerin yaş düzeyine uygun cevapları verecek, müstehcen, siyasi ve politik, dini vs. Hassas konularda onları yönlendirmekten ziyade anlayacakları bir dilde bilgilendirici gerektiğinde cevaptan kaçınıcı bir yapay zekâ ile öğrencilerin tanışması gerektiği kanaatindeyim. Diğer türlü konu başlıklarına göre birden çok riskle karşı karşıya kalabilir öğrencilerimiz." [Ö5]

"Sırların açığa çıkması öğrenciyi olumsuz etkiler özgüvenli şekilde paylaşım yapılamaz." [Ö8]

Tablo 3. "Yapay Zekâ Araçlarının Öğretime Katkısı" kategorisine ilişkin bulgular

Kodlar	**Katılımcılar**
Verimlilik	Ö1, Ö7, Ö10, Ö11
Etkileşim	Ö1
Kişiselleştirme	Ö1
Etkili ders planı	Ö1, Ö2
Materyal Geliştirme	Ö3, Ö4, Ö12
Asistan	Ö5, Ö6, Ö8, Ö9

Katılımcılar, yapay zekâ araçlarının öğretim sürecine verimlilik, etkileşim, kişiselleştirilmiş öğrenme imkânları gibi çeşitli yönlerden katkı sunduğunu belirtmiştir. Ayrıca, ders planlamasında etkinlik sağladığı ve materyal geliştirme süreçlerini desteklediği belirtilmiştir. Bu bulgular, öğretmenlerin yapay zekâ araçlarını pedagojik açıdan faydalı ve öğretim süreçlerini destekleyici olarak değerlendirdiklerini göstermektedir (Tablo 3).

"Yapay zekâ araçları, öğretim sürecine verimlilik ve etkileşim açısından büyük katkılar sağlayabilir. Öğrencilerin bireysel öğrenme hızlarına ve ihtiyaçlarına göre içerik sunarak, öğretmenlerin daha etkili ders planlamasına yardımcı olabilir." [Ö1]

"Materyal ve görsel sunumlar için kullanılabilir." [Ö3]

"Görselleştirme açısından katkısı olabilir. Somutlaştırılması zor konularda kolaylık sağlar özellikle ilkokul ortaokul seviyesinde." [Ö4]

"Soru çözümlerinde öğrencilere yetişemediğimiz zaman güzel katkı sağlıyor." [Ö8]

Tablo 4. "Yapay Zekânın Eğitimdeki Yeri" kategorisine ilişkin bulgular

Kodlar	**Katılımcılar**
Evet Olmalı	Ö1, Ö2, Ö5, Ö8, Ö10, Ö11
Kısmen	Ö3, Ö4, Ö7, Ö9
Hayır	Ö6

Katılımcıların büyük bir kısmı yapay zekânın eğitimde önemli bir yere sahip olduğunu ifade etmiştir. Bununla birlikte bazı öğretmenler bu durumu "kısmen" olarak ifade ederken, sadece bir katılımcı yapay zekânın eğitimde yerinin olmadığını belirtmiştir. Bu durum, öğretmenler arasında yapay zekânın eğitim sistemindeki yeri ve işlevine ilişkin algı farklılıklarının bulunduğunu göstermektedir. Bu farklılıkların öğretmenlerin bilgi düzeyleri, deneyimleri ve teknolojik yeterlilikleri ile ilişkilendirilebileceği düşünülmektedir (Tablo 4).

"Destekliyorum. Çünkü bu teknoloji, öğretmenlere destek olabilecek ve öğrencilerin öğrenme deneyimini daha etkili hale getirebilecek güçlü bir araç. Ancak, yapay zekanın eğitimin temel insani yönlerini koruyarak kullanılması gerektiğine inanıyorum." [Ö1]

"Destekliyorum. Çünkü eğitim sistemine katkısının olacağına inanıyorum." [Ö2]

"Evet bazı yerlerde destekliyorum ama yine öğretmen ve öğrenci arasındaki ilişki devam etmeli." [Ö4]

"Evet destekliyorum. Çağa ayak uyduramayan toplumlar yok olmaya mahkumdur. Geleceğimizin teminatı çocuklarımızın çağın getirilerine göre hareket etmeleri ve yeniliklere entegre olmaları ülkemiz için önem arz ettiği düşüncesindeyim." [Ö5]

"Hayır. Faydalı olduğu kadar zararları da çok." [Ö6]

Sonuç

Bu araştırma, öğretmenlerin yapay zekâ teknolojilerine ilişkin farkındalık, kullanım ve görüşlerini incelemiştir. Nitel desenle yürütülen çalışmada öğretmenlerin yapay zekâya yönelik algılarının çoğunlukla olumlu olduğu, ancak kullanım düzeylerinin düşük kaldığı görülmüştür. Katılımcılar, yapay zekâyı bilgiye erişim, verimlilik ve kişiselleştirme açısından faydalı bulurken; etik, güvenlik ve algoritmik önyargılar konusunda temkinli davranmışlardır.

Öğretmenlerin önemli bir kısmı, yapay zekâ araçlarını aktif kullanmadıklarını; bunun başlıca nedenlerinin bilgi eksikliği, rehberlik yetersizliği, altyapı sorunları ve güvenilirlik kaygıları olduğunu belirtmişlerdir. Bulgular, entegrasyonun yalnızca teknik değil, pedagojik bir dönüşüm gerektirdiğini göstermektedir. Ayrıca öğretmenler, yapay zekâyı öğretmeni destekleyici bir araç olarak değerlendirmişlerdir.

Sonuç olarak, yapay zekânın eğitimde etkili biçimde kullanılabilmesi için öğretmenlere yönelik hizmet içi eğitimlerin güçlendirilmesi, teknolojik altyapının iyileştirilmesi ve uygulamalı rehberlik mekanizmalarının geliştirilmesi gerekmektedir.

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Fostering Learner Autonomy through AI-Assisted Reflection in a B1-Level English Club at a University English Preparatory Program

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Abstract

This study investigates how AI tools and structured reflection can foster learner autonomy in B1-level university preparatory students. Over a ten-week English with AI club cycle (24 participants), learners engaged in weekly AI-supported tasks combined with guided self-reflection. Tools such as ChatGPT, Grammarly, Quillbot, and MagicSchool provided feedback and tracked prompt-writing quality, while teacher mediation scaffolded interpretation. Weekly surveys and final projects were analyzed through a mixed-methods design. Results indicated increased motivation, confidence, and ownership of learning, though students continued to value teacher guidance. The findings highlight an "autonomy paradox": AI promotes independence yet simultaneously reinforces the need for human mediation. This paper proposes a transferable framework for integrating AI-assisted reflection into preparatory-level English programs.

Keywords: learner autonomy; artificial intelligence; reflection; English preparatory program; B1 learners

Introduction

Artificial intelligence (AI) has moved from experimental applications to mainstream classroom practice, particularly in language education. Beyond correcting discrete errors, AI now provides interactive environments that support multiple skills simultaneously. This shift raises important questions about how AI can contribute to learner autonomy, a long-standing goal in second language acquisition (Little, 1991).

In preparatory English programs, autonomy is critical for long-term success, yet fostering it among B1-level learners remains challenging. Students at this level often rely heavily on teacher guidance and lack confidence in independent decision-making. Reflection has been shown to strengthen autonomy by encouraging learners to evaluate their strategies and progress (Farrell, 2015; Yang, 2010). When combined with AI, reflection gains new affordances: learners receive immediate feedback, critically evaluate it, and decide how to act.

This study explores how AI-assisted reflection was implemented in a B1-level English club at a Turkish university preparatory program. Over ten weeks, students engaged in structured AI-supported activities and reflective practices. The study demonstrates both the benefits and limitations of AI in supporting autonomy, offering an innovative and transferable framework.

Methodology

Context and Participants

The study received approval from the university's ethics committee. Participants were 24 B1-level students who had completed at least one semester in the preparatory program. While some had progressed from A2 to B1 in the fall semester and others were repeating the B1 level, these distinctions were not central to the study. The English with AI Club comprised ten weekly sessions, each lasting 50 minutes and held at the same day and time each week. All instructional content was designed by the researcher, drawing on a pilot version of the club implemented in the previous semester. Informed by student feedback, personal reflections, and recent developments in the field, the materials and activities were revised to better address learners' needs. From the second week onward, students received targeted input and engaged in hands-on practice with AI tools under the researcher's guidance, with particular emphasis on effective and ethical use. The tenth week was dedicated to a showcase activity.

Participation in the clubs was voluntary; however, in line with the School of Languages' policy, students who attended at least seven of the ten weekly sessions and the final showcase week received one additional point toward their overall preparatory program grade. This incentive applied to all clubs equally and was not specific to the English with AI Club. Although participants came from different academic departments, at the time of the study they were all enrolled in the English preparatory program.

Research Design

A mixed-methods design was adopted, combining quantitative and qualitative approaches. Quantitative data were collected through weekly Likert-scale surveys measuring clarity, helpfulness, engagement, and perceived learning gains. Qualitative data consisted of open-ended survey responses and final project outcomes. Integrating these sources enabled the identification of statistical trends alongside in-depth learner perceptions, allowing for triangulation and strengthening the validity of the findings.

Procedure

The English with AI Club followed a ten-week cycle. Each session combined explicit instruction on prompt-writing strategies with hands-on practice using AI tools for a targeted language skill. Students first learned how to formulate effective prompts for the week's focus area, then applied these prompts with free versions of AI tools under the researcher's guidance. Teacher mediation ensured both effective and ethical use of AI tools.

Week 1: Club introduction, orientation, discussion of ethical AI use, and overview of available tools

Week 2: Introduction to prompt-writing strategies and guided practice in creating effective prompts

Week 3: Vocabulary development — designing prompts for vocabulary expansion, followed by practice with AI-supported vocabulary tools

Week 4: Writing development — prompt design for drafting and revising texts, followed by AI-assisted feedback and revision

Week 5: Speaking practice — prompts for role-play and pronunciation tasks, followed by practice with AI speaking tools

Week 6: Reading and cross-textual analysis — prompts for summarizing and comparing texts, followed by AI-supported analysis

Week 7: Grammar-focused practice — prompts for error correction and explanation, followed by AI grammar tools

Week 8: Debates — prompts for generating arguments and counterarguments, followed by real-time debate practice

Week 9: Project preparation and reflective activities — prompts for planning, self-assessment, and refining final outputs

Week 10: Final project showcase presentations (5 minutes per student), where learners reflected on their AI learning experience and articulated future goals

Each weekly session lasted 50 minutes and was held at the same day and time. The researcher designed all instructional content, drawing on a pilot version of the club conducted in the previous semester. Based on student feedback, personal reflections, and recent developments in the field, the materials and activities were revised to better meet learners' needs.

Instruments

Surveys: Weekly surveys administered during the pilot and main study included Likert-scale items (1–5) on ease of use, helpfulness, engagement, and perceived learning gains. They also contained binary and multiple-choice items on recommendations and future use, as well as open-ended questions eliciting challenges, suggestions, and reflections on students' experiences with AI-supported learning.

Final projects and presentations: In the final week, students completed individual speaking or writing presentations (maximum five minutes) in which they demonstrated integration of AI tools, reflected on their learning process, and articulated future goals. These presentations served both as a culminating learning activity and as a qualitative data source.

Data analysis

Quantitative survey data were analyzed descriptively through means, percentages, and frequency counts to capture overall trends in students' perceptions of AI-supported learning. Weekly mean scores were calculated for key dimensions such as helpfulness, engagement, clarity, improvement, and confidence, allowing for comparison across different skill-focused sessions (e.g., vocabulary, writing, speaking, grammar).

Qualitative data, consisting of open-ended survey responses and final project presentations, were coded thematically. Deductive codes were drawn from the research focus (e.g., autonomy, motivation, confidence, technical challenges, teacher mediation), while inductive codes emerged from the data (e.g., prompt-writing strategies, ethical AI use, tool preferences, overreliance on ChatGPT). This dual approach ensured that both anticipated and unexpected themes were captured.

Triangulation across quantitative survey results, qualitative survey responses, and final projects supported a comprehensive and credible interpretation of learner experiences. The integration of numerical trends with illustrative qualitative insights enabled a nuanced understanding of how students engaged with AI tools across different skills and how their perceptions evolved throughout the ten-week cycle.

Results

Overview of weekly outcomes

The ten-week cycle revealed consistently positive perceptions of AI-supported learning, with notable skill-specific variations. As shown in *Table 1*, speaking and grammar sessions yielded the strongest helpfulness ratings, while cross-textual analysis achieved the highest clarity scores. In contrast, final project confidence ratings dipped slightly, reflecting the authentic performance pressure of a showcase.

Table 1. Weekly focus areas, mean ratings, and notable insights (Weeks 3–10)

Week	Focus	Key rating (Mean, 1–5)	Notable insights
3	Vocabulary	Helpfulness: 4.27; Engagement: 4.10	Interest in expanding vocabulary and prompt skills
4	Writing	Improvement: 4.16; Future use: 4.47	Gains in grammar, structure, idea generation
5	Speaking	Helpfulness: 4.53; Future use: 4.29	Role-play/pronunciation boosted confidence
6	Cross-textual analysis	Clarity: 4.60; Exercises: 4.60	Strong strategy understanding, moderate sequencing challenges
7	Grammar	Error ID: 4.53; Rule explanation: 4.32	Limited customization; high engagement
8	Debates	Confidence: 4.21; Helpfulness: 4.32	Authenticity concerns; value in argument practice
9	Project preparation	Confidence in requirements: 4.17	Overreliance on ChatGPT; diverse skill focus
10	Final project showcase	Presentation confidence: 3.89; Language improvement: 4.32	Preference for blended AI–teacher support

Vocabulary and writing (Weeks 3–4)

As indicated in Table 1, vocabulary-focused activities received strong helpfulness ratings (M = 4.27), reflecting students' interest in expanding their lexical range and prompt-writing skills. Writing tasks were also rated positively (M = 4.16–4.47), with improvements in grammar, organization, and idea generation. Qualitative comments emphasized a desire for more detailed grammar feedback, signaling growing metacognitive awareness and strategy use at the B1 level.

Speaking (Week 5)

Speaking sessions achieved the highest helpfulness rating across the cycle (M = 4.53; see Table 1). Students particularly valued role-play, pronunciation feedback, and low-stakes conversation practice. However, they also noted challenges with spontaneity and occasional technical barriers, suggesting that while AI was a valuable tool for oral practice, guided interaction remained essential.

Cross-textual analysis and grammar (Weeks 6–7)

Learners rated both cross-textual analysis and grammar sessions very highly (M = 4.60 and M = 4.53, respectively; see Table 1). Students appreciated the clarity of strategy-focused exercises but noted moderate difficulties with task sequencing. Grammar support was perceived as engaging and helpful, though limited customization highlighted the need for teacher mediation to provide contextualized explanations.

Debates and projects (Weeks 8–10)

As presented in Table 1, debate sessions strengthened students' confidence (M = 4.21) and enhanced argumentation skills, yet also revealed concerns about authenticity when compared to human partners. In the project-focused weeks, confidence in requirements was moderate (M = 4.17), with students showing overreliance on ChatGPT as a single tool. While the final showcase demonstrated perceived language improvement (M = 4.32), presentation confidence was lower (M = 3.89), underscoring the importance of blended AI–teacher support.

Discussion

Findings indicate that AI can scaffold learner autonomy by providing immediate feedback, extended practice, and accessible resources. However, as reflected in Table 1, autonomy did not emerge automatically. Structured reflection and consistent teacher mediation were necessary for students to contextualize and internalize strategies. Over the ten weeks, learners progressed from initial curiosity to routine integration of AI, particularly in speaking and grammar tasks.

A key theme was the "autonomy paradox": while students credited AI with fostering independence, they simultaneously relied on human guidance for reassurance, contextualization, and accuracy. This tension resonates with previous discussions of learner autonomy as both individual agency and socially mediated practice (Benson, 2013; Little, 1991; Chong & Reinders, 2022). The tendency to depend heavily on ChatGPT, especially during project preparation, highlighted the risks of tool overreliance. Diversification of AI resources and teacher scaffolding thus appear essential to building sustainable digital literacy and balanced learner autonomy. This paradox aligns with broader debates on the relational nature of autonomy, where independence is often intertwined with guidance and mediation.

Conclusions

AI-assisted reflection can foster autonomy among B1-level learners, enhancing motivation, confidence, and self-regulation across skills. Autonomy is best conceptualized as interdependence: learners thrive when AI is embedded in pedagogically designed tasks, reflective practice, and sustained teacher mediation. While the findings are context-specific to one English preparatory program, the proposed framework is transferable to similar contexts and warrants further exploration across different proficiency levels and institutional settings. Future research could investigate longitudinal effects of AI-supported reflection and examine how diverse AI tools influence learner autonomy and digital literacy development.

Acknowledgements

I would like to thank the participating students and the university English preparatory program for their support in conducting this study.

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Yükseköğretim Kurumlarının Çevrimiçi Eğitim Yönetiminde Stratejik Farklılaşma Yaklaşımı

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Özet

Günümüzde bilgi ve iletişim teknolojilerine dayalı web tabanlı çevrimiçi eğitim uygulamaları hızla yaygınlaşmakta; e-öğrenme platformları her geçen gün daha fazla kullanıcıya ulaşmaktadır. Bu dijital dönüşüm, geleneksel yükseköğretim modelleri üzerinde baskı oluşturarak üniversiteleri, dijitalleşmeye stratejik bir yaklaşımla uyum sağlamaya ve yeni nesil öğrenme modellerine entegre olmaya zorlamaktadır.

Bu çalışmada, stratejik farklılaşma yaklaşımı çerçevesinde yükseköğretim kurumlarının çevrimiçi eğitim yönetimini, teknolojik ve kurumsal yetkinliklerini kullanarak diğer kurumlardan ayrışacak biçimde nasıl yapılandırabilecekleri ele alınmaktadır. Çalışma kapsamında, çevrimiçi öğrenme süreçlerinde rekabet avantajı sağlayabilecek temel farklılaşma alanları belirlenmekte ve bu doğrultuda yükseköğretim kurumları için stratejik öneriler sunulmaktadır.

Anahtar Kelimeler: Yükseköğretim, Çevrimiçi Eğitim, Yönetim, Strateji, Farklılaşma

Abstract

Today, web-based online education applications based on information and communication technologies are rapidly spreading; e-learning platforms are reaching an increasing number of users every day. This digital transformation is putting pressure on traditional higher education models, forcing universities to adapt to digitalization with a strategic approach and integrate with next-generation learning models.

This study examines how higher education institutions can structure their online education management within the framework of a strategic differentiation approach, leveraging their technological and institutional capabilities to differentiate themselves from other institutions. Within the scope of the study, key areas of differentiation that can provide a competitive advantage in online learning processes are identified, and strategic recommendations for higher education institutions are presented accordingly.

Keywords: Higher Education, Online Education, Management, Strategy, Differentiation

Giriş

Çevrimi eğitim ve buna bağlı öğrenme yöntemlerinin gelişmeye ilişkin etkilendiği dönem pandemi süreci ve sonrasıdır. Bilindiği üzere; Eğitimde kesintilerin yaşanmaması ve sürekliliğin sağlanabilmesi için Türkiye dahil çoğu ülkede teknoloji odaklı çevrimiçi acil uzaktan öğretim kararı alınmıştır. Bu kapsamda dersler web tabanlı toplantı ve video konferans uygulamalarında çevrimiçi verilmiştir (Çankırlı, 2023). Yükseköğretim kurumlarında çevrimiçi uygulamaların dijital olgunluk seviyelerinin yeterliğinin gelişime açık olduğu gözlemlenmektedir. Özellikle internet erişim hızının ve mobil cihazların artması ve, buna bağlı yoğun kullanım nedeniyle dijital teknolojiler hızlı gelişmiş ve gelişmeye devam etmektedir. Eğitim sektöründe dönüşüme yol açmış ve çevrimiçi eğitim modelleri giderek yaygınlaşmıştır. Çevrimi eğitime yönelik uygulamalar kapsamında tüm süreçleri kapsayan öğrenme yönetim sistemlerinin artışı, üniversitelerde uygulamaların başlaması, bu teknolojilerin öğrenen kitlesinde talep görmesi üniversitelerin için ayrıca gelir artırıcı ve meşruiyet kazanma aracı haline dönüşmektedir. Bu bağlamda yükseköğretim kurumlarını çevrimiçi eğitim konusunda yalnızca teknolojik altyapı yatırımlarına değil, aynı zamanda kurumsal misyon, vizyon ve amaçlarına ilişkin stratejik yönetim yaklaşımlarını yeniden düşünmeye zorlamaktadır. Dolayısıyla çevrimiçi eğitim üniversitelerin marka değerini, öğrenci memnuniyetini, uzun dönem sürdürülebilir faaliyetlerini etkileyen, rekabet üstünlüğünü belirleyen stratejik bir alan haline gelmiştir. Dijitalleşmenin etkisi giderek artmaktadır. Özellikle çevrimiçi eğitim yönetiminde stratejik farklılaşma yaklaşımı ile verilen kaliteli eğitimin rekabet avantajı elde etmede kritik bir unsur olduğu değerlendirilebilir. Dolayısıyla çalışmada stratejik yönetim süreci, dijitalleşme ve çevrimiçi yönetiminin sağlayacağı rekabet üstünlüğü ile öğrenci memnuniyetini etkileyen olası stratejik yaklaşımlar incelenmiş ve önerilerde bulunulmuştur.

Yöntem

Araştırma nitel bir çalışma olup ikincil verilerin incelemesine dayanmaktadır. Veri toplama sürecinde Scopus, Web of Science, Google Scholar, EDUCAUSE, OECD, UNESCO ve Yükseköğretim Kurulu (YÖK) bilgileri taranmıştır. Arama sürecinde "çevrimiçi eğitim", "dijital dönüşüm", "yükseköğretim", "stratejik farklılaşma", "mikroöğrenme" ve "yapay zekâ" anahtar kelimeleri kullanılmıştır. Genel olarak incelemenin kapsadığı dönem 2010–2025 yılları arasıdır. Konu kapsamında çevrimiçi eğitimde bir kurumu diğerlerinden ayırabilecek örgütsel performansı, öğrenci memnuniyetini ve rekabet avantajı üzerindeki potansiyel etkilerini tartışmaya ilişkin veriler değerlendirilmiş ve betimsel analiz yöntemiyle yorumlanmıştır. Çalışmanın sınırlılığı, yalnızca ikincil verilere dayanmasıdır. Gelecekte yapılacak araştırmalarda anket, mülakat ve vaka çalışmalarıyla birincil verilerden faydalanılması önerilmektedir.

Bulgular

Çevrimiçi eğitimde farklılaşmanın yalnızca teknolojiye değil; pedagojik tasarım, öğrenci desteği ve kurumsal kültüre bağlı olduğunu öngörülebilir. Türkiye'deki üniversitelerin dijital olgunluk seviyeleri farklılık gösterse de stratejik farklılaşmayı başaran kurumların rekabet avantajı elde ettiği ve stratejik farklılaşmanın sadece teknoloji kullanmakla sınırlı olmadığı, pedagojik yaklaşım ve öğrenci desteğiyle bütünleşik olması gerektiği tartışılabilir. Yükseköğretim kurumlarının eğitim süreçlerinde stratejik farklılaşmayı sadece bir pazarlama aracı olarak değil, kurumsal stratejinin bir parçası olarak benimsemesi, farklılaşmanın uyarlanabilir dijital öğrenme ortamları ve Yapay Zeka (AI) ile nasıl kesiştiği ile ilgili olan çalışmalar da her geçen gün artmakta ve bu konuda küresel, ulusal kural koyucular tarafından tüm kurumlar motive edilmektedir. Dolayısıyla bu yaklaşımlara uyum çerçevesinde yükseköğretim kurumlarında stratejik bilincin, stratejik planlamanın ve tüm bunları kapsayan stratejik yönetim sürecinin ciddi anlamda ele alınması ve uygulanması gerekliliği önem arz etmektedir. Yükseköğretim kurumlarında stratejik olarak ele alındığında, çevrimiçi eğitimin yalnızca teknolojik bir yatırım değil, aynı zamanda kurumsal stratejik farklılaşma aracı olduğu da değerlendirilmelidir. Bu yaklaşım OECD'nin (2023) dijital eğitim raporunda vurgulanan "İnsan Merkezli ve Pedagojik Olarak Uygun Etkileşim" Yaklaşımına göre; stratejik farklılaşma aracı haline gelen çevrimiçi Üretken Yapay Zeka uygulamalarını kullanan araştırmacılar ve eğitimciler Üretken Yapay Zeka'yı kullanıp kullanmayacaklarına ve nasıl kullanacaklarına karar verirken, insan iradesine ve insanlar ile Yapay Zeka araçları arasında sorumlu, pedagojik olarak uygun etkileşime öncelik vermelidir.

Araç(lar)ın kullanımı, insanların ihtiyaçlarına katkıda bulunmalı ve öğrenme veya araştırmayı teknolojisiz veya diğer alternatif yaklaşımlardan daha etkili hale getirmelidir. Eğitimcilerin ve öğrencilerin araç(lar)ı kullanımı kendi içsel motivasyonlarına dayanmalıdır. Araç(lar)ın kullanım süreci eğitmenler, öğrenenler veya araştırmacılar tarafından kontrol edilmelidir. Araç(lar)ın seçimi ve organizasyonu ile oluşturdukları içerik, öğrencilerin yaş aralığına, beklenen sonuçlara ve hedef bilgi türüne (örneğin olgusal, kavramsal, işlemsel veya üstbilişsel) veya hedef probleme (örneğin iyi yapılandırılmış veya kötü yapılandırılmış) uygun olmalıdır. Kullanım süreçleri, insanların ÜYZ ile etkileşimli katılımını ve üst düzey düşünme becerilerini teşvik etmelidir. Ayrıca, YZ tarafından üretilen içeriğin doğruluğu, öğretim veya araştırma stratejileri ve bu stratejilerin insan davranışları üzerindeki etkilerine ilişkin kararların sorumluluğu insanlara ait olmalıdır (UNESCO, 2024).

Çevrimiçi eğitim ve araştırmada Üretken Yapay Zekâ kullanımının birlikte tasarlanması kapsamında; Üretken Yapay Zeka (ÜYZ)'nın eğitim ve araştırmada kullanımı ne tepeden inmeci bir yaklaşımla dayatılmalı ne de ticari konularla yönlendirilmelidir. Bunun yerine, güvenli ve etkili kullanımı öğretmenler, öğrenciler ve araştırmacılar tarafından birlikte tasarlanmalıdır (UNESCO, 2024). Ayrıca, farklı kullanımların etkinliğini ve uzun vadeli etkisini incelemek için sağlam bir pilot uygulama ve değerlendirme sürecine ihtiyaç vardır. Önerilen ortak tasarımı kolaylaştırmak amacıyla, pedagojik olarak uygun etkileşimleri desteklemek ve insan iradesine öncelik vermek için aşağıdaki altı perspektiften oluşan bir çerçeve sunmaktadır:

1. Uygun bilgi alanları veya problemler,
2. Beklenen sonuçlar,
3. Uygun ÜYZ araçları ve karşılaştırmalı avantajlar,
4. Kullanıcılar için gereksinimler,
5. Gerekli pedagojik yöntemler ve örnek komutlar,
6. Etik riskler.

ÜYZ kullanımında ortak tasarım sürecinin araştırma uygulamalarını nasıl bilgilendirebileceğine, öğretime nasıl yardımcı olabileceğine, temel becerilerin kendi hızında edinilmesi için nasıl koçluk sağlayabileceğine, üst düzey düşünmeyi nasıl kolaylaştırabileceğine ve özel ihtiyaçları olan öğrencileri nasıl destekleyebileceğine dair örnekler, ÜYZ'nin artan sayıda potansiyelinin sadece görünen kısmını temsil etmektedir. Elde edilenler, üniversitelerde farklılaşma startejilerinin yapılandırılması gerektiğinin bir işareti olarak değerlendirilebilir.

UNESCO'nun Eğitim ve Araştırmada Üretken Yapay Zekâ Kılavuzu (2024), ülkeleri acil eylemleri uygulama, uzun vadeli politikalar planlama ve bu yeni teknolojilerin insan merkezli bir vizyona sahip olmasını sağlamak için insan kapasitesini geliştirme konusunda desteklemeyi amaçlamaktadır.Eğitim kurumlarının, eğitim için etik ve pedagojik uygunluk açısından Üretken Yapay Zeka sistemlerini doğrulama ihtiyacını vurgulamaktadır. Konunun bilgi, öğretim, öğrenim ve değerlendirme açısından uzun vadede doğuracağı sonuçlar üzerinde düşünülmesi için uluslararası topluma çağrıda bulunmaktadır. Bu çağrı çerçevesinde yükseköğretim kurumlarının sürdürülebilirlik hedeflerini teşvik etme ve yapay zeka gibi teknolojilerin dönüştürdüğü belirsiz bir geleceğe hazırlanma zorunluluğuna dikkat çekilmektedir. Üretken Yapay Zeka'nın sorumlu ve yaratıcı kullanımını kolaylaştırmak için Kurumsal Stratejilere de yer verilmektedir. Eğitim ve araştırma kurumları; öğretim, öğrenim ve araştırma ihtiyaçlarını karşılamak için Üretken Yapay Zeka sistemlerinin ve uygulamalarının sorumlu ve etik kullanımına kılavuzluk edecek uygun stratejiler ve etik çerçeveler geliştirmeli, uygulamalı ve bunları test etmelidir.

UNESCO (2025) verilerine göre; Dünya genelinde üniversitelere kayıtlı yaklaşık 264 milyon öğrenci bulunmaktadır. Talepteki artışa rağmen, genel kayıt oranı %43'tür ve ülkeler ve bölgeler arasında büyük farklılıklar göstermektedir. Herkese yüksek kaliteli yükseköğretim fırsatları sunmak için yeterliliklerin tanınmasına ve kalite güvencesine özel önem verilmelidir. Bunun yanında öğrencilerin fırsatlarını ve hareketliliğini artırmak için çalışılmaktadır. Dünya çapında bağlantının yaygınlaşması, çevrimiçi ve karma öğrenmenin büyümesini hızlandırır. Bu nedenle yükseköğretim kurumlarının daha iyi planlama, finansman ve kalite için verileri kullanmalarına yardımcı olmakta, Yapay Zeka, Büyük Veri ve Yükseköğretim Yönetim Bilgi Sistemleri gibi dijital hizmetlerin önemini ortaya koyulmaktadır. İşgücü piyasaları, artan dijitalleşme ve ekonomilerin yeşillenmesi ile birlikte, aynı zamanda yükseköğretimin artan uluslararasılaşması ile çevrimiçi eğitimde hızlı değişimler yaşandığını işaret etmektedir. UNESCO tarafından sürdürülebilir kalkınma ve inovasyon için vazgeçilmez olan fen, teknoloji, mühendislik ve matematik (STEM) eğitiminin geliştirilmesine büyük önem verilmektedir. Özellikle okuryazarlık, mesleki ve teknik eğitim, STEM ve yükseköğretim alanlarında gençler ve yetişkinler için beceri gelişimini, bireysel, işgücü piyasası ve toplumsal talepleri karşılamak üzere güçlendirmeyi amaçlayan çalışmaları yapılmaktadır. 2030 yılına kadar 17 Sürdürülebilir Kalkınma Hedefi aracılığıyla yoksulluğu ortadan kaldırmayı amaçlayan küresel bir hareketin parçası olan Eğitim 2030 Gündemi yönetilmekte, koordine edilmektedir. Tüm bu hedeflere ulaşmak için olmazsa olmaz olan eğitimde, "kapsayıcı ve eşitlikçi kaliteli eğitim sağlama ve herkes için yaşam boyu öğrenme fırsatlarını teşvik etme" amaçlanmaktadır.

COVID-19 salgını dijital dönüşümü hızlandırmış ve sınır ötesi eğitimden kıyı ötesi eğitime kadar uzanan eğitim sağlayıcılarının sayısını ve derece seçeneklerinin çeşitliliğini artırmıştır. Bilişim teknolojilerinin kullanımı ve hem kampüste hem de çevrimiçi yeni öğrenme fırsatlarının geliştirilmesi de dahil olmak üzere, erişimi ve kapsayıcılığı genişletmeye yönelik yenilikçi yaklaşımlar konusunda teknik destek ve politika danışmanlığı da sağlanmaktadır.

Bu dönüşüm pedagojik açıdan değerlendirildiğinde, Salmon'un (2011) e-moderatörlük modeli ile Garrison, Anderson ve Archer'ın (2000) Community of Inquiry çerçevesi, çevrimiçi öğrenmede öğrenci katılımı ve topluluk inşasının başarı için kritik rol oynadığını göstermektedir. Dolayısıyla farklılaşmanın yalnızca teknoloji değil, pedagojik tasarım ve öğrenci desteği ile birlikte ele alınması gerekliliğini ortaya çıkarmaktadır.

Benzer şekilde Siemens'in (2005) ağlarla bağlanma (connectivism) kuramı, bilgi ağlarının ve dijital toplulukların öğrenme sürecinde temel hale geldiğini öne sürmektedir. Bulgusu yükseköğretim kurumlarının ağ yapısını stratejik avantaj olarak kullanabileceğini göstermektedir.

Türkiye bağlamında ise YÖK'ün (2019) dijital dönüşüm raporunda üniversitelerin dijital altyapılarını güçlendirmeleri gerektiği vurgulanmıştır. Yıldırım'ın (2023) çalışmasında da ifade edildiği gibi, Türkiye'de dijital dönüşüm sürecinin pedagojik ve kurumsal kapasite ile desteklenmesi gerektiği sonucunu doğrulamaktadır. Bunlara ilave olarak çevrimiçi eğitimin yönetiminde etkili olacak üretken yapay zeka da stratejik bir olgu olarak değerlendirilmektedir. Holmes, Bialik ve Fadel'in (2019) yapay zekânın eğitimde öğretmen rollerini yeniden tanımlayarak stratejik farklılaşmaya katkı sağladığını ortaya koymaktadır. Bu yaklaşım üniversitelerin dijital pedagojik yetkinliklerini artırarak rekabet avantajı elde edebileceğini göstermektedir.

Bu bilgiler ışığında üniversitelerin çevrimiçi eğitim ve yönetiminde nasıl kalıcı rekabet avantajı sağlayabileceğini açıklamak için "değer zinciri" (value chain) kavramına bakmak yönetim sürecinde ayrı bir önemli konu olabilir. "Değer zinciri analizi , bir şirketin değer zincirindeki her bir faaliyeti değerlendirerek iyileştirme fırsatlarının nerede olduğunu anlamanın bir yoludur. Bir değer zinciri analizi yapmak, her adımın nihai ürün veya hizmetinize nasıl değer kattığını veya katma değer yarattığını değerlendirmenizi sağlar. Bir faaliyeti daha verimli ve dolayısıyla daha az maliyetli hale getirerek maliyet azaltma, ürününün öne çıkmasına yardımcı olabilecek araştırma ve geliştirme, tasarım veya pazarlama gibi faaliyetlere daha fazla zaman ve kaynak yatırma gibi bir tür rekabet avantajı elde edilebilecek aktiviteler bileşenidir (Stobierski, 2020)." Dolayısıyla rekabet avantajı, yüksek öğretim kurumunun faaliyetlerini nasıl organize ettiğine ve bu faaliyetlerden nasıl değer yarattığına bağlıdır. Bu temel bilgiler bağlamında konu incelendiğinde kurumsal açıdan çevrimiçi öğrenme süreçlerinde stratejik yönetim önemli bir alandır. Uzaktan eğitim bağlamında çevrimiçi eğitim stratejisi ve yönetimi aşamalarının iyi uygulanması, farklılaşmanın oluşmasına zemin hazırlamaktadır (Fırat, 2021). Çevrimiçi eğitim yönetimi aynı zamanda uzaktan öğretimin stratejik bir parçasıdır.Amaç ve hedeflerine ulaşabilmesi için fonksiyon üstü kararların alınması, uygulanması ve değerlendirilmesi de gerekmektedir. Stratejik yönetimin en temelde; uzun vadeli düşünmeye, stratejik konulara odaklanmaya ve hızla değişen dünyada değişime ayak uydurmaya yardımcı olur. Uzaktan öğretim gibi teknoloji odaklı hem de kitlesel bir sistemin stratejik yönetimden yararlanmaması düşünülemez (Fırat, 2021). Vizyon, misyon, amaç ve hedefler stratejik yönetimin temel kavramlarından bazıları olup özellikle stratejik yönlendirme için önemlidir. Bu bağlamda çevrimiçi eğitim de uzaktan eğitim modeli olduğu için bu kavramlara uygun vizyon, misyon amaç ve hedefler oluşturmalıdır. Stratejik amaç ve hedefler daha operasyoneldir. Bu nedenle istenilen zamana dayalı beklenen sonuçlar misyonun gerçekleşmesini sağlar. Amaçlar hedefler ve planlamalar için orta vadeli bir çerçeve sunarken esas operasyonel işleri hedefler yapacaktır. Bu bağlamda çevrimiçi eğitimin yönetimin ulaşacağı sonuçları ede edecek, ilk adım olan amaçlar belirlenmeli ve buna bağlı hedefler oluşturmalıdır.

Yükseköğretim kurumları kavramı içinde üniversiteler de birer işletme olduğu için varlığını sürdürebilme ve bunun da ötesinde bulunduğu ortamlarda rekabet avantajı sağlayabilme amacı taşımaktadır. Dolayısıyla işletmenin varlığını sürdürebilmesi ve rekabet üstünlüğünü sağlayabilmesi için başarılı olacak bir stratejik yönetim sürecini oluşturması ve uygulaması gerekmektedir. Çevre faktörlerinin, üretim, bilgi ve iletişim teknolojilerinin inanılmaz boyutlarda geliştiği ve değiştiği, ticari sınır ve sınırlamaların kalktığı, değişim ve belirsizliklerin kaçınılmaz olduğu dinamik bir iş dünyasında devamlı bir süreç olarak uygulanmadığı takdirde stratejik yönetim çalışmaları başarılı olamaz (Ülgen ve Mirze, 2024). Dolayısıyla yükseköğretim kurumlarında geleneksel yönetim fonksiyonları olan planlama, yürütme, yöneltme ve kontrol işlevlerine ilave olarak stratejik bilinç, stratejik planlama ve stratejik yönetim sürecinin de dahil edilmesi gerekmekte ve çevrimiçi eğitimin yönetimi bu çerçevede ele alınmalıdır.

Stratejik Yönetim Süreci

Stratejik bilince sahip yöneticiler stratejik yönetim sürecini uygulayabilecek stratejistlerin seçimini yaparlar ve daha sonra da işletmenin mevcut misyon, vizyon ve amaçları ışığında işletme dışı ve içi çevre faktörlerinin analizi ile ilgili çalışmaları başlatırlar (Ülgen ve Mirze, 2024).

- Stratejik bilinç
- Stratejileri seçme ve görevlendirme
- Stratejik analiz: Dış çevre ve İç çevre analizi
- Stratejik yönlendirme: Misyon, Vizyon, Amaç ve Hedefler
- Strateji oluşturma: Temel stratejiler, Alt stratejiler
- Stratejik uygulama
- Stratejik kontrol

Stratejik yönetim sürecinin genel başlıkları olup bunların birbiriyle uyumlu çalışması önem arz etmektedir.

Porter'a (1985), Stratejik olarak üç yol olsa da firmaların "üstün performans" elde etmesinin iki temel yolunu vurgular:

1. Farklılaşma (differentiation): Ürün veya hizmetlere müşteri gözünde eşsiz değer katan özellikler eklemek.
2. Maliyet liderliği (cost leadership): Rakiplerden daha düşük maliyetle üretim yaparak fiyat avantajı sağlamak.
3. Porter ayrıca, bu stratejilerin "odaklanma (focus)" stratejisiyle belirli bir pazar segmentine yönelerek de uygulanabileceğini belirtmektedir.

Porter'a (1985) göre, rekabet avantajı değer zincirindeki faaliyetlerin toplamından doğar. Tek bir faktör değil, firmanın tüm faaliyet sisteminin nasıl bir araya geldiği belirleyicidir. Bu yüzden "değer zinciri" yaklaşımı geliştirilmiştir. Değer zinciri analizinde; Bir işletme, girdi tedarikinden satış sonrası hizmetlere kadar uzanan faaliyetleriyle değer yaratır. Bu zincirdeki her faaliyet ya maliyet avantajı ya da farklılaşma kaynağı olabilir. Sürdürülebilir rekabet avantajı için tutarlılık gerekir. Strateji, "her şeyi yapmaya çalışmak" değildir. Şirket ya maliyet liderliğini ya da farklılaşmayı seçmeli; ikisini birden yapmaya çalışan firmalar genellikle "araya sıkışır" ("stuck in the middle"). Endüstri yapısı ve rekabet gücü belirleyicidir. Fakat endüstri içi rekabetin stratejiyi şekillendirdiğini tekrar vurgular. Uzun vadeli üstünlük için: Strateji sadece rakipleri yenmek değil, işletmenin kendine özgü faaliyet sistemini inşa etmesidir. Bu faaliyet sistemi, rakipler tarafından kolayca taklit edilemeyecek şekilde bütünleşik olmalıdır. İlk defa Harvard Üniversitesi Profesörlerinden Michael Porter tarafından literatüre kazandırılan Değer Zinciri Modeli şimdiye kadar hem teoride hem de pratik çalışmalarda kendisine uygulama alanı bulmuştur. İki ana kısımdan oluşan modelin birincil faaliyetlerini giren lojistik, operasyon (işlem), çıkan lojistik, pazarlama ve satış ve hizmetler oluştururken, destekleyici faaliyetlerini ise, firma altyapısı,insan kaynakları yönetimi, teknoloji geliştirme ve satınalma (tedarik)halkaları meydana getirmektedir.

Diğer taraftan Barney (1991), bir firmanın kalıcı rekabet avantajı elde etmesinin yalnızca dış çevre koşullarına değil (ör. Porter'ın endüstri yapısı analizleri), aynı zamanda firma içi kaynakların niteliğine bağlı olduğunu savunur. Yani rekabet üstünlüğünün kaynağı firmanın kontrol ettiği kaynaklardır. Barney'ye (1991) göre, kalıcı rekabet avantajı ancak değerli, nadir, taklit edilemez ve ikame edilemez kaynaklarla mümkündür.

Kaynakların stratejik önemi çerçevesinde; Her kaynak rekabet avantajı sağlamaz. Bir kaynağın rekabet avantajı yaratabilmesi için dört özelliğe sahip olması gerekir. Kısaca VRIN kriterleri olarak bilinen;

- Valuable (Değerli): Firma için fırsatlardan yararlanmayı veya tehditleri azaltmayı sağlamalıdır.
- Rare (Nadir): Rakip firmalarda yaygın olmamalıdır.
- Inimitable (Taklit edilemez): Kolayca kopyalanamamalıdır. Bu genellikle tarihsel koşullar, nedensel belirsizlik ve sosyal karmaşıklık nedeniyle oluşur.
- Non-substitutable (İkamesi yok): Başka bir kaynakla kolayca yer değiştirilememelidir.

Sürdürülebilir rekabet avantajı bağlamında yalnızca dış çevredeki konum değil, firmanın sahip olduğu benzersiz kaynak ve yetenekler avantajın sürdürülebilirliğini belirler. Örneğin marka itibarı, özel bilgi birikimi, şirket kültürü veya nadir organizasyonel süreçler bunlardan bazılarıdır. Porter (1985) ve Barney (1991) Yaklaşımlarının boyut, dışsal ve içsel yaklaşım olarak karşılaştırması yapıldığında;

Boyut	**Porter (1985) – Dışsal Yaklaşım**	**Barney (1991) – İçsel Yaklaşım (RBV)**
Temel Odak	Endüstri yapısı ve rekabet güçleri	Firma içi kaynaklar ve yetenekler
Analiz Birimi	Endüstri ve rakipler	Firma
Rekabet Avantajının Kaynağı	Konumlandırma (maliyet liderliği, farklılaşma, odaklanma)	Değerli, nadir, taklit edilemez ve ikame edilemez (VRIN) kaynaklar
Anahtar Kavramlar	Beş Güç Analizi, Değer Zinciri	Kaynak Temelli Görüş, VRIN/VRIO
Yaklaşımın Sınırları	Endüstri içi benzer kaynaklara sahip firmalar arasında farklılıkları açıklamakta sınırlı	Kaynakların çevresel değişimlere uyum sürecini açıklamakta sınırlı

Tablo1. Porter (1985) ve Barney (1991) Yaklaşımlarının Karşılaştırması

Bu yaklaşımlar stratejik yönetim yaklaşımı bağlamında; firmalar, sahip oldukları kaynakları analiz ederek hangi alanlarda sürdürülebilir rekabet avantajı elde edebileceklerini belirlemelidir. Bu içsel bakış açısı, dışsal "endüstri yapısı" analizine alternatif değil, tamamlayıcıdır.

Çevrimiçi öğrenme stratejisi ve yönetimi

Salmon (2011), çevrimiçi öğrenme ortamlarında öğrenme sürecini kolaylaştıran eğitmenin (e-moderator) rolünü merkez alır. Yüz yüze öğretimden farklı olarak, çevrimiçi eğitimde öğretim görevlisinin görevi yalnızca bilgi aktarmak değil, aynı zamanda katılımcılar arasında etkileşim, motivasyon ve topluluk inşasını desteklemektir. Temel katkısı, çevrimiçi öğrenme sürecini 5 aşamalı bir gelişim modeli ile açıklamasıdır. 5 Aşamalı Modelde (Five Stage Model);

1. Erişim ve Motivasyon (Access and Motivation): Öğrencilerin çevrimiçi ortama teknik olarak erişimi sağlanır. Katılım için motive edilmeleri gerekir.
2. Çevrimiçi Sosyalleşme (Online Socialization): Katılımcılar birbirlerini tanır, güven ortamı kurulur. Dijital topluluk oluşmaya başlar.
3. Bilgi Değişimi (Information Exchange): Katılımcılar arasında bilgi paylaşımı gerçekleşir. Temel içerikler tartışılır ve işlenir.
4. Bilgi Yapılandırma (Knowledge Construction): Katılımcılar iş birliği yaparak yeni bilgi ve anlam üretir. Kritik düşünme ve ortak öğrenme öne çıkar.
5. Gelişim (Development): Öğrenciler öğrendiklerini bağımsız olarak uygulamaya başlar. Eleştirel düşünce gelişir ve öğrenme süreci derinleşir.

Eğitmen rolü "e-moderator" olarak yeniden tanımlanmalıdır. Çevrimiçi uzaktan öğrenmede rehberlik, yönlendirme, destek ve etkileşim yönetimi kritik önemdedir. Çevrimiçi topluluk (community of learning) başarı için anahtardır. Katılımcılar arasındaki sosyal bağ ve işbirliği öğrenmenin kalitesini artırır. Öğrenme aşamalı ve yapılandırılmış bir süreçtir. Salmon'un 5 aşamalı modeli, çevrimiçi ders tasarımında bir yol haritası sunar. Dijital dönüşüm sadece teknolojik değil, pedagojik bir süreçtir. Öğrenme ortamı; teknik destek, pedagojik tasarım ve sosyal etkileşim üçgeninde tasarlanmalıdır.

Bates & Sangra (2011), yükseköğretim kurumlarının bilgi ve iletişim teknolojilerini sadece ders sunumunu kolaylaştıran araçlar olarak değil, öğretim ve öğrenme süreçlerini dönüştüren stratejik unsurlar olarak ele alması gerektiğini savunur. Teknolojinin üniversitelerde kurumsal düzeyde yönetilmesi, strateji geliştirilmesi ve pedagojik yeniliklerle bütünleştirilmesi gerektiğini vurgular.

Bir kuruluşun yönetimi esas ise bu da bir yükseköğretim kurumu ise fiziksel yönetim fonksiyonları gibi bir çeşit sanal yönetim alanın olan Uzaktan/Çevrimiçi eğitimde benzer fonksiyonlar olan planlama, örgütleme, yöneltme, kontrol fonksiyonlarının oluşturulması gerekmektedir.

Teknoloji yönetimi bir strateji meselesidir. Üniversitelerde teknolojinin kullanımı, sadece altyapı yatırımı değil; öğretim, öğrenme ve araştırma vizyonuyla bütünleşmiş bir strateji olmalıdır. Pedagoji ve teknoloji birlikte düşünülmelidir. Teknoloji, mevcut dersleri dijitalleştirmek için değil, öğrenme deneyimini dönüştürmek için kullanılmalıdır. Öğrenci merkezli öğrenme, etkileşimli içerikler ve esnek öğrenme yolları öne çıkar. Kurumsal liderlik ve kültür kritik önemdedir. Başarılı dijital dönüşüm, üniversite yönetiminin liderliği, akademisyenlerin katılımı ve kurumsal kültürün değişime açıklığı ile mümkündür. Değişim yönetimi gereklidir. Teknolojiyi sadece teknik bir mesele değil, kurumsal dönüşümün bir parçası olarak görmek gerekir. Bu nedenle, vizyon geliştirme, personel eğitimi, teşvik mekanizmaları ve kalite güvencesi süreçleri ön plandadır. Sürdürülebilirlik için stratejik planlama gerekir. Teknoloji yatırımları maliyet, insan kaynağı, teknik altyapı ve pedagojik uyum açısından bütünsel düşünülmelidir. Bates ve Sangrà'ya (2011) göre, yükseköğretimde teknolojinin etkili yönetimi yalnızca teknik bir konu değil, stratejik bir dönüşüm sürecidir.

Westerman, Bonnet ve McAfee (2014), dijital dönüşümün yalnızca teknoloji yatırımı değil, aynı zamanda stratejik liderlik, kültürel değişim ve kurumsal olgunluk meselesi olduğunu savunur. Araştırmalarında, farklı sektörlerde dijital teknolojiyi başarılı şekilde kullanan şirketlerin, hem finansal performans hem de operasyonel verimlilik açısından rakiplerine üstünlük sağladığını ortaya koymuşlardır. "Dijital ustalık (digital mastery)" kavramı etrafında şekillenirler. Dijital ustalık, teknolojiyi etkin kullanmanın ötesinde, liderlerin dijital vizyon oluşturması, organizasyonel kültürü dönüştürmesi ve çalışanların dijital yetkinliklerini geliştirme ile sağlanır.

Dijital dönüşüm ≠ teknoloji yatırımı: Başarının anahtarı yalnızca teknolojik araçları benimsemek değil; bunları stratejik hedeflerle uyumlu biçimde entegre etmektir.

- Dijital ustalık (Digital Mastery) modeli: Dijital Yetenekler (Digital Capabilities): Teknolojiyi iş süreçlerine, müşteri deneyimine ve inovasyona entegre etme gücü.
- Liderlik Yetkinlikleri (Leadership Capabilities): Dijital vizyon geliştirme, strateji belirleme ve kültürel dönüşümü yönlendirme kapasitesi.

Bu iki boyut birleştiğinde kurumlar "dijital ustalar" haline gelir.

- Performans üstünlüğü: Dijital ustalar, hem gelir artışı hem de kârlılıkta dijital olarak geri kalanlara göre belirgin rekabet avantajı elde eder.
- Olgunluk yolculuğu: Dijital dönüşüm, adım adım olgunlaşma gerektiren bir süreçtir; tek seferlik bir proje değil, sürekli gelişim stratejisidir.

Westerman, Bonnet ve McAfee (2014), dijital dönüşümün başarısının sadece teknolojik araçlarla değil, stratejik liderlik ve organizasyonel kültürle mümkün olduğunu; dijital ustalık düzeyine ulaşan şirketlerin sürdürülebilir rekabet avantajı sağladığını ortaya koymaktadır. Diğer taraftan küresel bağlamda yükseköğretim kurumları üniversitelerin akademisyenleri ve karar vericiler tarafından takip edilen ve tavsiyelerine başvurulan Educase raporlarına göre; Yükseköğretim kurumlarının dijital dönüşüm sürecinde karşılaştıkları zorlukları ve bu süreçte dikkate almaları gereken stratejik alanları vurgulamaktadır. Yapay Zeka 'nın (YZ) eğitimdeki rolü, dijital okuryazarlık, çalışan deneyimi ve kültürel değişim gibi konular, dijital dönüşümün başarısı için kritik öneme sahiptir. Kurumlar, bu alanlarda stratejik adımlar atarak dijital dönüşüm sürecini etkin bir şekilde yönetebilirler. Educause (2020) raporuna göre, Kültürel, işgücü ve teknoloji değişikliklerinde; Dijital dönüşüm, kurumların kültürel yapısını, iş gücü dinamiklerini ve teknolojik altyapısını dönüştürmektedir. Dijital dönüşümün erken aşamaları ele alındığında; Birçok kurum, dijital dönüşüm sürecine yeni başlamış veya bu süreçte erken aşamalardadır. İlerleme beklentileri kapsamında; Kurumlar, önümüzdeki beş yıl içinde dijital dönüşümde ilerleme kaydetmeyi beklemektedir. Dijital dönüşüm, sadece teknoloji yatırımlarından ibaret olmayıp, kurumun tüm yönlerini kapsayan bir değişim sürecidir. Kültürel Değişimin Önemi: Kurumlar, dijital dönüşüm sürecinde kültürel değişimi yönetmeli ve bu değişimi destekleyici stratejiler geliştirmelidir. Educause Horizon (2024) raporuna göre, Dijital dönüşümün zorlukları noktasında COVID-19 sonrası yükseköğretim kurumları, değerlerini yeniden kanıtlama ve azalan kayıtları telafi etme baskısıyla karşı karşıya kalmıştır. Bu durum, dijital dönüşümün önemini artırmıştır. Veri ve Analitik Kapasiteleri bağlamında veri ve analitik yetenekleri gelişmeye devam etmekte olup, bu durum kurumlar için yeni fırsatlar ve riskler doğurmaktadır. Yapay Zeka (YZ) eğitimde öğretim ve öğrenme süreçlerini değiştirme potansiyeline sahiptir. Ancak, bu değişime hazırlıklı olmak için dijital okuryazarlık ve YZ'nin sorumlu kullanımı konusunda çalışmalar yapılmalıdır. Dijital Dönüşümün stratejik önemi bağlamında ise kurumlar, dijital dönüşümü sadece teknoloji olarak değil, kültürel ve yapısal bir değişim olarak ele almalıdır. YZ'nin eğitimdeki rolü öğretim süreçlerini kişiselleştirme ve verimliliği artırma potansiyeline sahiptir. Ancak, etik ve güvenlik konuları da göz önünde bulundurulmalıdır.

Educause Horizon (2025) raporuna göre ise, evrensel Dönüşüm noktasında Yükseköğretim, büyük bir dönüşüm ve belirsizlik dönemindedir. YZ ve sanal gerçeklik gibi teknolojik gelişmeler, öğrencilerin içerikle etkileşimini, bilişsel süreçlerini ve öğrenmenin nasıl belgelendiğini yeniden şekillendirmektedir. Dijital okuryazarlık ve güvenlik çerçevesinde YZ'nin etkili kullanımı, dijital okuryazarlık, öğrenci beklentilerinin yönetimi ve siber güvenlik gibi temellerin güçlendirilmesini gerektirmektedir. Diğer taraftan çalışan deneyimine bakıldığında öğretim ve öğrenme profesyonelleri, esnek çalışma düzenlemeleri, teknoloji entegrasyonu, iş yükü ve profesyonel gelişim gibi konularda zorluklar yaşamaktadır. Teknolojinin entegrasyonu iyi yapılmalı ve teknolojiler, pedagojik yaklaşımlarla uyumlu bir şekilde entegre edilmelidir. Bu entegrasyon, öğretim kalitesini artırabilir. Ayrıca çalışanların desteklenmesi, öğretim ve öğrenme profesyonellerinin desteklenmesi, dijital dönüşümün başarısı için kritik öneme sahiptir.

Bazı çalışmalarda Türkiye'deki üniversitelerde dijital dönüşüm süreçleri ve çevrimiçi eğitim uygulamaları incelenmektedir. Araştırmalarda, dijital dönüşümün eğitim süreçlerine entegrasyonunu, mevcut uygulamaların etkinliğini ve karşılaşılan zorlukları ele alınmaktadır. Sonuçlar, dijital dönüşümün eğitim kalitesini artırma potansiyeline sahip olduğunu, ancak altyapı eksiklikleri ve öğretim üyelerinin dijital yeterliliklerinin artırılması gerektiğini göstermektedir (Yıldırım,2023).

Dijital dönüşümün önemi bağlamında üniversitelerin küresel rekabette öne çıkabilmesi için dijital dönüşümün stratejik bir öncelik olarak benimsemesi gerekmektedir. Dijital dönüşümün başarılı olabilmesi için güçlü bir dijital altyapı ve öğretim üyelerinin dijital pedagojik yeterliliklerinin artırılması önemlidir. Çevrimiçi eğitim uygulamalarının etkinliğinin sürekli olarak değerlendirilmesi ve iyileştirilmesi gerekmektedir (Yıldırım,2023).

Diğer bir görüşte, matematik ve fen bilimleri eğitiminde teknoloji destekli yaklaşımlardan biri olan mikro öğrenme (microlearning) yöntemini incelemektedir. Mikro Öğrenme; kısa süreli ve odaklanmış içeriklerle öğrenmeyi destekleyen bir yaklaşımdır. Araştırma, mikro öğrenme içeriğinin tasarımını, uygulanabilirliğini ve mobil öğrenme ile ilişkisini ele almaktadır. Sonuçlar, mikro öğrenmenin öğrencilerin kavramsal anlayışlarını geliştirdiğini ve öğrenme süreçlerini daha etkili hale getirdiğini göstermektedir (Selçuk ve Köseoğlu, 2023).

Kısa ve odaklanmış içeriklerde, öğrencilerin dikkat sürelerini ve bilgi işleme kapasitelerini daha verimli kullandığı görülmektedir. Mobil öğrenme entegrasyonu, mikro öğrenme uygulamaları mobil cihazlar aracılığıyla her zaman ve her yerde erişilebilir olduğundan, öğrenme süreçlerini esnek ve erişilebilir kılmaktadır. Öğrenci katılımının artırılması noktasında öğrencinin aktif katılımını teşvik eden mikro öğrenme ve etkileşimli oyunlaştırma uygulamaları, öğrencilerin öğrenmeye olan ilgisini ve motivasyonunu artırmaktadır (Selçuk ve Köseoğlu, 2023).

Tartışma

Araştırmanın bulguları, çevrimiçi eğitim yönetiminde stratejik farklılaşma yaklaşımlarının yükseköğretim kurumlarının rekabet avantajı elde etmesinde etkili olduğunu göstermektedir. Özellikle mikro öğrenme uygulamaları (Selçuk & Köseoğlu, 2023), çevrimiçi öğrenme toplulukları modeli (Garrison, Anderson, & Archer, 2000) ve e-moderatörlük yaklaşımı (Salmon, 2011) bulgularla uyumludur. Türkiye bağlamında, Yıldırım (2023) ve YÖK'ün (2019) Dijital Dönüşüm Projesi bulguları desteklemektedir. Stratejik farklılaşmanın rekabet avantajına katkısı, kaynak temelli yaklaşım ve konumlandırma stratejileri ile açıklanabilir (Barney, 1991; Porter, 1985).Bulgular, OECD'nin (2023) dijital eğitim raporunda belirtilen dijital olgunluk düzeyi ile uyumluluk göstermektedir. UNESCO'nun (2021, 2024, 2025) raporlarında yapay zekâ ve dijitalleşmenin öğrenci başarısı ve öğretim kalitesine katkısı vurgulanmaktadır. YÖK'ün (2024) Dijital Dönüşüm Projesi kapsamlı strateji planı, Türkiye yükseköğretim sisteminde dijitalleşmeye yönelik somut adımların önemini ortaya koymaktadır. Holmes, Bialik ve Fadel (2019) tarafından yapay zekânın eğitimdeki rolüne dair yapılan çalışmalar da bu araştırmanın sonuçlarını desteklemektedir. Ayrıca Siemens'in (2005) bağlantıcılık kuramı, öğrenenlerin dijital ağlar aracılığıyla bilgiye ulaşma biçimlerini açıklayarak bulguları teorik olarak çerçevelemektedir. Westerman, Bonnet ve McAfee'nin (2014) dijital liderlik çalışmaları da üniversitelerin dijital dönüşüm stratejilerini desteklemektedir. Bu bağlamda, bulgular literatürdeki güncel eğilimlerle tutarlıdır ve yükseköğretim kurumlarının stratejik farklılaşma yoluyla sürdürülebilir rekabet avantajı elde edebileceğini göstermektedir.

Sonuç

Öğrenme süreçlerinde mobilite her geçen gün artmakta ve teknoloji destekli küresel uygulamalar yoğun kullanılmaktadır. Özellikle yükseköğretim kurumları üniversiteler geleneksel yüz yüze öğretim süreçlerine çevrimiçi eğitimi dahil etmiştir. Programlar, dersler artık çevrimiçi de yapılmaktadır. Hatta sadece uzaktan eğitim veren fiziki kampüs ortamı olmadan kurulan sanal/açık üniversiteler de çoğalmaktır. Sınırları ve sınırlamaları aşan bir öğrenme aracı haline dönüşen çevrimiçi eğitim yükseköğretim kurumları için farklı lokasyonlardan gelir edilen ve öğrenci getiren stratejik bir farklılaşma alanı haline gelmiştir. Yükseköğretimde dijital dönüşümün stratejik önemi her geçen gün artmakta ve farklılaşma için en uygun alan olarak kullanılmaktadır. Öğretim süreçlerinin iyileştirilmesi dahil son dönemlerde yapay zekanın eğitimde yıkıcı etkisi tartışılmaktadır. 2020 yılı itibariyle özellikle Covid-19 Pandemisi sonrası çevrimiçi öğrenme süreçleri değişmiş ve dönüşmüştür. Bu süreçle beraber yükseköğretim kurumları için çevrimi eğitime ilişkin veri analitiği ve dijital okuryazarlığın rolü belirleyici olmuştur. Kurum kültürünün çevrimiçi eğitime uyumlu hale getirilmesi ve çalışan deneyiminin dijital dönüşümde olumlu ya da olumsuz etkisi tercihler konusunda belirleyici olmuştur. Konu sadece teknoloji yatırımı değil, aynı zamanda kültürel ve yapısal bir değişim noktasındadır. Yükseköğretimde bu konuda başarılı bir dönüşüm, stratejik planlama ve süreç yönetimi ile sağlanabilir. Dolayısıyla kurumsal amaç ve hedefler çevrimi eğitim yönetimi ile uyumlu olmalı ve hatta çevrimiçi eğitim yönetimi özerk hale getirilmelidir. Dolayısıyla bu bakış açısıyla çevrimiçi eğitim sektöründe donanım ve yazılım tedarik zinciri, üretim, pazarlama ve dağıtım süreçlerinin stratejik analizi, katma değer yaratma süreçlerinin optimizasyonu, sektörde rekabet avantajı için kaynakların ve yeteneklerin etkin kullanımı değerli duruma gelir. Yükseköğretim Kurumları, değer yaratma süreçlerini analiz ederek rekabet avantajı elde edebilir. Her bir faaliyet basamağı, stratejik yönetim ve kaynak optimizasyonu ile iyileştirilebilir. Öğrenen odaklılık, verimlilik ve etkililik yükseköğretim kurumunu sektörel başarısı için kritik önemde görünmektedir. Yükseköğretim kurumları için çevrimiçi eğitim, artık yalnızca bir alternatif değil, kurumsal rekabetin ve sürdürülebilirliğin temel unsurlarından biri haline gelmiştir. İnternet ve dijital teknolojilerin hızlı gelişimi, öğrenci beklentilerini ve öğrenme biçimlerini dönüştürmekte; bu durum yükseköğretim kurumlarının stratejik olarak farklılaşma ihtiyacını artırmaktadır. Çalışmanın bulguları, üniversitelerin yalnızca çevrimiçi ders sunmakla sınırlı kalmamaları, bunun ötesinde benzersiz değer önerileri oluşturmaları gerektiğini ortaya koymaktadır. Stratejik farklılaşma, kurumların pedagojik tasarımları, teknolojik altyapıları, içerik kalitesi, uluslararası işbirlikleri ve öğrenci deneyimi üzerinden özgün bir konum elde etmelerini sağlayabilir.

- Teknolojik Altyapı Güçlendirilmesi: Üniversiteler, yapay zekâ tabanlı kişiselleştirilmiş öğrenme sistemleri, mobil uyumlu platformlar ve güvenli ölçme-değerlendirme araçlarıyla çevrimiçi eğitim süreçlerini desteklemelidir.
- Pedagojik Yenilikler: Oyunlaştırma, mikro öğrenme, ters yüz sınıf ve proje tabanlı öğrenme gibi çağdaş yöntemler kullanılarak öğrenci motivasyonu ve katılımı artırılmalıdır.

- İçerik ve Sertifikasyon Farklılaşması: Disiplinlerarası programlar, kısa dönem mikro sertifikalar ve uluslararası tanınırlığa sahip rozet sistemleri ile kurumlar küresel ölçekte cazibe merkezi olabilir.
- Akademik Kadro ve Endüstri İşbirliği: Öğretim üyelerinin dijital pedagojik yetkinlikleri geliştirilerek sektörel iş birlikleriyle uygulamaya dönük içerikler üretilmelidir.
- Öğrenci Deneyimi ve Destek Hizmetleri: Öğrencilere 7/24 çevrimiçi destek, mentorluk ve topluluk tabanlı öğrenme fırsatları sunularak bağlılık ve memnuniyet artırılmalıdır.
- Uluslararasılaşma Stratejileri: Çok dilli ders içerikleri ve yabancı üniversitelerle ortak programlar aracılığıyla uluslararası öğrenci kitlesine erişim sağlanmalıdır.

Yükseköğretim kurumlarının çevrimiçi eğitim yönetiminde stratejik farklılaşma yaklaşımı, yalnızca teknolojik bir zorunluluk değil, aynı zamanda marka değeri, öğrenci çekme kapasitesi ve akademik itibarı artıran kritik bir stratejik yönetim aracı olarak öne çıkmaktadır. Çevrimiçi eğitimde rekabet avantajı, stratejik farklılaşmaya dayanır. Farklılaşma, sürdürülebilir başarı için kritik bir unsur olarak değerlendirilmelidir. Dolayısıyla sürdürülebilir rekabet avantajı bağlamında yalnızca dış çevredeki konum değil, yükseköğretim kurumunu sahip olduğu benzersiz kaynak ve yetenekler rekabet avantajının sürdürülebilirliğini belirler. Yükseköğretim kurumlarının, çevrimiçi eğitimde stratejik olarak farklılaşmak için kaynaklarını ve stratejilerini düzenli gözden geçirmelidir. Yükseköğretim kurumsal yapısında çevrimiçi eğitimin yönetiminin özerk hale getirilmesi stratejik farklılaşmada atılacak önemli adımlardan biri olarak değerlendirilebilir. Bulgularda çevrimiçi eğitim yönetiminde stratejik farklılaşma yaklaşımlarının yükseköğretim kurumları için kritik öneme sahip olduğu ortaya konmakta ve dijital dönüşüm sürecinde kurumların yenilikçi yaklaşımlar geliştirmeleri gerektiği vurgulanmaktadır. Gelecekte konuyla ilgili diğer araştırmacılar tarafından yapılacak çalışmaların, birincil verilerle desteklenmesi ve farklı kurum örnekleri üzerinden karşılaştırmalı analizlerin yapılması önerilmektedir.

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Yapay Zeka Okuryazarlık Becerilerinin Geliştirilmesine Yönelik Tasarlanan Eğitim Platformunun Tanıtımı ve Okuryazarlığa Etkisi

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Özet

Bu çalışmada, yapay zekâ teknolojileri konusunda farkındalık oluşturmaya, bilgi ve becerileri geliştirmeye yönelik hazırlanmış olan web tabanlı eğitim uygulamasının okuryazarlığa etkisinin incelenmesi amaçlanmaktadır. Çalışma kapsamında, akademik çalışmalarda sıklıkla kullanılan yapay zekâ destekli araçlara (Consensus, ChatGPT, Deepseek,Semantic Scholar, SciSpace, NotebookLM, Thesify, DeepL, Julius) ilişkin tanıtıcı videolar ve bilgilendirici metinler içeren bir dijital eğitim platformu hazırlanmıştır. Platforma kayıt olan kullanıcılar, giriş yaptıktan sonra Polatgil ve Güler (2023) tarafından Türkçe'ye uyarlanan Yapay Zekâ Okuryazarlığı Ölçeği (YAPZEKO)'ni öntest olarak yanıtlayacaktır. Daha sonra platformdaki içerikleri ilgi ve ihtiyaçları doğrultusunda kullanabilecek ve sürecin sonunda aynı ölçek sontest olarak tekrar uygulanacaktır.

Bu araştırma, web tabanlı bir yapay zekâ eğitim platformunun bireylerin yapay zekâ okuryazarlık düzeylerine etkisini incelemeye yönelik olarak tasarlanmış tek grup öntest-sontest yarı deneysel desen kullanılarak yürütülecektir. Bu desen, müdahale öncesi ve sonrası ölçümler yapılarak uygulamanın etkisini değerlendirmek amacıyla sıklıkla tercih edilmektedir (Karasar, 2005). Katılımcılar 18-60 yaş aralığında yer alan yetişkin bireylerden oluşacaktır. Toplanan veriler SPSS programı kullanılarak analiz edilecektir. Yapay zekâ okuryazarlığı puanlarının, farklılaşması tekrarlayan ölçümler için t-testi ile incelenecektir. Ayrıca, kullanıcıların sistem üzerinde en çok etkileşimde bulundukları araçlar, içerik türleri ve platformdaki gezinme davranışları gibi veriler sistem kayıtları üzerinden toplanarak betimsel istatistiksel analizlerle sunulacaktır.

Bu çalışma sonucunda, dijital ortamda sağlanan yapay zekâ araçlarına ilişkin kısa eğitimlerin, bireylerin yapay zekâ okuryazarlığı üzerinde ne derece etkili olduğunun ortaya konulması hedeflenmektedir. Elde edilecek bulguların, akademik araştırma yöntemleri ve dijital beceri geliştirme süreçlerine katkı sağlaması beklenmektedir.

Keywords: Yapay Zekâ Okuryazarlığı, Web Tabanlı Eğitim, YAPZEKO, Dijital Okuryazarlık

The Introduction of an Educational Platform Designed to Enhance Artificial Intelligence Literacy Skills and Its Impact on AI Literacy

Abstract

This study aims to examine the impact of a web-based educational application developed to raise awareness and improve knowledge and skills regarding artificial intelligence (AI) technologies on individuals' AI literacy. Within the scope of the study, a digital education platform has been designed, featuring informative texts and introductory videos on frequently used AI-supported tools in academic work (such as Consensus, ChatGPT, Deepseek, Semantic Scholar, SciSpace, NotebookLM, Thesify, DeepL, and Julius). After registering to the platform, users will complete the Artificial Intelligence Literacy Scale (YAPZEKO), adapted into Turkish by Polatgil and Güler (2023), as a pre-test. Subsequently, they will interact with the platform's content based on their interests and needs. At the end of the process, the same scale will be administered again as a post-test.

This research will be conducted using a single-group pretest-posttest quasi-experimental design to assess the effect of the web-based AI training platform on participants' AI literacy levels. This design is frequently used to evaluate the effect of an intervention by comparing pre- and post-application measurements (Karasar, 2005). The participants will consist of adult individuals aged between 18 and 60. The collected data will be analyzed using the SPSS software. Changes in AI literacy scores will be examined using paired samples t-test. Additionally, data

such as the tools users interact with the most, the types of content accessed, and their navigation behaviors on the platform will be collected via system logs and presented through descriptive statistical analyses.

This study aims to reveal the extent to which short AI-related training sessions provided in digital environments influence individuals' AI literacy. The findings are expected to contribute to academic research methods and digital skill development processes.

Keywords: Artificial Intelligence Literacy, Web-Based Education, YAPZEKO, Digital Literacy

Giriş

Sağlıktan endüstriye, eğitimden ticarete, finanstan ulaşıma kadar birçok alanda kullanılan yapay zeka(YZ), insanların bu alanda kendilerini geliştirmelerini ve ortaya koyduğu yeniliklere uyum sağlamaları için gerekli becerileri edinmelerini zorunlu hâle getirmektedir (Erdoğan ve Kırılmaz, 2020; Wang, Rau ve Yuan, 2023).

YZ teknolojilerinin yaşamın her alanına entegre olmasıyla birlikte, bireylerin bu sistemleri yalnızca kullanabilmesi değil, aynı zamanda anlayabilmesi, sorgulayabilmesi ve etik biçimde yönlendirebilmesi de önemli hale gelmiştir. İnsanlar birçok alanda kullanılan YZ hizmetlerinin ve cihazlarının varlığını kabul etmekte, ancak bunların arkasındaki kavramlar ve teknoloji hakkında nadiren bilgi sahibi olmakta veya potansiyel etik sorunların farkında olmamaktadır (Burgsteiner, Kandlhofer ve Steinbauer, 2016; Ghallab, 2019). Bu noktada "yapay zeka okuryazarlığı" kavramı, bireylerin bu teknolojileri anlamlı, eleştirel ve etik bir şekilde kullanma yeterliliklerini kapsayan çok boyutlu bir yeterlilik alanı olarak tanımlanmaktadır (Long & Magerko, 2020; Pinski & Benlian, 2024).

YZ teknolojilerinin etkili kullanımının, bireylerin bu teknolojilere yönelik tutumlarını ve günlük kullanım alışkanlıklarını önemli ölçüde etkileyebileceği düşünülmektedir. Bu nedenle, YZ okuryazarlığını ölçmek ve geliştirmek tüm insanlığın bu teknolojilerden en verimli şekilde faydalanabilmesi için büyük önem arz etmektedir (Lee ve Choi, 2017; Luo, Tong, Fang ve Qu, 2019; Metelskaia, Ignatyeva, Denef ve Samsonowa, 2018). Çoğu insan YZ tabanlı hizmet ve cihazların varlığının farkındadır; ancak yapay zekâya dair kavram ve teknolojilere ilişkin bilgileri sınırlıdır (Burgsteiner, Kandlhofer & Steinbauer, 2016). YZ okuryazarlığı kavramı ise, yalnızca temel bilgi ve analitik değerlendirmeyi değil, aynı zamanda uzman olmayan bireylerin yapay zeka uygulamalarını eleştirel biçimde kullanabilme yeterliliğini de kapsamaktadır (Laupichler, Aster, Haverkamp & Raupach, 2023) YZ okuryazarlığının geliştirilmesi, bireylerin eğitim süreçlerinde daha etkili olmalarını sağlayarak, teknolojinin eğitim ile iletişim üzerindeki etkilerini artırabilir ve bu anlamda yapılan eğitimlerin, bireylerin problem çözme becerilerini ve eleştirel düşünme yeteneklerini geliştirmeye katkı sağlayacağı öngörülmektedir.

Yapılan sistematik analizlerde, YZ okuryazarlığının altı temel bileşeni tanımlanmıştır: "Tanıma", "Bilme ve Anlama", "Kullanma ve Uygulama", "Değerlendirme", "Yaratma" ve "Etik Olarak Yön Verme" (Almatrafi et al., 2024). Bu yapıların çeşitli yaş ve kullanıcı gruplarına göre farklı biçimlerde öne çıktığı ve ölçme araçlarının da bu bileşenler etrafında geliştirildiği vurgulanmaktadır.

Yükseköğretim kurumlarında öğrencilerin ve öğretim elemanlarının YZ kullanımına yönelik tutumları ve algıları incelenmiş, araştırmada, katılımcıların büyük bir kısmının YZ araçlarını yeterince tanımadığı ve yanlış kullanım ya da cezalandırma korkusu nedeniyle bu araçlardan uzak durduğu belirlenmiştir (Brown et al., 2024). YZ okuryazarlığının geliştirilmesi için etkili eğitim yöntemlerinin belirlenmesi büyük önem taşımaktadır. Bu durum, üniversitelerin bu alanda net ve rehberlik edici politikalar geliştirmesi gerektiğini de ortaya koymaktadır

Tüm bu çalışmalar, YZ okuryazarlığının yalnızca teknik bilgiyle sınırlı kalmadığını; etik, sosyal ve bilişsel boyutlarıyla çok katmanlı bir yapı olduğunu göstermektedir. Bireylerin yalnızca YZ araçlarını kullanabilen değil, aynı zamanda bu araçları bilinçli ve eleştirel bir şekilde değerlendirebilen kullanıcılar hâline gelmesini gerekli kılmaktadır. Bu alandaki okuryazarlığın artırılması, bireylerin teknolojiyi yalnızca tüketen değil, sorgulayan, yön veren ve dönüştüren birer aktör olmalarını sağlayabilir ve bu nedenle de, YZ okuryazarlığı dijital becerilerin önemli bir bileşeni olarak öne çıkmaktadır. Son yıllarda YZ araçlarının kullanımı üzerine çok sayıda eğitim içeriği olmasına rağmen, bu alanda hazırlanmış eğitim platformlarının YZ okuryazarlığı üzerine etkisinin literatürde yeterince araştırılmadığı görülmüştür.

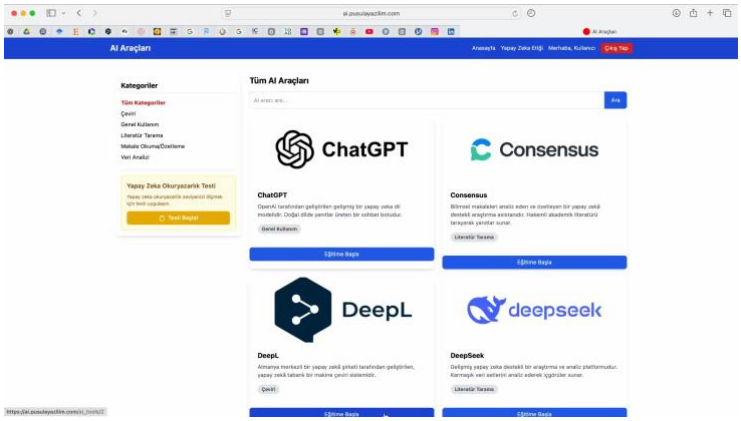
Bu amaçla, araştırmacılar tarafından, bireylerin YZ okuryazarlık becerilerinin geliştirilmesine ve YZ araçlarının tanıtımına yönelik dijital eğitim platformu tasarlanmasına ve pilot bir uygulama yapılmasına karar verilmiştir. Geliştirilen eğitim platformunun etkinliğinin değerlendirilmesi, YZ okuryazarlığının geliştirilmesine yönelik stratejilerin belirlenmesine de katkı sağlayacaktır.

Yöntem

Geliştirilen bu platform, kullanıcıların YZ teknolojilerine ilişkin farkındalıklarını artırmak ve temel kullanım becerilerini geliştirmek amacıyla tasarlanmıştır. Platforma erişim yalnızca kayıtlı kullanıcılar tarafından sağlanabilmektedir. Kullanıcılardan platforma giriş yaparak, eğitim süreci öncesinde ve eğitim sonrasında, YZ okuryazarlığını ölçmek amacı ile Polatgil ve Güler (2023) tarafından uyarlanan Yapay Zekâ Okuryazarlığı Ölçeğini (YAPZEKO) doldurmaları istenmektedir. Bu ölçek, bireylerin yapay zekâya ilişkin farkındalık, kullanım, değerlendirme ve etik düzeylerini ölçmeye yönelik hazırlanmış olup, kullanıcıların öğrenme süreçlerinin daha etkin ve kişiselleştirilmiş bir şekilde planlanmasına katkı sağlamaktadır.

Platform, öncelikle YZ etiği başlıklı bir video ile başlamaktadır. Kullanıcı deneyimini yapılandırmak amacıyla Çeviri, GenelKullanım, Literatür Tarama, Makale Okuma/Özetleme, Veri Analizi olmak üzere beş ana kategori altında organize edilmiştir. Bu kategorilerin her birinde, YZ tabanlı güncel araçların (ChatGPT, Consensus, DeepL, DeepSeek, Julius, NotebookLM, SciSpace, Semantic Scholar, Thesify) tanıtımına yer verilmiştir. Her araç için, temel işlevlerinin açıklandığı kısa ekran videoları, kullanım alanları, sağladığı avantajlar ve sınırlılıkları içeren bilgilendirici metinler sunulmaktadır.

Bu içerikler, kullanıcıların yalnızca araçları tanımasını değil, aynı zamanda hangi bağlamlarda en verimli şekilde kullanılabileceklerine dair farkındalık geliştirmelerini de amaçlamaktadır. Platformda yer alan materyaller kullanıcı merkezli, uygulamalı ve etkileşimli bir öğrenme anlayışıyla hazırlanmıştır. Böylelikle, platform sadece bilgi aktarımına dayalı değil; aynı zamanda eleştirel düşünme, karşılaştırmalı değerlendirme ve etik farkındalık gibi yüksek düzey bilişsel becerilerin desteklenmesini de hedeflemektedir.



Bu araştırmada tek grup ön test-son test zayıf deneysel desen kullanılmıştır. Katılımcı grubumuz web tabanlı platform adresinin paylaşılması yoluyla, YZ öğrenmeye ilgi duyan 18 yaş üstü bireylerin gönüllülük esasına dayalı katılım göstermesi ile oluşmuştur. Programa 55 kişi kayıt olmuş, bunlardan 20 kişi öntest ve son testi tamamlamıştır. Araştırmada erişilebilir örnekleme deseni kullanılmıştır. Bu durum, çalışmanın sınırlılıklarından biri olmakla birlikte, yapay zekâya ilgi duyan gerçek kullanıcı profilini yansıtması açısından önemlidir. Veri toplama aracı olarak Polatgil ve Güler tarafından Türkçe'ye uyarlanan Yapay Zekâ Okuryazarlığı Ölçeği (YAPZEKO) tercih edilmiştir. Süreçte, katılımcılar öncelikle platforma kayıt olmuş ve ön test formunu doldurmuşlardır. Ardından platform üzerindeki eğitim içeriklerini bireysel ilgi ve ihtiyaçlarına göre kullanmışlardır. Sürecin sonunda aynı ölçek son test olarak tekrar uygulanmıştır.

Verilerin Analizi:

Araştırmanın bulguları jamovi analiz programı kullanılarak elde edilmiştir. Analiz Türleri: Betimsel istatistikler (ortalama, medyan, standart sapma)

Katılımcıların ön test toplam puanlarının ortalaması 46.3, son test toplam puanlarının ortalaması ise 49.8 olarak bulunmuştur. Medyan değerler sırasıyla 46 ve 51.5'tir. Skewness ve kurtosis değerleri, dağılımların normal dağılıma uygun olduğunu desteklemektedir.

Descriptives		
	ÖN TEST TOPLAM PUAN	SON TEST TOPLAM PUAN
N	20	20
Missing	0	0
Mean	46.3	49.8
Median	46.0	51.5
Standard deviation	5.92	6.44
Minimum	36	37
Maximum	57	59
Skewness	0.246	-0.449
Std. error skewness	0.512	0.512
Kurtosis	-0.154	-0.569
Std. error kurtosis	0.992	0.992
SE	1.32	1.44

Ön test ve son test toplam puanlarının dağılımları incelenmiştir. Tüm testlerde $p > 0.05$ olduğu için veriler normal dağılım sergilemektedir. Ön test ve son test puanları arasındaki fark eşleştirilmiş t-testi ile analiz edilmiştir. Sonuçlar, son test puanlarının ön test puanlarına göre istatistiksel olarak anlamlı biçimde arttığını göstermektedir. Etki büyüklüğü Cohen's $d = 0.679$ olarak hesaplanmış olup, bu orta düzeyde bir etkinin varlığına işaret etmektedir.

Paired Samples T-Test

								95% Güven Aralığı	
			statistic	df	p		Effect Size	Lower	Üst
ÖN TEST TOPLAM PUAN	SON TEST TOPLAM PUAN	Student's t	-3.04	19.0	0.007	Cohen d	-0.679	-1.16	-0.184
Not. H_a $\mu_{Measure\ 1\ -\ Measure\ 2} \neq 0$									

Sonuçlar

Bu çalışmada eğitim platformunun yapay zeka okuryazarlığı üzerindeki etkisi 20 katılımcı üzerinde ön test ve son test karşılaştırmalı olarak analiz edilmiştir. Bulgular, uygulanan eğitim platformunun katılımcıların yapay zeka okuryazarlık düzeyini artırdığını ortaya koymaktadır. Normallik testlerinin sağlanması ve orta düzeydeki etki büyüklüğü, programın etkisinin hem istatistiksel hem de pratik olarak anlamlı olduğunu desteklemektedir. Bu nedenle, bu platformun ya da benzer eğitim içeriklerinin daha geniş öğrenme gruplarına uygulanması önerilmektedir.

Yapılan çalışmada yalnızca ön ve son test puanları değerlendirilmiştir. Programın kalıcı etkilerini belirleyebilmek için uzun dönem takip ölçümlerinin yapılması önemlidir. Araştırma yetişkinler üzerinde gerçekleştirilmiştir. Benzer eğitim içeriklerinin K-12 düzeyindeki öğrenciler üzerinde etkinliği de ileride araştırılabilir. Platforma 55

kişi kaydolmuş ama 20 kişi eğitimleri bitirerek son testi tamamlamıştır. Bu da benzer ortamlarda kullanıcı bağlılığının sorun olmaya devam ettiğini göstermekte olup, oyunlaştırma gibi kullanıcı bağlılığını artırıcı uygulamaların etkilerinin incelenmesi önerilmektedir.

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İstatistik Eğitiminde İstatistik Kaygısı Derecelendirme Ölçeğinin Güvenilirliğinin Değerlendirilmesi: Güvenilirlik Genellemesi Meta-Analizi

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Özet

İstatistik kaygısı, etkili öğrenme ve akademik başarı üzerinde bir engel oluşturabilmektedir. İstatistik derslerinde yüksek düzeyde kaygı yaşayan öğrenciler, derse karşı daha düşük katılım, başarısızlık ve olumsuz tutumlar sergileyebilmektedir. Bu nedenle, öğrencilerin kaygı düzeylerini değerlendirirken psikometrik açıdan güvenilir ölçme araçlarına başvurmak, eğitimciler ve araştırmacılar için kritik öneme sahiptir. Bu çalışmada, alanda yaygın olarak kullanılan bir ölçme aracı olan İstatistik Kaygısı Derecelendirme Ölçeği (Statistical Anxiety Rating Scale (STARS))'nin bileşenlerine ait iç tutarlılık katsayılarının farklı çalışmalardaki dağılımını incelemek üzere bir güvenilirlik genellemesi meta-analizi yapılması amaçlanmıştır. Dahil edilme kriterlerini karşılayan toplam 40 hakemli çalışma incelenmiş ve 10342 katılımcıya ait verilerden elde edilen 46 bağımsız Cronbach alfa katsayısı analiz edilmiştir. Sistematik derleme süreci REGEMA yönergelerine uygun şekilde yürütülmüştür. Analizlerde rassal etkiler modeli kullanılmış, orman grafiği (forest plot) çizilmiş, heterojenlik analizi (Q testi ve I^2 istatistiği) yapılarak yayın yanlılığı huni grafikleri ve Egger regresyon testi ile değerlendirilmiştir. Moderatör analizinde coğrafi bölge, eğitim düzeyi ve akademik disiplin gibi çeşitli değişkenleri içeren karma etkili bir meta-regresyon analizi yapılmıştır. Ölçek bileşenlerine ait güvenilirlik katsayıları 0,58 ile 0,97 arasında değişmekte olup, çalışmalar genelinde orta ile yüksek düzeyde iç tutarlılık göstermektedir. Egger testi sonuçlarına göre yayın yanlılığına dair anlamlı bir bulgu saptanmamıştır. Moderatör analizleri, iç tutarlılık katsayılarındaki farklılığın coğrafi bölge, eğitim düzeyi veya akademik disiplin gibi bağlamsal faktörlerle anlamlı biçimde açıklanamadığını göstermiştir. Bu durum, ölçeğin farklı eğitimsel ve kültürel düzeylerde geçerliliğini koruduğunu desteklemektedir. Elde edilen bulgular, ölçeğin psikometrik açıdan sağlam olduğunu ve farklı öğrenci gruplarında istatistik kaygısını değerlendirmede etkili bir araç olarak kullanılabileceğini ortaya koymaktadır. İstatistik eğitimi ve psikolojik ölçme alanlarında yapılacak gelecekteki araştırmalarda, ölçümlerin güvenilirliğini sistematik ve şeffaf biçimde değerlendirebilmek adına güvenilirlik genellemesi yöntemlerinin daha yaygın olarak kullanılması önerilmektedir.

Anahtar Kelimeler: İstatistik Kaygısı, Güvenilirlik Genellemesi, Meta-Analiz, Cronbach Alfa, İstatistik Kaygısı Derecelendirme Ölçeği, STARS

Evaluating the Reliability of Statistical Anxiety Rating Scale (STARS) in Statistics Education: A Reliability Generalization Meta-Analysis

Abstract

Statistics anxiety is a well-documented barrier to effective learning and academic success in quantitative disciplines. Students who experience high levels of anxiety in statistics courses may demonstrate reduced engagement, lower achievement, and negative attitudes toward the subject. Accordingly, educators and researchers must rely on psychometrically robust instruments when evaluating students' anxiety levels. This study aimed to perform a reliability generalization (RG) meta-analysis of the *Statistical Anxiety Rating Scale* (STARS), a widely used measure in the field, to assess the internal consistency of its component scores across diverse empirical applications. A total of 40 peer-reviewed studies met the inclusion criteria, producing 46 independent Cronbach's alpha coefficients based on data from 10,342 individuals. The systematic review was carried out following the REGEMA guidelines. A random-effects model was used to obtain pooled reliability estimates, and publication bias was assessed via funnel plots and Egger's regression test. To explore potential sources of heterogeneity, a mixed-effects meta-regression was conducted using several moderators, including geographic region, educational level, and academic discipline. The pooled reliability estimates for the STARS subscales ranged from 0.58 to 0.97, indicating moderate to high internal consistency across studies. Furthermore, Egger's regression tests revealed no significant evidence of publication bias. Moderator analyses revealed that geographic location, educational level, and academic discipline did not significantly account for variability in internal consistency estimates. The STARS is not meaningfully influenced by these contextual factors, further supporting its broad applicability in psychological and educational research. These results support the psychometric robustness of the instrument and confirm its utility in assessing statistics anxiety among diverse student populations in various educational and cultural contexts. It is recommended that future research on statistics education and psychological measurement more frequently utilize RG approaches to ensure reliability is systematically and transparently evaluated.

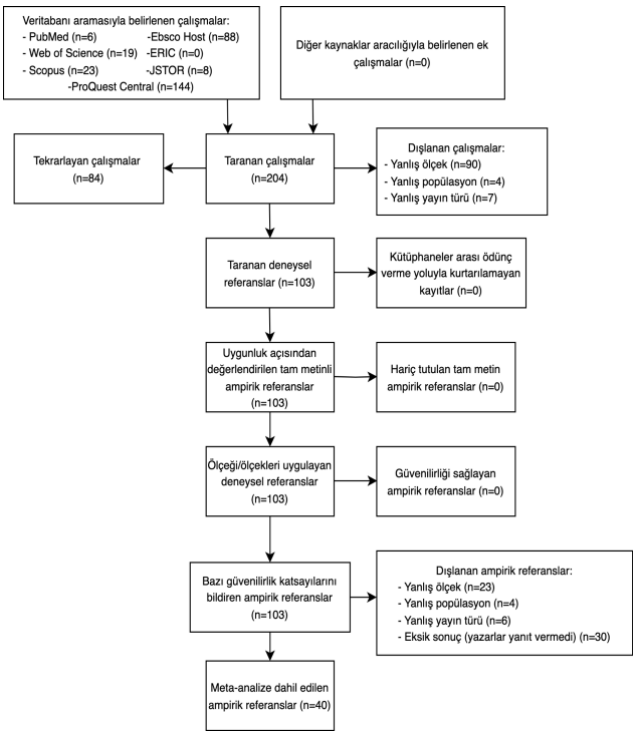
Keywords: statistics anxiety, reliability generalization, meta-analysis, STARS, Cronbach's alpha

Giriş

İstatistik, verilerin sistematik biçimde toplanması, analiz edilmesi ve yorumlanmasına ilişkin yöntemleri kapsayan temel bir bilim dalıdır ve birçok disiplinde zorunlu ders niteliği taşımaktadır (Hand, 2008). Ancak soyut yapısı nedeniyle öğrencilerde sıkça kaygı uyandırmaktadır. İstatistik kaygısı, genel kaygı ve matematik kaygısından ayrışan, istatistiksel içeriklere yönelik bilişsel, duyuşsal ve davranışsal tepkileri içeren özgün bir yapıdır (Baloglu, 1999; Primi & Donati, 2023). Bu kaygı, akademik performansın yanı sıra öğrencilerin öğrenme motivasyonu ve istatistiğe yönelik tutumlarını da olumsuz etkilemektedir (Fitzgerald et al., 1996; Onwuegbuzie, 2000). İstatistik kaygısının doğru ölçülmesi hem bireysel destek stratejilerinin geliştirilmesi hem de öğretim programlarının iyileştirilmesi açısından önemlidir (Onwuegbuzie & Wilson, 2003). Bu amaçla geliştirilen ölçeklerden en yaygını, altı boyutlu yapısıyla İstatistik Kaygısı Derecelendirme Ölçeği'dir (STARS; Cruise et al., 1985). STARS'ın farklı kültürlerde yapılan faktör analizleri ölçeğin geçerli ve güvenilir olduğunu göstermektedir (Liu et al., 2011; Papousek et al., 2012). Güvenilirlik değerlendirmelerinde en sık kullanılan Cronbach alfa katsayısı, örnekleme bağlı farklılıklar gösterebildiğinden, aynı ölçek farklı çalışmalarda değişen sonuçlar verebilmektedir (Bonett, 2002). Bu değişkenliği değerlendirmek üzere güvenilirlik genellemesi (Reliability Generalization, RG) meta-analizi önerilmektedir (Henson & Thompson, 2002). Ancak STARS için bugüne dek tüm alt boyutları kapsayan bir RG çalışmasına rastlanmamıştır. Bu araştırmada, STARS'ın alt boyutlarına ait Cronbach alfa değerlerinin sistematik biçimde sentezlenmesi ve güvenilirlik katsayılarındaki farklılıkların olası moderatörler (eğitim düzeyi, coğrafi bölge, akademik disiplin) açısından incelenmesi amaçlanmıştır. Böylece, istatistik kaygısı araştırmalarında kullanılan ölçümlerin metodolojik gücüne katkı sağlanması hedeflenmektedir.

Yöntem

STARS, istatistik kaygısını ölçmek üzere geliştirilmiş 51 maddelik, altı boyutlu (istatistiğin değeri, yorumlama kaygısı, sınav ve ders kaygısı, hesaplama öz-yeterliliği, yardım isteme korkusu, öğretim elemanından duyulan kaygı) bir Likert ölçeğidir (Cruise et al., 1985). Çok boyutlu yapısı sayesinde öğrencilerin farklı kaygı bileşenleri ayrı ayrı değerlendirilebilmektedir. Ölçeğin orijinal çalışmasında alt boyutların Cronbach alfa değerleri 0,68–0,94 arasında bulunmuş ve güvenilirliği doğrulanmıştır. Bu meta-analiz, güvenilirlik genellemesi araştırmalarında önerilen REGEMA kontrol listesi (Sánchez-Meca et al., 2021) temel alınarak yürütülmüştür (Şekil 1).



Şekil 1. Çalışmaların Tarama Süreci (REGEMA Akış Diyagramı)

Dahil edilme kriterleri: (i) STARS'ın orijinal versiyonunu kullanmak, (ii) öğrenci örneklemleri üzerinde uygulanmış olmak ve (iii) en az bir alt boyut için Cronbach alfa katsayısı raporlamaktır. Kongre bildirileri, sistematik derlemeler, alfa değeri içermeyen veya öğrenci dışı örneklemlerle yapılmış çalışmalar kapsam dışı bırakılmıştır. Literatür taraması PubMed, Scopus, Web of Science, EBSCOhost, ERIC, JSTOR ve ProQuest Central veri tabanlarında 2004–2024 dönemi için gerçekleştirilmiştir. Aramalarda "statistics anxiety rating scale" anahtar sözcüğü kullanılmıştır. Başlangıçta 288 çalışma tespit edilmiş, tekrarlar ve uygun olmayan kayıtlar Rayyan yazılımı (Ouzzani et al., 2016) ile ayıklanmıştır. İki bağımsız araştırmacı tarafından yapılan seçim sürecinde görüş

ayrılıkları müzakere ile çözülmüş ve Cohen's kappa=0,89 bulunmuştur. Nihai olarak 40 çalışma ve 46 bağımsız Cronbach alfa değeri analize dahil edilmiştir. Her çalışma için yıl, örneklem büyüklüğü, ülke, eğitim düzeyi, akademik alan ve alt boyutlara ait alfa katsayıları kodlanmıştır. Meta-analizler R (v4.4.1) kullanılarak "*metafor*" ve "*meta*" paketleriyle yapılmıştır (Viechtbauer, 2010). Heterojenlik Cochran'ın Q ve I^2 istatistikleri ile değerlendirilmiş; %25, %50 ve %75 değerleri sırasıyla düşük, orta ve yüksek heterojenlik olarak yorumlanmıştır (Higgins & Thompson, 2002). Yayın yanlılığı huni grafikleri ve Egger testi ile incelenmiştir (Egger et al., 1997). Olası heterojenlik kaynaklarını belirlemek üzere meta-regresyon analizlerinde katılımcıların eğitim düzeyi, akademik disiplini ve çalışmanın yürütüldüğü coğrafi bölge moderatör olarak test edilmiştir.

Bulgular

Veritabanı taramaları sonucunda 288 çalışma saptanmış, uygunluk değerlendirmeleri sonrası 40 çalışma meta-analize dahil edilmiştir. Dört çalışmada birden fazla ölçüm zamanı raporlandığından toplam 46 bağımsız Cronbach alfa katsayısı analiz edilmiştir. STARS ölçeğinin alt boyutlarına ilişkin Cronbach alfa güvenirlik katsayılarının meta-analiz sonuçları Şekil 2'de sunulmuştur. Alt boyutlara ilişkin bulgular incelendiğinde, Yorumlama Kaygısı alt ölçeği yüksek iç tutarlılık göstermiş (α=0,87) ve heterojenlik düşük düzeyde bulunmuş, yayın yanlılığına rastlanmamıştır. Sınav ve Ders Kaygısı alt ölçeğinde de yüksek güvenilirlik (α=0,86) elde edilmiş, heterojenlik orta düzeyde (I^2=%37) olmasına rağmen yayın yanlılığı tespit edilmemiştir. Yardım İstemekten Korkma alt ölçeği iyi düzeyde güvenilirlik sunmuş (α=0,82) ve heterojenlik düşük–orta düzeyde (I^2=%26) bulunmuş, yine yayın yanlılığı görülmemiştir. İstatistiğin Değeri alt ölçeği en yüksek güvenilirlik katsayısına sahip olmuş (α=0,93), sonuçlar oldukça homojen (I^2=%3) ve yayın yanlılığı açısından sorunsuzdur. Hesaplama Öz-Yeterliği alt ölçeğinde yüksek güvenilirlik (α=0,87) ve düşük heterojenlik (I^2=%7) elde edilmiş, ancak yayın yanlılığı sınırda anlamlılık göstermiştir. Son olarak, İstatistik Öğretmeninden Korkma alt ölçeği kabul edilebilir düzeyde güvenilirlik (α=0,80) sunarken, heterojenlik orta düzeyde (I^2=%37) bulunmuş ve yayın yanlılığına dair anlamlı kanıtlar saptanmıştır. STARS alt boyutlarına ilişkin Cronbach α katsayıları, heterojenlik düzeyleri ve yayın yanlılığı sonuçları Tablo 1'de özetlenmiştir.

Tablo 1. STARS Alt Boyutlarının Güvenilirlik Genellemesi Bulguları

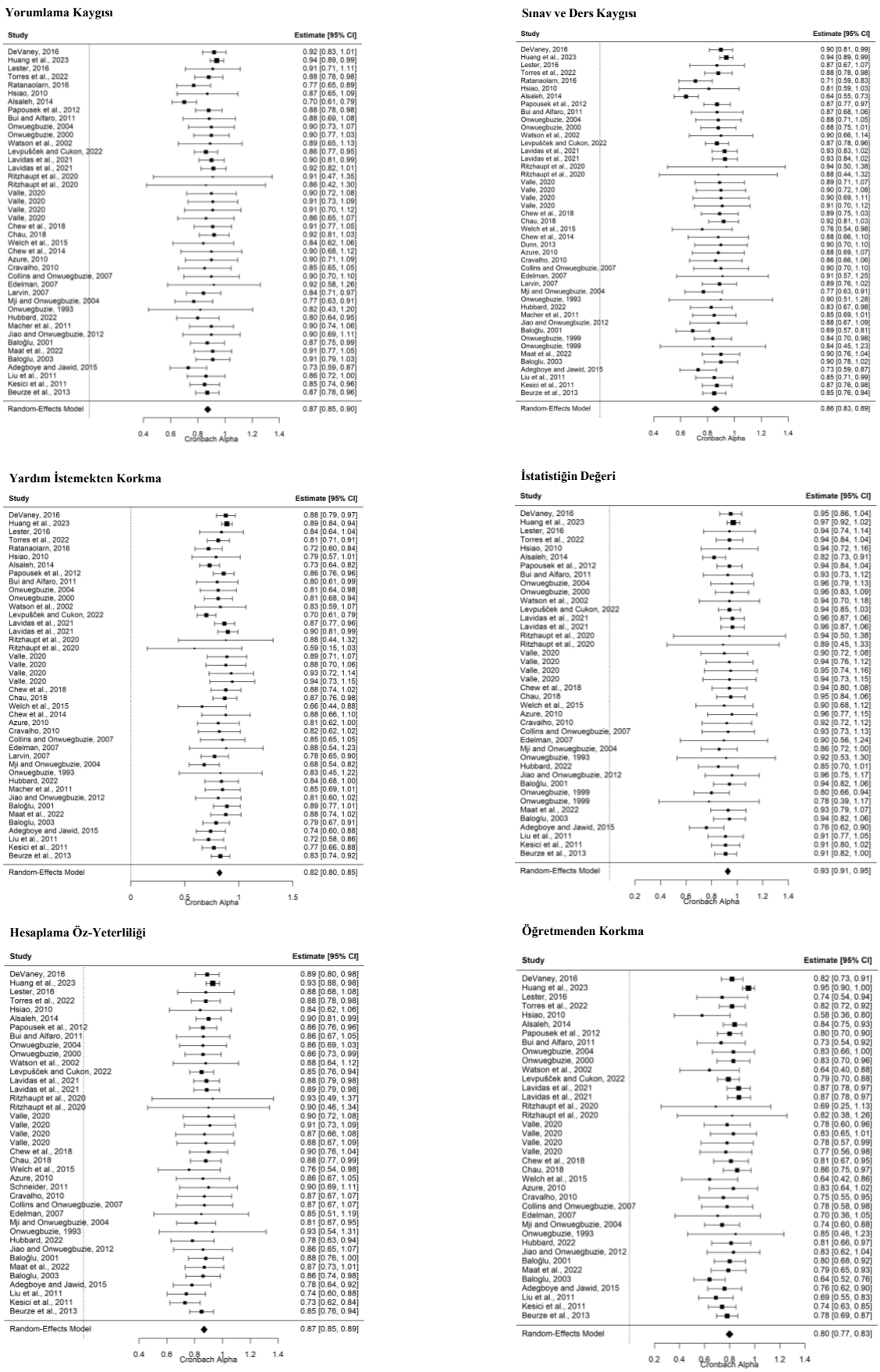
STARS Boyutları	Cronbach α	%95 GA	Heterojenlik (I^2)	Yayın Yanlılığı	Psikometrik Durum
Yorumlama Kaygısı	0,87	0,85-0,90	%20,1 (Düşük)	Yok (p=0,260)	Mükemmel
Sınav ve Ders Kaygısı	0,86	0,83-0,89	%36,5 (Orta)	Yok (p=0,293)	Çok İyi
Yardım İstemekten Korkma	0,82	0,80-0,85	%26,1 (Orta)	Yok (p=0,247)	İyi
İstatistiğin Değeri	0,93	0,91-0,95	%3,3 (Çok Düşük)	Sınırda (p=0,099)	Mükemmel
Hesaplama Öz-Yeterliliği	0,87	0,85-0,89	%7,3 (Düşük)	Sınırda (p=0,055)	Çok İyi
Öğretmenden Korkma	0,80	0,77-0,83	%37,0 (Orta)	Var (p<0,001)	Kabul Edilebilir

Moderatör analizleri sonucunda, coğrafi bölge, eğitim düzeyi ve akademik disiplin değişkenlerinin güvenilirlik katsayılarındaki farklılıkları açıklamada genel olarak anlamlı bir etkisi olmadığı görülmüştür. Bununla birlikte, yalnızca Hesaplama Öz-Yeterliği alt boyutunda akademik disiplin değişkeni sınırda anlamlılık göstermiş, bu da özellikle sosyal ve fen bilimleri grupları arasında potansiyel farklılıklar olabileceğine işaret etmiştir. Genel olarak, STARS'ın farklı eğitim düzeylerinde, akademik disiplinlerde ve coğrafi bölgelerde güvenilirliğini koruduğu, ancak güvenilirlikteki küçük varyasyonların anlaşılabilmesi için daha geniş örneklemler ve farklı moderatör değişkenlerin incelenmesine ihtiyaç duyulduğu sonucuna ulaşılmıştır.

Sonuçlar

Bu meta-analiz, STARS'ın altı alt boyutuna ait Cronbach alfa katsayılarını sistematik biçimde sentezlemiş ve ölçeğin genel olarak yüksek düzeyde güvenilir olduğunu göstermiştir. En yüksek iç tutarlılık "İstatistiğin Değeri" (α≈0,93), en düşük ise "İstatistik Öğretmeninden Kaygı" (α≈0,80) alt boyutunda bulunmuş; diğer boyutlar α=0,82–0,87 aralığında güvenilir sonuçlar vermiştir. Heterojenlik düzeyleri genellikle düşük ya da orta seviyede olup, yayın yanlılığı yalnızca öğretmen kaygısı boyutunda anlamlı bulunmuştur. Moderatör analizleri, coğrafi bölge, eğitim düzeyi ve akademik disiplinin güvenilirlik katsayılarını anlamlı biçimde etkilemediğini, yalnızca hesaplama öz-yeterliği boyutunda disiplin değişkeninin sınırda anlamlılık gösterdiğini ortaya koymuştur. Bu bulgular, STARS'ın farklı bağlamlarda güvenilirliğini koruduğunu, ancak belirli boyutlarda disipline bağlı farklılıkların daha ayrıntılı araştırılması gerektiğini düşündürmektedir.

Sonuçlar, STARS'ın istatistik kaygısını çok boyutlu yapısıyla geçerli ve güvenilir biçimde ölçebildiğini desteklemekte ve ölçeğin hem araştırma hem de eğitim ortamlarında güvenle kullanılabileceğini göstermektedir.



Şekil 2. STARS ölçeği alt boyutlarına ait Cronbach alfa güvenirlik katsayılarının meta-analizi orman grafikleri (forest plots)

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Dijital Çağda Öğretmenlerin Siber Güvenlik Profili: Balıkesir İli Örneklemi

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Özet

Günümüz dünyasında, eğitimden sağlığa, bankacılıktan kamu hizmetlerine kadar yaşamın her alanı hızla dijitalleşmektedir. Bu dijital dönüşüm, verimlilik ve erişim kolaylığı gibi önemli avantajlar sunarken, aynı zamanda bireyleri ve kurumları veri hırsızlığı, oltalama saldırıları ve siber gasp gibi giderek karmaşıklaşan tehditlerle karşı karşıya bırakmaktadır. Bu bağlamda siber güvenlik, yalnızca teknik bir altyapı sorunu olmaktan çıkıp, dijital vatandaşlığın temel bir bileşeni ve toplumsal dayanıklılığın vazgeçilmez bir unsuru haline gelmiştir. Özellikle eğitim ekosisteminde, siber güvenlikte en zayıf halka olarak kabul edilen 'insan faktörü' kritik bir rol oynamaktadır. Öğretmenler, bu ekosistemde hem öğrencilerin kişisel verilerini koruyan birer 'güvenlik bekçisi' hem de gelecek nesillere dijital okuryazarlık becerileri kazandıran birer 'dijital rehber' olarak çift yönlü bir sorumluluk üstlenmektedir. Bu kritik rolden hareketle, araştırmanın amacı, öğretmenlerin siber güvenlik algı ve uygulamalarını çok boyutlu bir çerçevede incelemek ve bu algıların çeşitli demografik değişkenlere göre nasıl farklılaştığını ortaya koymaktır. Araştırmada, nicel araştırma yöntemlerinden tarama modeli kullanılmıştır. Veriler, Balıkesir ilinde görev yapan 68 öğretmenden, Arpacı ve Sevinç (2021) tarafından geliştirilen "Siber Güvenlik Ölçeği" aracılığıyla toplanmıştır. Verilerin analizinde betimsel istatistikler ile normallik varsayımının karşılanmadığı durumlarda Mann-Whitney U ve Kruskal-Wallis H testleri kullanılmıştır. Araştırma bulguları, öğretmenlerin genel olarak siber güvenliğe yönelik olumlu bir algıya sahip olduğunu göstermiştir. Katılımcıların cinsiyet ve yaş değişkenlerine göre siber güvenlik puanlarında anlamlı bir farklılık tespit edilmemiştir. Mesleki tecrübe değişkeninin ise yalnızca "Kullanılabilirlik" alt boyutunda anlamlı bir farklılık yarattığı görülmüştür ($p < .05$). Araştırmanın en dikkat çekici bulgusu, siber güvenlik konusunda formal bir eğitim almayan öğretmenlerin, "Gizlilik" ve "Kontrol/Sahiplik" alt boyutlarında eğitim alan meslektaşlarına göre istatistiksel olarak anlamlı düzeyde daha yüksek puanlara sahip olmasıdır. Bu durum, formal eğitimlerin, bilgi eksikliğinden kaynaklanan aşırı temkinli tutumları rasyonel bir risk algısına dönüştürebileceğine işaret etmektedir. Sonuçlar, öğretmenlere yönelik siber güvenlik eğitimlerinin, sadece teknik becerilere değil, aynı zamanda doğru risk algısı yönetimine de odaklanması gerektiğini ortaya koymaktadır.

Anahtar Kelimeler: siber güvenlik, siber güvenlik farkındalığı, insan faktörü.

Teachers' Cybersecurity Profile in the Digital Age: A Sample from Balıkesir Province

Abstract

In the contemporary world, every aspect of life — from education and health to banking and public services — is undergoing rapid digitalization. This digital transformation offers significant advantages, such as enhanced efficiency and ease of access, yet it simultaneously exposes individuals and institutions to increasingly complex threats, including data theft, phishing attacks, and cyber extortion. In this context, cybersecurity has evolved from merely being a technical infrastructure issue to a fundamental component of digital citizenship and an essential element of societal resilience.

Specifically within the educational ecosystem, the “human factor,” often considered the weakest link in cybersecurity, plays a critical role. Teachers, in this environment, assume a dual responsibility: they act as “security guardians,” protecting students’ personal data, and as “digital guides,” imparting digital literacy skills to future generations. Building on this critical role, this research aims to investigate teachers’ cybersecurity perceptions and practices within a multidimensional framework and to examine differences across demographic variables.

The study employed a quantitative research design using a survey-based approach. Data were collected from 68 teachers working in Balıkesir province, Turkey, using the Cybersecurity Scale developed by Arpacı and Sevinç

(2021). Data analysis involved descriptive statistics along with the Mann-Whitney U and Kruskal-Wallis H tests when the assumption of normality was not met.

The findings indicate that teachers generally possess positive attitudes and awareness regarding cybersecurity. No statistically significant differences were found based on gender and age. However, professional experience revealed a significant difference only in the “Usability” sub-dimension ($p < .05$). The most striking finding of the study is that teachers who had not received formal cybersecurity training scored significantly higher in the “Confidentiality” and “Control/Ownership” sub-dimensions compared to their colleagues who had received such training. This suggests that formal training may transform overly cautious attitudes — often resulting from a lack of information — into a more rational perception of risk. The study concludes that cybersecurity training programs for teachers should focus not only on technical skills but also on cultivating accurate risk perception management.

Keywords: Cybersecurity, Cybersecurity Awareness, Human Factor

Giriş

Günümüz bilgi toplumunda dijital teknolojilerin yaygınlaşması, bireylerin ve kurumların gündelik yaşam pratiklerini köklü bir biçimde dönüştürmüştür. Bankacılıktan sağlığa, eğitimden kamu hizmetlerine kadar pek çok temel faaliyet, internet tabanlı platformlar üzerinden yürütülmektedir. Türkiye İstatistik Kurumu (TÜİK) tarafından yayımlanan 2024 yılı verileri, bu dijital entegrasyonun boyutunu açıkça ortaya koymaktadır: 16-74 yaş grubundaki bireylerin internet kullanım oranı %88,8’e ulaşmış, e-devlet gibi kamu hizmetlerinden yararlananların oranı ise %73,7 olarak gerçekleşmiştir (*Hanehalkı Bilişim Teknolojileri (BT) Kullanım Araştırması*, 2024). Bu dijitalleşme, bireylere hız, erişim kolaylığı ve verimlilik gibi önemli fırsatlar sunarken, aynı zamanda veri hırsızlığı, kimlik sahtekarlığı, oltalama (phishing) saldırıları ve siber gasp gibi ciddi güvenlik risklerini de beraberinde getirmektedir. Bu bağlamda, dijital varlıkların ve kişisel mahremiyetin korunması hem bireysel hem de toplumsal düzeyde kritik bir öncelik haline gelmiştir.

Siber güvenlik, bu yeni tehdit ortamında dijital dünyanın temel yapı taşı olarak öne çıkmaktadır. Uluslararası Standartlar ve Teknoloji Enstitüsü (NIST), siber güvenliği "saldırıları önleyerek, tespit ederek ve bunlara yanıt vererek bilgiyi, sistemleri ve ağları koruma süreci" olarak tanımlarken, Uluslararası Telekomünikasyon Birliği (ITU) ise bu kavramı daha geniş bir çerçevede ele alarak "siber ortamı, kuruluş ve kullanıcı varlıklarını korumak için kullanılabilecek araçlar, politikalar, güvenlik kavramları, kılavuzlar, risk yönetimi yaklaşımları, eylemler, eğitim, en iyi uygulamalar, güvence ve teknolojiler bütünü" olarak belirtmektedir (Solms & Niekerk, 2013). Bu tanımlar, siber güvenliğin yalnızca teknolojik önlemlerden ibaret olmadığını, aynı zamanda insan, süreç ve politika boyutlarını da içeren çok katmanlı bir yapıya sahip olduğunu göstermektedir.

Siber Güvenliğin Zayıf Halkası: İnsan Faktörü

Gelişmiş güvenlik yazılımları, şifreleme teknolojileri ve ağ savunma mekanizmalarına rağmen, siber güvenlik alanındaki en zayıf halkanın "insan faktörü" olduğu, akademik literatürde ve endüstri raporlarında sıklıkla vurgulanan bir gerçektir (Linkov vd., 2019). Yapılan araştırmalar, başarılı siber saldırıların ve veri ihlallerinin %90 ila %95 gibi ezici bir çoğunluğunun, doğrudan veya dolaylı olarak insan hatasından kaynaklandığını göstermektedir (Lugo vd., 2023). Bu hatalar; dikkatsizlik, bilgi eksikliği, ihmal veya sosyal mühendislik taktiklerine kanma gibi çeşitli biçimlerde ortaya çıkabilmektedir. Dolayısıyla, siber güvenlik stratejilerinin başarısı, yalnızca teknolojik altyapının gücüne değil, aynı zamanda kullanıcıların bilgi, tutum ve davranışlarına da bağlıdır.

Bu noktada, siber güvenlik farkındalığı ile güvenli davranış arasındaki ilişki, doğrusal ve basit bir denklem değildir. Literatür, bireylerin siber riskler hakkında bilgi sahibi olmalarının, her zaman güvenli davranışlar sergileyecekleri anlamına gelmediğini ortaya koyan "farkındalık-davranış açığı" (awareness-behavior gap) olgusuna dikkat çekmektedir. Kullanıcılar, genellikle güvenlik ve kolaylık arasında bir seçim yapmak zorunda kalmakta ve daha pratik olan ancak daha riskli olan seçeneğe yönelebilmektedirler. Örneğin, karmaşık ve benzersiz parolalar oluşturmanın önemini bilmelerine rağmen, hatırlanması kolay ve birden fazla hesapta aynı olan parolaları tercih etmeleri bu duruma tipik bir örnektir. Bu durum, siber güvenlik probleminin çözümünün, sadece teknik bilgi aktarımından daha fazlasını gerektirdiğini; bireylerin motivasyonlarını, algılarını, alışkanlıklarını ve karar verme süreçlerini anlamayı zorunlu kıldığını göstermektedir. Bu nedenle, siber güvenlik, salt bir teknoloji sorunu olmaktan çıkıp, davranışsal ve psikolojik boyutları olan sosyo-teknik bir mesele olarak ele alınmalıdır.

Eğitim Ekosisteminin Stratejik Önemi ve Kırılganlığı

İnsan faktörünün kritik rol oynadığı alanların başında eğitim kurumları, özellikle de ilk seviye okulları gelmektedir (Arishia vd., 2024; McCampbell, 2025; Richardson vd., 2020). Okullar, dijital dönüşüm sürecinde hem büyük fırsatlar yakalamış hem de yeni ve ciddi risklerle karşı karşıya kalmıştır. Bu kurumlar, siber suçlular için oldukça cazip hedeflerdir çünkü öğrenci ve personel kimlik bilgileri, sağlık kayıtları, ailevi detaylar ve akademik veriler

gibi büyük miktarda hassas ve değerli bilgiyi barındırırlar (Arishia vd., 2024; Juan, 2024). Bununla birlikte, okulların genellikle açık erişimi ve bilgi paylaşımını teşvik eden kültürel yapısı, sınırlı bilişim teknolojileri (BT) bütçeleri ve siber güvenlik alanında uzman personel eksikliği gibi faktörler, onları siber saldırılara karşı daha da savunmasız kılmaktadır.

Bu hassas ekosistem içerisinde öğretmenler, kilit bir rol üstlenmektedir. Öğretmenler, yalnızca dijital teknolojileri kullanan birer son kullanıcı değil, aynı zamanda çift yönlü bir sorumluluğa sahip stratejik aktörlerdir (Arishia vd., 2024; Gallego-Arrufat vd., 2024). Bir yandan, kurumsal verilerin ve öğrencilerin kişisel bilgilerinin güvenliğinden sorumlu birer "veri koruyucusu" olarak hareket ederler. Diğer yandan ise, dijital çağın vatandaşlarını yetiştiren, onlara güvenli internet kullanımı, eleştirel düşünme ve siber tehditleri tanıma becerilerini kazandıran birer "dijital rehber" konumundadırlar. Bu çift rol, öğretmenlerin siber güvenlik yetkinliklerinin önemini katbekat artırmaktadır. Bir öğretmenin siber güvenlik konusundaki bilgi, algı ve uygulama düzeyi, yalnızca kendi kişisel ve kurumsal verilerini değil, aynı zamanda sorumlu olduğu tüm öğrencilerin dijital refahını da doğrudan etkilemektedir. Yetersiz güvenlik pratiğine sahip bir öğretmen, farkında olmadan tüm sınıfı ve okulu riske atabilirken; yetkin bir öğretmen ise kurumun güvenlik duruşunu güçlendiren ve öğrenciler için pozitif bir rol model oluşturan bir "insan güvenlik duvarı" işlevi görebilir. Bu durum, öğretmen yetkinliğinin "çarpan etkisi" yarattığını ve okullarda siber güvenliği artırmaya yönelik en yüksek kaldıraç etkisine sahip müdahale alanlarından biri olduğunu göstermektedir.

Araştırma Problemi, Amaç ve Önem

Siber güvenlikte insan faktörünün ve özellikle eğitim ortamlarının kritik önemine rağmen, Türkiye'deki öğretmenlerin siber güvenlik algı ve uygulamalarını bütüncül bir yaklaşımla ele alan çalışmaların sayısı sınırlıdır. Mevcut araştırmalar genellikle üniversite öğrencileri veya farklı sektörlerdeki çalışanlar üzerine yoğunlaşmıştır (Bottyan, 2023; Çalişkan, 2025; Karacı vd., 2017). Öğretmenlerin benzersiz ve stratejik rolü göz önüne alındığında, bu alandaki mevcut durumun ampirik verilerle ortaya konulması büyük önem taşımaktadır.

Bu çalışmanın temel amacı, Balıkesir ilinde görev yapan öğretmenlerin siber güvenlik algı ve uygulamalarını, Sevinç ve Arpacı (2021) tarafından geliştirilen ve uluslararası literatürde kabul görmüş Parkerian Hexad modeline dayanan "Siber Güvenlik Ölçeği" (CS-S) aracılığıyla kapsamlı bir şekilde incelemektir (Arpaci & Sevinc, 2022). Bu model; Gizlilik, Kontrol/Sahiplik, Bütünlük, Özgünlük, Kullanılabilirlik ve Fayda olmak üzere altı temel boyutta bireylerin siber güvenlik yetkinliklerini değerlendirmek için sağlam bir teorik çerçeve sunmaktadır. Bu doğrultuda çalışma, aşağıdaki temel araştırma sorularına yanıt aramaktadır:

1. Öğretmenlerin siber güvenlik algı ve uygulama düzeyleri, ölçeğin altı boyutunda ne durumdadır?
2. Bu düzeyler; cinsiyet, yaş, mesleki tecrübe, bilişim teknolojileri eğitimi alma durumu ve siber güvenlik eğitimi alma durumu gibi temel demografik ve mesleki değişkenlere göre anlamlı bir farklılık göstermekte midir?

Bu araştırma, öğretmenlerin siber güvenlik konusundaki mevcut durumlarına ilişkin kanıta dayalı bir tablo sunarak, onların güçlü ve zayıf yönlerini tespit etmeyi hedeflemektedir. Elde edilecek bulguların, Türkiye'deki eğitim sistemi için daha etkili, hedefe yönelik ve uygulamalı siber güvenlik eğitim programlarının ve politikalarının geliştirilmesine rehberlik etmesi beklenmektedir. Bu sayede, eğitim ekosisteminin en önemli unsuru olan öğretmenlerin yetkinliklerini artırarak, okulların dijital tehditlere karşı dayanıklılığının güçlendirilmesine katkı sağlanması amaçlanmaktadır.

Yöntem

Bu araştırmada, öğretmenlerin siber güvenlik algı ve uygulamalarını mevcut durumları ile betimlemek ve bu algıları çeşitli demografik değişkenler açısından karşılaştırmak amacıyla nicel araştırma yöntemlerinden tarama (survey) modeli kullanılmıştır. Tarama modeli, bir konuya veya olaya ilişkin katılımcıların görüşlerinin, ilgilerinin, becerilerinin veya tutumlarının ne olduğunu belirlemek amacıyla kullanılan bir araştırma yaklaşımıdır.

Çalışma Grubu

Araştırmanın çalışma grubunu, 2023-2024 eğitim-öğretim yılında Balıkesir ilindeki çeşitli devlet okullarında görev yapan ve araştırmaya gönüllü olarak katılan 68 öğretmen oluşturmaktadır. Katılımcıların belirlenmesinde kolayda örnekleme yöntemi kullanılmıştır.

Veri Toplama Aracı

Araştırmanın nicel verileri, Arpacı ve Sevinç (2021) tarafından geliştirilen “Siber Güvenlik Ölçeği (CS-S)” kullanılarak toplanmıştır (Arpaci & Sevinc, 2022). Ölçek, 5’li Likert tipinde (“1-Kesinlikle Katılmıyorum” ile “5-Kesinlikle Katılıyorum” arasında) derecelendirilmiş maddelerden oluşmaktadır. Bu çalışma kapsamında, ölçeğin

orijinalindeki altı boyuttan beşi kullanılmıştır. Bu boyutlar; **Gizlilik** (4 madde), **Kontrol/Sahiplik** (5 madde), **Bütünlük** (4 madde), **Kullanılabilirlik** (4 madde) ve **Fayda** (3 madde) olup, toplamda 20 madde üzerinden analizler gerçekleştirilmiştir.

Verilerin Analizi

Verilerin analizi, IBM SPSS Statistics 30 paket programı kullanılarak yapılmıştır. Verilerin analizinde aşağıdaki istatistiksel prosedürler izlenmiştir:

1. **Betimsel İstatistikler:** Öğretmenlerin siber güvenlik ölçeği ve alt boyutlarından aldıkları puanların genel dağılımını belirlemek amacıyla ortalama, standart sapma, minimum ve maksimum değerler hesaplanmıştır.
2. **Normallik Testi:** Gruplar arası karşılaştırmalarda kullanılacak parametrik testlerin ön şartı olan normal dağılım varsayımının karşılanıp karşılanmadığı, her bir alt grup için Shapiro-Wilk testi ile incelenmiştir.
3. **Karşılaştırmalı Analizler:** Normallik testi sonuçlarına göre, çoğu grupta verilerin normal dağılım göstermediği ($p < .05$) tespit edilmiştir. Bu nedenle, analizlerde tutarlılığı sağlamak amacıyla parametrik olmayan testlerin kullanılmasına karar verilmiştir.
    - İki bağımsız grubun (cinsiyet, eğitim alma durumu) puanlarını karşılaştırmak için **Mann-Whitney U testi** kullanılmıştır.
    - İkiden fazla bağımsız grubun (yaş, mesleki tecrübe) puanlarını karşılaştırmak için **Kruskal-Wallis H testi** kullanılmıştır.
    - Kruskal-Wallis H testi sonucunda anlamlı bulunan farklılıkların hangi gruplar arasında olduğunu tespit etmek amacıyla, tamamlayıcı post-hoc analizi olarak **Bonferroni düzeltmeli Mann-Whitney U testi** uygulanmıştır.

Tüm istatistiksel analizlerde anlamlılık düzeyi (p) .05 olarak kabul edilmiştir.

Sonuç

Bu bölümde, araştırmaya katılan öğretmenlerin "Siber Güvenlik Ölçeği" ve ölçeğin alt boyutlarından aldıkları puanlara ilişkin betimsel istatistikler ve demografik değişkenlere göre yapılan karşılaştırmalı analizlerin sonuçları sunulmuştur.

Betimsel Bulgular

Araştırmaya katılan 68 öğretmenin Siber Güvenlik Ölçeği'nin geneli ve alt boyutlarından aldıkları puanlara ilişkin betimsel istatistikler Tablo 1'de sunulmuştur. Puanlar, 1 (Kesinlikle Katılmıyorum) ile 5 (Kesinlikle Katılıyorum) arasında derecelendirilen 5'li Likert tipi ölçek üzerinden hesaplanan ortalamaları ifade etmektedir.

Tablo 1. Siber Güvenlik Ölçeği ve Alt Boyutlarına İlişkin Betimsel İstatistikler

Boyutlar	Madde Sayısı	N	Ortalama (Ort.)	Standart Sapma (SS)	Min.	Maks.
Gizlilik	4	68	4,28	0,72	1,75	5,00
Kontrol/Sahiplik	5	68	4,45	0,59	2,60	5,00
Bütünlük	4	68	2,90	0,84	1,00	5,00
Kullanılabilirlik	4	68	4,01	0,93	1,00	5,00
Fayda	3	68	4,05	0,74	1,67	5,00
Toplam Puan	**20**	**68**	**3,94**	**0,53**	**2,65**	**4,85**

Tablo 1 incelendiğinde, öğretmenlerin siber güvenlik algı ve uygulamalarına ilişkin genel ortalamalarının 3,94 (SS = 0,53) olduğu görülmektedir. Bu bulgu, katılımcıların siber güvenliğe yönelik genel olarak olumlu bir algıya ve farkındalığa sahip olduğunu göstermektedir.

Alt boyutlar özelinde bakıldığında, öğretmenlerin en yüksek ortalamaya **Kontrol/Sahiplik** (Ort. = 4,45) boyutunda sahip oldukları görülmektedir. Bu durum, öğretmenlerin şifre güvenliği, hesap yönetimi gibi kişisel kontrolü gerektiren konularda oldukça hassas davrandıklarını düşündürmektedir. Bunu sırasıyla **Gizlilik** (Ort. = 4,28), **Fayda** (Ort. = 4,05) ve **Kullanılabilirlik** (Ort. = 4,01) boyutları izlemektedir. En düşük ortalamanın ise **Bütünlük** (Ort. = 2,90) alt boyutunda olduğu tespit edilmiştir. Bu boyutun maddelerinin (ör. "Siber ortamda sakladığım bilgi ve belgeler kaybolmaz veya silinmez.") ters puanlandığı dikkate alındığında, bu ortalama öğretmenlerin siber

ortamdaki verilerin bütünlüğüne ve değişmezliğine yönelik güvensizliklerinin ve şüphelerinin olduğunu, bu konuda temkinli bir yaklaşıma sahip olduklarını göstermektedir.

Demografik Değişkenlere Göre Karşılaştırmalı Bulgular

Öğretmenlerin siber güvenlik algı ve uygulama puanlarının demografik değişkenlere göre farklılaşıp farklılaşmadığı incelenmiştir. Analiz yöntemi seçimi için öncelikle her bir alt grup için Shapiro-Wilk testi ile normallik varsayımı kontrol edilmiştir. Cinsiyet değişkenine göre yapılan incelemede, 'Gizlilik' alt boyutu puanlarının normal dağılım gösterdiği ($p > .05$), ancak diğer alt boyutların ve toplam puanın normal dağılım varsayımını karşılamadığı ($p < .05$) görülmüştür. Benzer şekilde, diğer demografik gruplamaların çoğunda da normallik varsayımı karşılanmamıştır. Bu nedenle, analizlerde tutarlılığı sağlamak ve Tip I hatayı önlemek amacıyla tüm karşılaştırmalar için parametrik olmayan testler olan Mann-Whitney U ve Kruskal-Wallis H testlerinin kullanılması tercih edilmiştir.

Cinsiyet Değişkenine Göre Bulgular

Kadın ve erkek öğretmenlerin siber güvenlik ölçeği puanları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan Mann-Whitney U testi sonuçları Tablo 2'de özetlenmiştir.

Tablo 2. Cinsiyete Göre Siber Güvenlik Puanlarına İlişkin Mann-Whitney U Testi Sonuçları

Boyutlar	Mann-Whitney U	p (Anlamlılık)
Gizlilik	387,500	,053
Kontrol/Sahiplik	428,000	,157
Bütünlük	526,500	,888
Kullanılabilirlik	534,500	,969
Fayda	394,500	,066
Toplam Puan	445,500	,241

Analiz sonuçlarına göre, öğretmenlerin siber güvenlik ölçeği **toplam puanları (U = 445,500, p > .05)** ile **Kontrol/Sahiplik (U = 428,000, p > .05)**, **Bütünlük (U = 526,500, p > .05)** ve **Kullanılabilirlik (U = 534,500, p > .05)** alt boyutlarında cinsiyete göre istatistiksel olarak anlamlı bir farklılık bulunmamaktadır.

Bununla birlikte, **Gizlilik (p = .053)** ve **Fayda (p = .066)** alt boyutlarında gruplar arasındaki farkın istatistiksel anlamlılık sınırına oldukça yakın olduğu gözlemlenmiştir. Bu durum, kişisel bilgilerin mahremiyetine yönelik hassasiyet ile dijital araçlardan elde edilen fayda algısının cinsiyete göre farklılaşma eğiliminde olabileceğine işaret etmektedir. Ancak mevcut örneklemde bu farklar istatistiksel olarak anlamlı düzeyde değildir.

Yaş Değişkenine Göre Bulgular

Öğretmenlerin siber güvenlik algı ve uygulama düzeylerinin yaş gruplarına göre farklılık gösterip göstermediğini belirlemek amacıyla Kruskal-Wallis H testi uygulanmıştır. Analiz sonuçları Tablo 3'te sunulmuştur.

Tablo 3. Yaş Gruplarına Göre Siber Güvenlik Puanlarına İlişkin Kruskal-Wallis H Testi Sonuçları

Boyutlar	Kruskal-Wallis H	sd	p (Anlamlılık)
Gizlilik	,807	3	,848
Kontrol/Sahiplik	,715	3	,870
Bütünlük	2,986	3	,394
Kullanılabilirlik	2,288	3	,515
Fayda	4,013	3	,260
Toplam Puan	2,141	3	,544

Kruskal-Wallis H testi sonuçlarına göre, öğretmenlerin yaş grupları arasında siber güvenlik ölçeği toplam puanı [$H(3) = 2,141$, $p > .05$] ve alt boyutlarının hiçbirinde istatistiksel olarak anlamlı bir farklılık tespit edilmemiştir ($p > .05$). Bu bulgu, araştırmaya katılan öğretmenlerin siber güvenlik algı ve uygulamalarının yaşa bağlı olarak değişmediğini göstermektedir.

Mesleki Tecrübe Değişkenine Göre Bulgular

Öğretmenlerin görev süresinin (mesleki tecrübe) siber güvenlik algı ve uygulamaları üzerinde bir fark yaratıp yaratmadığı Kruskal-Wallis H testi ile incelenmiştir. Test sonuçları Tablo 4'te özetlenmiştir.

Tablo 4. Mesleki Tecrübeye Göre Siber Güvenlik Puanlarına İlişkin Kruskal-Wallis H Testi Sonuçları

Boyutlar	Kruskal-Wallis H	sd	p (Anlamlılık)
Gizlilik	3,570	4	,467
Kontrol/Sahiplik	,494	4	,974
Bütünlük	2,551	4	,636
Kullanılabilirlik	**11,193**	**4**	**,024***
Fayda	6,497	4	,165
Toplam Puan	**3,508**	**4**	**,477**

Sonuçlar incelendiğinde, öğretmenlerin mesleki tecrübe gruplarına göre siber güvenlik ölçeği toplam puanlarında ve Gizlilik, Kontrol/Sahiplik, Bütünlük ve Fayda alt boyutlarında istatistiksel olarak anlamlı bir fark bulunmadığı görülmektedir ($p > .05$). Ancak, **Kullanılabilirlik** alt boyutunda mesleki tecrübe grupları arasında istatistiksel olarak anlamlı bir farklılık tespit edilmiştir [$H(4) = 11,193$, $p < .05$]. Bu bulgu, öğretmenlerin antivirüs programı, güvenlik duvarı gibi dijital güvenlik araçlarını kullanma alışkanlıklarının ve bu konudaki algılarının mesleki kıdemlerine göre anlamlı düzeyde farklılaştığını göstermektedir.

Kullanılabilirlik alt boyutunda gözlemlenen anlamlı farklılığın hangi mesleki tecrübe grupları arasında olduğunu belirlemek amacıyla, Bonferroni düzeltmesi uygulanarak ikili karşılaştırmalar için Mann-Whitney U testi yapılmıştır. Düzeltilmiş anlamlılık düzeyi $\alpha = .005$ olarak kabul edilmiştir. İleri analiz sonuçlarına göre; **2-5 yıl** ile **16-20 yıl** ($U = 0.00$, $p < .001$) ve **6-10 yıl** ile **11-15 yıl** ($U = 45.00$, $p = .0001$) deneyime sahip öğretmenler arasında anlamlı farklılıklar bulunmuştur.

Alınan Eğitimlerin Etkisine İlişkin Bulgular

Öğretmenlerin daha önce genel "Bilişim Teknolojileri" ve spesifik "Siber Güvenlik" konularında eğitim alıp almamalarının, siber güvenlik algı ve uygulamaları üzerindeki etkisi Mann-Whitney U testi ile ayrı ayrı incelenmiştir. Her iki analizin sonuçları karşılaştırmalı olarak Tablo 5'te sunulmuştur.

Tablo 5. Alınan Eğitim Türüne Göre Siber Güvenlik Puanlarına İlişkin Mann-Whitney U Testi Sonuçları

	Bilişim Tek. Eğitimi	Siber Güv. Eğitimi
Boyutlar	**p (Anlamlılık)**	**p (Anlamlılık)**
Gizlilik	**,033***	**,005***
Kontrol/Sahiplik	**,089**	**,004***
Bütünlük	,446	,252
Kullanılabilirlik	,795	,099
Fayda	,206	,443
Toplam Puan	,425	,075

Analiz sonuçları, her iki eğitim türü için de oldukça dikkat çekici ve benzer bir desen ortaya koymaktadır. Genel olarak ölçek toplam puanlarında ve Bütünlük, Kullanılabilirlik, Fayda alt boyutlarında, eğitim alan ve almayan öğretmenler arasında istatistiksel olarak anlamlı bir fark bulunmamaktadır ($p > .05$).

Buna karşın, hem genel bilişim teknolojileri eğitimi ($p < .05$) hem de spesifik siber güvenlik eğitimi ($p < .01$) için **Gizlilik** alt boyutunda, eğitimi **almayan** öğretmenlerin lehine anlamlı bir fark tespit edilmiştir. Benzer şekilde, siber güvenlik eğitimi almayan öğretmenlerin **Kontrol/Sahiplik** ($p < .01$) puanları da eğitim alanlara göre anlamlı düzeyde daha yüksektir.

Bu beklenmedik bulgular, formal bir eğitim almamış olan öğretmenlerin, kişisel verilerinin mahremiyeti (Gizlilik) ve dijital hesaplarının yönetimi (Kontrol/Sahiplik) gibi konularda, eğitim almış olan meslektaşlarına göre daha endişeli, şüpheci veya aşırı temkinli bir tutum sergilediklerini düşündürmektedir. Bu durum, alınan eğitimlerin

bilgi düzeyini artırırken, risk algısını ve buna bağlı aşırı temkinli davranışları rasyonel bir seviyeye çekiyor olabileceğine işaret etmektedir.

Bulgular

Bu araştırmada, Balıkesir ilinde görev yapan öğretmenlerin siber güvenlik algı ve uygulamaları incelenmiş; bu algı ve uygulamaların çeşitli demografik değişkenlere göre farklılaşıp farklılaşmadığı analiz edilmiştir. Araştırmadan elde edilen bulgular, öğretmenlerin siber güvenlik konusundaki mevcut durumlarına ilişkin önemli sonuçlar ortaya koymuştur.

Araştırmanın betimsel bulguları, öğretmenlerin siber güvenliğe yönelik genel olarak olumlu bir algıya (Ort. = 3,94/5,00) sahip olduğunu göstermektedir. Alt boyutlar incelendiğinde, öğretmenlerin en yüksek hassasiyeti şifre yönetimi ve hesap güvenliği gibi konuları içeren **Kontrol/Sahiplik** boyutunda gösterdikleri, en temkinli yaklaşımı ise verilerin siber ortamdaki bütünlüğüne ve değişmezliğine yönelik şüphelerini yansıtan **Bütünlük** boyutunda sergiledikleri görülmüştür. Bu durum, öğretmenlerin kişisel kontrol alanlarındaki siber güvenlik pratiklerine hakim olduklarını ancak verilerin bulut ortamlarındaki güvenilirliğine dair endişe taşıdıklarını göstermektedir.

Demografik değişkenlere göre yapılan karşılaştırmalı analizlerde, öğretmenlerin siber güvenlik algılarının **cinsiyet** ve **yaş** değişkenlerine göre anlamlı bir farklılık göstermediği tespit edilmiştir. Bu bulgu, siber güvenlik farkındalığının belirli bir cinsiyet veya yaş grubuna özgü olmaktan çıkıp, eğitimciler arasında daha evrensel bir yetkinlik haline gelmeye başladığı şeklinde yorumlanabilir.

Buna karşın, **mesleki tecrübe** değişkeninin, güvenlik yazılımlarının kullanımını ifade eden **Kullanılabilirlik** alt boyutunda anlamlı bir farklılık yarattığı görülmüştür. Özellikle 11-15 yıl tecrübeye sahip öğretmenlerin bu konudaki puanlarının diğer bazı gruplara göre daha düşük olması, bu tecrübe grubundaki öğretmenlerin teknoloji adaptasyon süreçlerinde özel bir desteğe ihtiyaç duyabileceğine işaret etmektedir.

Araştırmanın en dikkat çekici bulgusu ise **alınan eğitimler** ile ilgilidir. Hem genel bilişim teknolojileri hem de spesifik siber güvenlik eğitimi **almayan** öğretmenlerin, **Gizlilik** ve **Kontrol/Sahiplik** alt boyutlarında eğitim alan meslektaşlarına göre istatistiksel olarak anlamlı düzeyde daha yüksek puanlara sahip olduğu görülmüştür. Bu beklenmedik sonuç, formal eğitimlerin bilgi ve beceriyi artırırken, aynı zamanda siber risklere karşı daha gerçekçi ve dengeli bir bakış açısı kazandırarak, bilgi eksikliğinden kaynaklanan aşırı endişe ve temkinli tutumları rasyonel bir seviyeye indirgediğini düşündürmektedir. Diğer bir deyişle, eğitim almayan öğretmenler, belirsizlik nedeniyle daha kaygılı ve aşırı korumacı bir tavır sergiliyor olabilirler.

Öneriler

Bu sonuçlar doğrultusunda şu öneriler geliştirilmiştir:

- **Uygulamaya Yönelik:** Öğretmenlere yönelik düzenlenecek siber güvenlik eğitimlerinin, sadece teknik bilgi ve beceri aktarımına odaklanmaması; aynı zamanda doğru bir risk algısı oluşturmayı, panik ve aşırı güvenden arındırılmış, bilinçli ve dengeli güvenlik alışkanlıkları kazandırmayı hedeflemesi önerilmektedir. Özellikle 11-15 yıl kıdeme sahip öğretmenlerin teknoloji kullanım alışkanlıklarına yönelik özel modüller geliştirilebilir.
- **Gelecek Araştırmalara Yönelik:** Bu çalışmanın bulguları 68 öğretmen ile sınırlıdır. Bulguların genellenebilirliğini artırmak için daha geniş ve farklı coğrafi bölgelerden örneklemlerle benzer çalışmalar yapılabilir. Ayrıca, eğitim almayan öğretmenlerin neden daha temkinli davrandığını derinlemesine anlamak amacıyla, nitel araştırma yöntemlerinin (görüşme, odak grup vb.) kullanıldığı karma desenli çalışmalar tasarlanabilir.

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Ortaokul Öğrencilerinde Su Ayak İzi Farkındalığının Gelişiminde STEAM ve Oyunlaştırmanın Rolü

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Özet

Bu çalışma, ortaokul 7. sınıf öğrencilerinin su ayak izi farkındalığını, oyunlaştırma ve Web 2.0 araçlarıyla zenginleştirilmiş STEAM (Fen, Teknoloji, Mühendislik, Sanat, Matematik) temelli disiplinler arası etkinlikler aracılığıyla artırmayı amaçlamaktadır. Küresel su krizinin giderek derinleştiği günümüzde, genç nesillerde sürdürülebilir yaşam bilinci oluşturmak kritik önem taşımaktadır. Nitel araştırma desenlerinden durum çalışması olarak tasarlanan araştırmaya, 11'i kız 11'i erkek olmak üzere toplam 22 öğrenci gönüllü olarak katılmıştır. Dört haftalık uygulama sürecinde katılımcılar, uzman seminerleri, teknoloji destekli kavramsal oyunlar, yağmur suyu hasat prototipi incelemesi ve mühendislik tasarım görevi gibi çeşitli etkinliklere dahil olmuşlardır. Veriler, duygu panoları, Mentimeter kelime bulutları, gözlem notları ve öğrencilerin tasarım formları aracılığıyla toplanmıştır.

Araştırmanın bulguları, oyunlaştırma stratejilerinin öğrencilerin öğrenme sürecine yönelik duyuşsal katılımını artırdığını ve başlangıçtaki kaygıları olumlu bir deneyime dönüştürdüğünü ortaya koymuştur. Katılımcıların, ekolojik ayak izi gibi soyut bir kavrama ilişkin genel farkındalıktan, "arıtma", "sensörler" ve "verimli sulama" gibi spesifik ve çözüm odaklı bir anlayışa geçtikleri tespit edilmiştir. En önemlisi, öğrencilerin mühendislik tasarım döngüsünün temel adımlarını başarıyla uygulayarak tarımsal sulamaya yönelik yenilikçi ve uygulanabilir sistemler tasarladıkları görülmüştür. Bu durum çalışması, oyunlaştırma ve STEAM yaklaşımının, karmaşık çevre sorunlarının öğretiminde, öğrencileri pasif bilgi alıcısından aktif problem çözücüye dönüştüren etkili bir pedagojik araç olduğu sonucuna varmıştır. Çalışma, çevre eğitiminin 21. yüzyıl becerilerini geliştiren uygulamalı deneyimler sunması gerektiğini vurgulamaktadır.

Anahtar Kelimeler: Ekolojik Ayak İzi, Su Ayak İzi, STEAM Eğitimi, Oyunlaştırma, Çevre Eğitimi, Durum Çalışması.

The Role of STEAM and Gamification in Enhancing Water Footprint Awareness Among Middle School Students

Abstract

This study aims to enhance water footprint awareness in seventh-grade students through STEAM (Science, Technology, Engineering, Art, Mathematics)-based interdisciplinary activities enriched with gamification and Web 2.0 tools. As the global water crisis deepens, fostering a sense of sustainable living in younger generations is critically important. Designed as a qualitative case study, the research included 22 volunteer students (11 girls and 11 boys). Over a four-week intervention period, participants engaged in various activities, including expert seminars, technology-supported conceptual games, examining a rainwater harvesting prototype, and an engineering design challenge. Data were collected using emotion boards ("duygu panoları"), Mentimeter word clouds, observation notes, and students' design forms. The findings revealed that gamification strategies boosted students' affective engagement in the learning process, transforming initial anxieties into a positive experience. It was observed that participants transitioned from a general awareness of an abstract concept like the ecological footprint to a specific and solution-oriented understanding, incorporating terms like "purification," "sensors," and "efficient irrigation". Most significantly, students successfully applied the basic steps of the engineering design cycle to develop innovative and feasible systems for agricultural irrigation. This case study concludes that the gamification and STEAM approach is an effective pedagogical tool for teaching complex environmental issues, converting students from passive information receivers to active problem-solvers. The study emphasizes that environmental education must provide applied experiences that cultivate 21st-century skills.

Giriş

İnsan faaliyetlerinin gezegenin ekosistemleri üzerindeki etkilerinin geri dönülemez bir noktaya yaklaştığı Antroposen çağında, iklim değişikliği, biyolojik çeşitlilik kaybı ve kaynakların tükenmesi gibi küresel krizler, sürdürülebilirlik kavramını hem bilimsel hem de toplumsal gündemin merkezine taşımıştır (Steffen vd., 2007). Bu krizlerin temelinde, insanlığın tüketim alışkanlıkları ve üretim modelleri yatmaktadır. Bu karmaşık ilişkiyi somutlaştırmak ve ölçülebilir kılmak amacıyla geliştirilen **ekolojik ayak izi**, bireylerin, toplulukların veya ülkelerin gezegenin ekolojik kapasitesi üzerindeki talebini hesaplayan bilimsel bir metrik olarak öne çıkmaktadır (Wackernagel & Rees, 1998). Ekolojik ayak izinin en kritik bileşenlerinden biri olan **su ayak izi** ise, tüketilen mal ve hizmetlerin üretim süreçlerinde kullanılan ve kirletilen tatlı su miktarını ifade ederek, su kaynakları üzerindeki görünmez baskıyı ortaya koymaktadır (Aldaya vd., 2012).

Küresel su krizinin derinleştiği günümüzde, gelecek nesillerin çevreye duyarlı ve sürdürülebilir yaşam alışkanlıkları benimsemesi, gezegenin geleceği için hayati önem taşımaktadır. Bu alışkanlıkların kazandırılması ise ancak kalıcı davranış değişiklikleri yaratan etkili öğrenme deneyimleriyle mümkündür. Öğrenme, bireyin çevresiyle etkileşimi sonucunda bilgi, beceri ve tutumlarında meydana gelen kalıcı izli değişimler olarak tanımlanır ve bu değişimlerin davranışa dönüşmesi, eğitimin temel hedeflerindendir (Senemoglu, 2020). Özellikle erken yaşlarda başlayan çevre eğitimi, bireylerin doğaya karşı olumlu tutumlar geliştirmesinde ve çevre sorunlarına yönelik sorumluluk bilinci kazanmasında kritik bir rol oynamaktadır (Gülay, 2011). Bu nedenle, ekolojik ayak izi ve su kıtlığı gibi soyut ve çok boyutlu kavramların, öğrencilerin bilişsel düzeyine uygun ve anlamlı bir şekilde öğretilmesi gerekmektedir.

Ancak bu tür soyut kavramların geleneksel öğretim yöntemleriyle aktarılması, öğrencilerin konuyu içselleştirmesinde ve günlük yaşamlarıyla ilişkilendirmesinde yetersiz kalabilmektedir. Bu noktada, 21. yüzyılın pedagojik yaklaşımları, teknoloji ve yenilikçi yöntemlerle zenginleştirilmiş öğrenme ortamları sunmaktadır. Bu yaklaşımlardan biri olan **oyunlaştırma**, oyun dışı bir bağlama oyun mekaniklerinin, dinamiklerinin ve estetiğinin entegre edilmesiyle, öğrencilerin motivasyonunu, katılımını ve bağlılığını artırmayı hedefler (Deterding vd., 2011). Puanlar, rozetler, liderlik tabloları gibi oyun elementleri, öğrenme sürecini daha keyifli ve rekabetçi hale getirerek kalıcılığı destekler (Kapp, 2012). İnternetin evrimiyle ortaya çıkan ve kullanıcıların içerik oluşturmasına olanak tanıyan interaktif **Web 2.0** araçları (Mentimeter, Kahoot vb.) ise oyunlaştırma stratejilerinin uygulanması için dinamik platformlar sunarak öğrenci merkezli bir eğitim anlayışını güçlendirmektedir (Günüç & Kuzu, 2014).

Bu çalışmada benimsenen **STEAM (Fen, Teknoloji, Mühendislik, Sanat ve Matematik)** yaklaşımı ise, bu disiplinleri bütünleştirerek öğrencilerin problem çözme, eleştirel düşünme ve yaratıcılık gibi üst düzey becerilerini geliştirmeyi amaçlar. STEAM eğitimi, öğrencilere ekolojik sorunları disiplinlerarası bir bakış açısıyla ele alma ve mühendislik tasarım süreçlerini kullanarak yenilikçi çözümler üretme fırsatı tanır. Alan yazın incelendiğinde, uluslararası düzeyde su okuryazarlığı ve farkındalık eğitimlerinin müfredatlarda yer aldığı, ancak ulusal düzeyde bu konunun genellikle çevre eğitimi başlığı altında dolaylı olarak ele alındığı ve spesifik, teknolojiyle zenginleştirilmiş uygulamaların sınırlı olduğu görülmektedir (Çabuk & Karacaoğlu, 2003).

Bu bağlamda mevcut çalışma, ortaokul 7. sınıf öğrencilerinin su ayak izi farkındalıklarını artırmak amacıyla tasarlanan, oyunlaştırma ve Web 2.0 araçlarıyla desteklenmiş STEAM temelli etkinliklerin uygulanmasını ve sonuçlarını incelemektedir. Çalışma, bu yenilikçi pedagojik yaklaşımın öğrencilerin soyut bir çevre sorununu somutlaştırma, anlama ve çözüm üretme süreçleri üzerindeki etkisini ortaya koyarak alan yazındaki bir boşluğu doldurmayı hedeflemektedir.

Yöntem

Bu araştırma, ortaokul öğrencilerinin su ayak izi farkındalıklarını ve bu konudaki mühendislik tasarım becerilerini derinlemesine incelemeyi amaçladığından, nitel araştırma desenlerinden **durum çalışması (case study)** deseniyle yürütülmüştür. Durum çalışması, sınırlı bir sistemin (bu çalışmada belirli bir öğrenci grubu ve onlara uygulanan etkinlikler bütünü) kendi doğal ortamı içerisinde, çoklu veri kaynakları kullanılarak bütüncül bir yaklaşımla araştırılmasına olanak tanır (Creswell & Poth, 2016). Bu desen, STEAM temelli etkinliklerin öğrenci algıları, duyuşsal tepkileri ve öğrenme süreçleri üzerindeki etkilerini zengin ve bağlama duyarlı bir biçimde anlamak için en uygun yaklaşım olarak belirlenmiştir.

Çalışma Grubu

Araştırmanın çalışma grubu, amaçlı örnekleme yöntemlerinden **ölçüt örnekleme** ile belirlenmiştir. Araştırmanın temel ölçütleri, katılımcıların 7. sınıf düzeyinde öğrenim görüyor olmaları ve çalışmaya gönüllü olarak katılmayı kabul etmeleridir (Yıldırım & Simsek, 2018). Bu kapsamda, 2023-2024 eğitim-öğretim yılında Balıkesir ilindeki bir devlet ortaokulunun üç farklı 7. sınıf şubesinde öğrenim gören toplam 90 öğrenciye çalışma hakkında bilgilendirme semineri düzenlenmiştir. Seminer sonrası çalışmaya katılmak istediğini belirten 25 öğrenci

arasından, devamlılık sağlayabilen ve veli izinleri tamamlanan 11'i kız, 11'i erkek olmak üzere toplam 22 öğrenci nihai çalışma grubunu oluşturmuştur. Katılımcıların yaşları 11 ile 13 arasında değişmektedir.

Veri Toplama Süreci ve Araçları

Araştırmada veriler, bir dizi planlanmış etkinlikten oluşan ve yaklaşık dört hafta süren bir uygulama sürecinde, çoklu veri toplama araçları kullanılarak toplanmıştır. Veri çeşitlemesi (triangulation) ile araştırmanın geçerliği ve güvenirliği artırılmaya çalışılmıştır (Denzin, 2012). Veri toplama süreci, STEAM (Fen, Teknoloji, Mühendislik, Sanat ve Matematik) yaklaşımının temel ilkelerine uygun olarak disiplinler arası bir yapıda tasarlanmıştır.

1. **Duyuşsal Durum Belirleme Formları:** Etkinliklerin başında ve sonunda, öğrencilerin sürece ilişkin beklentilerini, kaygılarını ve duygularını belirlemek amacıyla **"Duygu Bulutu Panosu"** kullanılmıştır. Öğrencilerin yapışkan not kağıtlarına yazdıkları ifadeler, nitel veri kaynağı olarak toplanmış ve bu verilerden betimsel istatistikler (frekanslar) elde edilmiştir.

2. **Web 2.0 Tabanlı Kavram Haritaları:** Öğrencilerin "ekolojik ayak izi" kavramına ilişkin ön bilgilerini ve metaforik algılarını ortaya çıkarmak amacıyla interaktif bir Web 2.0 aracı olan **Mentimeter** uygulaması kullanılmıştır. Katılımcıların verdikleri yanıtlarla oluşturulan kelime bulutları, nitel veri olarak kaydedilmiştir.

3. **Yapılandırılmış Etkinlikler ve Gözlem:** Süreç boyunca TEMA Vakfı gönüllüsü tarafından verilen "İklim Değişikliği Semineri", kuruyan su kaynakları sunumu, **"Yağmur Suyu Hasat Sistemi Prototipi"** incelemesi ve alg ile su numunelerinin incelendiği **mikroskop çalışmaları** gerçekleştirilmiştir. Bu etkinlikler sırasında araştırmacı tarafından **katılımcı gözlem** yapılarak önemli diyaloglar ve davranışlar not edilmiştir.

4. **Oyunlaştırma Materyalleri:** Öğrenme sürecini desteklemek amacıyla, su ayak izi ve iklim krizi temalı, araştırmacılar tarafından tasarlanan **"Tabu Oyunu"** ve puanlama sistemine dayalı bir **soru-cevap oyunu** oynatılmıştır. Bu oyunlar, öğrencilerin kavramsal anlamalarını ve katılım düzeylerini gözlemlemek için bir araç olarak kullanılmıştır.

5. **Mühendislik Tasarım Formları:** Çalışmanın ana veri toplama aracı olarak, öğrencilerin tarımsal sulamaya yönelik alternatif bir yağmur suyu hasat sistemi tasarlamalarını isteyen **yarı yapılandırılmış bir form** kullanılmıştır. Bu form, öğrencilerin (a) araştırma ve bilgi toplama, (b) alternatif çözüm geliştirme, (c) materyal seçimi ve (d) mühendislik tasarım sürecini açıklama becerilerini ölçen açık uçlu sorular ile tasarımlarını çizecekleri bir alandan oluşmaktadır. Bu formlardan elde edilen çizimler ve yazılı yanıtlar, zengin birer nitel veri kaynağı oluşturmuştur.

Verilerin Analizi

Araştırmada toplanan nitel ve nicel verilerin analizinde bütünleşik bir yaklaşım benimsenmiştir.

Nitel Verilerin Analizi: Mühendislik tasarım formlarındaki açık uçlu yanıtlar, çizimler, Mentimeter kelime bulutları ve duygu panosu ifadeleri **içerik analizi** ve **betimsel analiz** teknikleri kullanılarak analiz edilmiştir. Analiz sürecinde öncelikle veriler sayısallaştırılmış, ardından anlamlı birimlere (kodlar) ayrılmıştır. Bu kodlardan yola çıkılarak ortak temalar ve kategoriler oluşturulmuş ve bulgular bu temalar altında düzenlenerek yorumlanmıştır (Yıldırım & Şimşek, 2018). Özellikle katılımcıların tasarım süreçleri ve problem çözme yaklaşımları bu yöntemle derinlemesine incelenmiştir.

Betimsel Nicel Verilerin Analizi: Duygu bulutu panosundan elde edilen duyuşsal durumlara (kaygı, beklenti, duygu vb.) ilişkin veriler, frekans (f) ve yüzde (%) gibi **betimsel istatistikler** kullanılarak analiz edilmiştir. Bu analizler, öğrencilerin etkinlik öncesi ve sonrası duyuşsal durumlarındaki değişimi sayısal olarak özetlemek amacıyla kullanılmıştır.

Sonuçlar

Bu bölümde, araştırmanın alt problemleri doğrultusunda toplanan verilerin analiz edilmesiyle elde edilen bulgulara yer verilmiştir. Bulgular, katılımcıların etkinlik öncesi ve sonrası duyuşsal durumları, ekolojik ayak izi kavramına ilişkin ön bilgileri ve mühendislik tasarım süreçlerine yönelik geliştirdikleri ürünler olmak üzere üç ana başlık altında sunulmuştur.

Katılımcıların Etkinlik Öncesi ve Sonrası Duyuşsal Durumlarına İlişkin Bulgular

Katılımcıların STEAM temelli etkinliklere başlamadan önceki kaygıları, beklentileri ve duyguları ile etkinlikler tamamlandıktan sonraki son duygularını belirlemek amacıyla "Duygu Bulutu Panosu" kullanılmıştır. Panoya yazılan ifadelerin frekans analizine dayalı betimsel istatistik sonuçları Tablo 1'de özetlenmiştir.

Tablo 1. Katılımcıların Etkinlik Öncesi ve Sonrası Duyuşsal Durumlarına İlişkin Frekans Dağılımları

Kategori	Duyuşsal İfade	Frekans (f)
Kaygılar	Sıkıcı geçmesi	7
	Kaygısız	6
	Yemek yememek	5
	Verimsiz olması	2
Beklentiler	Verimli geçmesi	9
	Eğlenceli geçmesi	7
	Güzel geçmesi	5
Başlangıç Duyguları	Mutlu-Heyecanlı	7
	Heyecanlı	6
	Mutlu	5
	Heyecanlı-Mutlu-Meraklı	2
	Meraklı	1
Son Duygular	Güzel	7
	Eğlenceli	5
	Mutlu-Verimli	3
	Mükemmel	2
	Mutlu-Eğlenceli	2

Tablo 1 incelendiğinde, katılımcıların etkinlik öncesinde en belirgin kaygısının, sürecin **"sıkıcı geçmesi"** (f=7) olduğu görülmektedir. Buna karşın, en büyük beklentilerinin ise etkinliğin **"verimli geçmesi"** (f=9) yönünde olduğu tespit edilmiştir. Etkinlikler başlamadan önce katılımcıların kendilerini büyük oranda **"mutlu-heyecanlı"** (f=7) ve **"heyecanlı"** (f=6) olarak tanımladığı görülmüştür. Etkinliklerin tamamlanmasının ardından ise katılımcıların son duygularının ezici bir çoğunlukla olumlu olduğu, en sık ifade edilen duyguların **"güzel"** (f=7) ve **"eğlenceli"** (f=5) olduğu bulgulanmıştır. Bu durum, başlangıçtaki "sıkıcılık" kaygısının giderildiğini ve "verimlilik" beklentisinin karşılandığını göstermektedir.

Katılımcıların Ekolojik Ayak İzi Kavramına İlişkin Ön Bilgilerine Yönelik Bulgular

Katılımcıların "ekolojik ayak izi" kavramına ilişkin zihinlerindeki ilk çağrışımları ve metaforik algılarını belirlemek amacıyla Mentimeter uygulaması kullanılmıştır. Katılımcılara yöneltilen "Ekolojik ayak izi denildiğinde aklınıza gelen ilk kavram nedir?" ve "Ekolojik ayak izi … gibidir" sorularına verilen yanıtlarla oluşturulan kelime bulutları Şekil 1 ve Şekil 2'de sunulmuştur.

Şekil 1: a) Ekolojik Ayakizi Denildiğinde Aklınıza Gelen İlk Kavram Nedir? b) "Ekolojik Ayak İzi … Gibidir" sorularına ait kelime bulutları

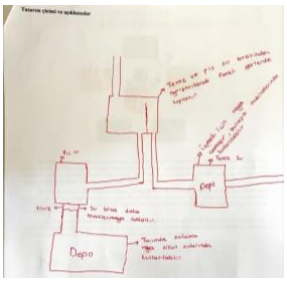
Şekil 1a'daki kelime bulutu incelendiğinde, katılımcıların ekoloji kavramını en çok **"doğa"**, **"ekolojik ayak izi"**, **"çevre ve su"** ve **"su tasarrufu"** gibi temel çevre kavramlarıyla ilişkilendirdiği görülmektedir. Bu bulgu, öğrencilerin konuya ilişkin temel bir farkındalığa sahip olduğunu göstermektedir. Şekil 1b'de ise, ekolojik ayak izi kavramına yönelik metaforik algıların **"çevre kirliliği"**, **"çevre"**, **"tasarruf"**, **"doğayı korumak"** ve **"geri dönüşüm"** gibi hem sorunu hem de çözümü işaret eden kavramlar etrafında yoğunlaştığı tespit edilmiştir. Bu durum, öğrencilerin kavramı sadece bir tanım olarak değil, aynı zamanda sorumluluk ve eylem gerektiren bir olgu olarak algıladıklarına işaret etmektedir.

Katılımcıların Mühendislik Tasarım Süreçlerine İlişkin Bulgular

Katılımcıların tarımsal sulama amaçlı bir yağmur suyu hasat sistemi tasarlamaları istenen mühendislik tasarım formlarından elde edilen nitel veriler, içerik analizi yoluyla incelenmiştir. Analiz sonucunda, öğrencilerin problem çözme yaklaşımları dört ana tema altında toplanmıştır: (1) Bilgi Toplama ve Araştırma Stratejileri, (2) Geliştirilen Çözüm Önerilerinin Niteliği, (3) Sistem Tasarımında Kullanılan Materyal Bilgisi ve (4) Mühendislik Tasarım Süreci Algısı.

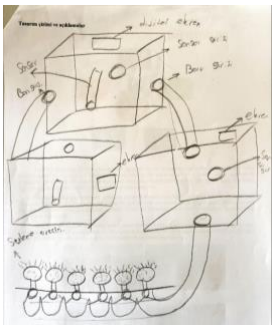
Tema 1: Bilgi Toplama ve Araştırma Stratejileri Katılımcıların büyük bir bölümü, bir mühendislik problemine çözüm üretmeden önce bilgi toplamanın gerekliliğini ifade etmiştir. Bilgi kaynağı olarak en sık belirtilen yöntem **"internet araştırması"** olmuştur. Örneğin, Katılımcı-1, *"İnternet yoluyla kullanılabilecek maddelerin neler olduğu ve geliştirilecek sistem için hangi maddelerin daha uygun olduğu konusunda araştırmalar yapabilirim"* ifadesiyle materyal seçimi odaklı bir araştırma süreci planladığını belirtmiştir. Katılımcı-14 ise *"Bu konuda bilgili kişileri dinlemeliyiz"* diyerek uzman görüşüne başvurmanın önemini vurgulamıştır. Katılımcı-2'nin *"...kurulacak bölgedeki yağış oranını alıp ona göre bir depo tasarlanmalıdır"* şeklindeki yanıtı ise probleme yönelik spesifik ve veriye dayalı bir araştırma yapma eğilimini göstermesi açısından dikkat çekicidir.

Tema 2: Geliştirilen Çözüm Önerilerinin Niteliği Öğrencilerin tasarımlarında üç temel çözüm önerisinin öne çıktığı görülmüştür: (a) Yağmur suyunun toplanması ve depolanması, (b) Toplanan suyun arıtılması ve filtrelenmesi, (c) Suyun verimli kullanılması (damla sulama vb.). Katılımcı-4, *"Yağmur suyunu kullanmalı ve depolayıp tarlanın ihtiyacı olan noktaya dağıtılmalıdır"* diyerek temel bir toplama ve dağıtma sistemi önermiştir. Katılımcı-10 ise sistemi bir adım ileri taşıyarak, *"Temiz ve pis farklı su birbirinden ayrışmalı... Su biraz daha temizlenmeye gidebilir"* ifadesiyle bir arıtma ve geri dönüşüm mekanizması tasarlamıştır (Şekil 2). En yenilikçi fikirlerden biri ise Katılımcı-18 tarafından sunulan *"çiğ mantığı"* ile sulama yapma önerisidir. Bu öneri, farklı doğa olaylarından faydalanarak alternatif su kaynakları yaratma potansiyelini göstermesi açısından önemlidir.



Şekil 2. Katılımcı-10'un Arıtma Odaklı Sistem Tasarımı

Tema 3: Sistem Tasarımında Kullanılan Materyal Bilgisi Katılımcıların tasarımlarında kullandıkları materyaller, temel yapı elemanlarından (depo, boru, fıskiye) ileri teknoloji bileşenlerine kadar geniş bir yelpazede yer almaktadır. Katılımcı-6, *"Paslanmaya, çatlamaya erimeye ve donmaya dayanıklı uzun ömürlü f/p ürünler"* ifadesiyle malzeme biliminin temel prensiplerine (dayanıklılık, uzun ömürlülük, maliyet-etkinlik) atıfta bulunmuştur. Katılımcı-2 ve Katılımcı-17 gibi bazı öğrenciler ise tasarımlarına **"sensör"**, **"güneş paneli"**, **"dijital ekran"** ve **"akü"** gibi otomasyon ve sürdürülebilir enerji kaynaklarını entegre ederek, etkinlikte inceledikleri prototipten edindikleri bilgileri tasarımlarına başarıyla yansıtmışlardır (Şekil 3).



Şekil 3. Katılımcı-2'nin Sensör ve Otomasyon İçeren Sistem Tasarımı

Tema 4: Mühendislik Tasarım Süreci Algısı Katılımcılara "Bir mühendis olarak bu sistemi nasıl tasarlarsın?" sorusu yöneltildiğinde, verdikleri yanıtlar, mühendislik tasarım döngüsünün temel adımlarını (problemi anlama, planlama/tasarlama, prototip oluşturma, test etme ve yaygınlaştırma) büyük ölçüde yansıtmaktadır. Katılımcı-18, süreci, *"İlk olarak sorunu belirleyip çözüm önerilerinden birini seçer ve bir planlama çizimi yaparım. Ardında küçük bir maket ile çalışıp çalışmayacağını denerim. Çalışırsa gerçek hayata geçiririm"* şeklinde özetlemiştir. Benzer şekilde Katılımcı-20, *"...ilk prototip yapılmalı, prototip başarılı olursa kaliteli malzemelerle inşa edilmeli"* diyerek test etme ve iyileştirme adımlarının önemini vurgulamıştır. Bu bulgular, öğrencilerin etkinlikler aracılığıyla mühendislik mesleğinin problem çözme metodolojisine dair temel bir anlayış geliştirdiklerini göstermektedir.

Sonuç

Bu araştırmanın bulguları, teknolojiyle zenginleştirilmiş, oyunlaştırma ve STEAM yaklaşımını temel alan disiplinler arası bir uygulamanın, ortaokul öğrencilerinin su ayak izi farkındalığı ve mühendislik tasarım becerileri üzerinde çok yönlü olumlu etkiler yarattığını göstermektedir.

Katılımcıların etkinlik öncesi duyuşsal durumları incelendiğinde, en büyük kaygılarının "sıkıcılık" olmasına rağmen en temel beklentilerinin "verimlilik" olması, öğrencilerin geleneksel öğrenme ortamlarının dışına çıkan etkinliklere hem bir miktar endişe hem de yüksek bir beklenti ile yaklaştığını göstermektedir. Etkinlik sonunda ise "güzel" ve "eğlenceli" gibi olumlu duyguların baskın hale gelmesi, oyunlaştırma stratejilerinin başarısını teyit etmektedir. Bu bulgu, oyun mekaniklerinin öğrenme sürecine entegre edilmesinin, öğrencilerin motivasyonunu, katılımını ve süreçten aldıkları keyfi artırdığını öne süren geniş bir alan yazınla tutarlıdır (Hamari vd., 2014; Seaborn & Fels, 2015). Özellikle, öğrenme sürecinin eğlenceli hale getirilmesi, öğrencilerin karmaşık ve soyut konulara yönelik olası önyargılarını ve kaygılarını azaltarak bilişsel kaynaklarını konuyu anlamaya yöneltmelerine yardımcı olmaktadır.

Katılımcıların ekolojik ayak izi kavramına ilişkin ön bilgileri, temel düzeyde bir farkındalığa işaret etse de kavramı daha çok "çevre kirliliği" ve "doğayı korumak" gibi genel ifadelerle ilişkilendirdikleri görülmüştür. Etkinlikler ve özellikle mühendislik tasarım görevi sonrasında, öğrencilerin bu genel farkındalıktan, "yağmur suyu hasadı", "arıtma", "sensörler" ve "verimli sulama" gibi spesifik problem ve çözüm odaklı bir anlayışa geçiş yaptıkları tespit edilmiştir. Bu durum, uygulamalı ve proje tabanlı STEAM eğitiminin, öğrencilerin soyut bilimsel kavramları gerçek dünya problemleriyle ilişkilendirerek somutlaştırmalarına ve içselleştirmelerine olanak tanıdığını gösteren çalışmalarla paralellik göstermektedir (Kelley & Knowles, 2016). Öğrenciler, sadece sorunun ne olduğunu değil, aynı zamanda çözümün bir parçası olabileceklerini de uygulamalı olarak deneyimlemişlerdir.

Araştırmanın en dikkat çekici bulgularından biri, 7. sınıf düzeyindeki öğrencilerin kısa süreli bir uygulamanın ardından mühendislik tasarım döngüsünün temel adımlarını (problemi anlama, planlama, prototip, test) büyük bir isabetle ifade edebilmeleri ve uygulayabilmeleridir. Katılımcıların, sunulan prototipteki "sensör", "güneş paneli" gibi teknik bileşenleri kendi özgün tasarımlarına entegre etmeleri ve hatta "çiğ mantığı" gibi yenilikçi fikirler üretebilmeleri, bu yaş grubundaki öğrencilerin yaratıcı potansiyelini ve üst düzey düşünme becerilerini ortaya koymaktadır. Bu bulgu, çevre eğitiminde oyunlaştırma ve simülasyon gibi teknoloji destekli yöntemlerin, öğrencileri pasif bilgi alıcıları olmaktan çıkarıp aktif problem çözücüler ve tasarımcılar haline getirdiğini savunan çalışmalarla desteklenmektedir (Lee & Hammer, 2011).

Bu durum çalışması, ortaokul öğrencilerinin su ayak izi farkındalığını artırmada oyunlaştırma ve Web 2.0 araçlarıyla desteklenmiş STEAM temelli etkinliklerin etkili bir pedagojik yaklaşım olduğu sonucuna varmıştır. Araştırma, bu tür bir müdahalenin;

1. Öğrencilerin öğrenme sürecine yönelik duyuşsal katılımını artırdığını ve olası kaygılarını azalttığını,

2. Ekolojik ayak izi gibi soyut ve karmaşık bir kavramın somut ve anlaşılır hale getirilmesini sağladığını,
3. Öğrencilerin bir çevre sorununa yönelik bilimsel ve teknik bilgileri kullanarak mühendislik tasarım becerilerini uygulamalarına ve yenilikçi çözümler geliştirmelerine olanak tanıdığını ortaya koymuştur.

Sonuç olarak, bu çalışma, çevre eğitiminin sadece bilgi aktarımından ibaret olmaması gerektiğini; öğrencileri eleştirel düşünmeye, tasarlamaya ve çözüm üretmeye teşvik eden disiplinler arası, uygulamalı ve teknolojiyle zenginleştirilmiş öğrenme deneyimleri sunması gerektiğini güçlü bir şekilde göstermektedir.

Uygulamaya Yönelik Öneriler:

- Fen Bilimleri, Sosyal Bilgiler ve Teknoloji ve Tasarım gibi derslerin müfredatlarına, ekolojik ayak izi ve sürdürülebilirlik konularını içeren, oyunlaştırma ve STEAM temelli disiplinler arası proje tabanlı öğrenme etkinlikleri entegre edilebilir.
- Öğretmenlere, Web 2.0 araçlarını ve oyunlaştırma tekniklerini derslerinde etkili bir şekilde kullanabilmeleri için hizmet içi eğitimler düzenlenmelidir.

Gelecek Araştırmalara Yönelik Öneriler:

- Bu çalışma, nitel bir durum çalışmasıdır. Gelecek araştırmalarda, daha büyük örneklem gruplarıyla, öğrencilerin bilgi ve tutum düzeylerindeki değişimi nicel olarak ölçen ön-test son-test kontrol gruplu deneysel tasarımlar kullanılabilir.
- Öğrencilerin kazandıkları farkındalığın ve bilgilerin, uzun vadede gerçek davranış değişikliğine dönüşüp dönüşmediğini inceleyen boylamsal çalışmalar yapılabilir.
- Farklı ekolojik ayak izi bileşenlerine (karbon, gıda vb.) odaklanan benzer STEAM etkinliklerinin etkililiği araştırılabilir.

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Web 2.0 Destekli Eğitsel Oyun Tasarımının Öğretmen Adaylarının Öz-yeterlik ve Teknolojiye Yönelik Tutumlarına Etkisi

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Özet

Öğretim teknolojileri; çağdaş yöntemleri destekleyen, öğrenci merkezli ve anlamlı öğrenmeyi kolaylaştıran dijital araçları kapsamaktadır. Son yıllarda dijital eğitsel oyunlar; öğrencilerin motivasyonunu artırmaları, problem çözme ve eleştirel düşünme gibi üst düzey bilişsel becerileri geliştirmeleri ve öğrenmeyi eğlenceli kılmaları nedeniyle dikkat çeken bir öğretim materyali hâline gelmiştir. Bu doğrultuda araştırmanın amacı, öğretmen adaylarının kendi belirledikleri konulara dayalı olarak dijital eğitsel oyunlar tasarlamalarının; dijital oyun geliştirme öz-yeterlikleri ve öğretim teknolojilerine yönelik tutumlarına etkisini incelemektir. Araştırma, nicel yöntemlerden tek grup ön test-son test zayıf deneysel desen ile yürütülmüştür. Çalışma grubunu, bir devlet üniversitesinin eğitim fakültesinin farklı bölümlerinde öğrenim gören 81 öğretmen adayı oluşturmaktadır. Örneklem seçiminde uygun örnekleme yöntemi kullanılmıştır. Uygulama sürecinde aynı bölümdeki öğretmen adaylarından 3-4 kişilik gruplar oluşturulmuştur. Bu gruplardan, kendi seçtikleri bir konu belirlemeleri, bu konuya uygun bir ders planı hazırlamaları ve ders planın içinde dijital eğitsel bir oyuna yer vermeleri istenmiştir. Dijital oyunlar, web 2.0 araçlarından faydalanarak öğretmen adayları tarafından tasarlanmıştır. Veri toplama aracı olarak, "Dijital Eğitsel Oyun Geliştirme Öz-yeterlik Ölçeği" ile "Öğretim Teknolojileri ve Materyal Tasarımı Dersine Yönelik Tutum Ölçeği" kullanılmıştır. Veriler, ölçekler aracılığıyla ön test ve son test şeklinde toplanmış ve verilerin analizinde bağımlı örneklem t-testi uygulanmıştır. Ayrıca, öğretim teknolojilerine yönelik tutum ile dijital oyun geliştirme öz-yeterlikleri arasındaki ilişkiyi belirlemek amacıyla Pearson korelasyon analizi gerçekleştirilmiştir. Araştırma bulgularına göre, uygulama süreci sonunda öğretmen adaylarının dijital eğitsel oyun geliştirme öz-yeterliklerinde ve öğretim teknolojilerine yönelik tutumlarında anlamlı düzeyde artış gözlemlenmiştir. Bu sonuçlar, dijital eğitsel oyun geliştirme süreçlerinin öğretmen adaylarının teknolojik pedagojik yeterliklerini artırmada etkili bir araç olabileceğini göstermektedir.

Anahtar kelimeler: Dijital eğitsel oyun, öğretim teknolojilerine yönelik tutum, dijital öz-yeterlik, öğretmen adayları

The Effect of Web 2.0-Supported Educational Game Design on Pre-Service Teachers' Self-Efficacy and Attitudes Towards Technology

Abstract

Instructional technologies encompass digital tools that support contemporary methods, facilitate student-centered and meaningful learning. In recent years, digital educational games have attracted attention as an instructional material due to their ability to increase students' motivation, develop higher-order cognitive skills such as problem-solving and critical thinking, and make learning enjoyable. Accordingly, the purpose of this study is to examine the effect of pre-service teachers' design of digital educational games based on self-determined topics on their digital game development self-efficacy and attitudes toward instructional technologies course. The study was conducted using The One-Group Pretest-Posttest Design, one of the quantitative research methods. The study group consisted of 81 pre-service teachers enrolled in different departments of the faculty of education at a public university. Convenience sampling method was used in sample selection. During the implementation process, groups of 3-4 pre-service teachers from the same department were formed. These groups were asked to select a topic, prepare a lesson plan on that topic, and include a digital educational game in the plan. The digital games were designed by the pre-service teachers using Web 2.0 tools. As data collection instruments, the "Digital Educational Game Development Self-Efficacy Scale" and the "Attitudes Towards Instructional Technologies and Material Development Course Scale" were used. Data were collected through pre-tests and post-tests, and paired sample t-tests were applied for analysis. In addition, Pearson correlation analysis was conducted to determine the relationship between attitudes toward instructional technologies and digital game development self-efficacy. According to the findings of the study, significant increases were observed in pre-service teachers' digital

educational game development self-efficacy and their attitudes toward instructional technologies at the end of the implementation process. These results indicate that digital educational game development processes can be an effective tool in enhancing pre-service teachers' technological pedagogical competencies.

Keywords: Digital educational game, attitude toward instructional technologies, digital self-efficacy, pre-service teachers

Giriş

Günümüzde hızlı bir biçimde ilerleme kaydeden teknoloji sayesinde her alanı dijitalleştirmek zorunlu bir ihtiyaç haline gelmiştir. Eğitim alanı da dinamik bir şekilde gelişme gösteren bu süreçten oldukça etkilenmiştir ve her geçen gün bu alanda da dijitalleşmeye olan yönelim artmaktadır. Dijital ortam ile eğitimin doğru bir şekilde entegre edilebilmesi için öğretmenler, öğrenciler ve hatta veliler bile bu konuda eğitimler almaktadır. Eğitimde önem kazanan dijital araç ve gereçler, bu süreçte hızlandırıcı rol oynamaktadır (Livari, Sharma ve Ventä-Olkkonen, 2020; Arslan ve Coştu, 2022). Dijitalleşme sürecinden etkilenen eğitim alanında, internet tabanlı uygulamalardan yararlanılmaktadır. Birçok internet tabanlı uygulama eğitim içeriklerini sözel öğelerden görsel öğelere dönüştüren tasarım özellikleriyle dikkat çekmektedir (Gros, 2007). İnternet tabanlı dijital araçlar arasında yer alan dijital oyunlar eğitim alanında önemli bir yer tutmaktadır (Riopel vd., 2020). Teknolojinin gelişmesiyle birlikte gerçek hayatta oynanan oyunların oynandığı ortamlar gerçeklikten sanal ortama geçiş yapmıştır. Sanallaşan oyunlar ilgi çekici, fantastik ve zenginleştirilmiş içerikleri ile her yaş grubuna hitap eder hale gelmiştir (Bülbül, 2022). Dijital oyunlar, keyifli vakit geçirirken aynı zamanda bireyin yaratıcı ve stratejik düşünme becerilerini artıran; zihinsel ve duygusal gelişimini, alışkanlıklarını ve karakter yapısını destekleyen; sosyalleşmesine, öz güveninin artmasına ve cesaretlenmesine katkıda bulunan önemli araçlardır (Bülbül, 2022; Gündoğdu, 2021). Dijital oyun teknolojileri, yaşamda yer alan gerçek olguları simülasyona dönüştürerek eğitimi ve kullanıcıları yönlendirir ve deneyim edinmesini sağlar. Bu bağlamda dijital oyunlar, yeni nesil bireylerin odak noktası haline gelerek farklı bir boyut kazanmıştır (Demir ve Hazar, 2018; Bülbül, 2022). Bununla birlikte dijital oyunların eğitime entegre edilmesi eğlenceli bir öğrenme ortamı oluşturma ve öğretim sürecini yapılandırma açısından büyük değer taşır. Web 2.0 tabanlı araçlar sayesinde öğretmen ve öğrenciler, oyun temelli içerikleri etkileşimli bir şekilde oluşturabilmekte ve paylaşabilmektedirler (Turan, Küçük ve Karabey, 2022). Günümüzde dijital eğitsel araçları etkili bir şekilde ders planına entegre edebilecek ve bu araçları tasarlayıp uygulayabilecek öğretmenlere ihtiyaç duyulmaktadır. Bu sebeple, öğretmen adaylarının dijital eğitsel oyun tasarımı deneyimi kazanmalarının, bu araçları pedagojik amaçlarla etkili bir şekilde kullanmaları açısından önemli olduğu düşünülmektedir. Bütün bu bulgulara karşın, öğretmen adaylarının Web 2.0 tabanlı dijital eğitsel oyun tasarlama sürecine aktif katılımlarının hem dijital oyun geliştirme öz-yeterlikleri hem de öğretim teknolojilerine yönelik tutumları üzerindeki bütüncül etkisini inceleyen çalışmaların sınırlı olduğu görülmektedir (Engin, 2022; Rüth, Birke ve Kaspar, 2022). Bu araştırmanın, söz konusu boşluğu doldurarak öğretmen adaylarının tasarım temelli dijital oyun geliştirme deneyimlerinin mesleki yeterlik ve teknoloji tutumlarına katkısını ortaya koymayı amaçlayan bir adım niteliğinde olduğu düşünülmektedir.

Araştırmanın Amacı ve Problem Cümlesi

Bu araştırmanın amacı, öğretmen adaylarının kendi seçtikleri konulara dayalı olarak ders planına entegre edilmiş dijital eğitsel oyunlar tasarlamalarının, dijital oyun geliştirme öz yeterlikleri ve öğretim teknolojileri dersine yönelik tutumlarına etkisini ortaya koymaktır. Bu araştırma aşağıdaki problem cümlesi çerçevesinde yürütülmüştür.

Web 2.0 tabanlı dijital eğitsel oyun tasarlama sürecinin, öğretmen adaylarının dijital eğitsel oyun geliştirme öz-yeterlikleri ile öğretim teknolojilerine yönelik tutumları üzerindeki etkisi nedir?

Alt Problemler

1. Öğretmen adaylarının dijital eğitsel oyun öz-yeterlik ölçeği ön test-son test puan ortalamaları arasında istatistiksel olarak anlamlı bir fark var mıdır?
2. Öğretmen adaylarının öğretim teknolojilerine yönelik tutum ölçeği ön test-son test puan ortalamaları arasında istatistiksel olarak anlamlı bir fark var mıdır?
3. Öğretim teknolojilerine yönelik tutum ölçeği ve dijital eğitsel oyun öz-yeterlik ölçeği arasında anlamlı bir ilişki var mıdır?

Yöntem

Araştırma Deseni ve Süreci

Araştırma, nicel yöntemlerden tek grup ön test-son test zayıf deneysel desen ile yürütülmüştür. Bu desende aynı gruptaki katılımcılara deneysel işlem öncesinde ve sonrasında ölçümler yapılarak farkların ortaya konması amaçlanır (Fraenkel, Wallen ve Hun, 2012). Çalışma grubu, 2023-2024 eğitim-öğretim yılı bahar döneminde bir devlet üniversitesinin Eğitim Fakültesinin farklı bölümlerinde öğrenim gören 81 öğretmen adayından oluşmaktadır. Örneklem seçiminde uygun örnekleme yöntemi tercih edilmiştir. Araştırma yürütülürken ilk olarak aynı bölümde öğrenim gören öğretmen adaylarından 3-4 kişilik gruplar oluşturulmuştur. Bu gruplardan, kendi seçtikleri bir konu belirlemeleri, bu konuya uygun bir ders planı hazırlamaları ve ders planın içinde dijital eğitsel bir oyuna yer vermeleri istenmiştir. Öğretmen adayları ders planlarını ve dijital oyunları tasarlamadan önce ölçekler ön-test olarak uygulanmıştır. Uygulama tamamlandıktan 3 hafta sonra aynı ölçekler son-test olarak uygulanıp süreç tamamlanmıştır.

Veri Toplama Araçları

Veri toplama aracı olarak, "Dijital Eğitsel Oyun Geliştirme Özyeterlik Ölçeği (DEOGÖÖ)" ile " Öğretim Teknolojileri ve Materyal Tasarımı Dersine Yönelik Tutum Ölçeği (ÖTMTDYTÖ)" kullanılmıştır. Araştırma kapsamında öğrencilerin dijital eğitsel oyun geliştirme öz-yeterliklerini belirlemek amacıyla kullanılan ölçek, Kelleci ve Kulaksız (2020) tarafından geliştirilmiştir. Ölçek, 5'likert tipi ve 21 maddeden oluşmaktadır. "Eğitim ve Oyun Geliştirme" şeklinde tanımlanan iki faktörlü yapıya sahiptir. Ölçeğin Cronbach alpha güvenirlik katsayısı araştırmacılar tarafından 0,972 olarak hesaplanmıştır. Öğretim Teknolojileri ve Materyal Tasarımı Dersine Yönelik Tutum Ölçeği ise Çetin vd. (2013) tarafından geliştirilmiştir. Ölçeğin Cronbach alpha güvenirlik katsayısı 0,931 olarak hesaplanmıştır. 5'li likert tipi ve 41 maddeden oluşan ölçek, "Hoşlanma, Yadsıma ve Yararlılık" olarak adlandırılan üç alt boyuttan oluşmaktadır.

Bulgular

Araştırmada kullanılan iki ölçeğin de araştırmanın örneklemi için Cronbach alpha güvenirlik katsayıları ayrı ayrı hesaplanmıştır. DEOGÖÖ'nün Cronbach alpha güvenirlikkatsayısı 0,922 olarak; ÖTMTDYTÖ'nün Cronbach alpha güvenirlikkatsayısı 0,931 olarak hesaplanmıştır. Nunnaly ve Berstein (1994), 0,70 ve üzerinde güvenirlik katsayısına sahip ölçeklerin güvenilir kabul edilerek çalışmalarda veri toplama aracı olarak kullanılabileceğini belirtmişlerdir.

Verilerin normal dağılım gösterip göstermediğini belirlemek amacıyla yapılan betimsel analizler sonucunda, her iki ölçeğin de öntest-sontest (dijital eğitsel oyun öz-yeterlik ölçeği ve öğretim teknolojilerine yönelik tutum ölçeği) puanlarının normal dağılım varsayımını sağladığı görülmüştür. Özellikle, her iki ölçeğin toplam puanları için yapılan basıklık ve çarpıklık katsayıları hesaplamaları, değerlerin ±1.0 aralığında olduğunu göstermiştir. Basıklık ve çarpıklık katsayısının ±1.0 aralığında olması puanların normal dağılımdan önemli bir sapma göstermediği şeklinde yorumlanabilir (Büyüköztürk, 2010). Ayrıca, mod, medyan ve ortalama değerlerinin birbirine yakın olduğu belirlenmiştir. Bu bulgu dağılımların simetrik ve normal olduğunu destekleyen bir diğer bulgu olmuştur (Büyüköztürk, 2010). Normal dağılımın sağlandığı tespit edildikten sonra, öğretmen adaylarının uygulama öncesi ve sonrası puanlarını karşılaştırmak amacıyla her iki ölçek ve alt boyutları için ilişkili örneklemler t-testi uygulanmıştır.

Dijital Eğitsel Oyun Geliştirme Öz-Yeterlik Ölçeğine İlişkin Bulgular

Öğretmen adaylarının dijital eğitsel oyun geliştirme öz-yeterlik ölçeğinin öntest ve sontest olarak uygulanması sonucunda elde ettikleri puan ortalamaları arasındaki farkın istatistiksel olarak anlamlı olup olmadığının belirlenmesi amacıyla ilişkili örneklemler t-testi yapılmış ve bulgular Tablo 1'de gösterilmiştir.

Tablo 1. Dijital eğitsel oyun geliştirme öz-yeterlik ölçeği öntest-sontest ortalama puanlarının t-testi sonuçları

DEOGÖÖ	N	x̄	S	sd	t	p
Öntest	81	3,47	0,45	80	-9,545	,000*
Sontest	81	4,05	0,51			

*p<,001

Uygulamanın, öğretmen adaylarının Dijital Eğitsel Oyun Geliştirme Öz-yeterlik Ölçeğinden aldıkları değerler üzerindeki etkisini belirlemek için ilişkili örneklemler t-testi yürütülmüştür. Öğretmen adaylarının dijital oyun geliştirme süreci sonunda dijital eğitsel oyun geliştirme öz-yeterliklerinde istatistiksel olarak anlamlı bir artış olduğu sonucuna ulaşılmıştır, t(80) = -9,545, p< ,001. Öğretmen adaylarının uygulama öncesi dijital eğitsel oyun geliştirme öz-yeterlik puanlarının ortalaması 3,47 iken, dijital oyun geliştirme süreci sonrasında söz konusu ortalama 4,05'e yükselmiştir. Bu bulgu, dijital oyun geliştirme/tasarlama sürecinin öğretmen adaylarının öz-yeterliklerini artırmada anlamlı bir etkiye sahip olduğunu göstermektedir.

Ölçeğin toplam puanına yönelik analizlerin yanı sıra, dijital eğitsel oyun geliştirme öz-yeterlik düzeyindeki değişimleri daha ayrıntılı olarak incelemek amacıyla alt boyutlar düzeyinde de ilişkili örneklemler t-testi uygulanmıştır. Yapılan analizler sonucunda elde edilen bulgular Tablo 2'de gösterilmiştir.

Tablo 2. Dijital eğitsel oyun geliştirme öz-yeterlik ölçeği faktörleri için öntest-sontest ortalama puanlarının t-testi sonuçları

Faktörler	Gruplar	N	x̄	ss	sd	t	p
Eğitim	Öntest	81	3,70	0,48	80	-4,380	,000*
	Sontest	81	4,05	0,53			
Oyun Geliştirme	Öntest	81	3,42	0,49	80	-9,505	,000*
	Sontest	81	4,03	0,70			

*p<,001

Dijital eğitsel oyun öz-yeterlik ölçeğinin alt boyutları incelendiğinde, öğretmen adaylarının Eğitim alt boyutunda ön test (x̄= 3,70, ss= 0,48) ve son test x̄= 4,05, ss = 0,53) puanları arasında anlamlı bir artış gözlenmiştir, t(80) = -4,38, p < ,001. Benzer şekilde, Oyun Geliştirme alt boyutunda da ön test (x̄= 3,42, ss = 0,49) ve son test (x̄= 4,03, ss = 0,70) puanları arasında istatistiksel olarak anlamlı bir yükselme kaydedilmiştir, t(80) = -9,51, p < ,001. Bu sonuçlar, dijital eğitsel oyun geliştirme sürecinin öğretmen adaylarının hem eğitim süreçlerine yönelik hem de oyun geliştirme becerilerine ilişkin öz-yeterlik algılarını anlamlı biçimde artırdığını göstermektedir.

Öğretim Teknolojileri ve Materyal Tasarımı Dersine Yönelik Tutum Ölçeğine İlişkin Bulgular

Uygulamanın, öğretmen adaylarının Öğretim Teknolojileri ve Materyal Tasarımı Dersine Yönelik Tutum Ölçeğinden aldıkları değerler üzerindeki etkisini belirlemek için ilişkili örneklemler t-testi yürütülmüştür. Bulgular Tablo 3'teki gibidir.

Tablo 3. Dijital eğitsel oyun geliştirme öz-yeterlik ölçeği öntest-sontest ortalama puanlarının t-testi sonuçları

ÖTMTDTÖ	N	x̄	S	sd	t	p
Öntest	81	3,55	0,41	80	-4.679	,000*
Sontest	81	3,76	0,45			

*p<,001

İlişkili örneklemler t-testi sonucunda, öğretmen adaylarının dijital oyun geliştirme süreci sonunda öğretim teknolojileri dersine yönelik tutumlarının anlamlı düzeyde arttığı görülmüştür, $t(80) = -4,679$, $p < ,001$. Uygulama öncesinde ortalama tutum puanı 3,55 iken, uygulama sonrasında bu ortalama 3,76'ya yükselmiştir. Bu sonuç, dijital oyun geliştirme sürecinin öğretmen adaylarının öğretim teknolojileri dersine yönelik tutumlarını olumlu yönde etkilediğini göstermektedir.

Ölçeğin toplam puanına ilişkin yapılan analizlerin yanı sıra, öğretim teknolojileri dersine yönelik tutumun hangi boyutlarda değişim gösterdiğini daha ayrıntılı biçimde ortaya koymak amacıyla alt faktörler düzeyinde de ilişkili örneklemler t-testi yapılmıştır. Bu analiz ile uygulamanın yalnızca genel tutum üzerinde değil, aynı zamanda yararlılık, hoşlanma ve yadsıma alt boyutları üzerinde farklı etkiler yaratıp yaratmadığı incelenmiş ve bulgular Tablo 4'te verilmiştir.

Tablo 4. Öğretim teknolojileri ve materyal tasarımı dersine yönelik tutum ölçeği faktörleri için öntest-sontest ortalama puanlarının t-testi sonuçları

Faktörler	Gruplar	N	x̄	ss	sd	t	p
Yararlılık	Öntest	81	3,81	0,41	80	-1,592	,115
	Sontest	81	3,91	0,60			
Hoşlanma	Öntest	81	3,18	0,65	80	-5,600	,000*
	Sontest	81	3,58	0,78			
Yadsıma[1]	Öntest	81	3,31	0,48	80	-0,939	,351
	Sontest	81	3,38	0,63			

[1] Yadsıma alt boyutundaki maddeler ters çevrilmiş olup yüksek puanlar daha olumlu tutumu ifade etmektedir.

*p<,001

Tablo 4'te görüldüğü üzere, yararlılık alt boyutunda ön test ($\bar{x}$= 3,81, ss = 0,41) ve son test ($\bar{x}$=3,91, ss = 0.60) puanları arasında istatistiksel olarak anlamlı bir fark bulunmamıştır, $t(80) = -1.59$, p=0,115. Benzer şekilde, yadsıma alt boyutunda da ön test ($\bar{x}$=3,31, ss = 0,48) ve son test ($\bar{x}$ = 3,38, ss=0.63) puanları arasında anlamlı bir farklılık gözlenmemiştir, $t(80) = -0,94$, p= 0,351. Ancak hoşlanma alt boyutunda, ön test ($\bar{x}$=3,18, ss=0,65) ve son test ($\bar{x}$=3,58, ss= 0,78) puanları arasında anlamlı bir artış saptanmıştır, $t(80) = -5,60$, $p < ,001$.

Bu bulgular, dijital oyun geliştirme sürecinin öğretmen adaylarının öğretim teknolojilerinden hoşlanma düzeylerini anlamlı biçimde artırdığını, ancak teknolojilerin yararlılığına ilişkin algılarında ve olumsuz yargılarında (yadsıma) anlamlı bir değişim yaratmadığını göstermektedir. Özellikle yadsıma alt boyutunun maddeleri ters çevrilmiş olduğundan, yüksek puanların olumlu tutumu temsil ettiği göz önünde bulundurulmuş; buna rağmen, uygulama sonrasında öğretmen adaylarının olumsuz tutumlarında anlamlı bir azalma ortaya çıkmamıştır.

Pearson Korelasyon Analizine İlişkin Bulgular

Bu araştırmada, öğretmen adaylarının DEOGÖÖ ile ÖTMTDTÖ puanları arasındaki ilişki incelenmiştir. Bu doğrultuda, her iki ölçeğin son testlerinden elde edilen puan ortalamaları arasındaki ilişkiyi belirlemek amacıyla Pearson korelasyon analizi gerçekleştirilmiştir. Analiz sonucunda elde edilen korelasyon katsayıları, değişkenler arasındaki ilişkinin yönü, düzeyi ve istatistiksel anlamlılığı açısından değerlendirilmiş; ayrıca, determinasyon katsayısı (r^2) hesaplanarak değişkenler arasında paylaşılan ortak varyans oranı yorumlanmış ve bulgular Tablo 5'de gösterilmiştir.

Tablo 5. Dijital eğitsel oyun öz-yeterliği ve öğretim teknolojileri dersine yönelik tutum puan ortalamaları arasındaki korelasyon

		Öğretim Teknolojileri Dersine Yönelik Tutum Ölçeği
Dijital Eğitsel Oyun Geliştirme Özyeterliği	Pearson r	0,661
	p	,000*
	N	81

*p<,05

Yapılan Pearson korelasyon analizi sonucunda, Dijital Eğitsel Oyun Geliştirme Özyeterlik Ölçeği ile Öğretim Teknolojilerine Yönelik Tutum Ölçeği puanları arasında pozitif yönde yüksek düzeyde anlamlı bir ilişki olduğu görülmüştür ($r = ,661$, $p <,05$). Korelasyon katsayısının karesi ($r^2 = 0,436$) incelendiğinde, öğretmen adaylarının dijital eğitsel oyun geliştirme özyeterlikleri ile öğretim teknolojilerine yönelik tutum puanlarının toplam varyanslarının yaklaşık %44'ünün ortak olduğu görülmektedir. Yani dijital eğitsel oyun geliştirme özyeterliği puanlarındaki değişimin yaklaşık %44'ü öğretim teknolojileri dersine yönelik tutum puanlarıyla ortaklaşa açıklanabilmektedir. Bu bulgular, özyeterlik düzeyi yüksek olan öğretmen adaylarının tutum düzeylerinin de genellikle yüksek olduğunu, benzer şekilde özyeterliği düşük olanların tutumlarının da düşük olma eğilimi gösterdiğini ortaya koymaktadır.

Tartışma ve Sonuç

Bu çalışmada öğretim teknolojileri dersinde dijital eğitsel oyun içeriği de dahil edilerek öğrencilere kendi alanlarına uygun ders planları hazırlatılmıştır. Böylece dijital eğitsel oyun özyeterliklerine ve materyal tasarımına yönelik tutumlarındaki değişim incelenmiştir. Bu incelemede öğrencilerin aktif öğrenmesi ve dersin daha dikkat çekici hale getirilmesi sağlanmıştır. Bazı çalışmalarda da öğrenme açısından dijital oyunun daha etkili olduğu, ezberci öğrenme yerine tasarlama ile bilginin kalıcılığı gibi anlamlı sonuçlar elde edilmiştir (Wouters vd., 2013; Dönmez Usta ve Turan Güntepe, 2019).

Araştırma bulguları, dijital eğitsel oyun geliştirme sürecinin öğretmen adaylarının öz-yeterlik algılarını anlamlı şekilde güçlendirdiğini göstermektedir. Benzer biçimde, çevrim içi derslerde dijital oyunlara dayalı etkinliklerin incelendiği başka çalışmalarda da öğrencilerin öz-yeterlik ve motivasyonlarında artış gözlenmiş, öz-düzenleme seviyeleri incelendiğinde ise anlamlı bir değişim bulunmamıştır (Gündüzalp, 2021). Ayrıca, katılımcıların dersin başlangıcında dijital oyunları sınıfta kullanma konusunda kendilerini yeterince rahat, özgüvenli ve esnek hissetmedikleri, ancak süreç sonunda bu konuda çok daha rahat ve kendilerine güvenir hâle geldikleri bulunmuştur (An, 2018; Hung, Huang ve Hwnag, 2014). Öğretmen adayları üzerinde yapılan diğer araştırmalar da bu bulguları desteklediği görülmektedir. Bu sonuçlar birlikte ele alındığında, dijital oyun tasarlama ve geliştirme uygulamalarının hem öğretmen adaylarının hem de öğrencilerin öz-yeterlik ve motivasyonlarını destekleyen etkili bir öğrenme yöntemi olduğu söylenebilir.

Araştırmada alt boyut düzeyindeki analizler, uygulamanın yalnızca genel özyeterlik üzerinde değil, özellikle Eğitim ve Oyun Geliştirme gibi alt boyutlarda da anlamlı etkiler yarattığını göstermiştir. Bulgular, teknoloji temelli üretim süreçlerine aktif katılımın öğretmen adaylarının özgüvenini ve teknoloji kullanımına yönelik inançlarını artırdığı yönündeki literatürle (Turan, Küçük ve Karabey, 2022; Rüth, Birke ve Kaspar, 2022) uyumludur. Ayrıca bu süreç, adayların pedagojik planlama, yaratıcı düşünme ve problem çözme becerilerini destekleyerek TPACK (Teknolojik Pedagojik Alan Bilgisi) yeterliklerini güçlendirmiştir (Kuo ve Kuo, 2024). Bu sonuç, literatürde dijital oyun projelerine katılan öğretmen adaylarında inanç, motivasyon ve öz-yeterlik düzeylerinde belirgin artışlar saptayan çalışmalarda yer alan eğilimlerle paralellik göstermektedir. Özellikle, dijital oyun tabanlı uygulamaların öğrenenlerin öz-yeterlik algılarını güçlendirdiği ve bu algıların teknoloji temelli öğretim süreçlerine katılımı desteklediği yönündeki literatür, elde edilen alt boyut artışlarıyla uyum içindedir. Ayrıca, öğretmenlerin oyunlaştırma yaklaşımına karşı tutumları ve uygulama niyetleriyle bunlara ilişkin öz-yeterlik algıları arasındaki pozitif ilişkiyi ortaya koyan çalışmalar da araştırmanın bulgularını sağlamlaştırmaktadır (Leiss vd., 2025).

Araştırma sonuçları, öğretmen adaylarının dijital eğitsel oyun geliştirme öz-yeterlikleri ile öğretim teknolojilerine yönelik tutumları arasında güçlü ve anlamlı bir ilişki olduğunu ortaya koymaktadır. Verilerin normal dağılım gösterdiği belirlenmiş ve uygulama öncesi-uygulama sonrası yapılan analizler, her iki değişkenin de süreç sonunda anlamlı biçimde yükseldiğini göstermiştir. Bu bulgular, sınıfta dijital oyunları kullanmaya yönelik olumlu tutumların Web 2.0 geliştirme becerileri ve tasarım öz-yeterlikleriyle de pozitif yönde ilişkili olduğunu, ayrıca öğretmen adaylarının tasarım öz-yeterlik algılarının daha yüksek olduğunu gösteren çalışmalarla uyuşmaktadır. Diğer yandan, dijital materyal geliştirme öz-yeterliğine yönelik olumsuz bakış açısının dijital oyunlara karşı olumsuz tutumları da artırdığı bildirilmektedir (Akkaya ve Kapıdere, 2021).

Araştırmanın bulguları, dijital oyun geliştirme sürecinin öğretmen adaylarının öğretim teknolojileri dersine yönelik tutumlarında hoşlanma alt boyutunda anlamlı artış sağladığını, ancak yararlılık ve yadsıma boyutlarında bir değişim olmadığını göstermektedir. Öğretmen adayları eğitsel oyunların öğrenmeyi daha yaratıcı ve iyi bir noktaya götüreceğini, öğrenme deneyimlerini zenginleştireceğini, öğretmenlerin bu doğrultuda rahatlayacaklarını düşünmektedir (Ustabulut, 2021). Dijital oyun geliştirme sürecinin öğretmen adaylarının öğretim teknolojilerine yönelik tutumlarını olumlu etkilemede bu bulguların hoşlanma alt boyutunda anlamlı artışa destek olabileceği düşünülmektedir. Bu anlamlı artışın sürdürülebilirliği için öğretmen adaylarının gelişimi kritik role sahiptir. Öğretmen adaylarının mezuniyet aşamasından önce mesleki yeterliliklerinin niteliğini arttırabilmek adına kazanımlara yönelik eğitsel dijital oyunlar geliştirme dersleri eklenebilir veya sayısında artış yapılabilir. Yararlılık algısının gelişebilmesi için sürecin daha uzun süreli, uygulamalı ve mesleki bağlama entegre edilmesi gerektiği söylenebilir (Alagöz, 2023). Buna karşın yararlılık ve yadsıma boyutlarında anlamlı bir değişimin olmaması, adayların mesleki faydayı yeterince deneyimleme fırsatlarının olmaması ile açıklanabilir. Önceki araştırmalarda öğretmen adaylarının oyun tasarlarken içerikle ilişkilendirme, oyunun özgünlüğü ve seçimi, öğrenci düzeyine uygun olması sorunları (Akcanca ve Sömen, 2018) ve oyun bağımlılığı dezavantajı (Engin, 2023) görüşleri göze çarpmaktadır. Dolayısıyla, dijital oyun geliştirme süreçlerinin öğretmen adaylarının yalnızca hoşlanma düzeyinde değil incelenen diğer alt boyutlarda da etkili olabilmesi için bu süreçlerin daha planlı ve öğretmen adaylarının

süreci daha verimli devam ettirebilmesi adına mesleki faydayı öne çıkaran bütünleştirilmiş bir şekilde yapılandırılması gerekmektedir.

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Kurumsal Kalite Raporları Kapsamında Yükseköğretimde Açıklığın İncelenmesi

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Özet

İçeriğin veya sistemin şeffaflığı ve özgürlüğü bağlamında ele alınan açıklık kavramı, geçmişten beri eğitim dâhil pek çok alanda kullanılmaktadır. Eğitimde açıklık süreçlerin, sistemlerin, bilginin ve öğrenme kaynaklarının erişilebilir, şeffaf ve paylaşılabilir bir biçimde sunulmasını ifade etmektedir. Birleşmiş Milletler tarafından yayınlanan Sürdürülebilir Kalkınma Amaçlarında, herkes için kapsayıcı ve kaliteli eğitim vurgusu yapılmaktadır. UNESCO 2030 Eylem Planında, kurumlara kendi bağlamlarına uygun, erişilebilir, kapsayıcı ve yüksek kaliteli kaynaklar sunmaları çağrısında bulunmaktadır. Türkiye'de Yükseköğretim Kurumu (YÖK) ise açıklık çerçevesinde açık erişim, açık veri, açık eğitim ve açık kaynakları teşvik etmektedir. Uluslararası kuruluşların ve YÖK'ün çağrıları, açıklık ilkesinin benimsenmesi ve uygulamaya aktarılmasıyla karşılık bulabilir. Bu araştırma, Türkiye'deki yükseköğretim kurumlarının açıklık kavramına yönelik yaklaşımlarını kapsamlı bir bakış açısıyla sunmayı amaçlamaktadır. Araştırmada doküman incelemesi yöntemi kullanılmış olup, veri kaynağını Yükseköğretim Kalite Kurulu Başkanlığı tarafından yayımlanan, 205 üniversiteye ait 2024 yılı kurum iç değerlendirme raporları (KİDR) oluşturmaktadır. Veri analizi sürecinin ilk aşamasında betimsel analiz, ikinci aşamasında içerik analizi kullanılmıştır. Araştırma bulgularına göre, kurumsal raporlarda en çok açık erişim, açık bilim ve açık eğitim kavramlarına yer verilmiştir. Buna karşılık açık kurs, açık üniversite, açık standart, açık içerik, açık tasarım ve açık eğitsel uygulama kavramlarına hiç değinilmemiştir. Ayrıca raporlarda, özellikle açık eğitsel kaynaklar ile kitlesel açık çevrimiçi derslere yönelik uygulamaların yetersizliği dikkat çekmektedir. Öne çıkan kavram olan açık erişim kapsamında, 65 üniversitenin açık arşiv/açık erişim sistemine sahip olduğu, 22 üniversitenin açık erişim yayın desteği sağladığı veya "oku ve yayınla" anlaşmasının yapıldığı ve 15 üniversitenin açık eğitime yönelik etkinlik/eğitim düzenlediği tespit edilmiştir. Açık bilim kapsamında ise üniversite raporlarında en fazla politika geliştirme odaklı ifadeler bulunmaktadır. Açık bilim politikasını, sırasıyla arşiv sistemi/açık bilim platformu ile açık bilime yönelik eğitim/etkinlik kodları takip etmektedir. Araştırma sonuçları, yükseköğretimde açıklığın sınırlı boyutlarda ele alındığını ve bu alanda yeni stratejiler geliştirilmesi gerektiğini göstermektedir.

Anahtar Kelimeler: Yükseköğretim, açıklık, açık eğitsel uygulamalar, kalite.

Examining Openness in Higher Education Through Institutional Quality Reports

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Abstract

The concept of openness, examined within the context of content and system transparency and freedom, has been used in many fields including education since the past. In education, openness refers to the provision of processes, systems, knowledge, and learning resources in an accessible, transparent, and shareable. The United Nations' Sustainable Development Goals emphasize inclusive and quality education for all. UNESCO's 2030 Action Plan calls on institutions to offer accessible, inclusive, and high-quality resources tailored to their contexts. In Türkiye, the Council of Higher Education (CoHE) promotes open access, open data, open education, and open resources within the framework of openness. The calls from international organizations and CoHE can be addressed by adopting and implementing the principle of openness. This study aims to present a comprehensive perspective on the approaches of higher education institutions in Türkiye toward the concept of openness. Document review method was used in the research and the data source consists of 2024 internal evaluation reports of 205 universities published by the Higher Education Quality Council. Descriptive analysis was applied in the first phase of data analysis, followed by content analysis in the second phase. According to the research findings, the concepts of open access, open science and open education were most frequently included in institutional reports. In contrast, terms such as open course, open university, open standard, open content, open design, and open educational practice were not mentioned. Furthermore, the reports highlight the insufficiency of practices related to open educational resources and massive open online courses. Within the prominent theme of open access, it was found

that 65 universities have an open archive/open access system, 22 provide open access publication support or have a “read and publish” agreement, and 15 organize events/training for open education. Regarding open science, university reports mostly focus on policy development, followed by archive systems/open science platforms and open science-related training/events. The research results indicate that openness in higher education is addressed to a limited extent and that new strategies need to be developed in this area.

Keywords: Higher Education, openness, open educational practices, quality.

Giriş

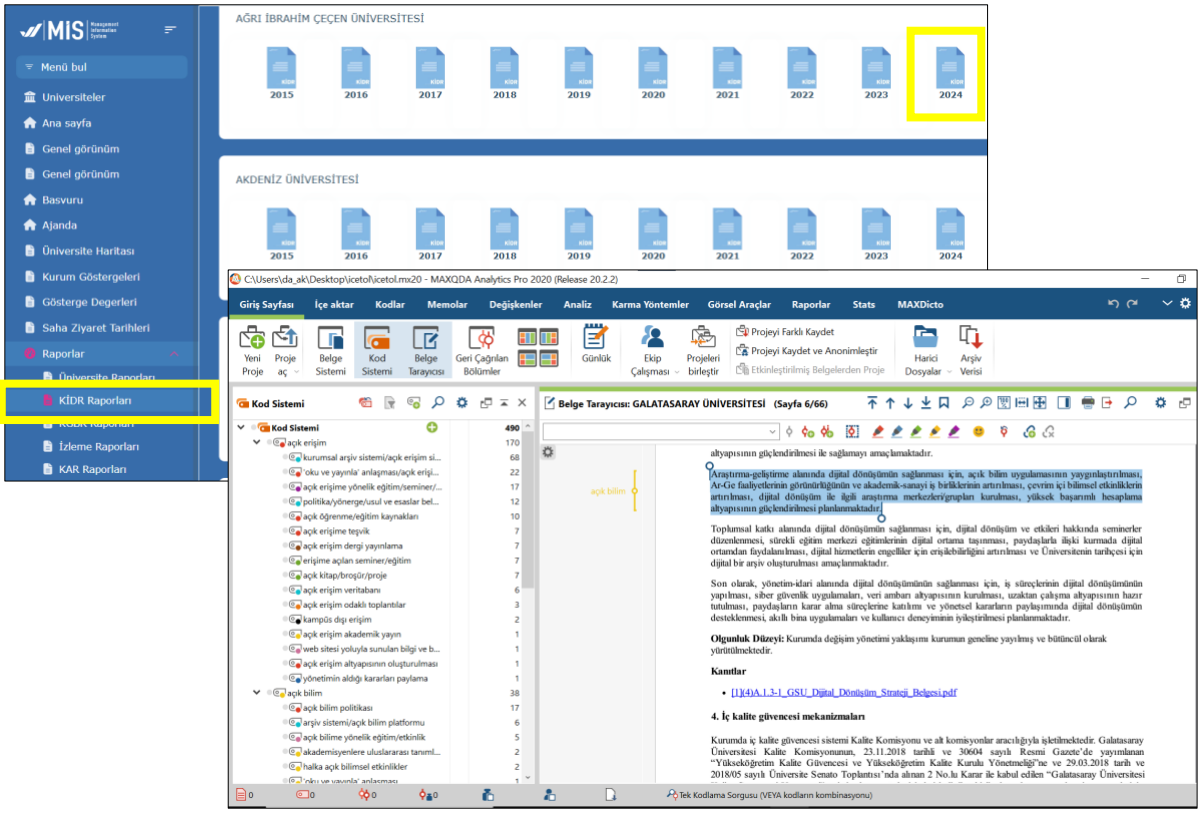
İçeriğin veya sistemin şeffaflığı ve özgürlüğü olarak ifade edilen açıklık (Baker, 2016), açık kültür, açık hükümet, açık erişim, açık bilgi gibi eğitimin dışındaki birçok alanda da kullanılan bir kavramdır (Bayne vd., 2015). Açıklık, kurum temelli sınırlamaları, mekân/zaman ve kaynak engellerini aşmanın yolu olarak sunulmaktadır (Edwards, 2015). Eğitim bağlamında açıklığın öğretim, müfredat tasarımı, ders kitapları, araştırma, politika ve akademik strateji gibi boyutları etkilediği ifade edilmektedir (Wiley & Green, 2016). Yaşayan bir kavram olarak açıklığın en temel katkısının eğitim fırsatlarına erişim olduğu ifade edilmektedir (Koçdar vd., 2023). Bu katkı ile açıklığın eşitlik ve sosyal adaleti sağlayarak eğitimi dönüştürebileceği vurgulanmaktadır. Ayrıca gelişen teknolojilerle birlikte açıklığın kapsamı güçlenmiş ve hedef kitlesi de genişlemiştir (Bozkurt & Stracke, 2023). Açıklık, hayat boyu öğrenmeyi destekleme, eğitim kurumlarının öğrenme üzerindeki tekellerini azaltma ve akran öğrenmesi ile bilgi üretimini teşvik etme gibi katkılara da zemin hazırlamaktadır (Edwards, 2015). Eğitim alanında açıklık hareketinin özellikle açık eğitsel kaynaklar ve kitlesel açık çevrimiçi derslerle önemli bir gelişim gösterdiği ifade edilmektedir (Bayne vd., 2015).

Birleşmiş Milletler tarafından 2015 yılında yayınlanan Sürdürülebilir Kalkınma Amaçlarında yer alan “Nitelikli Eğitim” boyutunda “kapsayıcı ve hakkaniyete dayanan nitelikli eğitimi sağlamak ve herkes için yaşam boyu öğrenim fırsatlarını teşvik etmek.” amaçlanmaktadır. İlgili boyutun diğer maddelerinde de eğitimde eşitlik ve erişilebilirlik vurgusu dikkat çekmektedir. UNESCO’nun 2030 yılı için yayınladığı eylem planında ise gelişen teknoloji ile birlikte eğitime erişim imkanlarının desteklenmesi için kurumlara, kendi bağlamlarında kapsayıcı ve erişilebilir kaynaklar sunma çağrısında bulunmaktadır (UNESCO, 2016, s.20). Ülkemizde Yükseköğretim Kurumunun (YÖK) 2019-2023 Stratejik Planında açıklığa odaklanılarak “Üniversitelerin dijital çağa ayak uydurması ve bilgiye ulaşımda açık erişim ve açık bilim uygulamalarının hayata geçirilmesi amacıyla açık erişim altyapıları ile uyumu sağlanacaktır.” hedefi yer almaktadır (YÖK, 2019, s.13). Birçok yükseköğretim kurumu açıklık düşüncesinin sunduğu katkılardan hareketle açık eğitsel uygulamalar, açık eğitsel kaynaklar ve kitlesel açık çevrimiçi dersler gibi girişimlerde bulunmaktadır (Bozkurt & Stracke, 2023). Ancak eğitim araştırmalarında açıklığın daha az gelişmiş toplumlara büyük katkılar sunabilme potansiyeline rağmen bu bölgelerde açıklığa dair ilginin düşük olduğu belirtilmektedir (Koçdar vd., 2023). Eğitime erişimi artırma potansiyeline bağlı yapılan uluslararası çağrılar ve gelişen teknoloji imkânlarının destekleyici gücü dikkate alındığında mevcut durumda açıklığın ne düzeyde gerçekleştiğinin anlaşılması büyük önem taşımaktadır. Araştırma, Türkiye'deki yükseköğretim kurumlarının açıklık uygulamalarına yönelik yaklaşımlarını kapsamlı bir bakış açısıyla sunmayı amaçlamaktadır. Bu doğrultuda araştırmada “Türkiye’deki yükseköğretim kurumlarının açıklık uygulamalarına ilişkin eğilimleri nasıldır?” sorusuna yanıt aranmaktadır.

Yöntem

Araştırma kapsamında doküman incelemesi yöntemi kullanılmış olup, YÖK tarafından yayınlanan 205 üniversiteye ait 2024 yılı kurum iç değerlendirme raporları incelenmiştir. Doküman analizi, basılı ya da elektronik formattaki mevcut dokümanların sistematik olarak incelenmesi süreci olarak tanımlanmaktadır. Çoğunlukla kamuya açık dokümanların kullanıldığı bu yöntem, yeni veri toplamak yerine mevcut verilere dayanması nedeniyle hem verimli hem de maliyet açısından ekonomiktir (Bowen, 2009).

Veri toplama sürecinin ilk aşamasında Yükseköğretim Kalite Kurulu web sitesinde (https://www.yokak.gov.tr/tag/kurum-ic-degerlendirme-raporu/) arşivlenen devlet ve vakıf olmak üzere 205 üniversiteye ait 2024 yılı kurum iç değerlendirme raporları indirilmiştir. Kurumun öz değerlendirme çalışmalarının kritik çıktısı olan bu raporlar, kurumların güçlü ve gelişmeye açık yönlerini tanımalarını ve iyileştirme süreçlerine katkı sağlamayı amaçlamaktadır. İkinci aşamada analiz için bu raporlar MAXQDA 2020 uygulamasına aktarılarak önce betimsel analiz daha sonra içerik analizi gerçekleştirildi. Araştırmanın veri toplama ve analiz sürecine ait örnek ekran görüntüleri Şekil 1’de sunulmaktadır.



Şekil 1. Veri toplama ve analiz süreci

Betimsel analiz için açıklık felsefesini temel alan açık eğitsel uygulamalar çerçevesi (Köseoğlu & Bozkurt, 2018) kullanıldı. Bu çerçeveye göre tüm raporlarda ilk aşamada şu ifadeler aratılmış ve bulunan cümleler kodlanmıştır: açık eğitim, açık eğitsel uygulamalar, açık eğitsel kaynaklar, açık erişim, açık içerik, açık ders, açık veri, açık tasarım, açık bilgi, açık öğrenim, açık lisans, açık akademi, açık standart, açık öğretim, açık üniversite. İkinci aşamada ise kodlarla ilişkilendirilen cümle veya paragraflar içerik analizine tabi tutularak kod kapsamında gerçekleştirilen alt amaç veya faaliyetler belirlendi.

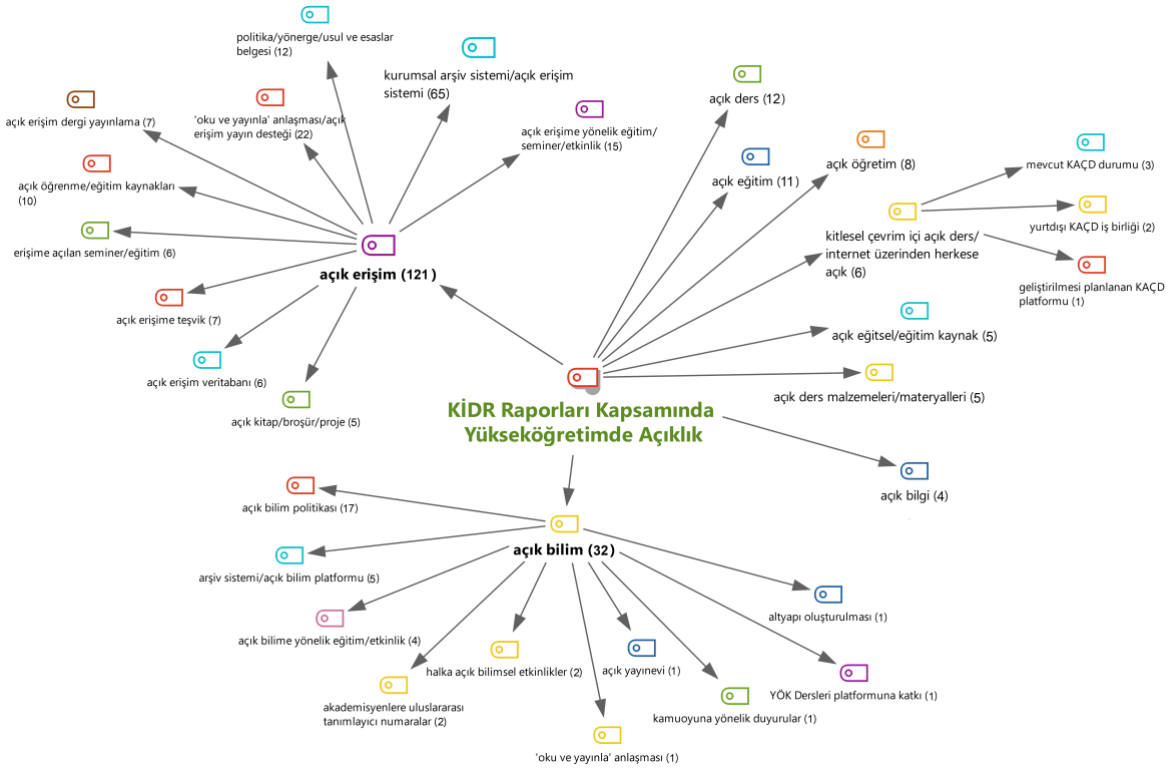
Bulgular

Araştırma kapsamında Türkiye'deki yükseköğretim kurumlarının açıklık uygulamalarına ilişkin eğilimlerini belirlemek amacıyla YÖK KİDR raporları analiz edildi. Buna göre ilgili raporlarda yükseköğretim kurumlarının yarısından fazlası açık erişim (n=121) kavramına yer vermiştir. Bu kavramı sırasıyla açık bilim (n=32), açık ders (n=12), açık eğitim (n=11) ve açık öğretim (n=8) kavramları takip etmektedir. Açıklık bağlamında ele alınan tüm kavramların KİDR raporlarında kullanımına ait veriler Tablo 1'de sunulmaktadır.

Tablo 1. Açıklık bağlamındaki kavramların KİDR raporlarında kullanımı

Kavram	n	Yüzde
Açık erişim	121	%59.02
Açık bilim	32	%15.61
Açık ders	12	%5.85
Açık eğitim	11	%5.37
Açık öğretim	8	%3.90
Kitlesel çevrimiçi açık ders/internet üzerinden herkese açık kurs	6	%2.93
Açık ders malzemeleri/materyalleri	5	%2.44
Açık eğitsel/eğitim kaynağı	5	%2.44
Açık bilgi	4	%1.95
Açık öğrenme	3	%1.46
Açık veri	3	%1.46
Açık lisans	1	%0,49
Açık kurs-açık üniversite-açık standart-açık tasarım-açık eğitsel uygulama-açık içerik	0	0

Araştırmada açık erişim ve açık bilim için üniversitelerin KİDR raporlarında belirttiği faaliyetler içerik analizi ile belirlendi. Buna göre açık erişim kapsamında raporlarda en fazla yer verilen uygulama kurumsal arşiv sistemi/açık erişim sisteminin (n=65) bulunması veya kurulması yönündedir. 22 üniversite raporlarında açık erişim yayın desteği için oku ve yayınla anlaşması yapıldığına, 15 üniversite ise açık erişime yönelik eğitim/seminer veya etkinlik gerçekleştirdiğine yer vermektedir. Diğer plan ve faaliyetler sırasıyla açık erişime yönelik politika/yönerge/usul ve esaslar belgeleri (n=12), açık öğrenme/eğitim kaynakları (n=10), açık erişim dergi yayınlama (n=7), açık erişime teşvik etme (n=7), açık erişim veri tabanı (n=6), erişime açılan seminer/eğitim (n=6) ve açık kitap/broşür veya proje yayınlama (n=5) olarak belirlendi. Açık bilim kapsamında ise KİDR raporlarında en fazla açık bilim politikası (n=17) oluşturulduğundan bahsedilmektedir. Ek olarak halka açık bilimsel etkinlik gerçekleştirdiğini beyan eden yalnızca iki üniversite bulunmaktadır. Üniversitelerin raporlarında açıklık temelli kavramlara yer verme sıklıkları ile elde edilen tüm alt kodlar Şekil 2'de gösterilmektedir.



Şekil 2. KİDR raporlar kapsamında yükseköğretimde açıklık

KİDR raporlarında en az ifade edilen kavramlar kitlesel çevrimiçi açık ders/internet üzerinden herkese açık kurs (n=6), açık ders malzemeleri/materyalleri (n=5), açık eğitsel/eğitim kaynağı (n=5), açık bilgi (n=4), açık öğrenme (n=3), açık veri (n=3), açık lisans (n=1) olarak belirlendi. Öte yandan, incelenen raporların hiçbirinde açık kurs, açık üniversite, açık standart, açık tasarım, açık eğitsel uygulama ve açık içerik kavramlarına rastlanmamıştır. Tablo 2'de raporlarda az yer verilen kavramların hangi üniversite raporlarında geçtiğine dair bulgular sunulmaktadır.

Tablo 2. KİDR raporlarında en az yer verilen açıklık temelli kavramlar

Kavram	n	Üniversiteler
Kitlesel çevrimiçi açık ders/internet üzerinden herkese açık kurs	6	Ortadoğu Teknik Üniversitesi Necmettin Erbakan Üniversitesi MEF Üniversitesi İstanbul Okan Üniversitesi Gazi Üniversitesi Anadolu Üniversitesi
Açık ders malzemeleri/materyalleri	5	Ortadoğu Teknik Üniversitesi Kastamonu Üniversitesi Ankara Üniversitesi İstanbul Nişantaşı Üniversitesi Toros Üniversitesi

Açık eğitsel/eğitim kaynağı	5	Boğaziçi Üniversitesi Gazi Üniversitesi Atatürk Üniversitesi MEF Üniversitesi Muğla Sıtkı Koçman Üniversitesi
Açık bilgi	4	Zonguldak Bülent Ecevit Üniversitesi Mardin Artuklu Üniversitesi Gaziantep Üniversitesi Abdullah Gül Üniversitesi
Açık öğrenme	3	Necmettin Erbakan Üniversitesi Muğla Sıtkı Koçman Üniversitesi Anadolu Üniversitesi
Açık veri	3	Muğla Sıtkı Koçman Üniversitesi İzmir Yüksek Teknoloji Enstitüsü Hacettepe Üniversitesi
Açık lisans	1	Ankara Yıldırım Beyazıt Üniversitesi

Kitlesel açık çevrimiçi ders kapsamında Anadolu Üniversitesi AKADEMA, Orta Doğu Teknik Üniversitesi BilgeİŞ ve Necmettin Erbakan Üniversitesi de NEP 4.2 platformu ile ilgili açık ders faaliyeti beyan etmiştir. Gazi Üniversitesi ise açık eğitim kaynaklarına destek vermek amacıyla https://guzemxonline.gazi.edu.tr/ adresi üzerinden kitlesel açık çevrimiçi dersler paylaşacakları hedefine yer vermiştir. MEF Üniversitesi Coursera ve edX ile gerçekleştirdiği iş birliği ile bu platformlardan öğrencilerin aldıkları derslerin kredilendirildiğini, İstanbul Okan Üniversitesi ise Coursera platformu iş birliği ile hem öğreticilere hem öğrencilere öğrenme imkânı sunduğunu belirtmektedir.

Sonuç ve Öneriler

Bu araştırma, Türkiye'deki yükseköğretim kurumlarının açıklık uygulamalarına yönelik yaklaşımlarını KİDR raporları çerçevesinde kapsamlı bir şekilde sunmayı amaçlamaktadır. Bulgular, üniversitelerin açıklık bağlamında özellikle açık erişim ve açık bilim kavramlarına odaklandıklarını göstermektedir. Açık erişim bağlamında en fazla ifade edilen uygulama, kurumların dijital arşiv altyapılarını kurma ve geliştirme çabalarıdır. Bu faaliyet, bilimsel çıktıların kalıcı olarak saklanması ve erişime açılması açısından kritik bir adım olarak değerlendirilmektedir. Bununla birlikte, açık erişimi teşvik etmeye yönelik girişimlerin sınırlı olduğu ve yayınevleri ile gerçekleştirilen "oku ve yayınla" anlaşmalarının yaygınlık kazanmadığı belirlenmiştir. Açık bilim açısından ise raporlarda ağırlıklı olarak politika ve strateji geliştirme odaklı ifadelerin yer aldığı, açık bilimle ilgili eğitim ve etkinliklerin sınırlı olduğu görülmektedir. Ayrıca, açık kurs, açık üniversite, açık standart, açık içerik, açık tasarım ve açık eğitsel uygulamalar gibi kavramların raporlarda hiç yer almadığı dikkat çekmektedir. Araştırma bulguları, Türkiye'deki yükseköğretim kurumlarının açık eğitsel kaynaklar ve kitlesel açık çevrimiçi dersler alanındaki uygulamalarının oldukça yetersiz olduğunu ortaya koymaktadır. Bu sonuçlar doğrultusunda, aşağıda yükseköğretim kurumlarına yönelik öneriler sunulmaktadır.

- Açıklık yalnızca yayın ve bilimsel süreçlerle sınırlandırılmayıp açık içerik ve açık ders üretimine yönelik stratejiler geliştirilmelidir.
- Açık eğitsel kaynakların üretimi ve yaygınlaştırılması için teşvik mekanizmaları oluşturulmalıdır. Bu noktada özellikle öğreticilerin içerik üretimi ve paylaşımı için destek sağlanabilir.
- Açık erişim uygulamalarının yaygınlaştırılması için kaynak ayrılmalı ve "oku ve yayınla" anlaşmaları artırılmalıdır.
- Açık bilim kapsamında akademisyenlere yönelik eğitim programları, seminerler ve açık bilim etkinlikleri gerçekleştirilebilir.
- Açıklık kültürünün yaygınlaştırılması amacıyla finansal destek, teşvik mekanizmaları (ödüllendirme gibi) ve altyapı yatırımları planlanabilir.

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Üretken Yapay Zeka Destekli Programlama Eğitiminin Ortaokul Öğrencilerinin Bilgi İşlemsel Düşünme Becerileri, Programlama Başarıları Ve Tutumlarına Etkisi

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Özet

Programlama eğitimi, öğrencilerin problem çözme, algoritmik düşünme ve dijital okuryazarlık gibi çağdaş beceriler kazanmasında kritik bir rol oynamaktadır. Ancak özellikle metin tabanlı dillerle yapılan öğretim süreci, ortaokul öğrencileri için soyut ve karmaşık olabilmektedir. Bu zorluklara çözüm olarak üretken yapay zekâ (ÜYZ) destekli öğretim araçları, kişiselleştirilmiş öğrenme imkânı sunarak öğrenmeyi daha erişilebilir hâle getirebilir. Bu araştırmada, ÜYZ destekli programlama modülünün bilgi işlemsel düşünme becerileri, programlama başarısı ve tutuma etkisi incelenmiştir. Araştırma, açıklayıcı sıralı desen içeren karma yöntemle yürütülmüştür. Bitlis'teki bir devlet ortaokulunda 34 yedinci sınıf öğrencisi deney (n=17) ve kontrol (n=17) gruplarına ayrılmıştır. Deney grubu Python programlama eğitimini ÜYZ destekli bir web modülü üzerinden alırken, kontrol grubuna geleneksel yöntemle öğretim yapılmıştır. Araştırmada bilgi işlemsel düşünme öz değerlendirme ölçeği, programlamaya yönelik tutum ölçeği, programlama rubrik başarı testi ve öğrenci görüş formları kullanılmıştır. Veri toplama araçları olarak Bilgi İşlemsel Düşünme Öz Değerlendirme Ölçeği, Programlamaya Yönelik Tutum Ölçeği, Programlama Rubrik Başarı Testi ve öğrenci görüş formları kullanılmıştır. Nicel bulgulara göre, deney grubundaki öğrenciler programlama başarısı açısından anlamlı düzeyde gelişim göstermiştir. Bilgi işlemsel düşünme becerilerinin algoritmik düşünme, soyutlama ve ayrıştırma alt boyutlarında deney grubunda anlamlı artışlar gözlemlenmiştir. Ancak paralleleştirme ve otomasyon alt boyutlarında gruplar arası anlamlı bir fark saptanmamıştır. Her iki grupta da genel bilgi işlemsel düşünme düzeylerinde artış görülmüş, ancak toplam puan düzeyinde anlamlı bir farklılık bulunmamıştır. Tutum açısından ise her iki grupta olumlu gelişmeler görülmüş, fakat istatistiksel olarak anlamlı bir fark elde edilmemiştir. Nitel bulgular, öğrencilerin ÜYZ destekli eğitimin eğlenceli, yönlendirici ve motive edici bulduklarını ortaya koymuştur. Özellikle hata tespiti ve açıklayıcı dönüt mekanizması öğrenmeyi desteklemiştir. Sonuçlar, ÜYZ destekli öğrenme ortamlarının kişiselleştirilmiş rehberlik sunarak öğrencilerin programlama öğrenme süreçlerine olumlu katkı sağladığını göstermektedir. Bu bağlamda, ÜYZ tabanlı uygulamaların eğitimde daha yaygın ve sistematik biçimde kullanılmasına yönelik öğretmen eğitimi ve müfredat geliştirme çalışmaları teşvik edilmelidir.

Keywords: üretken yapay zekâ, programlama eğitimi, bilgi işlemsel düşünme, programlama başarısı, tutum.

The Effect of Generative Artificial Intelligence-Supported Programming Education on Middle School Students' Computational Thinking, Programming Achievement, and Attitudes

Abstract

Programming education plays a critical role in equipping students with contemporary skills such as problem-solving, algorithmic thinking, and digital literacy. However, instruction through text-based programming languages can often be abstract and challenging for middle school students. As a potential solution, generative artificial intelligence (GenAI)-supported instructional tools can provide personalized learning opportunities, making programming education more accessible. This study examined the effects of a GenAI-supported programming module on students' computational thinking skills, programming achievement, and attitudes toward programming. The research was conducted using an explanatory sequential mixed-methods design. A total of 34 seventh-grade students from a public middle school in Bitlis were divided into an experimental group (n=17) and a control group (n=17). While the experimental group received Python programming instruction through a GenAI-supported web module, the control group was taught using traditional methods. Data collection instruments included the Computational Thinking Self-Assessment Scale, the Programming Attitude Scale, the Programming Rubric Achievement Test, and student interview forms. Quantitative findings indicated that the experimental group showed significant improvement in programming achievement. Within computational thinking skills, significant

increases were observed in algorithmic thinking, abstraction, and decomposition, whereas no significant differences were found between groups in parallelization and automation. Both groups demonstrated overall improvements in computational thinking, but no significant difference emerged in total scores. In terms of attitudes, both groups showed positive development, although this difference was not statistically significant. Qualitative findings revealed that students found the GenAI-supported instruction enjoyable, guiding, and motivating. Particularly, the error-detection and explanatory feedback mechanisms were perceived as supportive for learning. Overall, the results suggest that GenAI-supported learning environments provide personalized guidance and contribute positively to students' programming learning processes. Therefore, teacher training and curriculum development initiatives should encourage the systematic and widespread integration of GenAI-based applications into education.

Keywords: generative artificial intelligence, programming education, computational thinking, programming achievement, attitude.

Giriş

21. yüzyıl becerileri arasında problem çözme, algoritmik düşünme ve dijital okuryazarlık kritik öneme sahiptir (Wing, 2006). Programlama eğitimi bu becerilerin gelişiminde önemli bir araç olup, öğrencilerin yalnızca teknik değil bilişsel süreçlerini de desteklemektedir (Grover & Pea, 2013). Özellikle ortaokul düzeyinde programlama öğretimi, algoritmik düşünme ve yaratıcı problem çözme becerilerini geliştirmektedir (Brennan & Resnick, 2012).

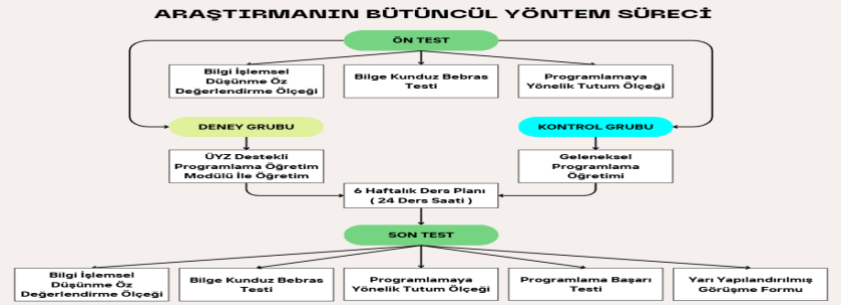
Ancak metin tabanlı dillerin soyut yapısı, öğrenciler için zorlayıcı olabilmektedir (Erümit vd., 2019). Bu zorluklar, hata ayıklama ve dönüt eksiklikleriyle birleştiğinde motivasyon kaybına yol açmaktadır (Korkmaz & Altun, 2017). Bu noktada yapay zekâ teknolojileri yeni fırsatlar sunmaktadır. Özellikle üretken yapay zekâ (ÜYZ), kişiselleştirilmiş dönüt ve hata tespiti sağlayarak öğrenmeyi kolaylaştırma potansiyeline sahiptir (Kasneci vd., 2023; Zawacki-Richter vd., 2019).

Türkiye'de MEB (2018) müfredatında Python gibi metin tabanlı dillerin yer alması, öğrencilerin bu süreçte destekleyici araçlara duyduğu ihtiyacı artırmaktadır. Bu çalışma, ÜYZ destekli bir programlama modülünün ortaokul öğrencilerinin bilgi işlemsel düşünme, programlama başarısı ve tutumlarına etkisini incelemektedir.

Bu araştırma, ortaokul düzeyinde geliştirilen ÜYZ destekli bir programlama öğrenme modülünün öğrencilerin bilgi işlemsel düşünme becerileri, programlama başarıları ve programlamaya yönelik tutumları üzerindeki etkisini incelemeyi amaçlamaktadır. Çalışmanın bulgularının, programlama eğitiminde yenilikçi yaklaşımların geliştirilmesine ve yapay zekâ tabanlı öğretim araçlarının müfredata entegrasyonuna yönelik katkılar sunması beklenmektedir.

Yöntem

Bu araştırmada, üretken yapay zekâ destekli öğrenme modülünün ortaokul programlama eğitimindeki etkilerini değerlendirmek amacıyla karma araştırma yöntemi kullanılmıştır. Karma araştırma yöntemi, nitel ve nicel veri toplama ve analiz süreçlerinin bir arada kullanılmasıyla, araştırma problemini derinlemesine inceleme olanağı sunar (Creswell, 2008). Araştırma, karma araştırma yöntemi kapsamında sıralı açıklayıcı desen kullanılarak gerçekleştirilmiştir. Bu desende öncelikle nicel veriler toplanmış ve analiz edilmiş, ardından bu sonuçları derinlemesine anlamlandırmak amacıyla nitel veriler toplanarak yorumlayıcı bir analiz yapılmıştır. (Creswell & Plano-Clark, 2017). Bu çalışmada da, öğrencilerin bilgi işlemsel düşünme becerilerinde ve programlama başarılarındaki değişimler önce nicel verilerle ortaya konmuş, ardından bu değişimlerin altında yatan nedenler nitel analizlerle açıklanmıştır. Böylece, araştırmada kullanılan öğrenme modülünün etkileri hem istatistiksel hem de pedagojik düzlemde çok boyutlu olarak değerlendirilmiştir. Çalışmanın karma yöntem kapsamındaki bütüncül araştırma süreci Şekil 1'de sunulmuştur.



Şekil 1. Araştırmanın Bütüncül Yöntem Süreci

Araştırmanın nicel bölümünde yarı deneysel desen kullanılmıştır. Yarı deneysel desen, deney ve kontrol grupları arasında gözlenen farklılıkların karşılaştırılmasını sağlar (Büyüköztürk, 2007). Çalışmada, ortaokul 7. sınıf öğrencilerinden rastgele seçilen iki şube, deney ve kontrol grubu olarak belirlenmiştir. Deney grubundaki öğrenciler, üretken yapay zekâ destekli öğrenme modülü kullanarak Python programlama dilini öğrenirken, kontrol grubundaki öğrenciler geleneksel yöntemlerle öğretilmiştir. Öğrencilerin programlama başarısı, bilgi işlemsel düşünme becerileri ve programlama tutumları nicel veri toplama araçları kullanılarak ölçülmüştür.

Araştırmanın nitel bölümü, belirli bir durumun derinlemesine incelenmesini sağlayan durum çalışması modeli ile yürütülmüştür (Yıldırım & Şimşek, 2006). Bu bölümde, üretken yapay zekâ destekli öğrenme modülünün uygulama süreci ve özellikleri öğrenci görüşleri aracılığıyla değerlendirilmiştir. Nicel analizler sonucunda elde edilen bulguların daha derinlemesine anlamlandırılması için öğrencilerle yarı yapılandırılmış görüşmeler yapılmıştır.

Katılımcılar

Çalışmanın katılımcılarını, Bitlis ili Merkez ilçesinde bulunan bir devlet ortaokulunun 7. sınıfında öğrenim gören toplam **34 öğrenci** oluşturmaktadır. Örneklem, 17'şer kişilik iki şubeden seçilmiş ve şubelerden biri **deney grubu**, diğeri **kontrol grubu** olarak belirlenmiştir. Deney grubundaki öğrenciler Python programlama eğitimini üretken yapay zekâ destekli web tabanlı bir modül üzerinden alırken, kontrol grubundaki öğrenciler geleneksel yöntemlerle öğrenim görmüştür. Katılımcıların 16'sı erkek, 18'i kız öğrencidir. Araştırmaya katılım tamamen gönüllülük esasına dayalıdır ve hem öğrencilerden hem de velilerden yazılı izin alınmıştır. Çalışma, Erzurum Atatürk Üniversitesi Etik Kurul onayıyla yürütülmüştür.

Veri Toplama Araçları

Çalışmada farklı değişkenleri değerlendirmek üzere çeşitli ölçme araçları kullanılmıştır:

- **Bilgi İşlemsel Düşünme Öz Değerlendirme Ölçeği** (Yıldız & Yılmaz, 2018) – algoritmik düşünme, paralelleştirme, ayrıştırma, otomasyon ve soyutlama alt boyutlarından oluşmaktadır.
- **Bebras Bilge Kunduz Testi** (Dagienė & Futschek, 2008; Dagienė & Sentance, 2016) – problem çözme, algoritma kurma ve veri işleme becerilerini ölçen uluslararası bir değerlendirme aracıdır.
- **Programlamaya Yönelik Tutum Ölçeği** (Altay & Kışla, 2018) – öğrencilerin programlamaya yönelik istek, inanç ve ilgilerini ölçmektedir.
- **Programlama Başarı Testi** – araştırmacılar tarafından geliştirilen ve 6 açık uçlu Python sorusundan oluşan bir rubrik testidir. Algoritma geliştirme, hata ayıklama ve problem çözme becerilerini değerlendirmektedir.
- **Yarı Yapılandırılmış Görüşme Formu** – öğrencilerin modüle ilişkin deneyimlerini ve algılarını derinlemesine anlamak için kullanılmıştır.

Uygulama Süreci

Araştırma süreci, eğitim teknolojilerinde yaygın olarak kullanılan **ADDIE modeli** (Analysis, Design, Development, Implementation, Evaluation) temel alınarak planlanmıştır. Uygulama 6 hafta sürmüş ve deney grubundaki öğrenciler, üretken yapay zekâ destekli modül aracılığıyla Python programlama konularında desteklenmiştir. Kontrol grubunda ise dersler öğretmen merkezli yöntemlerle yürütülmüştür.

Bulgular

Bilgi İşlemsel Düşünme Becerilerine İlişkin Bulgular

Deney ve kontrol gruplarının Bilgi İşlemsel Düşünme (BİD) ölçeğinden elde edilen son test puanları karşılaştırıldığında, algoritmik düşünme, soyutlama ve ayrıştırma alt boyutlarında deney grubu lehine anlamlı farklılıklar bulunmuştur ($p < .05$). Paralelleştirme ve otomasyon alt boyutlarında ise gruplar arasında anlamlı bir farklılık saptanmamıştır. Genel toplam puanlarda her iki grubun da gelişim gösterdiği, ancak bu gelişimin deney grubunda daha belirgin olduğu görülmüştür.

Tablo 1. Deney ve Kontrol Gruplarının Bilgi İşlemsel Düşünme Son Test Puanları

Değişkenler	**Deney**		**Kontrol**		*t*(16)	*p*	Cohen's *d*
	X̄	***SS***	**X̄**	***SS***			
Tablo 1 (devamı)							
Algoritmik Düşünme	3.89	.524	3.30	.596	3.05	.005	1.051
Paralelleştirme	3.84	.379	3.40	.919	1.84	.075	-
Ayrıştırma	4.16	.432	3.58	.809	2.57	.015	0.894
Soyutlama	3.80	.472	3.21	.754	2.72	.010	0.938
Otomasyon	4.03	.633	3.45	.781	2.41	.022	0.816
Genel Toplam	3.94	.324	3.39	.598	3.30	.002	1.144

Bebras (Bilge Kunduz) Testine İlişkin Bulgular

Bebras Testi sonuçları incelendiğinde, deney grubunun ortalama puanlarının kontrol grubuna göre daha yüksek olduğu görülmüş, ancak bu fark istatistiksel olarak anlamlı bulunmamıştır ($p > .05$). Özellikle orta ve zor düzey sorularda deney grubunun daha başarılı olduğu gözlense de genel toplamda gruplar arasında anlamlı bir fark elde edilmemiştir.

Programlamaya Yönelik Tutum Bulguları

Programlamaya Yönelik Tutum Ölçeği son test sonuçları, her iki grupta da olumlu yönde gelişim olduğunu göstermiştir. Deney grubunun ortalama puanları kontrol grubuna göre daha yüksek olmasına rağmen, bu fark istatistiksel olarak anlamlı değildir ($p > .05$). Alt boyutlar incelendiğinde, özellikle "programlamanın yararına yönelik inanç" faktöründe deney grubunun daha yüksek puan aldığı görülmüştür.

Tablo 2. Deney ve Kontrol Gruplarının Programlamaya Yönelik Tutum Son Test Puanları

Değişkenler	**Deney**		**Kontrol**		*t*(16)	*p*	Cohen's *d*
	X̄	***SS***	**X̄**	***SS***			
Programlamaya Yönelik İstek	4.41	.430	3.93	.969	1.858	.072	-
Programlamaya Yönelik İnanç	4.23	.598	3.66	.942	2.100	0.44	-0.722
Programlamaya Yönelik İlgi	3.84	.635	3.66	.799	.712	.481	-
Genel Toplam	4.25	.364	3.81	.772	2.089	.045	-0.729

Programlama Başarısına İlişkin Bulgular

Programlama Başarı Testi sonuçlarına göre, deney grubundaki öğrencilerin son test puanları kontrol grubuna göre **anlamlı düzeyde daha yüksektir** ($p = .012$). Cohen's d etki büyüklüğü yüksek düzeyde hesaplanmış olup, üretken yapay zekâ destekli modülün öğrencilerin programlama başarısı üzerinde güçlü bir etkiye sahip olduğunu göstermektedir.

Tablo 3. Deney ve Kontrol Gruplarının Programlama Başarı Son Test Puanları

Değişkenler	**Deney**		**Kontrol**		*p*	*t*	Cohen's *d*
	X̄	***SS***	**X̄**	***SS***			
Programlama Başarı Testi	82.94	12.12	71.47	12.96	.012	2.664	-0.914

Nitel Bulgular

Deney grubundaki öğrencilerle yapılan yarı yapılandırılmış görüşmelerden elde edilen bulgular, öğrencilerin ÜYZ destekli öğrenme modülünü eğlenceli, yönlendirici ve motive edici bulduklarını ortaya koymuştur. Özellikle hata tespit mekanizmasının ve anlık geri bildirimlerin öğrenme sürecini kolaylaştırdığı, öğrencilerin problem çözme süreçlerinde kendilerini daha güvende hissettikleri belirlenmiştir. Ayrıca öğrenciler, modülün kişiselleştirilmiş dönütler sunmasının motivasyonlarını artırdığını ve programlama öğrenmeyi daha keyifli hâle getirdiğini ifade etmişlerdir. İlgili öğrenci görüşleri nicel ve nitel bulgularla birlikte Tablo 4'te verilmiştir.

Tablo 4. Nicel Bulgular, Nitel Bulgular ve Örnek Öğrenci Görüşleri

NİCEL BULGULAR	NİTEL BULGULAR	ÖRNEK ÖĞRENCİ GÖRÜŞLERİ
Programlama başarısı deney grubunda anlamlı düzeyde daha yüksek bulundu.	Eğlenceli ve motive edici	"Dersler daha keyifli geçti, sıkılmadım."
BİD'de algoritmik düşünme, ayrıştırma ve soyutlama alt boyutlarında anlamlı artış görüldü.	Hata tespiti ve geri bildirim	"Yapay zekâ nerede hata yaptığımı söyledi, kolayca düzelttim."
Tutum ölçeğinde her iki grupta da gelişim var, fakat anlamlı fark yok.	Kişiselleştirilmiş rehberlik	"Benim seviyeme uygun açıklamalar yaptı, bu yüzden daha rahat öğrendim."
Bebras Testi sonuçlarında anlamlı fark bulunmadı.	Özgüven kazandırıcı	"Artık hata yapmaktan korkmuyorum, çünkü sistem hemen düzeltiyor."

Tartışma ve Sonuç

Bu araştırmanın bulguları, üretken yapay zekâ (ÜYZ) destekli programlama eğitiminin öğrencilerin programlama başarısı üzerinde anlamlı ve güçlü bir etkiye sahip olduğunu göstermektedir. Deney grubundaki öğrencilerin kontrol grubuna kıyasla daha yüksek başarı puanları alması, ÜYZ tabanlı öğrenme ortamlarının programlama eğitiminde öğrencilerin problem çözme ve hata ayıklama becerilerini desteklediğini ortaya koymaktadır. Bu sonuç, programlama öğretiminde kişiselleştirilmiş destek ve anında dönüt sağlayan sistemlerin öğrenme sürecini olumlu etkilediğini belirten önceki araştırmalarla paralellik göstermektedir (Holmes vd., 2019; Kasneci vd., 2023).

Bilgi işlemsel düşünme becerilerinde ise algoritmik düşünme, soyutlama ve ayrıştırma boyutlarında deney grubu lehine anlamlı gelişmeler saptanmıştır. Bu bulgu, programlama eğitiminin bilişsel beceriler üzerindeki etkisini vurgulayan çalışmalarla (Grover & Pea, 2013; Brennan & Resnick, 2012) uyumludur. Ancak paralelleştirme ve otomasyon boyutlarında anlamlı bir fark elde edilmemesi, bu becerilerin daha uzun süreli uygulamalar veya farklı öğretim stratejileriyle desteklenmesi gerektiğini düşündürmektedir.

Programlamaya yönelik tutum ölçeği sonuçlarında her iki grupta da olumlu gelişim gözlenmiş, fakat istatistiksel açıdan anlamlı bir fark bulunmamıştır. Bu durum, öğrencilerin programlama deneyimlerinin genel olarak motivasyon artırıcı olduğunu, ancak ÜYZ destekli uygulamaların özellikle kısa süreli deneyimlerde tutum üzerinde belirgin bir fark yaratmadığını göstermektedir. Literatürde de tutum değişimlerinin uzun vadeli öğrenme süreçleriyle daha güçlü biçimde ortaya çıktığı vurgulanmaktadır (Korkmaz & Altun, 2017).

Bebras Testi bulgularında ise deney grubunun ortalama puanları daha yüksek olsa da gruplar arasında anlamlı bir farklılık elde edilmemiştir. Bu sonuç, bilgi işlemsel düşünme testlerinin genel bilişsel süreçlerden ziyade belirli görev performanslarını ölçmesi nedeniyle kısa süreli müdahalelerde sınırlı etki göstermesiyle açıklanabilir (Dagienė & Sentance, 2016).

Nitel bulgular, ÜYZ destekli modülün öğrenciler tarafından eğlenceli, yönlendirici ve motive edici bulunduğunu ortaya koymuştur. Özellikle hata tespit mekanizması ve kişiselleştirilmiş geri bildirimlerin öğrenmeyi kolaylaştırıcı bir rol üstlendiği görülmüştür. Bu durum, yapay zekâ tabanlı öğrenme ortamlarının bireysel farklılıkları dikkate alan pedagojik destek sunma potansiyelini ortaya koymaktadır (Zawacki-Richter vd., 2019).

Sonuç olarak, bu araştırma ÜYZ destekli programlama eğitiminin öğrencilerin bilişsel ve duyuşsal gelişimlerine katkı sağlayabileceğini göstermektedir. Çalışmanın sınırlılıkları arasında örneklem büyüklüğünün küçük olması ve uygulama süresinin altı hafta ile sınırlı kalması yer almaktadır. Gelecek araştırmalarda daha geniş örneklemlerle

uzun süreli uygulamalar yapılması, farklı yaş grupları ve programlama dillerinde ÜYZ destekli öğretim araçlarının etkilerinin incelenmesi önerilmektedir. Ayrıca, öğretmen eğitimine yönelik çalışmalarla ÜYZ tabanlı araçların müfredata entegrasyonu desteklenmelidir.

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Dijital Ortamda Yer Alan Kitapların Kavramsal Yolculuğu: Elektronik Kitaplardan Artırılmış Gerçeklik Destekli Kitaplara

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Özet

Eğitim teknolojilerindeki hızlı gelişmeler, e-kitap içeriklerinin ve e-kitap biçimlerinin zenginleşmesine yol açmıştır. Bu çalışmada, elektronik ortamda yer alan kitap türlerinin adlandırılmasında yaşanan kavramsal karmaşayı ortaya koymak, bu kitap türlerinin içeriksel dönüşümü, avantajları, sınırlılıklarını ve öğrenme-öğretme süreçlerini etkilerini inceleyerek kavramların netleştirilmesine katkı sağlamak ve e-kitap türlerini karşılaştırmalı olarak ele alarak aralarındaki belirleyici ve ortak yönleri ortaya koymak amaçlanmıştır. Araştırma sonucunda e-kitap türlerinin belirleyici ve ortak yönleri ortaya konmuştur

Anahtar kelimeler: Elektronik kitap (e-kitap), zenginleştirilmiş kitap (z-kitap), etkileşimli e-kitap, artırılmış gerçeklik destekli kitaplar

The Conceptual Journey of Books in the Digital Environment: From E-books to Augmented Reality-Supported Books

Abstract

Rapid developments in educational technology have enriched e-book content and formats. This study aims to clarify the confusion surrounding the naming of book types in electronic media by examining their historical development, content transformation, advantages, limitations, and effects on the learning and teaching processes. Additionally, this study will reveal the defining and common features of these book types by comparing them. The defining and common aspects of book types were identified by comparatively evaluating concepts found in national and international literature.

Keywords: Electronic book (e-book), enriched book, interactive e-book, augmented reality supported books.

Giriş

20. yüzyılın sonlarında bilgi teknolojilerindeki gelişmelerle kitap kavramı fiziksel bir materyal olmanın ötesine geçerek dijital bir boyut kazanmış, öğrenme süreçlerini destekleyen dijital içeriklerin kullanımını gündeme getirmiştir. Ancak bu gelişmeler, dijital içeriklerin tanımı ve sınıflandırılmasında karmaşayı da beraberinde getirmiştir.

1. E-Kitapların Tarihçesi

E-kitapların düşünsel temelleri 1930'lara Bob Brown' un "okuma makinesi" fikrine uzanırken; 1945'te Bush'un "Memex" sistemi e-kitapların altyapısını hazırlamış, 1960'lı yıllarda Engelbart'ın NLS ve Andries van Dam' ın FRESS projelerinin geliştirilmesini sağlamıştır (Öngöz, 2019). Oluşan altyapıyla 1971 yılında Michael Hart, "Project Gutenberg" isimli projesi ile ilk e-kitabı başlatmış ve literatüre geçmiştir. 1980'lerden itibaren taşınabilir bilgisayarların, e-kitap okuyucularının, e-kitap programlarının geliştirilmesiyle süreç hız kazanmıştır. 1990'lı yıllarda, CD-ROM tabanlı "Living Books" örnekleri, taşınabilir e-kitap cihazları ve çevrimiçi e-kitap satış platformları ortaya çıkmıştır. 2000'li yıllarda ise e-kitapların yazılım ve donanımları gelişmeye devam etmiştir (Önder, 2010). 2010 sonrasında açık erişim ve abonelik modelleri gelişmiş; tabletler, akıllı telefonlar ve bulut senkronizasyonu okuma deneyimini dönüştürmüştür. COVID-19 pandemisi e-kitap kullanımını küresel ölçekte yaygınlaştırmış; 2020 sonrası ise artırılmış destekli dijital kitaplar gündeme gelmiştir.

2. Dijital Ortamda Yer Alan Kitaplar İçin Kullanılan Kavramlar

Dijital ortamda yer alan kitaplar farklı kavramlarla ifade edilmektedir. Ulusal (YÖK Tez Merkezi, Dergipark) ve uluslararası (ProQuest, WOS ve ERIC) veri tabanlarında yer alan kullanım biçimleri karşılaştırmalı olarak sunulmuştur.

Tablo 1. Dijital Ortamda Yer Alan Kitapların İsimlendirilmesi

Ulusal Alanyazın	Uluslararası Alanyazın
➢ elektronik kitap ➢ e-kitap	➢ electronic book(s) ➢ e-book(s)
➢ dijital kitap	➢ digital book(s)
➢ zenginleştirilmiş kitap ➢ z-kitap ➢ zenginleştirilmiş e-kitap	➢ multimedia book (s) ➢ enriched multimedia eBook (s) ➢ enriched e-book (s) ➢ enriched electronic book (s)
➢ etkileşimli elektronik kitap ➢ interaktif elektronik kitap ➢ etkileşimli e-kitap ➢ interaktif e-kitap ➢ interaktif dijital kitap	➢ interactive electronic book(s) ➢ interactive e-book(s) ➢ interactive digital book (s)

3. E-Kitap

Kitapların dijital ortama aktarılmasıyla ortaya çıkan yeni biçimi, Türkiye'de "elektronik kitap", "e-kitap" ve "dijital kitap"; uluslararası literatürde ise "electronic book(s)", "e-book(s)" ve "digital book(s)" olarak adlandırılmakta ve bu kavramlar çoğu zaman birbirinin yerine kullanılmaktadır.

"E-kitap" ile "dijital kitap" kavramlarının birbirinden farklı olduğunu öne süren yaklaşımlarda bulunmaktadır. Dijital kitap, herhangi bir yazılım gerektirmeden bilgisayarda okunabilen içeriklerken; e-kitap özel yazılımlarla hazırlanmış, taşınabilir cihazlarda kullanılmak üzere tasarlanan ve metni zenginleştiren içeriklerdir (Roncaglia, 2003). Bu bakış açısı, dijital kitapların e-kitaplardan ayrıştığını göstermektedir.

E-kitaplar başlangıçta basılı kitapların dijital ortama aktarılmış hâli (Sagar vd., 2011); kimi zaman ise doğrudan dijital ortamda tasarlanıp üretilmiş sayısal kitaplar olarak tanımlanmıştır (Chen, 2003). E-kitapları, bilgisayar, tablet, akıllı telefon veya e-kitap okuyucu gibi çeşitli elektronik cihazlar aracılığıyla erişilebilen dijital içerik olarak tanımlayan araştırmacılarda mevcuttur (Lam vd., 2009). Zamanla e-kitaplar, yalnızca metin içermekle sınırlı kalmamış ve ses, video, animasyon gibi çoklu ortam ögeleriyle zenginleşmiş; arama, not alma, işaretleme gibi kişiselleştirilmiş okuma deneyimleri sunan öğrenme materyalleri hâline gelmiştir (Gupta ve Dhawan, 2019).

E-kitap; başlangıçta basılı kitapların dijital ortama aktarılmış biçimleri olarak ortaya çıkan, zamanla teknolojik gelişmelerle özel olarak tasarlanmış donanım ve yazılımlarla oluşturulmuş, çoklu ortam (multimedya) ögeleriyle (ses, video, oyun, animasyon gibi) zenginleştirilen, kişiselleştirilebilir okuma deneyimleri (not alma, işaretleme, altını çizme ve arama gibi) sunan içeriklerdir.

E-kitapların çoklu ortam ögeleri ile zenginleştirilmesi süreci, başlangıçta ses, video, resim, animasyon, şekil, tablo, çizelge, grafik ve modellerle başlamış; zamanla oyun, simülasyon, QR kod, harita, sözlük, konuşan kelimeler, kavram haritaları, sunum dosyaları, problem durumları, öz-değerlendirme çalışmaları, anketler, blog/wiki ve web bağlantıları gibi ögelerin eklenmesiyle daha da kapsamlı hâle gelmiştir. Bu gelişim, "e-kitap" kavramının genişlemesini sağlamış ve ulusal literatürde "zenginleştirilmiş kitap", uluslararası alanyazında ise "enriched e-book" terimleri kullanılmaya başlanmıştır. Z-kitaplar, e-kitapların özel bir türü olarak ortaya çıkmıştır.

E-kitap ile z-kitap arasındaki temel fark etkileşim düzeyinde ortaya çıkmaktadır. E-kitaplar, okuyucuya çoğunlukla tek yönlü ve sınırlı bir etkileşim olanağı sunarken; z-kitaplar, çoklu ortam (multimedya) ögelerle zenginleştirilmiş yapıları sayesinde kullanıcıya içerikle çift yönlü bir etkileşim imkânı sağlamaktadır.

4. Zenginleştirilmiş Kitap (Z-Kitap)

E-kitabın çoklu ortam ögelerinin zenginleşmesiyle, Türkiye'de "zenginleştirilmiş kitap", "z-kitap" ve "zenginleştirilmiş e-kitap"; uluslararası literatürde ise "enriched e-book(s)", "enriched electronic book(s)", "multimedia book(s)" ve "enriched multimedia e-book(s)" terimleri yer almaktadır. Bu terimler çoğu zaman birbirlerinin yerine kullanılmaktadır.

Türkiye' de "z-kitap" kavramı FATİH Projesi kapsamında Milli Eğitim Bakanlığı' nın Eğitim Bilişim Ağı (EBA) platformunda ders kitaplarını dijital formata dönüştürülerek erişilebilir hâle getirilmesi ve çoklu ortam ögeleri eklenmesiyle ortaya çıkmıştır. Talim ve Terbiye Kurulu Başkanlığı tarafından onaylanmış ve okullarda okutulan basılı ders kitaplarının metinlerde herhangi bir değişiklik yapılmaksızın dijital formatına dönüştürülerek çoklu ortam ögeleriyle zenginleştirilmiş sürümleri olarak tanımlanmıştır (MEB, 2011). Z-kitaplar, basılı kitapların veya geleneksel e-kitapların dijital ortama aktarılmış; görsel, video, uygulama, animasyon, eğitsel oyun, simülasyon ve deney etkinlikleri gibi çoklu ortam ögeleriyle zenginleştirilmiş sürümleridir (Kapaniaris vd., 2013).

5. E-Kitap ve Z-Kitapların Avantajları ve Sınırlılıkları

E-kitaplar ve çoklu ortam ögeleriyle zenginleştirilmiş biçimleri olan z-kitaplar; kişiselleştirilebilir okuma deneyimi, güncellenebilir ve zengin içerik, erişilebilirlik, kullanım kolaylığı ve çevresel sürdürülebilirlik gibi pek çok avantaj sunmaktadır (Almekhlafi, 2021; Durmaz, 2019; Önder, 2010; Yıldırım, 2019).

Tablo 2. E-Kitap ve Z-Kitapların Avantajları

Kişiselleştirilebilir Okuma Deneyimi	Yazı tipi ve arka plan ayarı; not alma, işaretleme, altını çizme imkânı
Güncellenebilir İçerik	Hataların hızlıca düzeltilmesi, kolay güncelleme
Zengin İçerik	Resim, video, ses, animasyon, tablo ve grafik desteği; sözlük ve bağlantılarla öğrenmeyi kolaylaştırma
Erişilebilirlik	Görme engellilere uygunluk, dinleme özelliğiyle erişim kolaylığı
Taşınabilirlik	Yüzlerce kitabı tek cihazda depolama; her yerde ve zamanda okuma olanağı
Çevresel ve Ekonomik Katkı	Kâğıt kullanımını azaltma, düşük maliyet, telifsiz kitaplara erişim, fiziksel hasara dayanıklılık

E-kitap ve çoklu ortam ögeleriyle zenginleştirilmiş biçimleri olan z-kitaplar; fiziksel sorunlar, içerik ve kullanıcı sınırlamaları, yeniliğe uyum güçlükleri ve teknolojik donanım kaynaklı problemler gibi çeşitli sınırlılıklar da barındırmaktadır (Durmaz, 2019; Jeong, 2012; Önder, 2010; Yıldırım, 2019).

Tablo 3. E-Kitap ve Z-Kitapların Sınırlılıkları

Fiziksel Sorunlar	Uzun okumalar göz yorgunluğu ve baş ağrısına yol açabilir.
İçerik ve Kullanıcı Sınırlamaları	Üretim–dağıtım kısıtlı, teknoloji bilgisi yetersizse kullanım zorlaşır.
Yeniliğe Adaptasyon Zorlukları	Basılı kitap alışkanlığı adaptasyonu güçleştirir; direnç oluşabilir.
Teknolojik Cihaz Zorlukları	Cihaz ve bağlantı maliyetli; bazı formatlar özel donanım gerektirir; cihaz hassas, veri kaybı riski ve telif sorunları vardır; koleksiyon yönetimi zaman alır.

6. Öğrenme-Öğretme Süreçlerinde E-Kitap ve Z-Kitapların Etkileri

Öğrenme-öğretme süreçlerinde e-kitap ve çoklu ortam ögeleriyle zenginleştirilmiş biçimleri olan z-kitap kullanımının, öğrencilere pedagojik, bilişsel, duyuşsal ve fiziksel faydaları bulunmaktadır.

Tablo 4. Öğrenme-Öğretme Süreçlerinde E-Kitap ve Z-Kitapların Etkileri

Pedagojik	Bireyselleştirilmiş öğrenme imkânı sunar; öğretmenler öğrencilerin öğrenme süreçlerini ve materyallerle etkileşim düzeylerini izleyebilir (Emborg vd. 2012).
Bilişsel	Erken okuryazarlık, fonolojik farkındalık ve kelime dağarcığı becerilerini geliştirir (Korat vd., 2013; Rvachew vd., 2017).
Duyuşsal	Genel okuyucular ve özellikle okuma güçlüğü yaşayan öğrenciler için okuma sürecini keyifli hâle getirir ve motivasyonu artırır (Morgan, 2013; Shamir ve Shlafer, 2011)
Fiziksel	Ağır ders kitaplarının yerine geçerek ilkokul öğrencilerine konfor sağlar (Duran ve Ertuğrul, 2012).

7. Etkileşimli E-Kitap

E-kitapların kullanıcıya etkileşim imkânı sunan biçimi, Türkiye'de "etkileşimli e-kitap", "etkileşimli elektronik kitap", "interaktif e-kitap", "interaktif elektronik kitap" ve "interaktif dijital kitap"; uluslararası literatürde ise "interactive e-book(s)", "interactive electronic book(s)" ve "interactive digital book(s)" olarak adlandırılmakta ve bu kavramlar çoğu zaman birbirinin yerine kullanılmaktadır.

2011 yılında yazılımcı Mike Matas, "Teknoloji, Eğlence ve Tasarım" içerikli TED konferansında "Yeni Nesil Dijital Kitap" yazılımını tanıtmıştır. Sunumda, *Bizim Seçimimiz* adlı eser üzerinden etkileşimli özellikler örneklendirilmiştir. Kitap; hareketli kapak tasarımı, bölümler arasında serbest dolaşım, doğrudan sayfa erişimi, dokunmatik etkileşimler, interaktif haritalar, belgesel içerikler ve animasyonlar gibi yenilikçi unsurlarla zenginleştirilmiştir. Ayrıca, iPad ve iPhone arasında senkronize kullanım imkânı, okuma deneyimini farklı cihazlarda kesintisiz sürdürmeyi sağlamaktadır (Matas, 2011). Matas, bu uygulama aracılığıyla etkileşimin birden fazla kanal üzerinden gerçekleştiğini vurgulamıştır. Buna göre, kullanıcı ile dijital kitap, dijital kitap ile çevresi arasında çift yönlü bir etkileşim ve etkileşimli e-kitabı oluşturan unsurların kendi aralarında etkileşimi söz konusudur. Matas'ın çalışması, e-kitapları yalnızca bilgi sunan araçlar olmaktan çıkararak okuyucu, yazılım ve içerik arasında çok boyutlu bir etkileşime imkân veren "etkileşimli e-kitap" formatına dönüştürmüştür.

Etkileşimli e-kitap kavramına geçmeden önce "etkileşim" kavramının açıklanması yararlı olacaktır. Cambridge Dictionary (2025) bu kavramı "iki ya da daha fazla kişi veya nesnenin iletişim kurması ya da bir uyaran karşısında karşılıklı tepki vermesi" olarak açıklamaktadır. Erdem Aydın ve Yazıcı'ya (2019) göre etkileşimli e-kitaplarda üç temel etkileşim türü bulunmaktadır. Birincisi, kullanıcının çoklu ortam ögeleriyle bireysel etkileşim kurarak bilgi edinmesini ve öğrenme sürecini yönlendirmesini sağlayan **içerik–kullanıcı etkileşimi**dir. İkincisi, dokunma, tıklama veya sürükleme gibi eylemlerle ortaya çıkan ve yazılımın bu eylemlere geri bildirim vermesiyle gerçekleşen **yazılım–kullanıcı etkileşimi**dir. Üçüncüsü ise öğretmen ve öğrenciler arasında iş birliği, destek ya da denetim yoluyla gelişen **kullanıcılar arası etkileşim**dir.

Etkileşimli e-kitap; metin, görsel, ses, animasyon ve üç boyutlu nesnelerle zenginleştirilmiş, kullanıcı ile kitap arasında etkileşim kurmanın ötesinde, kitabı oluşturan ögelerin birbirleriyle ve çevreleriyle de etkileşim içinde olduğu dijital içeriklerdir (Bozkurt & Bozkaya, 2013).

E-kitaplar, okuyucuya çoğunlukla tek yönlü ve sınırlı bir etkileşim olanağı sunarken; z-kitaplar, çoklu ortam ögeleriyle zenginleştirilmiş yapıları sayesinde kullanıcıya içerikle çift yönlü bir etkileşim imkânı sunmaktadır. Etkileşimli e-kitaplar ise, okuyucu ile içerik arasında etkileşimin yanı sıra, dijital kitap ile çevresi arasında ve etkileşimli e-kitabı oluşturan unsurların kendi aralarında çift yönlü bir etkileşim sunmaktadır. Bu özellik, etkileşimli e-kitapları e-kitap ve z-kitaplardan ayıran temel unsur olarak öne çıkarmaktadır.

8. Etkileşimli E-Kitapların Avantajları ve Sınırlılıkları

E-kitaplar ve z-kitaplar, kişiselleştirilebilir okuma deneyimi, güncellenebilir ve zengin içerik yapısı, erişilebilirlik, kullanım kolaylığı ve çevresel sürdürülebilirlik gibi avantajlar sunmaktadır (Tablo 2). Bu avantajlara ek olarak, etkileşimli e-kitaplar, okuyucunun kitap ve çevre ile etkileşim kurmasına ve çoklu ortam ögelerinin kendi aralarında etkileşim sağlamasına imkân vererek, gerçek zamanlı katılım olanağı sunmaktadır (Bhattacharya ve Coombs, 2015; Erdem-Aydın ve Yazıcı, 2019).

E-kitaplar ve z-kitaplar, fiziksel sorunlar, içerik ve kullanıcı sınırlamaları, yeniliğe uyum güçlükleri ve teknolojik donanım kaynaklı problemler gibi çeşitli sınırlılıklar da barındırmaktadır (Tablo 3). Etkileşimli e-kitaplar, ek olarak üretim maliyetlerinin yüksekliği (içerik ve kullanıcı sınırlamaları) ve kullanılan okuma cihazlarının yüksek çözünürlük ve güç tüketimi gerektirmesi (teknolojik cihaz zorlukları) gibi sınırlamalar da içermektedir (Erdem-Aydın ve Yazıcı, 2019).

9. Öğrenme-Öğretme Süreçlerinde Etkileşimli E-Kitapların Etkileri

Öğrenme-öğretme süreçlerinde e-kitap ve z-kitap kullanımının öğrencilere pedagojik, bilişsel, duyuşsal ve fiziksel faydalar sağlamaktadır (Tablo 4). Etkileşimli e-kitaplar, kullanıcı ve e-kitap arasında **bireysel etkileşim**, e-kitap ve çevre arasında **ortam etkileşimi** ve kitabı oluşturan ögeler kendi arasında **çoklu ortam ögeleri etkileşimi** sağlaması nedeniyle ek pedagojik, bilişsel ve duyuşsal faydalar sağlamaktadır.

Tablo 5. Öğrenme-Öğretme Süreçlerinde Etkileşimli E-Kitapların Etkileri

Faydalar	Ek Özellikler
Pedagojik	• Öğretmen–öğrenci arasında iş birliği sağlar (Erdem-Aydın ve Yazıcı, 2019) • Öğrenci değerlendirmesi imkânı sağlar (Phadung, 2015).
Bilişsel	• Etkileşim düzeyi artması nedeniyle aktif katılım ve anlamlı öğrenme sağlar (Erişti vd., 2013). • Bilgilerin uzun süre hafızada kalmasına katkıda bulunur (Harjono, vd., 2020). • Özel gereksinimli öğrenciler için daha kolay öğrenme sağlar (Erdem-Aydın ve Yazıcı, 2019).
Duyuşsal	• Etkileşimli içerikler okuma motivasyonunu artırır; ilgiyi yükseltir (Alpay ve Okur, 2021; Ormancı ve Çepni, 2020) • Öğrenmeyi eğlenceyle ilişkilendirir; hayal gücünü uyandırır ve sürükleyici deneyim sağlar (Johnson vd., 2011).

10. Artırılmış Gerçeklik Destekli Kitaplar (AR Destekli Kitaplar)

Artırılmış gerçeklik, uygun teknolojik yazılımlar aracılığıyla fiziksel ortama eş zamanlı olarak iki ya da üç boyutlu video, metin, ses ve görsel gibi sanal öğelerin entegre edilmesi ve bu öğelerin kamera aracılığıyla gerçek ortamda görünür hâle gelmesi sürecidir (Delello, 2014).

Artırılmış gerçeklik teknolojisinin öğrenme-öğretme süreçlerinde kullanımı, somutlaştırma ve görselleştirme (Wojciechowski & Cellary, 2013), okuma-yazma becerilerinin gelişimi ve kavram kazanımı (Jeffri & Rambli, 2017) gibi faydalar sunmaktadır. Ayrıca keşfetmeye dayalı öğrenme fırsatlarıyla çocukların ilgi ve dikkatini

çekme, merak duygularını harekete geçirerek motivasyonlarını artırma, sürece aktif katılım sağlama (Bujak vd., 2013) ve gerçeğe yakınlık, kolay erişilebilir etkileşimli sanal nesneler sunma (Sun & Chen, 2019) gibi bilişsel, duyuşsal ve psikomotor becerilerin gelişimine destek olduğunu göstermektedir. Öte yandan artırılmış gerçeklik uygulamaları, bilişsel, duyuşsal ve psikomotor becerileri gerektirdiğinden, bu becerilere tam olarak sahip olmayan bireyler için kullanım sırasında zorlanma, sıkılma ve dikkat dağınıklığına yol açabilmektedir (Mahadzir & Phung, 2013). Ayrıca teknolojik ve altyapısal gereksinimler, yüksek üretim maliyetleri ve görsel tanıyıcıların hassasiyetindeki yetersizlikler, olumsuz kullanıcı deneyimlerine neden olabilmektedir (Chen, 2019).

Artırılmış gerçeklik destekli kitaplar, basılı ya da e-kitaplara entegre edilen görsel tanıyıcılar (QR kod, özel desenler, resim tabanlı işaretleyiciler gibi) aracılığıyla çalışan; kullanıcı bir mobil cihaz (akıllı telefon, tablet gibi) ile kitabın belirli bölümlerini taradığında üç boyutlu modeller, animasyonlar, sesli anlatımlar ve etkileşimli ögelerin devreye girdiği; geleneksel okuma sürecini zenginleştiren ve çoklu duyusal, etkileşimli ve deneyimsel bir öğrenme ortamı sunan yenilikçi öğrenme materyalleridir.

Etkileşimli e-kitaplar, okuyucu ile içerik, e-kitap ile çevresi ve etkileşimli e-kitabı oluşturan unsurların kendi aralarında çift yönlü bir etkileşim sunmaktadır. AR destekli kitaplar ise, fiziksel ve dijital öğeler arasında üç boyutlu ve gerçek zamanlı bir etkileşim sağlayarak kullanıcıya hem içerik hem de çevre ile daha kapsamlı ve deneyimsel bir etkileşim sunmaktadır. Bu yönüyle AR destekli kitaplar, etkileşimli e-kitaplardan ayrılmaktadır.

Sonuç

E-kitap ve dijital kitap kavramları çoğu zaman birbirinin yerine kullanılmıştır. Öte yandan, içerik ve kullanım açısından birbirinden farklılaşmaktadır. E-kitaplar üzerine yapılan tanımlar ise çoklu ortam ögelerinin eklenmesine göre değişmiş ve dönüşmüştür. E-kitaplara ses, video, resim, animasyon, şekil ve tablonun yanı sıra; oyun, simülasyon, QR kod, harita, sözlük, konuşan kelimeler, anketler ve web bağlantıları gibi çoklu ortam ögelerinin eklenmesiyle Türkiye' de "z-kitap", uluslararası alanyazında ise "enriched e-book" terimleri kullanılmaya başlanmıştır. Z-kitaplar, e-kitapların özel bir türü olarak ortaya çıkmıştır. E-kitaplar, okuyucuya çoğunlukla tek yönlü ve sınırlı bir etkileşim olanağı sunarken; z-kitaplar, çoklu ortam ögeleriyle zenginleştirilmiş yapıları sayesinde kullanıcıya içerikle çift yönlü bir etkileşim imkânı sunmaktadır.

Zaman içerisinde, e-kitaplar yalnızca bilgi sunan araçlar olmaktan çıkarak okuyucu, yazılım ve içerik arasında çok boyutlu bir etkileşime imkân veren "etkileşimli e-kitap" formatına dönüştürmüştür. Etkileşimli e-kitaplar ise, okuyucu ile içerik, dijital kitap ile çevresi ve etkileşimli e-kitabı oluşturan unsurların kendi aralarında çift yönlü bir etkileşim sunmaktadır. Bu özellik, etkileşimli e-kitapları e-kitap ve z-kitaplardan ayırmaktadır.

Uygun teknolojik yazılımlar aracılığıyla iki ya da üç boyutlu video, metin, ses ve görsel gibi sanal öğelerin entegre edilmesi ve bu öğelerin kamera aracılığıyla gerçek ortamda görünür hâle gelmesi ile etkileşimli e-kitaplar "artırılmış gerçeklik destekli kitaplar"a evrilmiştir. AR destekli kitaplar, fiziksel ve dijital öğeler arasında üç boyutlu ve gerçek zamanlı bir etkileşim sağlayarak kullanıcıya hem içerik hem de çevre ile daha kapsamlı ve deneyimsel bir etkileşim sunmaktadır. Bu yönüyle AR destekli kitaplar, etkileşimli e-kitaplardan ayrılmaktadır.

Tablo 6. Dijital Ortamda Yer Alan Kitapların Karşılaştırılması

Özellik	E-Kitap	Z-Kitap	Etkileşimli E-Kitap	AR Destekli Kitap
İçerik	Metin+görsel +ses+video	Metin+görsel+ses+video+animasyon+oyun+simülasyon+QR kod+harita+sözlük+konuşan kelimeler+anketler+web bağlantıları	Metin+çoklu ortam ögeleri+etkileşim	Metin+çoklu ortam ögeleri+3D animasyon+ video+simülasyon
Etkileşim Düzeyi	Düşük (tek yönlü)	Orta (sınırlı çift yönlü)	Yüksek (aktif katılım)	Çok yüksek (fiziksel + dijital etkileşim)
Teknoloji Gereksinimi	Temel dijital cihaz	Temel dijital cihaz + interaktif yazılım	Temel dijital cihaz + interaktif yazılım	AR destekli cihaz (tablet/telefon + uygulama)
Örnek	PDF roman	EBA Z-Kitapları	iBooks interaktif hikâye	AR destekli fen ve matematik kitapları

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Tarihim Dijitalde Projesi Bağlamında BİLSEM Öğrenme Ortamlarında Eğitsel Bir Araç Olarak Sanal Gerçeklik

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Özet

Sanal gerçeklik (VR) teknolojisi, 2020 sonrası dönemde yaşanan dijital dönüşümle birlikte eğitim, savunma, turizm, endüstri ve eğlence gibi birçok sektörde yaygın şekilde kullanılmaya başlanmıştır. Özellikle eğitim alanında VR uygulamalarının tarih, coğrafya, mühendislik, tıp, güzel sanatlar ve psikoloji gibi farklı disiplinlerde pedagojik destek sağladığı literatürde belirtilmektedir. Bu çalışmada, "Tarihim Dijitalde" adlı VR modeli aracılığıyla Balıkesir'de yer alan üç farklı tarihî yapının üç boyutlu tarayıcılar kullanılarak dijitalleştirilmesi ve bu modellerin sanal gerçeklik ortamına aktarılması süreci gerçekleştirilmiştir. Araştırmanın amacı, BİLSEM'de öğrenim gören öğrencilerin bu VR modelini deneyimledikten sonra eğitimde kullanımına ilişkin görüşlerini incelemektir. Veriler, "Tarihim Dijitalde" modelini deneyimleyen 27 öğrenciyle gerçekleştirilen yarı yapılandırılmış görüşmeler yoluyla toplanmıştır. Veri toplama sürecinde nitel araştırma desenlerinden olgubilim (fenomenoloji) deseni benimsenmiştir. Veriler içerik analizi yöntemiyle çözümlenmiştir. Elde edilen bulgular, öğrencilerin VR teknolojisini sadece tarih dersinde değil, diğer derslerde de etkili bir şekilde kullanmak istediklerini göstermiştir. Katılımcılar, sanal gerçeklik uygulamalarının dersleri daha eğlenceli, anlaşılır ve dikkat çekici hâle getirdiğini belirtmiştir. Ayrıca okul ortamında VR teknolojilerinin bulunmasının öğrenme sürecine olumlu katkı sunacağı ifade edilmiştir. Sonuç olarak, sanal gerçeklik teknolojisinin BİLSEM öğrencilerine yönelik eğitim ortamlarında uygulanabilirliği yüksek bulunmuş; derslerin verimliliğini artıran, öğrenmeyi destekleyen yenilikçi bir araç olarak değerlendirildiği sonucuna ulaşılmıştır.

Anahtar Kelimeler: Sanal gerçeklik (VR), tarih eğitimi, eğitim, dijitalleşme, BİLSEM

Virtual Reality as an Educational Tool in BİLSEM Learning Environments within the Context of the My History in Digital Project

Abstract

Following the digital transformation that accelerated after 2020, virtual reality (VR) technology has become increasingly widespread across various sectors, including education, defense, tourism, industry, and entertainment. In the field of education in particular, the literature highlights the pedagogical benefits of VR applications in diverse disciplines such as history, geography, engineering, medicine, fine arts, and psychology. This study focuses on the development and implementation of a VR model titled "Tarihim Dijitalde" (My History in Digital), through which three historical buildings located in the city of Balıkesir were digitized using three-dimensional (3D) scanning technology and integrated into a virtual reality environment. The primary aim of the research is to explore the views of students attending BİLSEM (Science and Art Centers for gifted students) after experiencing the VR model in an educational context. Data were collected through semi-structured interviews conducted with 27 students who interacted with the VR model. The study was designed using the phenomenological approach, one of the qualitative research designs, and the data were analyzed through content analysis. The findings reveal that students expressed a strong interest in utilizing VR not only in history courses but also across a broad range of subjects. Participants stated that VR-based lessons were more enjoyable, easier to understand, and more engaging. Furthermore, students emphasized that the presence of VR technology in schools would contribute positively to their learning experience. In conclusion, the use of virtual reality in educational settings tailored for gifted students, such as BİLSEM, was found to be highly applicable and effective. VR was evaluated as an innovative tool that enhances classroom efficiency and supports deeper learning.

Keywords: Virtual reality (VR), history education, digitization in education, BİLSEM

Giriş

Günümüzde eğitimde teknolojik yeniliklerin çeşitlenmesi, özellikle sanal gerçeklik (VR) teknolojisinin pedagojik ortamda kullanılmasını gündeme getirmiştir. VR, öğrencilere üç boyutlu, duyusal olarak zenginleştirilmiş deneyimler sunarak, soyut kavramları somutlaştırma, mekânsal ilişkileri anlama ve etkileşimli öğrenme fırsatları yaratma potansiyeline sahiptir (Li, 2025). VR'in tarih eğitimi bağlamında kullanımına ilişkin literatürde, tarihî yapıların öğrenciler tarafından sanal ortamda incelenmesinin öğrenme motivasyonunu ve bilgi kalıcılığını artırdığı yönünde olumlu bulgular mevcuttur (Victor, 2023).

VR destekli tarih eğitiminin etkili olduğu alanlar arasında bilgi kazanımı, öğrenci ilgisi ve olumlu tutumlar yer almaktadır. Bonsu (2025) tarafından yürütülen araştırmanın bulguları, VR'nin tarihî bilgi kazanımını anlamlı biçimde güçlendirdiğini ve öğrencilerde olumlu tutumlar geliştirdiğini ortaya koymuştur. Benzer şekilde, Victor (2023) VR'nin tarihî eğitime entegrasyonunun öğrencilerin öğrenme çıktıları, motivasyonu ve tarihî sorgulama becerilerini artırdığını göstermiştir. Bu bulgular, içerik açısından zengin, etkileşimli öğrenme ortamlarının tarih eğitimi süreçlerinde değerli katkılar sunabileceğini işaret etmektedir. Nitekim, VR'nin öğrenci motivasyonunu artırıcı etkisi yalnızca tarih eğitimiyle sınırlı olmayıp farklı disiplinlerde de benzer biçimde rapor edilmiştir (Radianti, Yadav, & Arnesen, 2020).

VR teknolojisinin tarihî yapıların sanal olarak yeniden inşası ve incelenmesindeki rolü, coğrafi ve kaynak sınırlamalarını aşarak öğrencilere daha geniş erişim imkânı sağlar. Li (2025), VR sayesinde öğrencilerin mimari stil, mekânsal düzen ve kültürel anlamlarla ilgili derinlemesine kavrayış elde ettiğini ve fiziksel erişim kısıtlamaları gibi sınırlamaların etkilerinin minimize edildiğini belirtmektedir. VR teknolojisinin farklı disiplinlerde esnek biçimde kullanılabilme potansiyeli, öğrenme ortamlarının zenginleştirilmesi açısından kritik görülmektedir (Slater & Sanchez-Vives, 2016). Bu durum, VR'nin eğitimde eşitlikçi ve kapsayıcı bir yaklaşımı destekleyebileceğini ortaya koymaktadır.

Bununla birlikte, VR uygulamalarının eğitsel faydalarına dair güçlü bulgular olsa da, kullanımında bazı zorluklar ve dikkate alınması gereken hususlar da mevcuttur. Villena-Taranilla (2025) VR'nin tarih eğitimine dair sunduğu etkileşimli ve sürükleyici öğrenme deneyimlerinin yanı sıra, uygulama sürecinde lojistik, teknik ve pedagojik entegrasyon açısından çözülmesi gereken sorunlara da işaret ettiğini savunmaktadır. Özellikle donanım erişimi, maliyet ve öğretmen eğitimi gibi boyutlar, VR teknolojilerinin eğitim ortamına entegrasyonunda kritik önem taşımaktadır.

Çalışmanın, Türkiye bağlamında BİLSEM (Bilim ve Sanat Merkezi) öğrencilerinin VR deneyimlerini incelemesine katkı sağlayacağı düşünülmektedir. BİLSEM'ler üstün yetenekli öğrencilerin potansiyellerini geliştirmeyi amaçlayan kurumlardır ve bu öğrencilerin yenilikçi teknolojilerle etkileşimleri, gelecekteki eğitim politikaları açısından yol gösterici olabilir. Literatürde BİLSEM öğrencilerinin VR deneyimlerine odaklanan araştırmaların sınırlı olduğu görülmektedir. Çalışma kapsamında, öğrencilerin VR teknolojisiyle ilgili deneyim ve algılarını çok boyutlu olarak ortaya koymak amaçlanmaktadır. Bu doğrultuda çalışmada, öğrencilerin sanal gerçeklik teknolojisine ilişkin *önceki deneyimlerinin nasıl şekillendiği*, *VR destekli üç boyutlu modellerin kendilerinde hangi duygusal tepkileri uyandırdığı* ve *bu teknolojinin derslerde kullanılabilirliğine dair görüşlerinin neler olduğu* sorgulanmıştır. Ayrıca*, VR deneyiminin öğrencilerde kültürel mirasın korunmasına yönelik farkındalık oluşturup oluşturmadığı*, *öğrenme verimliliğine ve diğer derslerde kullanımına ilişkin düşüncelerinin ne olduğu*, *son olarak da teknolojinin kendisine yönelik merak ve beklentilerinin hangi boyutlarda ortaya çıktığı* incelenmiştir.

Yöntem

Bu araştırma, nitel araştırma yaklaşımlarından olgubilim (fenomenoloji) deseni ile yürütülmüştür. Fenomenoloji, bireylerin belirli bir olguya ilişkin deneyimlerini, algılarını ve anlamlandırmalarını derinlemesine incelemeyi amaçlayan bir araştırma desenidir (Creswell, 2013). Bu çalışmada incelenen olgu, öğrencilerin "Tarihim Dijitalde" projesi kapsamında sanal gerçeklik (VR) destekli üç boyutlu (3B) tarihî yapı modellerini deneyimlemeleridir. Bu nedenle fenomenolojik yaklaşım, öğrencilerin öznel deneyimlerini anlamak ve ortak temaları ortaya çıkarmak açısından uygun görülmüştür.

Araştırmanın çalışma grubunu, Balıkesir'de Bilim ve Sanat Merkezinde (BİLSEM) öğrenim gören 27 öğrenci oluşturmaktadır. Katılımcılar amaçlı örnekleme yöntemiyle belirlenmiştir. Öğrenciler farklı yaş ve sınıf düzeylerinden (9–15 yaş aralığında, 4.–9. sınıf düzeylerinde) seçilmiştir. Katılımcıların seçiminde gönüllülük esas alınmıştır.

Veriler, yarı yapılandırılmış görüşme formu aracılığıyla toplanmıştır. Görüşme formu, VR deneyimi öncesinde literatür taraması ve uzman görüşleri doğrultusunda hazırlanmış yedi açık uçlu sorudan oluşmaktadır. Sorular; öğrencilerin önceki VR deneyimlerini, VR destekli 3B modeller karşısındaki duygularını, bu teknolojinin derslerde kullanılabilirliğine ilişkin düşüncelerini, tarihî yapıların korunmasına dair farkındalıklarını, öğrenme verimliliğine etkilerini, farklı derslerde kullanılabilirliğini ve teknolojiye yönelik meraklarını ölçmeyi amaçlamaktadır. Görüşmeler öğrencilerin 2025 bahar döneminde, VR deneyimini yaşamasının hemen ardından, 10-15 dakikalık sürelerde gerçekleştirilmiştir.

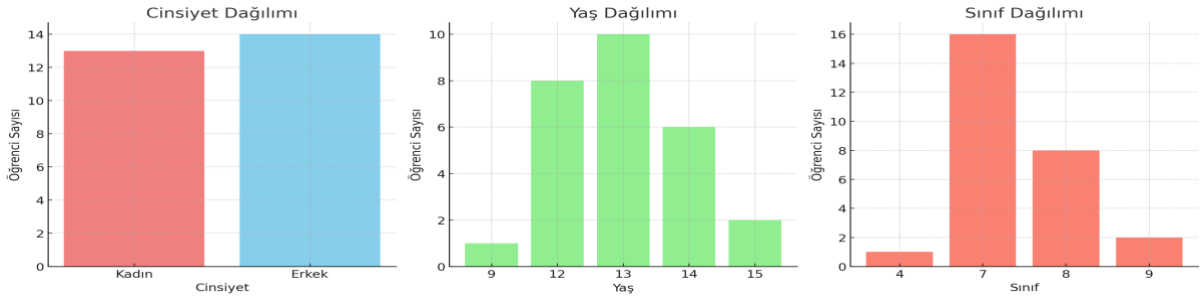
Çalışmanın güvenirliğini artırmak amacıyla araştırmacılar arası tutarlılık sağlanmaya çalışılmıştır. Ayrıca görüşme formu uzman görüşü alınarak hazırlanmış, elde edilen temaların geçerliliği üç alan uzmanı tarafından kontrol edilmiştir. Bulguların sunumunda öğrencilerin doğrudan ifadelerine yer verilerek nitel araştırmalarda önerilen "katılımcı sesi" ilkesine dikkat edilmiştir (Yıldırım & Şimşek, 2018).

Toplanan veriler, içerik analizi yöntemiyle çözümlenmiştir. Öncelikle görüşme yanıtları yazılı forma dönüştürülmüş, ardından kodlama süreci Microsoft Excel programı ile gerçekleştirilmiştir. Kodlama sırasında önceden belirlenen temalar (deneyim, duygusal tepki, eğitimsel kullanılabilirlik, kültürel miras farkındalığı, öğrenme verimliliği, teknolojiye merak) kullanılmış, bunun yanında katılımcı yanıtlarından türeyen alt kategoriler de dikkate alınmıştır. Kodlama sürecinde iki araştırmacı bağımsız olarak çalışmış ve elde edilen kodlar karşılaştırılmıştır. Uyuşmazlık durumunda tartışma yoluyla uzlaşıya varılmıştır.

Bulgular

Bu araştırmada, "Tarihim Dijitalde" projesi kapsamında VR destekli tarihî yapı modellerini deneyimleyen 27 öğrencinin görüşleri içerik analizi yöntemiyle incelenmiştir. Elde edilen veriler önceki deneyimler, duygusal tepkiler, eğitimde kullanılabilirlik, kültürel miras farkındalığı, öğrenme verimliliği ve teknolojiye yönelik merak temaları altında değerlendirilmiştir.

Katılımcı öğrencilerin demografik özellikleri incelendiğinde (Şekil 1), cinsiyet dağılımının dengeli olduğu görülmektedir; çalışmaya 13 kadın ve 14 erkek öğrenci katılmıştır. Yaş dağılımında çoğunluğun 12–14 yaş aralığında yoğunlaştığı, özellikle 13 yaş grubunun (10 öğrenci) öne çıktığı belirlenmiştir. Sınıf düzeyleri açısından en yüksek katılımın 7. sınıf öğrencilerinden (16 öğrenci) geldiği, bunu 8. sınıf (8 öğrenci) ve 9. sınıf (2 öğrenci) öğrencilerinin izlediği, 4. sınıf seviyesinden ise yalnızca bir öğrencinin yer aldığı saptanmıştır. Bu dağılımlar, örneklemin yaş ve sınıf düzeyi bakımından çeşitlilik gösterdiğini, ancak ortaokul kademesinde yoğunlaştığını ortaya koymaktadır.



Şekil 1: Katılımcıların cinsiyet, yaş ve sınıf dağılımı.

Önceki Deneyimler: Öğrencilerin büyük çoğunluğu sanal gerçeklik (VR) teknolojisini ilk kez tarihî yapıların incelenmesi bağlamında deneyimlemiştir. 24 öğrenci bu tür bir uygulamayı ilk defa kullandığını belirtirken, yalnızca bir öğrenci daha önce VR deneyimine sahip olduğunu dile getirmiştir. Bu bulgu, VR teknolojisinin

öğrenciler açısından hâlâ yeni ve keşfedilmemiş bir alan olduğunu göstermektedir. Ayrıca bu durum, öğrencilerin deneyim süresince sergiledikleri merak ve motivasyonun kaynağını açıklamaktadır.

Duygusal Tepkiler: VR deneyiminin öğrencilerde güçlü duygusal tepkiler uyandırdığı görülmüştür. Öğrencilerin yarısı (14 kişi) deneyimlerini "eğlenceli", "güzel", "çok iyi" gibi olumlu ifadelerle nitelendirmiştir. Bir öğrenci, "Çok iyi bir şeymiş. Çok güzel bir deneyimdi." diyerek sanal ortamın yarattığı gerçeklik hissini vurgulamıştır. 12 öğrenci ise dersin daha dikkat çekici ve katılımı artırıcı bir hâle geldiğini belirtmiştir. Ayrıca bir öğrenci deneyimini, "Çok eğlenceli ve güzeldi. Sanki gerçek hayattaki gibiydi." sözleriyle paylaşmıştır. Bu sonuçlar, VR teknolojisinin öğrencilerde yüksek düzeyde duygusal etki yarattığını ve ders motivasyonunu artırdığını göstermektedir.

Eğitimde Kullanılabilirlik: Öğrencilerin büyük çoğunluğu VR uygulamalarının yalnızca tarih dersleriyle sınırlı kalmaması gerektiğini vurgulamıştır. 10 öğrenci fen bilimlerinde, 5 öğrenci sosyal bilgiler/tarih derslerinde, 2 öğrenci matematikte ve yine 2 öğrenci sanat/mimarlık alanlarında bu tür uygulamaların faydalı olacağını belirtmiştir. Bir öğrenci, "Fen bilimlerinin dalları olabilir. Laboratuvarda gerçekleştirilmesi gereken tehlikeli deneyleri yapabiliriz." derken, bir diğeri "Matematik dersinde 3B şeyleri daha iyi kavramak için kullanılabilecek bir teknoloji." ifadesini kullanmıştır. Ayrıca 8 öğrenci genel kullanım kategorisinde görüş bildirmiştir. Bu bulgular, öğrencilerin VR teknolojisini disiplinler arası bir araç olarak gördüklerini ve özellikle soyut kavramların öğreniminde görselleştirmenin önemli olduğunu düşündüklerini ortaya koymaktadır.

Kültürel Miras Farkındalığı: Araştırmanın en güçlü bulgularından biri, VR deneyiminin öğrencilerde tarihî yapıların korunmasına yönelik farkındalık oluşturmasıdır. 13 öğrenci kültürel mirasın korunması gerektiğini, 12 öğrenci VR teknolojisinin geçmiş ile günümüz arasında bir köprü kurduğunu, 2 öğrenci ise gelecek nesillere aktarma açısından bu tür uygulamaların kritik olduğunu belirtmiştir. Katılımcılardan biri, "Bu yapıları bu şekilde görmek bile bana onların değerini hatırlattı" diyerek farkındalık boyutunu ifade etmiştir. Başka bir öğrenci ise, "VR sayesinde tarihî eserleri kaybolmadan önce korumamız gerektiğini anladım" sözleriyle bu katkıyı dile getirmiştir.

Öğrenme Verimliliği: Öğrencilerin büyük çoğunluğu (24 öğrenci) VR destekli öğrenmenin daha etkili olduğunu belirtmiştir. Görsel-işitsel destek sayesinde öğrenmenin kalıcı ve anlaşılır hale geldiği, derslerin daha ilgi çekici olduğu vurgulanmıştır. Bir öğrenci, "Öğrenme verimliliği sağlar. Çünkü yaşayarak görmek, anlama ve öğrenmek gibi birçok fırsat oluşturuyor." diyerek VR'nin derse olan etkisini aktarmıştır. Ayrıca 2 öğrenci öğrenmenin "yaşayarak" gerçekleştiğini, 1 öğrenci ise dikkatin daha yüksek olduğunu ifade etmiştir. Bir öğrenci bu durumu, "Çünkü yaşayarak öğrenmek en etkili öğrenme biçimidir." şeklinde ifade etmiştir.

Teknolojiye Yönelik Merak: Öğrenciler yalnızca içerikle sınırlı kalmayıp kullanılan teknolojiye yönelik de yoğun bir merak geliştirmiştir. 20 öğrenci gelecekte bu teknolojilerin nasıl gelişeceğini merak ettiğini, 6 öğrenci kullanılan yazılım ve programların teknik ayrıntılarını öğrenmek istediğini, 1 öğrenci ise maliyet ve erişilebilirlik konusunda kaygı duyduğunu dile getirmiştir. Örneğin bir öğrenci, "Hangi programlar kullanılıyor ve zor mu?" diye sorarken; başka bir öğrenci, "Ben modellerin VR ortamına nasıl aktarıldığını öğrenmek isterdim." sözleriyle bu tür ortamları oluşturma isteğini dile getirmiştir.

Araştırma bulguları, "Tarihim Dijitalde" projesi kapsamında kullanılan VR uygulamasının öğrencilerde hem bilişsel hem de duyuşsal düzeyde güçlü etkiler yarattığını ortaya koymaktadır. Öğrencilerin VR teknolojisini yalnızca tarih dersine değil farklı disiplinlere de uyarlamak istemeleri, teknolojinin esnek ve disiplinler arası kullanım potansiyelini desteklemektedir. Ayrıca kültürel mirasın korunması ve öğrenme motivasyonunun artması, projenin pedagojik katkısının yanı sıra değerler eğitimine de hizmet ettiğini göstermektedir.

Sonuç olarak, VR destekli tarihî yapı incelemeleri öğrencilerin öğrenme deneyimlerini zenginleştirmiş, tarihî bilince katkı sağlamış ve öğrenme süreçlerinde motivasyon artırıcı bir etki yaratmıştır. Bu bulgular, gelecekte VR teknolojilerinin eğitim ortamlarında daha yaygın kullanılabileceğine ve öğrencilerin bu tür yenilikçi araçlara yüksek düzeyde hazır bulunuşluk gösterdiğine işaret etmektedir.

Sonuçlar

Bu araştırmada, "Tarihim Dijitalde" projesi kapsamında geliştirilen VR destekli 3B tarihî yapı modellerinin öğrenciler tarafından nasıl deneyimlendiği incelenmiştir. Fenomenolojik desen kullanılarak yürütülen çalışmada, BİLSEM'de öğrenim gören 27 öğrencinin görüşleri yarı yapılandırılmış görüşme formu aracılığıyla toplanmış ve içerik analizi yöntemiyle çözümlenmiştir. Elde edilen bulgular, VR teknolojisinin eğitim ortamlarında hem bilişsel hem de duyuşsal boyutlarda güçlü etkiler yarattığını göstermektedir.

Araştırmanın ilk önemli bulgusu, öğrencilerin büyük çoğunluğunun VR deneyimini ilk kez yaşadıklarıdır. Bu durum, teknolojinin hâlâ öğrenciler için yeni ve keşfedilmeye açık bir alan olduğunu ortaya koymaktadır. Deneyimin yeniliği, öğrencilerin öğrenme sürecine daha meraklı ve motive bir biçimde katılmalarını sağlamıştır. Bu bağlamda VR'nin, özellikle farklı yaş ve sınıf düzeylerinde öğrenme ilgisini artıran bir araç olduğu sonucuna varılabilir.

İkinci olarak, öğrencilerin VR deneyimine verdikleri duygusal tepkiler dikkat çekicidir. Görüşmelerde öğrenciler "eğlenceli", "çok güzel", "etkileyici" gibi olumlu ifadeler kullanmış; VR ortamının derslere olan ilgiyi ve dikkat düzeyini artırdığı sıkça dile getirilmiştir. Öğrenme sürecinde olumlu duyguların harekete geçirilmesi, motivasyonun yanı sıra bilginin kalıcılığını da desteklemektedir. Bu bulgu, literatürde VR'nin öğrenci merkezli, ilgi çekici ve motive edici bir öğrenme ortamı sunduğunu vurgulayan çalışmalarla da örtüşmektedir (Victor, 2023; Bonsu, 2025).

Üçüncü bulgu, VR'nin yalnızca tarih dersleriyle sınırlı kalmaması gerektiğine yönelik öğrenci görüşleridir. Öğrenciler bu teknolojinin fen bilimleri, matematik ve sanat gibi farklı derslerde kullanılabileceğini vurgulamışlardır. Özellikle soyut kavramların görselleştirilmesi gereken derslerde VR'nin önemli bir öğrenme aracı olarak değerlendirildiği anlaşılmaktadır. Bu sonuç, VR'nin disiplinler arası esnek kullanım potansiyeline işaret etmektedir.

Çalışmanın bir diğer dikkat çekici sonucu, VR deneyiminin öğrencilerde **kültürel miras farkındalığı** oluşturmasıdır. Öğrenciler tarihî yapıların korunması gerektiğini vurgulamış, bu teknolojinin kültürel mirasın gelecek nesillere aktarılmasına katkı sunduğunu belirtmişlerdir. Dolayısıyla VR yalnızca pedagojik değil, aynı zamanda değerler eğitimi bağlamında da işlevsel bir araç olarak öne çıkmaktadır.

Öğrenme verimliliği açısından ise öğrencilerin neredeyse tamamı VR'nin daha etkili öğrenmeyi sağladığını ifade etmiştir. Görsel-işitsel destek ve "yaşayarak öğrenme" deneyimi, öğrencilerin bilgiye daha kalıcı ve anlamlı bir şekilde ulaşmalarını kolaylaştırmıştır. Bu bulgu, VR'nin öğrenme süreçlerine somutluk kazandırarak soyut kavramların anlaşılmasını desteklediğini göstermektedir.

Son olarak, öğrencilerin teknolojiye yönelik yoğun merakı öne çıkmıştır. Katılımcılar kullanılan yazılımlar, modellerin hazırlanma süreci ve teknolojinin geleceği hakkında sorular yöneltmişlerdir. Bu bulgu, VR'nin yalnızca öğrenme içeriğini zenginleştirmekle kalmayıp aynı zamanda öğrencilerde bilişsel merak ve teknolojiye yönelik ilgiyi de artırdığını göstermektedir.

Genel olarak değerlendirildiğinde, bu araştırma VR teknolojisinin eğitim ortamlarına entegrasyonunun çok boyutlu katkılar sunduğunu ortaya koymaktadır. Öğrencilerin motivasyonunu, öğrenme verimliliğini ve kültürel miras farkındalığını artıran VR, disiplinler arası kullanılabilirliğiyle de öne çıkmaktadır. Bununla birlikte, bu çalışmanın bulguları yalnızca sınırlı bir katılımcı grubuna dayalıdır. Gelecekte yapılacak araştırmalarda daha geniş örneklemlerle nicel ve nitel yöntemlerin bir arada kullanılması, VR'nin farklı bağlamlardaki etkilerinin daha kapsamlı biçimde anlaşılmasına katkı sağlayacaktır.

Sonuç olarak, "Tarihim Dijitalde" projesi, VR teknolojisinin eğitimdeki potansiyelini gözler önüne sermekte ve bu teknolojinin hem pedagojik hem de değer aktarımı boyutunda yenilikçi bir araç olarak kullanılabileceğini ortaya koymaktadır.

Tartışma ve Öneriler

Çalışmamız, VR destekli üç boyutlu tarihî yapı modellerinin öğrencilerde bilişsel ve duyuşsal düzeyde etkili öğrenme deneyimleri oluşturduğunu göstermektedir. Duygusal tepki teması altında, öğrencilerin büyük çoğunluğunun deneyimi "çok eğlenceli", "etkileyici" ve "ayrıca dikkat çekici hale getiren" ifadeleriyle tanımlaması, önceki VR eğitim bulgularıyla tutarlıdır (Radianti, Majchrzak, Fromm & Wohlgenannt, 2020). Eğitsel kullanabilirlik bağlamında ise öğrencilerin VR uygulamalarını fen, matematik ve sanat gibi diğer derslere de önermeleri, teknolojinin disiplinler arası kullanım potansiyelini açıkça ortaya koymaktadır (Slater & Sanchez-Vives, 2016).

Kültürel mirasa yönelik farkındalık temasında elde edilen bulgular, VR'nin sadece pedagojik değil aynı zamanda değerler eğitimi ve kültürel bilinç oluşturma açısından da güçlü bir araç olduğunu göstermektedir. VR'nin somut-dijital köprüsü kurarak geçmişi öğrenciler açısından erişilebilir hale getirmesi, tarih eğitiminde yeni bir yaklaşımsal katkı sunmaktadır.

Ancak, bu bulgular bazı sınırlılıklar çerçevesinde değerlendirilmelidir. Araştırmanın örneklemi yalnızca bir BİLSEM ile sınırlı ve nispeten küçük bir grubu kapsadığından, bulguların genellenebilirliği sınırlıdır. Ayrıca, verilerin toplandığı süreç kısa vadeli bir uygulamaya dayanmaktadır; uzun süreli VR kullanımların öğrenmeye etkisi incelenmemiştir. Gelecekte yapılacak araştırmalarda örneklem çeşitliliğinin artırılması, farklı okul türleri ve bölgelerdeki deneyimlerin karşılaştırılması, daha derinlemesine analizlere fırsat sağlayacaktır.

Bu çerçevede öneriler şu şekilde özetlenebilir:

- Mobil VR uygulamalarının farklı okul düzeyleri (ilkokul, lise) ve öğretmenlerin tutumlarıyla birlikte incelenmesi,
- Uzun vadeli uygulamaların öğrenme motivasyonuna ve akademik başarıya etkilerinin ölçümlenmesi,
- Öğrencilerin teknolojiye yönelik merakının nasıl pedagojik fırsata dönüştürülebileceğinin araştırılması.

Sonuç olarak, bu çalışma VR teknolojisinin tarih eğitimi bağlamında öğrenme, motivasyon ve kültürel bilinç oluşturma açılarından güçlü katkılar sunduğunu ortaya koymaktadır. Bununla birlikte, daha kapsamlı ve uzun soluklu çalışmalarla bu bulgular genişletilmeli, VR'nin eğitimde sürdürülebilir ve kapsayıcı bir araç olarak yerleşmesi desteklenmelidir.

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Yabancı Dil Eğitiminde Sanal Gerçeklik Kullanımının Lisansüstü Öğrencilerin Bilişsel Yük Algısına Etkisi

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Özet

Bu çalışma, sanal gerçeklik (SG) teknolojisinin yabancı dil eğitiminde kullanımının öğrencilerin bilişsel yük algıları üzerindeki etkisini incelemeyi amaçlamaktadır. Yabancı dil eğitiminde bağlam temelli öğrenme, öğrencilerin anlamlı ve kalıcı öğrenme yaşantıları geliştirmelerini sağlamada etkili bir yöntem olarak öne çıkmaktadır. Sanal gerçeklik teknolojileri, öğrencilere özgün dilsel bağlamlar sunarak hem duyuşsal hem de bilişsel etkileşimi artırmakta; böylece öğrenmenin etkinliğini güçlendirmektedir. Ancak, bu tür teknolojilerin karmaşık yapıları, öğrenciler üzerinde aşırı bilişsel yük oluşturma riski de taşımaktadır. Bu çerçevede araştırmanın temel amacı, SG tabanlı yabancı dil eğitim ortamının öğrencilerin bilişsel yük algılarına nasıl etki ettiğini anlamaktır.

Araştırma, nitel ve nicel veri toplama yöntemlerinin bir arada kullanıldığı karma yöntem desenine dayalı olarak tasarlanmıştır. Araştırmanın katılımcılarını bir devlet üniversitesinde lisansüstü düzeyde eğitim gören 42 öğrenci oluşturmaktadır. Katılımcılara, SG destekli bir yabancı dil eğitim ortamında çeşitli görevler sunulmuş ve uygulama süreci sonrasında bilişsel yük algılarını ölçmek amacıyla "Bilişsel Yük Ölçeği" uygulanmıştır. Nicel verilerin ardından, öğrenci deneyimlerini daha derinlemesine anlamak amacıyla odak grup görüşmeleri gerçekleştirilmiştir. Ayrıca her oturum sonrası katılımcılara görüşlerini ifade etmeleri amacıyla katılımcı günlüklerini doldurmaları istenmiştir. Elde edilen nicel veriler betimsel istatistiklerle, nitel veriler ise içerik analizi yöntemiyle analiz edilmiştir.

Araştırma sonuçları, öğrencilerin SG ortamında yaşadıkları bilişsel yükün genelde orta düzeyin üzerinde olduğunu ortaya koymuştur. Katılımcılar, dil öğrenim süreçlerinde anlamaya, telaffuza ve kelime seçimlerine yönelik zihinsel bir çaba gösterdiklerini, ancak bu çabanın öğrenmeye katkı sağladığını ifade etmişlerdir. Görüşmelerde öğrenciler, sanal ortamın sunduğu görsel-işitsel ipuçlarının dilsel anlamayı kolaylaştırdığını, bağlamın gerçekçiliğinin doğru telaffuz ve kelime hatırlama üzerinde olumlu etkileri olduğunu vurgulamıştır. Bununla birlikte, bazı öğrenciler teknolojik ekipman kullanımı ve görevlerdeki karmaşıklık nedeniyle bilişsel yüklerinin arttığını belirtmiştir.

Sonuç olarak, çalışma SG destekli yabancı dil eğitiminin öğrencilerin öğrenme deneyimlerini zenginleştirdiğini, ancak bu sürecin dikkatle yapılandırılmaması durumunda aşırı bilişsel yüke neden olabileceğini göstermektedir. Araştırma, SG teknolojilerinin eğitimsel bağlamda etkili bir şekilde kullanılabilmesi için pedagojik hedeflerle teknolojik tasarımın uyumlu olması gerektiğini vurgulamaktadır. Ayrıca, öğretim tasarımcılarının öğrencilerin bilişsel kapasitelerini göz önünde bulundurarak görevleri yapılandırmaları, öğrenme sürecinde anlamlı ve sürdürülebilir gelişim sağlamada kritik bir rol oynamaktadır.

Anahtar Kelimeler: Bilişsel yük, Sanal Gerçeklik, teknoloji destekli yabancı dil eğitimi,

Giriş

Öğrenme süreci, bireyin zihinsel süreçlerini etkin biçimde kullanmasını gerektiren karmaşık bir yapıdır. Bu süreçte bireylerin karşılaştıkları bilgi miktarı ve bu bilgiyi işleme biçimleri, öğrenmenin verimliliğini doğrudan etkilemektedir. Özellikle öğrenme süreci içerisinde dikkate alınması gereken en temel hususlardan biri, bireyin çalışma belleğinin sınırlı kapasitesidir. Sweller (2021), bireylerin sınırlı çalışma belleği kapasitesine sahip olduğunu ve bu sınırlılığın öğretim ortamlarının tasarımında mutlaka göz önünde bulundurulması gerektiğini savunduğu bilişsel yük kuramı ile bu alana önemli katkılar sunmuştur. Kurama göre etkili öğrenme ortamları, çalışma belleğine aşırı yüklenmeyi engelleyecek biçimde tasarlanmalı ve bilgilerin uzun süreli belleğe aktarımını destekleyecek şekilde yapılandırılmalıdır (Sweller, 2020). Bu bağlamda, bilişsel yükün dengelenmesi; öğrenmenin niteliğini artırmak, öğrenme sürecini daha sürdürülebilir hâle getirmek ve öğrencilerin motivasyonlarını koruyabilmek açısından kritik önemdedir.

Son yıllarda eğitim ortamlarında giderek yaygınlaşan sanal gerçeklik (SG) teknolojisi, öğrenme süreçlerine ilişkin yeni olanaklar sunmaktadır. SG'nin sürükleyici yapısı, yüksek çözünürlüklü içerikler ve çoklu duyusal uyaranlarla desteklenen etkileşimli öğrenme fırsatları, öğrencilerin dikkatini artırmakta ve öğrenmeye

aktif katılımlarını teşvik etmektedir (Freina & Canessa, 2015; Tepe, 2019). Ancak, bu teknolojinin öğrenme üzerindeki etkileri, özellikle bilişsel yük bağlamında literatürde farklı sonuçlarla tartışılmaya devam ettiği görülmektedir. Bazı araştırmalar SG ortamlarının zengin ve yoğun yapısı nedeniyle yüksek bilişsel yüke neden olabileceğini ve bu durumun öğrenmeyi olumsuz etkileyebileceğini öne sürmektedir (Makransky et al., 2019; Parong & Mayer, 2018). Nitekim, artan bilişsel yük sanal gerçeklikte uzun süreli belleği ve bağlam transferini zorlaştırabilir; bu nedenle dil eğitimi bağlamında içerik ve etkileşim arasında denge kurularak yükün dikkatle yönetilmesi gerekmektedir (Song et al., 2023). Öte yandan, SG'nin dikkat çekici ve motive edici yapısının daha düşük düzeyde bilişsel yük oluşturduğunu savunan çalışmalar da mevcuttur (Tai & Chen, 2021; Zak & Oppl, 2022). Ayrıca, sanal gerçekliğin sunduğu çok yönlü ve derin deneyimler, özellikle akademik ortamlarda dışsal bilişsel yükü artırabilir. Bu tür yükler, öğrenme sürecini doğrudan geliştirmese de dilsel anlama ve bilgiyi entegre etme gibi görevler için gerekli olan zihinsel kaynakları tüketerek öğrenmeyi olumsuz etkileyebilir (Song et al., 2023). Birbirinden farklı türde ortaya çıkan bu araştırma sonuçları, SG'nin öğrenme süreçlerinde nasıl yapılandırılması gerektiğine yönelik daha derinlemesine araştırmaları gerekli kılmaktadır.

Öğretim ortamlarının tasarım tasarım süreçleri bilişsel yükü etkileyen en önemli değişkenlerden biridir. Özellikle SG gibi görsel-işitsel uyaranlarla zenginleştirilmiş ortamlarda içerik yoğunluğu, görevlerin karmaşıklığı ve etkileşim düzeyi, bireylerin zihinsel kaynaklarını farklı biçimlerde etkileyebilmektedir (Sweller, 2021). Bu nedenle, SG destekli eğitim uygulamalarında bilişsel yükün öğrencilerin bireysel özellikleri, teknolojiye aşinalıkları ve öğrenme stilleri bağlamında değerlendirilmesi gerekmektedir. İnsan bilişsel mimarisi dikkate alınmadan tasarlanan eğitim ortamları, beklenen öğrenme çıktıları üzerinde istenen etkiyi yaratamayabilir (Sweller, 2020). Bu bağlamda, öğrenme ortamlarının yalnızca bilgi sunumunun niteliğine değil, aynı zamanda öğrenenin bireysel ihtiyaçlarına uygun biçimde tasarlanması da etkili öğrenmenin temel belirleyicilerinden biridir. Özellikle yabancı dil eğitimi türünde yoğun zihinsel süreçler içeren alanlarda, SG teknolojisinin öğrenen üzerindeki bilişsel etkilerinin ortaya konulması büyük önem taşımaktadır (Makransky et al., 2019).

Bu çalışmanın temel amacı, sanal gerçeklik destekli görev tabanlı yabancı dil eğitiminin lisansüstü öğrencilerin bilişsel yük algılarına etkisini incelemektir. Alan yazında SG teknolojisi ile bilişsel yük etkileşimini konu alan araştırmaların sayısının sınırlı olduğu ve özellikle dil eğitimi bağlamında daha çok deneysel çalışmalara ihtiyaç olduğu düşünülmektedir. Bu doğrultuda yürütülen bu araştırma, SG destekli yabancı dil eğitiminde bilişsel yük süreçlerinin öğrenenler açısından etkilerini ortaya koyarak alan yazına katkı sunmayı hedeflemektedir.

Yöntem

Araştırma Yöntemi

Araştırma kapsamında, lisansüstü öğrencilerin sanal gerçeklik ortamında sunulan yabancı dil etkinliklerine yönelik bilişsel yük algılarının ortaya çıkartılması amacıyla karma araştırma yöntemi kullanılmıştır. Karma yöntem araştırmaları: nitel ve nicel desenlerin bir arada kullanılmasına imkân sağladığı için araştırmalar çok yönlü bir şekilde incelenebilmekte ve derinlemesine analiz edilebilmektedir (McMillan & Schumacher, 2010) Karma araştırma yöntemi içerisinde yer alan çeşitleme (birleştirme) deseni kullanılarak nicel ve nitel verilerin birleştirilmesi hedeflenmiştir. Çeşitleme deseninin amacı; nicel ve nitel olarak farklı türde toplanmış olan verilerin birleştirilerek belirlenen problemin farklı boyutlardan ele alınmasını sağlamaktır (Creswell, 2017).

Katılımcılar

Araştırmanın katılımcılarını belirlemek amacıyla eğitim bilimleri enstitüsüne bağlı öğrencilerden kolay ulaşılabilir ve amaca yönelik örnekleme yöntemi kullanılarak 58 öğrenciye ulaşılmıştır. Fakat süreç içerisinde 13 öğrenci çalışmadan kişisel sebeplerden kaynaklı çıkmak istemiş, 3 kişi İngilizce seviyesi yüksek olduğu için çalışmaya dâhil edilmemiş ve uygulama 42 kişi ile tamamlanmıştır.

Veri Toplama Araçları

Bilişsel Yük Ölçeği

Araştırma kapsamında SG ortamında yabancı dil etkinlikleri sürecinde öğrencilerin dil etkinliklerini sergileme, diyaloglara katılma, kendilerine yöneltilen soruları cevaplama süreçlerinde bilişsel olarak ne kadar yüklendiklerini ölçmek amacıyla Paas ve Van Merrienber (1993) tarafından geliştirilen bilişsel yük ölçeği kullanılmıştır. Bilişsel yük ölçeği 1'den 9'a kadar derecelendirme ölçeği şeklindedir. Ölçeğin güvenirlik analizleri Paas ve Van Merrienber (1993) tarafından yapılmış, iç tutarlık katsayısı .82 olarak bulunmuştur. Ölçeğin Türkçe formunun uyarlama çalışması ise Kılıç ve Karadeniz (2004) tarafından yapılmış olup iç tutarlık katsayısı .90 olarak bulunmuştur.

Çalışmanın katılımcıları eğitim bilimleri enstitüsüne bağlı lisansüstü öğrencilerden oluştuğu için bilişsel yük kavramının ne anlama geldiğini bilmektedirler. Bununla birlikte öğrencilere ölçek uygulanmadan önce bilişsel

yük kavramı ile ilgili olarak gerekli açıklamalar ve bilgilendirmeler hatırlatma amacıyla yapılmış olup onlardan derecelendirme ölçeğini bu doğrultuda doldurmaları istenmiştir. Bunun yanı sıra araştırma kapsamında her ne kadar kullanılan ölçek olarak bilişsel yük ifade edilmiş olmasına karşılık çalışmanın bir sınırlılığı olarak ölçme süreçlerinin öğrencilerin özdeğerlendirmelerine dayalı olmasından kaynaklı olarak araştırmada ölçülen değişken bilişsel yük algısı olarak ifade edilmiştir.

Katılımcı Günlükleri

Çalışma kapsamında öğrencilerin bilişsel yük algılarının ölçülmesi amacıyla kendilerine sunulan ölçeğin yanı sıra katıldıkları her bir sanal gerçeklik oturumu sonrasında görüşlerini paylaşmaları istenmiştir. Bu sebeple ortam uygulamasını tamamladıktan hemen sonra kendilerine görüşlerini belirtebilecekleri boş bir kâğıt verilmiştir. Bu sayede o hafta ortamda gördükleri içerikler, konuşma deneyimleri, kendilerini rahatsız eden veya memnun kaldıkları boyutları belirtmeleri sağlanmıştır. Boş kağıtlar içerisine tüm görüşlerini istedikleri doğrultuda yazabilmeleri için uygun süre ve imkân tanınmıştır.

Yarı Yapılandırılmış Görüşme Formu

Çalışmaya katılan lisansüstü öğrencilerin SG destekli tasarlanmış olan yabancı dil eğitimi ortamına yönelik görüşlerinin alınması amacıyla araştırmacı tarafından hazırlanan yarı yapılandırılmış görüşme formu kullanılmıştır. Görüşme formu hazırlanırken öncelikle çalışmanın kapsamı ve araştırma soruları bağlamında bir taslak form hazırlanmıştır. Formda belli sorular olmakla birlikte öğrencilerin kendi görüşlerini rahatlıkla ifade edebilmeleri için açık uçlu ve görüşe dayalı sorular da form içerisine yerleştirilmiştir. Alan yazında benzer çalışmalardaki görüşme soruları incelenerek hazırlanan taslak form, öğretim teknolojileri ve yabancı dil eğitimi alan uzmanlarına gönderilmiştir. Alınan geri bildirimler sonucunda görüşme formunun son hâli oluşturulmuş, uygulama aşamasının tamamlanmasının ardından öğrencilerle yapılan görüşmelerde kullanılmıştır.

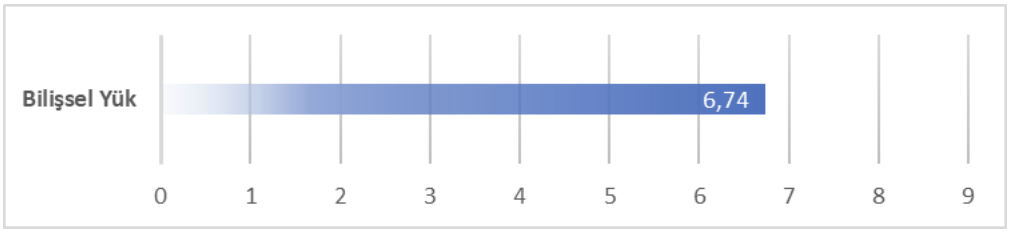
Veri Analizi

Çalışma kapsamında öğrencilerden her bir uygulama sonrasında katılımcı günlüklerini doldurmaları istenmiştir. Yapılandırılmamış bir formatta sunulan günlüklerin yanı sıra uygulama sonrasında odak grup görüşmesi yapılmıştır. Odak grup görüşmesinde araştırmacı tarafından oluşturulan yarı yapılandırılmış görüşme formu kullanılmıştır. Araştırmanın nitel verilerini oluşturan bu süreçte şunlar yer almaktadır;

- Öğrencilerin katılımcı günlükleri tek tek incelenmiştir.
- Öğrencilerle yapılan odak grup görüşmesi sonucunda herkesin söylediği ifadeler teker teker transkript edilmiştir.
- Katılımcı günlükleri ve odak grup görüşmesinden elde edilen veriler birlikte değerlendirilerek öğrencilerin bilişsel yük algılarına yönelik görüşleri ortaya çıkartılmıştır. Bu görüşler kodlara bölünmüştür
- Ortaya çıkan kodlar alan uzmanları ve akran değerlendirmesi yoluyla kontrol edilmiştir.

Bulgular

Araştırma kapsamında öğrencilerin bilişsel yük algılarının belirlenmesi amacıyla bilişsel yük ölçeği uygulanmıştır. Öğrencilerin en fazla 9 puan üzerinden değerlendirdikleri derecelendirme türü ölçeğe ait puanların ortalaması ($\bar{X}$) 6.74 olarak bulunmuştur. Uygulamaya katılan öğrencilerin bilişsel yük algılarının orta seviyede çıktığı tespit edilmiştir.



Şekil 1. Öğrencilerin Bilişsel Yük Algılarının Ölçeğe Dayalı Ortalaması

Öğrencilerin bilişsel yük algılarının belirlenmesi amacıyla uygulanan ölçek sonrasında derinlemesine veriler elde etmek amacıyla kullanıcı günlükleri ve yarı yapılandırılmış görüşme formu verileri analiz edilmiştir. Yapılan bu analizler doğrultusunda, öğrencilerin tasarlanan ortamla ilgili olarak gerek teknik açıdan gerekse yabancı dil becerisi açısından konuyu anlayabilme ve doğru telaffuz edebilme bağlamında bilişsel yük algılarının zaman

zaman arttığını ifade ettikleri belirlenmiştir. Analiz edilen tüm veriler ışığında aşağıda belirtilen kodlar ve örnek öğrenci ifadeleri sunulmuştur.

Zihinsel çabanın öğrenmeye katkısı

Öğrenciler anlamak ve doğru cevabı bulmak için aktif zihinsel çaba gösterdiklerini, bu çabanın öğrenmelerini desteklediğini belirtmişlerdir. Ayrıca bu zihinsel çabanın, özellikle telaffuzun öğrenilmesine ve kelime bilgisinin gelişimine etkisi vurgulanmıştır.

"Ben zihinsel olarak çok çaba sarfettim. Doğru cevabı bulmak için kendimi zorladım. Bu yönde bir çabaya girdim. Zihinsel olarak çabam öğrenmem üzerinde olumlu bir etki oluşturdu." (Ö13)

"Bazı diyaloglar alt yazılı ve alt yazısızdı. Ben alt yazısız olan yerlerde zihinsel olarak kendimi anlamak için zorladım. Öğrenmekten ziyade bir sonraki alt yazılı videoda alt yazıya daha az baktığımı fark ettim. Bu benim için olumlu bir durum oldu. Zihinsel olarak çaba sarf etmek beni olumlu etkiledi." (Ö42)

"Benim kendimi zorladığım ve telaffuzunu öğrendiğim kelimeler oldu. Bu çaba kesinlikle benim öğrenmem üzerinde etkisinin olduğunu düşünüyorum." (Ö15)

Motivasyonel etkiler

Bazı katılımcılar, zihinsel çabanın sadece öğrenmeyi değil, içsel motivasyonu da artırdığını belirtmiş; özellikle doğru cevaba ulaşmanın tatmin ve teşvik edici yönüne değinerek doğru cevabı bulmanın öğrenciler üzerinde motive edici bir etkisi olduğu dile getirilmiştir.

"Doğru kelimeyi bulma çabası çok oldu. Birkaç soruda baya bir zorlandım. Hangi kelimenin gelmesi söylenmesi gerektiği konusunda baya ciddi manada oturup kelimeleri düşündüğüm oldu. Doğru cevapları bulabiliyorsam motive ediyordu." (Ö33)

"Bazı diyaloglar alt yazılı ve alt yazısızdı. Ben alt yazısız olan yerlerde zihinsel olarak kendimi anlamak için zorladım. Bunun sonucunda alt yazılı videoda alt yazıya daha az baktığımı fark ettim. Bu benim için olumlu bir durum oldu. Zihinsel olarak çaba sarf etmek beni olumlu etkiledi ve sonraki videoyu anlamam benim için daha kolay oldu." (Ö20)

Aşırı bilişsel yük ve olumsuz deneyim

Zihinsel çabanın bazı durumlarda aşırı bilişsel yüke neden olarak motivasyon kaybı, yorgunluk ve öğrenme isteksizliği gibi olumsuz sonuçlara da yol açabileceği ifade edilmiştir. Sanal gerçeklik ortamında aşırı zihinsel yüklenmenin öğrenmeyi olumsuz etkilediği ve öğrencinin uygulamayı hızlıca tamamlayıp çıkmak istediği belirtilmiştir.

"Ben aşırı bilişsel yüklendiğim için sıkıldım ve bir an önce bitsin istedim. Zihinsel süreç beni çok yordu. Anlamadığım için yoruldum, parçaları birleştiremediğim için öğrenmem olumsuz etkilendi ve bitsin geçmek istedim." (Ö19)

Strateji Kullanımı ve Zihinsel Eylemler

Katılımcıların bazıları, anlamı artırmak için özel stratejiler (içten tekrar, sesli düşünme, yazılı-sözlü analiz vb.) geliştirdiklerini belirtmiştir. Bu eylemler, aktif bilişsel katılımı göstermektedir.

"Ben zihinsel olarak bir çaba sarfettim. Odaklanmamı sağladığı için öğrenmem üzerinde bir olumlu etkisi oldu. Hatta doğru olması için ben içimden kelimeleri seslendiriyordum."(Ö10)

"Bazı diyaloglar alt yazılı ve alt yazısızdı. Ben alt yazısız olan yerlerde zihinsel olarak kendimi anlamak için zorladım. Öğrenmekten ziyade bir sonraki alt yazılı videoda alt yazıya daha az baktığımı fark ettim. Bu benim için olumlu bir durum oldu. Zihinsel olarak çaba sarf etmek beni olumlu etkiledi." (Ö42)

"Ortamı anlama, diyalogları kaçırmama noktasında ve telaffuzlar konusunda kendimi zorladım. Benim kendimi zorladığım ve telaffuzunu öğrendiğim kelimeler oldu. Bu çaba kesinlikle benim öğrenmem üzerinde etkisinin olduğunu düşünüyorum." (Ö37)

Tartışma ve Sonuç

Öğrencilere uygulanan sanal gerçeklik (SG) ortamındaki dil eğitiminin, bilişsel yük algılarına etkisini belirlemek amacıyla önce Bilişsel Yük Ölçeği uygulanmış, ardından odak grup görüşmeleri gerçekleştirilmiştir. Ölçek sonuçları, katılımcı öğrencilerin bilişsel yük algılarının orta-üst düzeyde olduğunu ortaya koymuştur. Odak grup görüşmelerinde ise öğrenciler, kendilerine sunulan İngilizce içerikleri anlama ve doğru telaffuz etme sürecinde aşırı olmayan zihinsel bir çaba harcadıklarını belirtmiş; bu çabanın, kelimeleri doğru telaffuz etmeleri açısından olumlu katkılar sağladığını ifade etmişlerdir.

Alan yazın incelendiğinde, SG'nin öğrencilerin bilişsel yük algısına etkisine dair farklı bulgulara ulaşılmaktadır. Örneğin, Tai ve Chen (2021), SG'nin öğrencilere bağlam temelli öğrenme fırsatları sunduğunu ve bu sayede bilişsel yükü azalttığını ifade etmişlerdir. Bağlam temelli öğrenme, diyalog akışının ipuçları ve ortamdaki hareketler sayesinde tahmin edilebilir hâle gelmesini sağlayarak bilişsel yük üzerinde anlamlı bir etki yaratmaktadır. Aynı çalışmada, öğrencilerin SG sayesinde dış çevreden büyük ölçüde izole oldukları ve bu durumun onların içeriğe odaklanmasını kolaylaştırarak anlamayı artırdığı da belirtilmiştir.

Benzer şekilde, Xie ve arkadaşları (2019), SG ortamında sunulan etkinliklerin öğrencilerin bilişsel yükünü azalttığını ifade etmişlerdir. Öte yandan, DeWitt ve arkadaşları (2022) ile Juliano ve arkadaşlarının (2022) yürüttüğü çalışmalarda, SG ortamındaki yabancı dil etkinliklerinin katılımcılar üzerinde yüksek düzeyde bilişsel yük oluşturduğu ortaya konmuştur. Juliano vd. ayrıca, geleneksel bilgisayar ekranlarına kıyasla SG ortamında bilişsel yükün daha yüksek olduğunu belirtmiştir.

Huang ve arkadaşları (2020) tarafından geliştirilen SG destekli Çince yazma aracı ile yapılan çalışmada ise öğrencilerin yazma performansı ve öz yeterliklerinin geliştiği, bununla birlikte bilişsel yüklerinin azaldığı ifade edilmiştir. Zak ve Oppl (2022), SG ortamındaki senaryoların öğrenciler üzerinde düşük bilişsel yük oluşturduğunu belirtmiş; Liu ve arkadaşları (2022) ise SG ile eğitim alan deney grubunun, kontrol grubuna kıyasla anlamlı düzeyde daha düşük bilişsel yük algıladığını raporlamışlardır. Song ve arkadaşları (2023) tarafından yapılan bir başka araştırmada ise SG ortamında sunulan eğitim içeriklerinde bilişsel yük düzeyi %50 ve altında ölçülmüşken, geleneksel öğrenme senaryolarında bu oran %70'e kadar çıkmaktadır.

Bu bulgular doğrultusunda, alan yazında SG'nin bilişsel yük üzerindeki etkisine ilişkin farklı sonuçlar olduğu görülmektedir. Bu farkın; konu içeriği, öğrencilerin yabancı dil yeterlik düzeyi, ortamın tasarımı ve öğrencinin uygulamaya katılım derecesi gibi birçok etkene bağlı olduğu düşünülmektedir. Mevcut çalışmada ise öğrencilerin bilişsel yük algısı orta-üst düzeyde tespit edilmiştir. Orta düzeydeki bilişsel yük, öğrenme ve etkin katılım açısından olumlu sonuçlar doğurabilir (Huang, 2020). Bu nedenle, bilişsel yükün alt boyutlarının da dikkate alınarak dengede tutulması, öğrenme çıktıları açısından fayda sağlayacaktır.

Bilişsel yükü ölçmek amacıyla alan yazında sıklıkla bireylerin öz değerlendirmelerine dayalı ölçüm araçlarının kullanıldığı görülmektedir. Ancak özellikle sağlık ve teknoloji alanlarında yaşanan gelişmeler dikkate alındığında, bilişsel yükün standardize edilmiş araçlarla ölçülmesi, değerlendirme sürecine daha fazla güvenilirlik katacaktır. Bu yaklaşım, bireylerin öz değerlendirmeleri ile fiziksel ölçümler arasındaki tutarlılığın hesaplanmasını sağlayarak alan yazına da anlamlı bir katkı sunacaktır.

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The Impact of Virtual Reality in Foreign Language Education on Graduate Students' Cognitive Load Perception

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Abstract

This study aims to examine the impact of virtual reality (VR) technology on students' perceived cognitive load in foreign language education. In this context, context-based learning has emerged as an effective method in foreign language instruction, enabling students to develop meaningful and lasting learning experiences. Virtual reality technologies offer learners authentic linguistic contexts that enhance both affective and cognitive engagement, thereby improving the overall effectiveness of learning. However, the complex nature of such technologies may also pose a risk of imposing excessive cognitive load on learners. Accordingly, the primary aim of this study is to explore how a VR-based foreign language learning environment affects students' perceptions of cognitive load.

The research was designed using a mixed-method approach that incorporates both quantitative and qualitative data collection methods. The participants consisted of 42 graduate students enrolled at a public university. During the study, students were presented with various tasks in a VR-supported foreign language learning environment. Following the implementation process, the "Cognitive Load Scale" was administered to measure their perceived cognitive load. After the quantitative data collection, focus group interviews were conducted to gain a deeper understanding of the students' experiences. In addition, after each session, participants were asked to complete participant journals to express their reflections and opinions. The quantitative data were analyzed using descriptive statistics, while the qualitative data were examined through content analysis.

The results revealed that students generally experienced a cognitive load above the moderate level in the VR environment. Participants reported exerting significant mental effort in understanding the content, pronunciation, and word selection during language learning, and they noted that this effort positively contributed to their learning outcomes. In the interviews, students emphasized that the visual and auditory cues provided by the virtual environment facilitated linguistic comprehension, and the realism of the context positively influenced their pronunciation and word recall. However, some students indicated that their cognitive load increased due to the complexity of the tasks and the use of technological equipment.

In conclusion, the study suggests that VR-supported foreign language instruction enriches students' learning experiences; however, if not carefully designed, such environments may lead to cognitive overload. The findings underscore the importance of aligning pedagogical goals with technological design to ensure the effective use of VR technologies in educational contexts. Furthermore, instructional designers play a critical role in structuring tasks by taking students' cognitive capacities into account to promote meaningful and sustainable learning outcomes.

Keywords: Cognitive Load, Virtual Reality, Technology-Enhanced Foreign Language Education

Introduction

The learning process is a complex structure that requires individuals to effectively utilize their cognitive processes. Within this process, the amount of information encountered and the way in which individuals process this information directly influence the efficiency of learning. One of the most fundamental aspects that must be considered in the learning process is the limited capacity of the working memory. Sweller (2021) made significant contributions to this field with his Cognitive Load Theory, asserting that individuals have a limited working memory capacity and that this limitation must be taken into account in the design of instructional environments. According to the theory, effective learning environments should be designed in a way that prevents overloading the working memory and supports the transfer of information into long-term memory (Sweller, 2020). In this context, balancing cognitive load is critically important for enhancing the quality of learning, making the learning process more sustainable, and maintaining student motivation.

In recent years, virtual reality (VR) technology has become increasingly prevalent in educational settings, offering new possibilities for learning processes. The immersive nature of VR, supported by high-resolution content and multi-sensory stimuli, enhances students' attention and encourages their active engagement in learning (Freina & Canessa, 2015; Tepe, 2019). However, the effects of this technology on learning—particularly in the context of cognitive load—remain a topic of debate in the literature. Some studies suggest that the rich and intensive structure of VR environments may lead to high cognitive load, potentially hindering learning (Makransky et al., 2019; Parong & Mayer, 2018). Indeed, increased cognitive load in VR can impede long-term memory retention and context transfer; thus, in the context of language learning, it is essential to carefully manage cognitive load by balancing content and interaction (Song et al., 2023).

On the other hand, there are also studies arguing that the engaging and motivating nature of VR results in lower levels of cognitive load (Tai & Chen, 2021; Zak & Oppl, 2022). Furthermore, the multifaceted and immersive experiences provided by VR may increase extraneous cognitive load, especially in academic contexts. Although such load does not directly enhance the learning process, it may deplete the mental resources necessary for tasks such as linguistic comprehension and information integration, thereby adversely affecting learning (Song et al., 2023). These divergent research findings highlight the need for more in-depth investigations into how VR should be structured within learning environments to optimize its effectiveness.

The design of instructional environments is one of the most critical variables influencing cognitive load. Particularly in environments enriched with audiovisual stimuli such as virtual reality (VR), factors such as content density, task complexity, and the level of interaction can affect individuals' cognitive resources in various ways (Sweller, 2021). Therefore, in VR-supported educational applications, cognitive load should be evaluated in relation to learners' individual characteristics, familiarity with technology, and learning styles. Educational environments that are designed without considering human cognitive architecture may fail to achieve the intended learning outcomes (Sweller, 2020). In this context, effective learning is determined not only by the quality of information presentation but also by the extent to which learning environments are tailored to individual learners' needs. This is particularly important in cognitively demanding areas such as foreign language education, where understanding the cognitive effects of VR technology on learners is essential (Makransky et al., 2019).

The primary aim of this study is to examine the impact of virtual reality-supported, task-based foreign language instruction on graduate students' perceptions of cognitive load. In the existing literature, research investigating the interaction between VR technology and cognitive load remains limited, and there is a particular need for more experimental studies within the context of language education. Accordingly, this study seeks to contribute to the literature by exploring how cognitive load processes manifest in VR-based foreign language learning environments from the learners' perspective.

Methodology

In this study, a mixed methods research design was employed to investigate graduate students' perceptions of cognitive load during foreign language activities presented in a virtual reality (VR) environment. Mixed methods research enables the integration of both qualitative and quantitative approaches, allowing for a more comprehensive and in-depth analysis of the research problem (McMillan & Schumacher, 2010). Specifically, the triangulation (convergent) design within the mixed methods framework was adopted to combine quantitative and qualitative data. The aim of the triangulation design is to integrate data collected through different methods—quantitative and qualitative—to examine the research problem from multiple perspectives (Creswell, 2017).

Participants

To determine the study participants, a combination of convenience and purposive sampling methods was employed. A total of 58 graduate students enrolled in the Institute of Educational Sciences were initially recruited. However, during the process, 13 students voluntarily withdrew from the study due to personal reasons, and 3 students with advanced English proficiency levels were excluded. Consequently, the implementation phase was completed with 42 participants.

Data Collection Instruments

Cognitive Load Scale

In order to measure the extent of cognitive load experienced by students during foreign language activities in the VR environment—such as performing language tasks, participating in dialogues, and responding to questions—the Cognitive Load Scale developed by Paas and Van Merriënboer (1993) was employed. The scale is a single-item rating scale ranging from 1 to 9. Reliability analyses conducted by Paas and Van Merriënboer (1993) reported a Cronbach's alpha coefficient of .82. The Turkish adaptation of the scale was carried out by Kılıç and Karadeniz (2004), who found an internal consistency coefficient of .90.

Since the participants of the study were graduate students enrolled in the Institute of Educational Sciences, it was assumed that they already had a conceptual understanding of cognitive load. Nevertheless, prior to the administration of the scale, a brief explanation was provided to remind participants of the meaning of cognitive load. They were then instructed to complete the scale accordingly based on their perceived mental effort during the VR-supported language activities.

Although the term cognitive load is used throughout the study in reference to the measurement instrument, it should be noted that, as a limitation of the research, the measurement process relied on students' self-assessments. Therefore, the variable measured in this study is more accurately described as perceived cognitive load.

Participant Diaries

In addition to the Cognitive Load Scale, participants were also asked to share their reflections after each virtual reality session in order to assess their perceptions of cognitive load. Immediately following each session, students were provided with a blank sheet of paper on which they could freely express their thoughts. This allowed them to comment on the content they encountered that week, their speaking experiences, and aspects of the environment that either disturbed or satisfied them. Sufficient time and a comfortable setting were provided to enable participants to write down their reflections without constraints.

Semi-Structured Interview Form

To gather insights into the perceptions of graduate students regarding the VR-based foreign language learning environment, a semi-structured interview form was developed by the researcher. The initial draft of the form was prepared based on the scope of the study and the research questions. Although the form included a set of predetermined questions, open-ended and opinion-based questions were also incorporated to allow participants to express their views more freely.

The draft form was developed by reviewing interview questions from similar studies in the literature and was then submitted for review to experts in instructional technologies and foreign language education. Based on the feedback received, necessary revisions were made, and the final version of the form was used during interviews conducted with students after the implementation phase.

Data Analysis

As part of the study, participants were asked to complete a reflective diary after each VR-based learning session. In addition to these unstructured diaries, a focus group interview was conducted following the completion of the implementation process. A semi-structured interview form, developed by the researcher, was used during the focus group session. The qualitative data analysis process included the following steps:

- Each student's participant diary was examined individually.
- All verbal responses from the focus group interview were transcribed verbatim.
- The data obtained from both the participant diaries and focus group interviews were analyzed together to identify students' perceptions of cognitive load.
- The extracted views were segmented into codes representing recurring themes or concepts.
- The resulting codes were reviewed and validated through expert review and peer debriefing to ensure trustworthiness and analytical rigor.

Results

In order to determine students' perceived cognitive load within the scope of the study, the Cognitive Load Scale was administered. The scale, which is a single-item rating tool scored on a scale from 1 to 9, was used to measure the extent of mental effort perceived by the participants. The mean score ($\bar{X}$) obtained from students' self-ratings on the scale was 6.74. This result indicates that the participants' perceived cognitive load was at a moderate level during the implementation process.

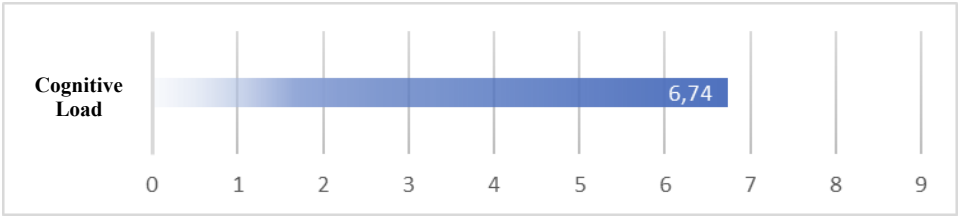

Figure 1. Mean Score of Students' Perceived Cognitive Load Based on the Scale

Following the administration of the cognitive load scale, participant diaries and data from the semi-structured interview form were analyzed to obtain more in-depth insights into students' perceptions of cognitive load. Based on the results of these analyses, it was found that students occasionally reported an increased cognitive load in relation to the designed environment—both from a technical perspective and in terms of their ability to comprehend content and produce accurate pronunciation in the foreign language. In light of the analyzed data, the following codes and sample student statements are presented below to illustrate the emerging themes.

Contribution of Mental Effort to Learning

Students reported exerting active mental effort in order to comprehend the content and identify correct responses, and they emphasized that this effort contributed positively to their learning. Furthermore, they highlighted that such cognitive effort had a particularly beneficial impact on pronunciation acquisition and the development of vocabulary knowledge.

"I exerted significant mental effort. I pushed myself to find the correct answer and made a conscious effort in that direction. This mental effort had a positive impact on my learning." (S13)

"Some of the dialogues had subtitles, while others did not. I mentally pushed myself to understand the parts without subtitles. Rather than focusing on learning at that moment, I noticed that in the next video with subtitles, I relied less on the subtitles. This was a positive outcome for me. Making a mental effort had a positive impact on me." (S42)

"There were words that I struggled with and learned how to pronounce. I definitely believe that this effort had a positive impact on my learning." (S15)

Motivational Effects

Some participants indicated that mental effort not only enhanced learning but also increased intrinsic motivation. They specifically emphasized the sense of satisfaction and encouragement that came with finding the correct answer, stating that successfully arriving at the correct response had a motivating effect on their learning experience.

"I made a lot of effort to find the right word. I really struggled with a few of the questions and had to seriously think about which word should come next. When I was able to find the correct answers, it motivated me." (S33)

"Some of the dialogues had subtitles, while others did not. I mentally pushed myself to understand the parts without subtitles. As a result, I noticed that I relied less on the subtitles in the next video. This was a positive experience for me. Making a mental effort had a positive impact on me, and it became easier for me to understand the next video." (S20)

Cognitive Overload and Negative Experiences

It was noted that in some cases, mental effort led to cognitive overload, resulting in loss of motivation, fatigue, and reluctance to engage in learning. Participants reported that excessive mental demands in the virtual reality environment negatively affected their learning process, with some expressing a desire to complete the activity quickly and exit the environment due to cognitive fatigue.

"I felt overwhelmed due to excessive cognitive load and just wanted it to be over as soon as possible. The mental process was exhausting for me. I got tired because I couldn't understand, and since I couldn't connect the pieces, my learning was negatively affected. I simply wanted to get through it and move on." (S19)

Strategy Use and Cognitive Actions

Some participants stated that they developed specific strategies—such as silent rehearsal, thinking aloud, and written or oral analysis—to enhance comprehension. These actions reflect active cognitive engagement during the learning process.

"I made a mental effort, and it had a positive impact on my learning because it helped me stay focused. In fact, I was silently pronouncing the words to myself to make sure they were correct." (S10)

"Some of the dialogues had subtitles, while others did not. I mentally pushed myself to understand the parts without subtitles. Rather than focusing on learning at that moment, I later realized that I relied less on the subtitles in the following video. This was a positive outcome for me. Making a mental effort had a positive effect on me." (S42)

"I pushed myself to understand the environment, to keep up with the dialogues, and to focus on pronunciation. There were words that I struggled with and eventually learned how to pronounce. I definitely believe that this effort had a positive impact on my learning." (S37)

Conclusions

In order to determine the effect of virtual reality (VR)-based language instruction on students' perceptions of cognitive load, the Cognitive Load Scale was first administered, followed by focus group interviews. The results of the scale revealed that the participants generally experienced a moderate-to-high level of cognitive load. In the focus group discussions, students reported that they exerted a manageable level of mental effort while trying to understand the English content and produce accurate pronunciation. They stated that this effort positively contributed to their ability to pronounce words correctly.

A review of the related literature reveals varied findings regarding the impact of VR on students' cognitive load perceptions. For instance, Tai and Chen (2021) found that VR provides students with context-based learning opportunities, which in turn help reduce cognitive load. Context-based learning creates predictability in dialogue flow through contextual cues and environmental movements, which has a significant impact on reducing cognitive load. The same study also noted that VR environments isolate learners from external distractions, allowing them to focus more easily on the content, thereby enhancing comprehension.

Similarly, Xie et al. (2019) reported that activities presented in virtual reality (VR) environments contributed to a reduction in students' cognitive load. On the other hand, studies conducted by DeWitt et al. (2022) and Juliano et al. (2022) demonstrated that foreign language activities in VR environments resulted in high levels of cognitive load among participants. Juliano et al. further noted that cognitive load was higher in VR environments compared to traditional computer screen-based settings.

In a study by Huang et al. (2020) utilizing a VR-supported Chinese writing tool, it was found that students' writing performance and self-efficacy improved, while their cognitive load decreased. Similarly, Zak and Oppl (2022) stated that scenario-based tasks in VR environments induced low cognitive load, and Liu et al. (2022) reported that the experimental group receiving instruction through VR perceived significantly lower levels of cognitive load compared to the control group. In another study by Song et al. (2023), cognitive load levels were measured below 50% in VR-based instructional content, whereas in traditional learning scenarios, the level reached up to 70%.

These findings highlight the divergent results in the literature concerning the impact of VR on cognitive load. This variation is likely influenced by multiple factors such as the content of the activity, students' foreign language proficiency levels, the instructional design of the VR environment, and the degree of student engagement during the implementation. In the current study, students' perceived cognitive load was found to be at a moderate-to-high level. According to Huang (2020), a moderate level of cognitive load can have positive effects on learning and active participation. Therefore, it is important to maintain a balanced level of cognitive load by considering its subcomponents, which can be beneficial for achieving optimal learning outcomes.

In the literature, it is observed that cognitive load is frequently measured through self-report instruments, relying on individuals' self-assessments. However, considering recent advancements in health sciences and technology, measuring cognitive load using standardized tools and physiological indicators may enhance the reliability of assessment processes. Such an approach would allow for the comparison and calibration between self-reported cognitive load and objective physiological measurements, thus contributing meaningfully to the field.

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Eğitimde Yapay Zekâ Teknolojileri ve Düşünme Becerileri: Sistematik İnceleme Çalışması

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Özet

Bu çalışma eğitim alanında kullanılan yapay zekâ teknolojilerinin düşünme becerileri üzerindeki etkilerini inceleyen bilimsel çalışmaların genel eğilimlerini ve bulgularını ortaya koymayı amaçlamaktadır. Çalışmada sistematik bir inceleme yöntemi kullanılmıştır. Sistematik incelemede PRISMA yönergeleri kullanılmıştır. Çalışma kapsamında ilgili çalışmalara erişmek için Web of Science ve Scopus veritabanları kullanılmıştır. Çalışmada SSCI indeksinde indekslenen dergi makaleleri incelenmiş ve çalışma kapsamında toplam 277 dergi makalesi belirlenmiştir. Belirlenen bu makalelerden çalışma kapsamına ve belirlenen kriterlere uygun olan 32 dergi makalesi analiz edilmiştir. Analizler sonucunda elde edilen bulgulara göre yayımlanan çalışmaların 2024 (n=21) yılında önemli bir artış göstererek en yüksek seviye ulaştığı görülmüştür. Çalışmaların önemli bir kısmında eleştirel düşünme becerileri (n=20) konu edilmiştir. Eleştirel düşünme becerileri (f=14), chatgpt (f=13) ve yapay zekâ (f=12) anahtar kelimeleri çalışmalarda sıklıkla kullanılmıştır. Yarı deneysel (n=10) ve karma araştırma (n=6) yöntemlerinin araştıma yöntemi olarak daha fazla çalışmada kullanıldığı görülmüştür. Birçok çalışmada lisans (n=13) ve lisansüstü (n=7) örneklem gruplarının ve 0-100 (n=15) ve 101-200 (n=7) örneklem büyüklüklerinin tercih edildiği belirlenmiştir. Çalışmalarda eleştirel düşünmeyi ölçen ölçme araçlarının sıklıkla kullanıldığı görülmüştür. Tanımlayıcı analiz yöntemleri (f=13), bağımlı (f=7) ve bağımsız (f=7) örneklem t-testlerinin çalışmalarda en çok tercih edilen veri analiz yöntemleri olduğu tespit edilmiştir. Çalışmalarda en çok kullanılan veri kaynaklarının ölçekler (n=17) ve anketler (n=9) olduğu görülmüştür. Eleştirel düşünme becerilerine ilişkin verilerin (f=15) çalışmalarda en fazla kullanılan veri türleri olduğu belirlenmiştir. Çalışmalarda eleştirel düşünme beceri düzeyleri (f=14) en çok test edilen değişken olmuştur. Chatgpt'nin eleştirel düşünme becerileri üzerindeki etkileri (f=9), çalışmalarda en fazla tercih edilen konular arasında yer almıştır. Çalışma bulgularına göre eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirdiğini (f=24, %75) gösteren çalışma bulgularının çoğunlukta olduğu görülmüştür. Buna ek olarak çalışma bulguları, eğitimde yapay zekâ teknolojileri kullanımının eleştirel ve farklı üst düzey düşünme becerilerini geliştirmede öğrencilere önemli avantajlar sağladığını göstermiştir.

Anahtar Kelimeler: Yapay zeka, düşünme becerileri, sistematik inceleme, eğitim

Artificial Intelligence Technologies in Education and Thinking Skills : A Systematic Review Study

Abstract

This study aims to reveal the general trends and findings of scientific studies that examine the effects of artificial intelligence technologies used in the field of education on thinking skills. A systematic review method was used in the study. PRISMA guidelines were used in the systematic review. Within the scope of the study, the Web of Science and Scopus databases were used to access relevant studies. In the study, journal articles indexed in the SSCI index were examined, and a total of 277 journal articles were identified within the scope of the study. Among these identified articles, 32 journal articles that fit the scope of the study and the determined criteria were analyzed. According to the findings obtained as a result of the analyses, it was observed that the number of published studies showed a significant increase in 2024 (n=21), reaching the highest level. In a significant portion of the studies, critical thinking skills (n=20) were addressed. The keywords critical thinking skills (f=14), ChatGPT (f=13), and artificial intelligence (f=12) were frequently used in the studies. Quasi-experimental (n=10) and mixed-method (n=6) research designs were found to be used more frequently as research methods. It was determined that many studies preferred undergraduate (n=13) and graduate (n=7) sample groups, as well as sample sizes of 0–100 (n=15) and 101–200 (n=7). It was observed that measurement tools assessing critical thinking were frequently used in the studies. Descriptive analysis methods (f=13), dependent (f=7), and independent (f=7) sample t-tests were identified as the most commonly preferred data analysis methods. It was found that the most commonly used data sources in the studies were scales (n=17) and questionnaires (n=9). Data related to critical thinking skills (f=15) were determined to be the most frequently used type of data in the studies. The level of critical thinking skills (f=14)

was the most frequently tested variable in the studies. The effects of ChatGPT on critical thinking skills (f=9) were among the most frequently studied topics. According to the findings, it was observed that the majority of studies indicated that artificial intelligence technologies used in education improved thinking skills (f=24, 75%). In addition, the findings showed that the use of artificial intelligence technologies in education provided students with significant advantages in developing critical and other higher-order thinking skills.

Keywords: Artificial intelligence, thinking skills, systematic review, education

Giriş

Günümüz eğitim sistemleri, öğrencilere bilgi toplumuna aktif katılımı destekleyen farklı beceri ve yetkinlikleri kazandırmaya ilişkin hedefleri ön planda tutmaktadır. Öğrencilerin düşünme becerilerini geliştirmeye yönelik hedefler bu bağlamda oldukça önemli görülmektedir. Öyleki günlük yaşamda karşılaşılan zorluklar ile baş edebilmek için gerekli olan bilişsel yeteneği zenginleştirmek (Conklin, 2011; Prayitno & Titikusumawati, 2018).) için düşünme becerilerinin geliştirilmesi gerekli görülür. Düşünme becerilerinin eğitimdeki önemi göz ardı edilemez, çünkü eğitim psikolojisi bağlamında değerlendirildiğinde düşünme becerilerinin, eleştirel düşünme, problem çözme ve karar vermenin de içinde yer aldığı geniş bir bilişsel süreci kapsadığı görülmektedir (Kartal, 2024). Bu nedenle düşünme becerileri ile ilişkili bilişsel süreçler, öğrencilerin eleştirel analiz, problem çözme ve inovasyon becerileri üzerinde hayati bir rol oynamaktadır (Asha & Venkatesha 2023). Nitekim düşünme becerileri, analiz, problem çözme, karşılaştırma, değerlendirme, karar verme ve öz-düzenlemeli öğrenme gibi çok yönlü ve çeşitli kavramları kapsar niteliklerdedir (Schraw & Robinson, 2011). Bu yüzden öğrenciler düşünme becerilerini geliştirerek farklı alanlardaki çok yönlü değişimlere ustalıkla uyum sağlayabilir. Bu durum onların toplumun sorumlu bireyleri olarak anlamlı bir şekilde, bilinçli kararlar alarak farklı alanlara katkılarda bulunmalarını sağlar (Kurniawati, 2021; Miterianifa vd., 2021; Saavedra & Opfer, 2012). Ancak bu bağlamda eğitim sistemlerinin öğrencilerin düşünme becerilerini istenilen düzeyde geliştirmede farklı zorluklar ile karşılaştığı görülmektedir. Bu zorlukları aşmak için eğitim sistemleri içerisinde oldukça önemli bir yeri olan eğitim öğretim ortamlarında farklı eğitim teknolojilerinden yararlanıldığı görülmektedir. Öyleki literatürde, farklı özelliklere sahip öğrencilerin düşünme becerilerinin geliştirilmesi ve desteklenmesinde eğitim teknolojilerinin önemini ortaya koyan çalışmaların bulgu ve sonuçları giderek artmaktadır. Yapay zekâ teknolojileri, son zamanlarda bu bağlamda yapılan çalışmalarda etkileri araştırılan teknolojiler arasında yer almıştır. Özellikle eğitim alanında kullanılan yapay zekâ teknolojileri, diğer eğitim teknolojileri arasında kendisine önemli bir yer edinmeye başlamıştır.

Yapay zekâ teknolojilerinin eğitim alanında kullanılması, neden-sonuç ilişkilerini analiz edecek şekilde model tabanlı akıl yürütmeyi geliştirmeyi, eleştirel düşünmeyi, problem çözmeyi ve farklı düşünme becerilerini kullanarak çıkarımlarda bulunmayı içeren (Rus vd., 2013) süreçleri desteklemektedir. Literatürde yer alan farklı çalışma bulgu ve sonuçlarının, eğitimde kullanılan yapay zekâ teknolojilerinin öğrenme ve öğretim süreçlerinde önemli bir rol oynadığını ve bireysel deneyimler üzerinde etkilerinin olduğunu göstermesi (Ilgun Dibek vd., 2025) buna işaret etmektedir. Bunun yanında çalışmaların bu teknolojilerin merak, azim, sebat ve dikkat gibi yaratıcılıkla ilgili becerilerin geliştirilmesinde destekleyici bir role sahip olduğunu ileri sürmeleri de (Belpaeme vd., 2018; Gordon vd., 2015) bu bağlamda değerlendirilebilir.Yapay zekâ teknolojilerinin eğitimde kullanımı, öğrencilere etkileşimli öğrenme deneyimleri sağlar, öğrencileri günlük yaşamda karşılaştıkları problemlerin çözümleri için elde ettikleri bilgileri kullanmaya teşvik ederken analiz, sentez ve değerlendirme gibi becerilerinin gelişimini destekler (Almeida & Simoes, 2019). Bu bağlamda öğrencilerin farklı düşünme becerileri üzerinde direk veya dolaylı olarak olumlu yönde etkilerinin olduğu söylenebilir. Ancak literatürdeki bazı araştırma bulgularında yapay zekâ ile üretilen içerik ve ürünlere aşırı güvenmenin öğrencilerdeki düşünme becerilerini olumsuz etkileyebileceğinin savunulduğu, bu teknolojilerin kullanımı ile ilgili olumsuz açıklamaların olduğu görülmektedir (Kooli, 2023).

Genel olarak literatürde yapay zekâ teknolojilerinin düşünme becerileri üzerindeki etkilerini farklı yönlerden inceleyen ve ortaya koyan kapsamlı araştırmalar yer almasına rağmen bu çalışmaların bulgu ve sonuçları arasından belirgin bir tutarlılık görülmemektedir. Öyleki aynı düşünme becerisi üzerindeki etkileri inceleyen çalışmalara ilişkin bazı bulgular, yapay zekâ teknolojileri kullanımının bu beceri üzerinde anlamlı ve olumlu etkilerinin olduğunu gösterirken, farklı çalışma bulguları bu teknolojileri kullanmanın aynı düşünme becerisi üzerinde anlamlı bir etkisinin olmadığını veya olumsuz bir etkisinin olduğunu göstermiştir (Ilgun Dibek vd., 2025). Bu durum literatürde bu bağlamda yapılan çalışmalardan elde edilen bulgu ve sonuçların sistematik olarak farklı açılardan incelenerek değerlendirilmesini gerekli kılmıştır. Çalışmada bu noktadan hareketle literatürde eğitimde alanında kullanılan yapay zekâ teknolojilerinin düşünme becerilerine etkilerini inceleyen çalışmaların metodolojik özelliklerini, bu teknolojilerin düşünme becerilerini nasıl etkilediğini ve düşünme becerilerini geliştirmedeki sağladığı avantaj ve sınırlılıklarının neler olduğunu ayrıntılı bir şekilde ortaya koymak amacıyla gerçekleştirilmiştir. Bu amaç kapsamında aşağıdaki araştırma sorularına cevaplar aranmıştır.

1. Eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerine etkilerini inceleyen çalışmaların metodolojik özellikleri nelerdir?
    a. Çalışmaların yıllara göre dağılımları nasıldır?
    b. Çalışmalara konu olan düşünme becerileri hangileridir?
    c. Çalışmaların anahtar kelimeleri nelerdir?
    d. Çalışmalarda kullanılan araştırma yöntemleri nelerdir?
    e. Çalışmalardaki örneklem grupları ve büyüklüklerinin dağılımı nasıldır?
    f. Çalışmalarda kullanılan ölçme araçları hangileridir?
    g. Çalışmalarda kullanılan veri analiz yöntemleri hangileridir?
    h. Çalışmalarda kullanılan veri kaynakları nelerdir?
    i. Çalışmalarda kullanılan veri türleri hangileridir?
    j. Çalışmalarda test edilen değişkenler hangileridir?
    k. Çalışmalardaki konuların dağılımları nasıldır?
2. Eğitimde kullanılan yapay zekâ teknolojileri düşünme becerilerini nasıl etkiler?
3. Eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirmedeki avantaj ve sınırlılıkları nelerdir?

Yöntem

Bu çalışma eğitim alanında kullanılan yapay zekâ teknolojilerinin düşünme becerileri üzerindeki etkilerini inceleyen bilimsel çalışmaların mevcut durumunu belirlemeyi amaçlamaktadır. Çalışmada sistematik bir inceleme yöntemi kullanılmıştır. Sistematik inceleme yöntemi, farklı niteliklerdeki birincil araştırma çalışmalarını tanımlamak, eleştirmek ve özetlemek için odaklanılmış olan bir soruya bağlı kalarak gerçekleştirilen bilimsel bir soruşturmadır (Baker & Weeks 2014). Çalışmada etkili bir sistematik inceleme için PRISMA yönergeleri kullanılmıştır. Bu yönergeler, araştırma başlamadan dikkatli bir planlama ve inceleme yapılması, inceleme sürecinin tutarlı bir şekilde yürütülmesi, araştırma bütünlüğü ve incelemelerin şeffaflığının desteklenmesinde kullanılabilir (Moher vd., 2015).

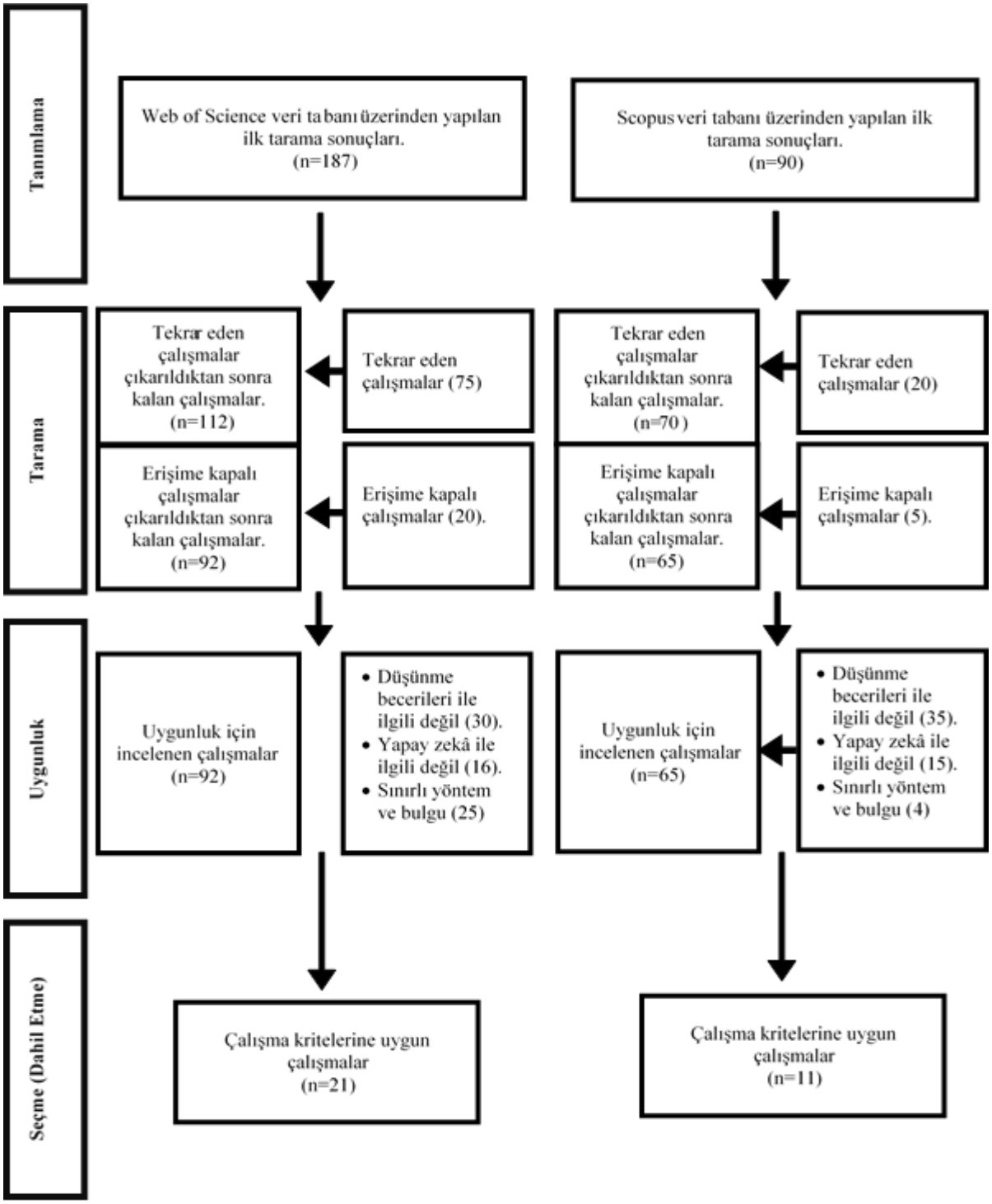
Veri Toplama

Çalışmanın amacına uygun şekilde sistematik bir inceleme yaparak ilgili çalışmalara erişmek için Web of Science ve Scopus veritabanı kullanılmıştır. Eğitim alanında kullanılan yapay zekâ teknolojilerinin düşünme becerileri üzerindeki etkilerini inceleyen bilimsel çalışmalar SSCI indeksi dergi makaleleri arasında farklı sorgular ile arandı. Arama işlemleri 14.02.2025 tarihinde tamamlanmıştır. Tarama sürecinde "Artifical Intelligence AND Thinking Skills", "Artifical Intelligence AND Thinking Skills AND Machine Learnig", "Artifical Intelligence AND Thinking Skills AND Deep Learning", "Artifical Intelligence AND Thinking Skills AND Natural Language Processsing", "Artifical Intelligence AND Thinking Skills AND Robotics", "Artifical Intelligence AND Thinking Skills AND Fuzzy Logic", "Artifical Intelligence AND Thinking Skills AND Computer Vision", "Artifical Intelligence AND Thinking Skills AND Expert Systems", "Artifical Intelligence AND Thinking Skills AND Chatgpt", "Artifical Intelligence AND Thinking Skills AND Chatbot", "Chatgpt AND Thinking Skills", "Chatbot AND Thinking Skills" sorguları kullanılmıştır.

Veri Analizi

Sistematik inceleme sürecinde yapılan sorgular ile erişilen çalışmalar araştırmacı tarafından analiz edilmiştir. Çalışmanın güvenirliğini artırmak için farklı bir araştırmacının analizleri kontrol etmesi sağlanmıştır. Çalışmaların veri analizleri için Microsoft Excel programı kullanılmıştır. Excel programında çalışmanın araştırma sorularını cevaplayan, farklı bölümlerden oluşan bir form oluşturulmuştur. Form çalışmanın başlığı, anahtar kelimeleri, yayın yılı, konusu, araştırma yöntemi, örneklem grubu, örneklem büyüklüğü, ölçme araçları, veri analiz yöntemleri, veri kaynakları, veri türleri, çalışmada test edilen değişkenler, yapay zekâ teknolojilerinin incelenen düşünme becerilerini nasıl etkilediğini ve bu teknolojilerin düşünme becerilerini geliştirmede sağladığı avantaj ve sınırlılıkları gösteren bölümlerden oluşmuştur. Sistematik inceleme sürecinde bu formdan yararlanılmıştır. Çalışmaya dâhil edilen çalışmalar ayrıntılı bir şekilde incelenmiş ve formdaki ilgili bölümler dikkatlice doldurulmuştur. Formdan elde edilen veriler grafik ve tablolara dönüştürülmüştür.

Belirlenen anahtar sözcükleri kullanılarak Web of Science üzerinde yapılan arama sorguları sonucunda toplam 187 çalışmaya ulaşılmıştır. Bu çalışmalardan 75 tanesinin arama da tekrar ettiği, 20 tanesinin ise erişime kapalı olduğu belirlenmiştir. Bu çalışmalar hariç tutulduğunda kalan çalışmalar uygunluk için incelendiğinde, 30 çalışmanın düşünme becerileri, 16 çalışmanın yapay zekâ teknolojileri ile ilgili olmadığı ve 25 çalışmanın sınırlı yöntemler ile gerçekleştirildiği ve bulgularının sınırlı olduğu belirlenmiştir. Scopus üzerinde yapılan sorgulama sonucunda toplam 90 çalışmaya ulaşılmıştır. Bu çalışmalardan 20 tanesinin arama da tekrar ettiği, 5 tanesinin ise erişime kapalı olduğu belirlenmiştir. Bu çalışmalar hariç tutulduğunda kalan çalışmalar uygunluk için incelendiğinde, 35 çalışmanın düşünme becerileri, 15 çalışmanın yapay zekâ teknolojileri ile ilgili olmadığı ve 4 çalışmanın sınırlı yöntemler ile gerçekleştirildiği ve bulgularının sınırlı olduğu belirlenmiştir. Bu durumlar dikkate alındıktan sonra geriye kalan 32 çalışmanın kriterlere uygun olduğu belirlenmiş ve bu çalışmaların analizleri yapılmıştır. Süreç Şekil 1'de ayrıntılı bir şekilde sunulmuştur.

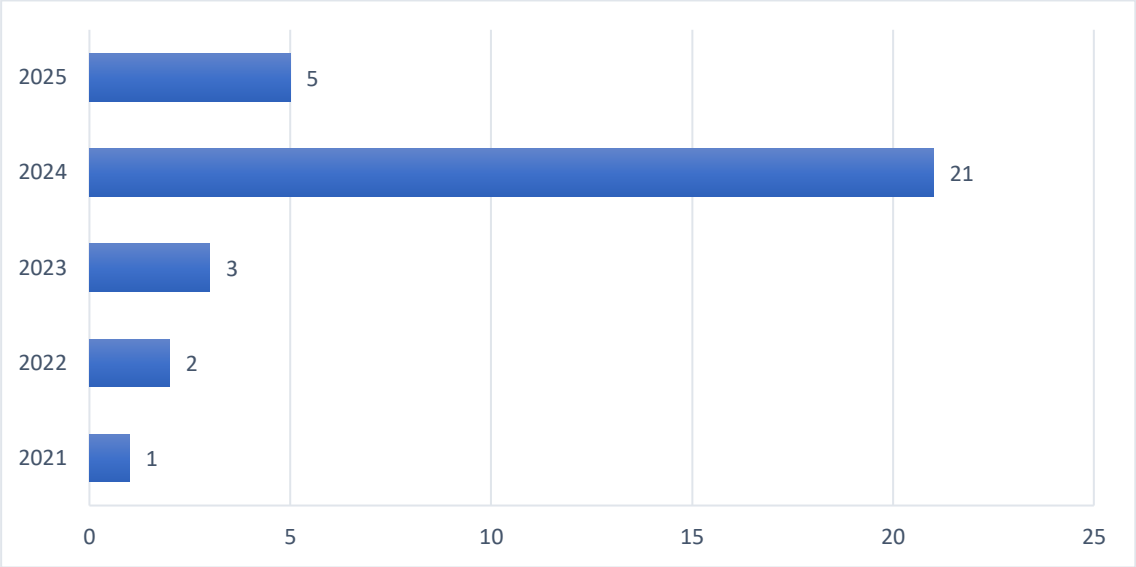


Şekil 1. PRISMA akış diyagramı.

Bulgular

Çalışmaların yıllara göre dağılımları

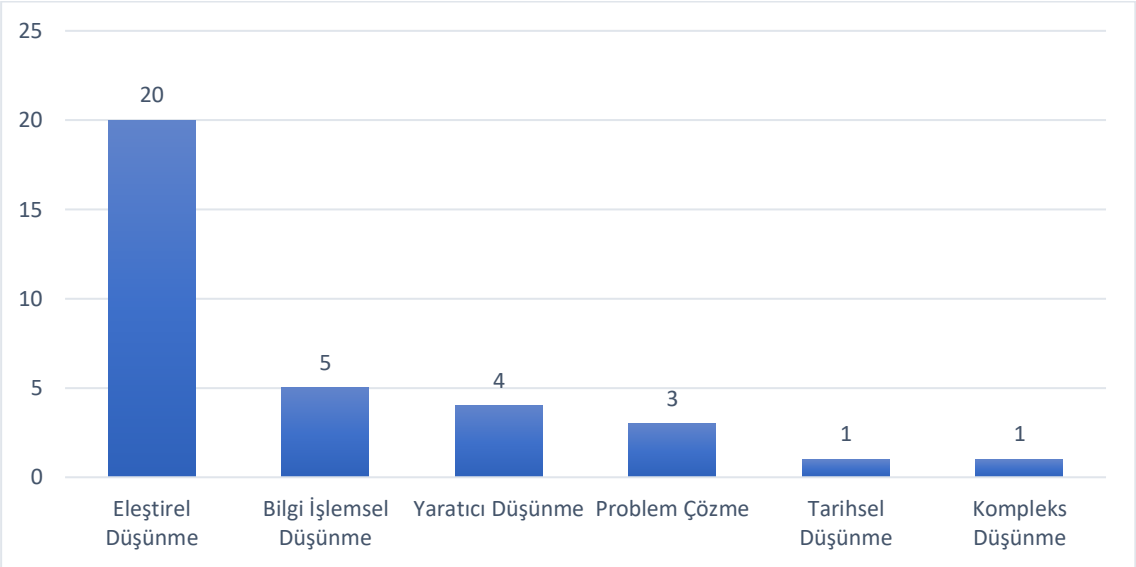
Çalışmaların yıllara göre dağılımlarını gösteren analizlere ilişkin bulgular Şekil 1'de sunulmuştur. Şekil 2'ye göre çalışma kapsamına uygun ilk çalışma 2021 yılında yayımlanmış olup, yayımlanan çalışmaların 2024 (n=21) yılında önemli bir artış göstererek en yüksek seviye ulaştığı belirlenmiştir.



Şekil 2. Çalışmaların yıllara göre dağılımları.

Çalışmalara konu olan düşünme becerileri

Çalışmalara konu edinilen düşünme becerilerinin dağılımları Şekil 3'te yer almaktadır. Şekil 3 incelendiğinde çalışmaların çoğunda eleştirel düşünme becerilerinin (n=20) konu edinildiği belirlenmiştir.



Şekil 3. Çalışmalara konu olan düşünme becerileri

Çalışmaların anahtar kelimeleri

Çalışmalarda kullanılan anahtar kelimeleri gösteren bulgular Tablo 1'de sunulmuştur. Tablo 1'e göre çalışmalarda en sık kullanılan anahtar kelimelerin eleştirel düşünme becerileri (f=14), chatgpt (f=13) ve yapay zekâ (f=12) olduğu görülmektedir.

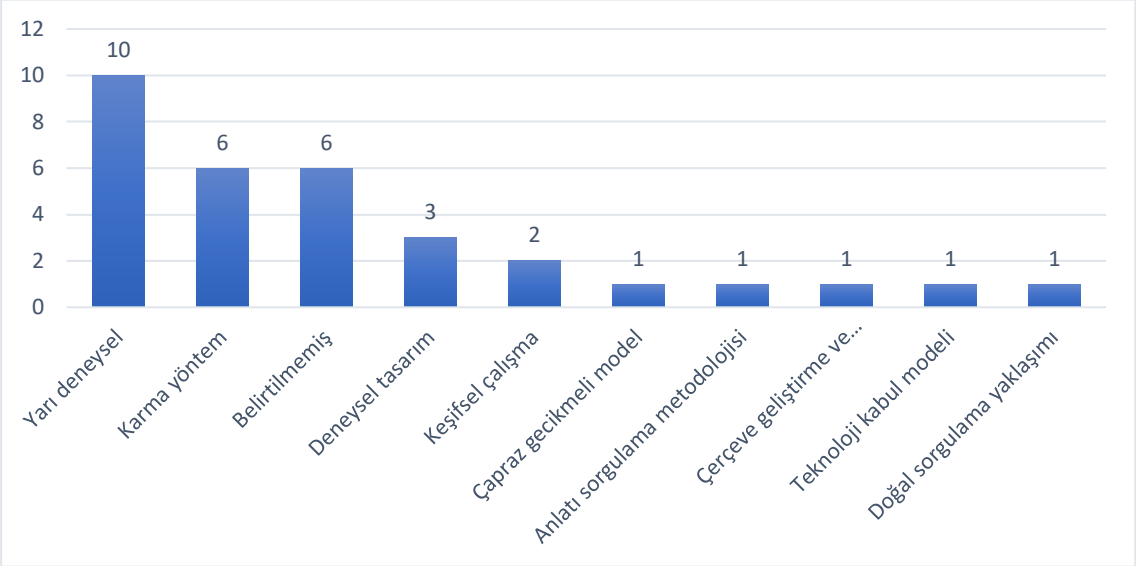
Tablo 1. Çalışmaların anahtar kelimeleri

Keyword	f	Keyword	f
Eleştirel düşünme becerileri	14	Öz yönetimli öğrenme yeterliliği	1
Chatgpt	13	Dil	1
Yapay zekâ	12	Yazma pedagojisi	1
Bilgi işlemsel düşünme	4	Anlatı metni	1
Dil öğrencileri	3	Çerçeve proram	1
Üst düzey düşünme becerileri	3	Artırılmış gerçeklik	1
Yüksek eğitim	3	Tarih öğretimi	1
Eğitim	3	Tartışma sınıfı	1
Üretken yapay zekâ	2	Epistemik ağ analizi	1
Yapay zekâ metin üreticiler	2	Eş zamanlılık	1
Düşünme becerileri	2	Eğitimsel inavasyon	1
Yapay zekâ okur yazarlığı	2	İnternet/Web tabanlı öğrenme	1
Yaratıcı düşünme	2	Karma öğrenme	1
Problem çözme becerileri	2	Bilgi yapılandırma	1
Yapay zekâ ile içerik üretme araçları	2	Birinci sınıf lisans	1
Yapay zekâ ile yazma	1	Disiplinlerarası	1
Yapay zekâ uygulamaları	1	Bilgisayar tabanlı öğrenme	1
Yapay zekâ tools	1	İkili süreç teorisi	1
Yapay zekâ -based chatbots	1	Öğrenci merkezli öğrenme	1
Makine öğrenmesi	1	Öz düzenlemeli öğrenme	1
Kompleks düşünme	1	Öğrenci bakış açıları	1
Tarihsel düşünme	1	Bloom taksonomisi	1
Tasarım odaklı düşünme yapısı	1	Büyük dil modeli	1
Tasarım tabanlı öğrenme aktiviteleri	1	Eğitim teknolojisi	1
Öğretmen eğitimi	1	İngiliz edebiyatı dersleri	1
Öğretmen adayları	1	Öğrenme motivasyonu	1
Lisansüstü yüksek öğretim	1	Öğretim teknoloji	1
İngilizce dil eğitimi	1	Endüstriyel tasarım	1
Coğrafya dersi	1	Öğrenci öz değerlendirmesi	1
Başarı	1	Pedagojik strateji	1
Hikaye anlatımı	1	Somutlaştırılmı biliş teorisi	1
Etik standartlar	1	ChatGPT aracılığı ile üretken yapay zeka	1
Hemşire eğitimi	1	Epistemik ağ analizi	1
Hemşirelik öğrencisi	1	Oyunlaştırma	1
Muhasebe öğrencileri	1	ChatGPT API	1
Z Kuşağı	1	Sürdürüleibilir kalkınma hedefleri	1
Sezgisel düşünme becerileri	1	Yaratıcı süreç	1

Sistematik düşünme becerileri	1	Programlama eğitimi	1
İngilizce söylem becerisi	1	Karma yöntemler	1

Çalışmalarda kullanılan araştırma yöntemleri

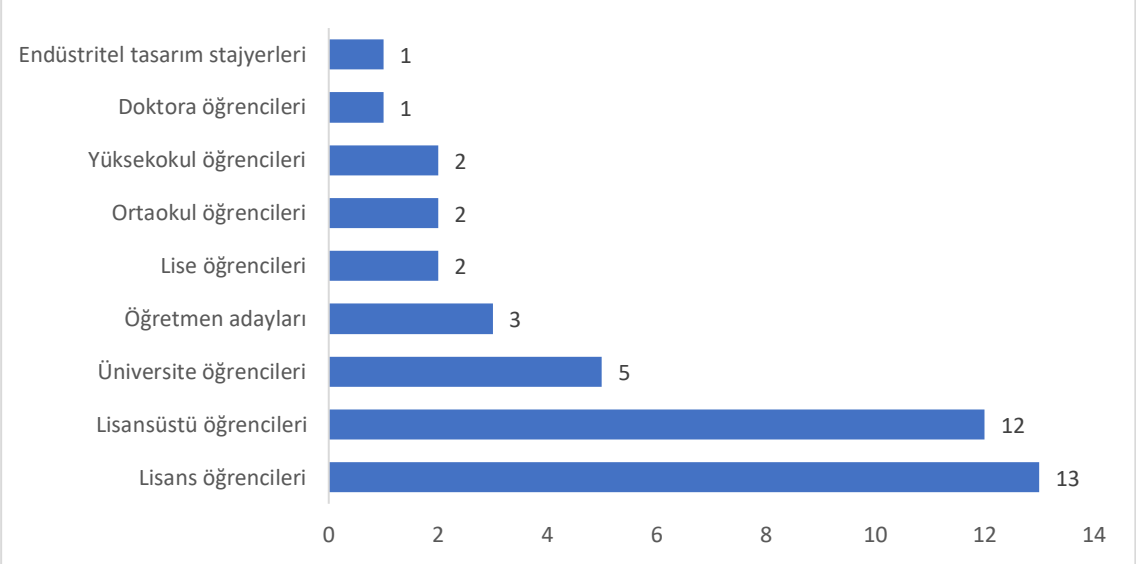
Çalışmalarda kullanılan araştırma yöntemlerine ilişkin bulgular Şekil 4'te yer almaktadır. Şekil 4 incelendiğinde yapılan çalışmalarda yarı deneysel (n=10) ve karma araştırma (n=6) yöntemlerinin ön planda tutulduğu ve araştırma yöntemi belirtilmeyen çalışmalarında olduğu (n=6) görülmetedir.



Şekil 4. Çalışmalarda kullanılan araştırma yöntemleri

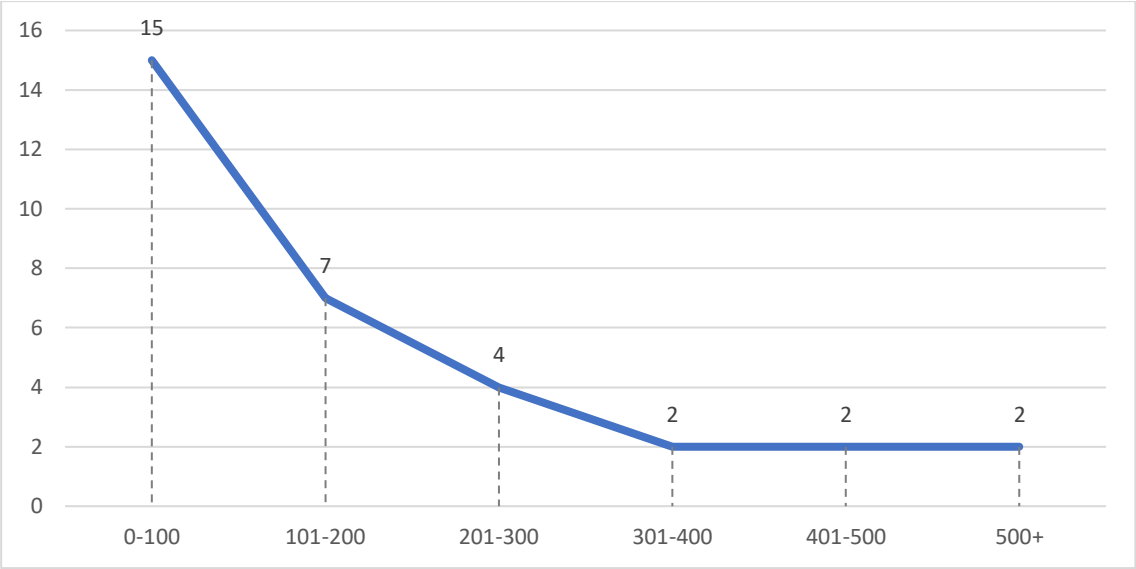
Çalışmalardaki örneklem grupları ve büyüklüklerinin dağılımı

Şekil 5'te çalışmalardaki örneklem gruplarına ilişkin bulgular gösterilmiştir. Şekil 5'göre çalışmaların çoğunda örneklem grubu olarak lisans (n=13) ve lisansüstü (n=7) öğrencilerin tercih edildiği görülmüştür.



Şekil 5. Çalışmalardaki örneklem grupları

Çalışmaların örneklem büyüklüklerini gösteren bulgular Şekil 6'da yer almaktadır. Şekil 6'da görüldüğü gibi çalışmalarda en çok kullanılan örneklem büyüklüklerinin 0-100 (n=15) ve 101-200 (n=7) arasında olduğu belirlenmiştir.



Şekil 6. Çalışmalardaki örneklem büyüklüklerinin dağılımı

Çalışmalarda kullanılan ölçme araçları

Çalışmalarda kullanılan ölçme araçları Tablo 2'te gösterilmiştir. Tablo 2'ye göre 10 çalışmada ölçme aracının belirtilmediği görülmüştür. Ayrıca Tablo 2 incelendiğinde çalışmalarda eleştirel düşünmeyi ölçen ölçme araçlarının sıklıkla kullanıldığı görülmüştür.

Tablo 2. Çalışmalarda kullanılan ölçme araçları

Ölçme Aracı	f
Belirtilmemiş	10
Anket	8
Bilgi işlemsel düşünme ölçeği	4
Yansıtıcı düşünme ölçeği	1
Yansıtıcı değerlendirme görüşmesi	1
Yansıtıcı günlükler	1
California eleştirel düşünme testi	1
Eleştirel düşünme tutum ölçeği	1
Eleştirel düşünme becerisi nesnel soruları	1
Eleştirel düşünme eğilim ölçeği	1
Eleştirel düşünme eğilim envanteri	1
Eleştirel düşünme öz değerlendirme ölçeği	1
Eleştirel akıl yürütme değerlendirmesi	1
Eleştirel düşünme duygusal eğilim anketi	1
Eleştirel düşünme bilişsel becerileri değerlendirme ölçeği	1
Yükseköğretim bilişsel becerileri değerlendirme ölçeği	1
Yazma görevleri	1
Anlatılar	1
Bireysel ve grup görüşmleri	1
Nicel ve nitel unsurlar içeren ölçme aracı	1

Dil testi	1
Gözlem göstergeleri	1
Likert ölçek	1
Dereceli puanlama anahtarı	1
Ecomplex-em	1
Üst düzey düşünme becerileri ölçeği	1
Sesli günlükler	1
Yarı yapılandırılmış görüşmeler	1
Öğrenmeye yönelik motivasyon stratejileri anketi	1
Yapay zekaya yönelik genel tutum ölçeği	1
Alternatif kullanım testi	1
Yapay zeka uygulamaları kullanarak coğrafya öğretimi için öğretmen kılavuzu	1

Çalışmalarda kullanıllan veri analiz yöntemleri

Tablo 3 çalışmalarda kullanılan veri analiz yöntemlerini göstermektedir. Tablo 3 incelendiğinde çalışmalarda en fazla tanımlayıcı analiz yöntemleri (f=13), bağımlı örneklem t-testi (f=7) ve bağımsız örneklem t-testlerinin (f=7) tercih edildiği görülmüştür.

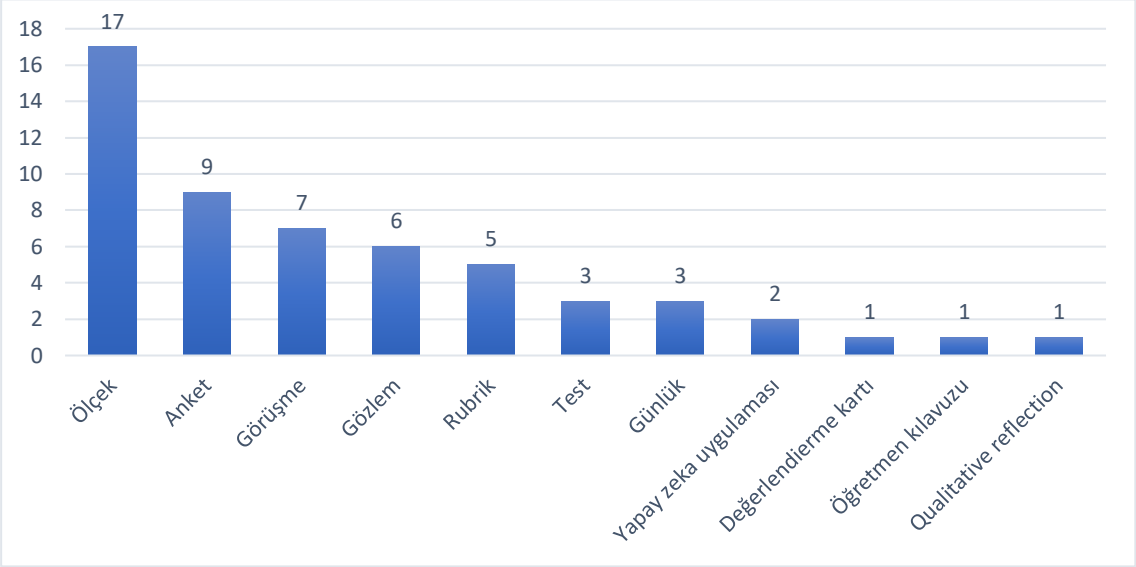
Tablo 3. Çalışmalarda kullanıllan veri analiz yöntemleri

Veri analiz yöntemi	f
Betimsel Analiz	13
Bağımlı örneklem t-testi	7
Bağımsız örneklem t-testi	7
Tematik analiz	5
Kısmi en küçük kareler-Yapısal eşitlik modeli	4
İçerik analizi	4
ANOVA	4
ANCOVA	3
Mann−Whitney testi	3
Ki kare	2
Wilcoxon işaretli sıra testi	2
MANOVA	2
ANCOVA	2
Pearson korelasyon	2
Doğrusal regrasyon analizi	2
Path analizi	2
İki değişkenli korelayon	1
Grafikler	1
Epistemik ağ analizi	1
Cohen Kappa testi	1
Ortalama varyans	1

Heterotrait–monotrait oranı	1
Koralsyon analizi	1
Spearman's sıra korelasyonu	1
Kruskal–Wallis testi	1
Pearson ki-kare testi	1
Lawshe tekniği	1
Kümeleme analizi	1
Faktör analizi	1
Frekans analizi	1
Bilişsel ağ modeli	1

Çalışmalarda kullanılan veri kaynakları

Analizi yapılan çalışmalarda kullanılan veri kaynakları Şekil 7'de yer almaktadır. Şekil 7'ye göre çalışmalarda en çok kullanılan veri kaynaklarının ölçekler (n=17) ve anketler (n=9) olduğu görülmektedir.



Şekil 7. Çalışmalarda kullanılan veri kaynakları

Çalışmalarda kullanılan veri türleri

Çalışmlarda kullanılan veri türlerine ilişkin bulgular Tablo 4'te sunulmuştur. Tablo 4'te çalışmaların çoğunda öğrencilerin eleştirel düşünme becerilerine ilişkin verilerin (f=15) kullanıldığı görülmektedir. Buna ek olarak tablodan öğrencilerin görüşleri (f=4) ve bilgi işlemsel düşünme becerilerine ilişkin verilerininde (f=4) çalışmalarda kullanıldığı anlaşılmaktadır.

Tablo 4. Çalışmalarda kullanılan veri türleri

Veri Türü	f
Eleştirel düşünme becerilerine ilişkin veriler	15
Öğrenci görüşlerine ilişkin veriler	4
Bilgi işlemsel düşünme becerilerine ilişkin veriler	4
Bilgi işlemsel düşünme becerilerine ilişkin görüşleri	3
Üst düzey düşünme becerilerine ilişkin veriler	2
Yaratıcı düşünme becerilerine ilişkin veriler	2

Problem çözme becerilerine ilişkin veriler	2
Yansıtıcı düşünme becerilerin ilişkin veriler	1
Chatgpt ile ilgili bilgi/deneyim düzeylerine ilişkin veriler	1
Yapay zekâ destekli yazma becerileri düzeylerine ilişkin veriler	1
Yapay zekaya yönelik tutumlara ilişkin veriler	1
Eleştirel düşünme becerilerine ilişkin gözlem verileri	1
Karmaşık düşünme becerileri düzeylerine ilişkin veriler	1
Tarihsel düşünme boyutu puanlarına ilişkin veriler	1
Öğrencilerin eleştirel düşünme becerilerini uygulama konusundaki öz güven düzeylerine ilişkin veriler	1
Öğrencilerin eleştirel düşünme becerilerine ilişkin test sonuçları	1
Öğrenci günlüklerinden elde edilen veriler	1
Öğrencilerin eleştirel düşünme becerilerine yönelik algı ve tutumlarına ilişkin veriler	1
Öğrencilerin eleştirel düşünme becerilerine ilişkin görüşleri	1
Öğrencilerin sezgisel düşünme becerilerine ilişkin veriler	1
Öğrencilerin sistematik düşünme becerilerine ilişkin veriler	1
Eleştirel düşünmeyi geliştirmede ChatGPT ve gerçek eğitmenler arasındaki algısal farklılıklara ilişkin veriler	1
Öğrencilerin bilgi işlemsel düşünme beceri düzeylerine ilişkin gözlemler	1

Çalışmalarda test edilen değişkenler

İncelenen çalışmalarda test edilen değişkenlere ilişkin elde edilen bulgular Tablo 5'te gösterilmiştir. Tablo 5'e göre birçok çalışmada öğrencilerin eleştirel düşünme beceri düzeyleri (f=14) test edilen değişken olmuştur.

Tablo 5. Çalışmalarda test edilen değişkenler

Değişken	f
Öğrencilerin eleştirel düşünme beceri düzeyleri	14
Öğrencilerin bilgi işlemsel düşünme beceri düzeyleri	4
Öğrencilerin üst düzey düşünme beceri düzeyleri	3
Öğrencilerin bilgi işlemsel düşünmeye ilişkin görüşleri	3
Öğrencilerin eleştirel düşünmeye ilişkin görüşleri	2
Öğrencilerin problem çözme beceri düzeyleri	2
Öğrencilerin yaratıcı düşünme beceri düzeyleri	2
Öğrencilerin eleştirel düşünmeye ilişkin algıları	2
Öğrencilerin yazma becerileri	1
Öğrenci görüşleri	1
Öğrencilerin karmaşık düşünme beceri düzeyleri	1
Öğrencilerin tarihsel düşünme beceri düzeyleri	1
Öğrencilerin eleştirel düşünme becerilerini uygulama konusunda özgüven düzeyleri	1
Öğrencilerin sezgisel düşünme beceri düzeyleri	1
Öğrencilerin sistematik düşünme beceri düzeyleri	1
Öğrencilerin ChatGPT ile ilgili bilgi/deneyim düzeyleri	1

Öğrencilerin yapay zekâya yönelik tutumları	1
Öğrencilerin yansıtıcı düşünme beceri düzeyleri	1
Öğrencilerin eleştirel düşünme becerilerine ilişkin tutumlar	1

Çalışmalardaki konuların dağılımları

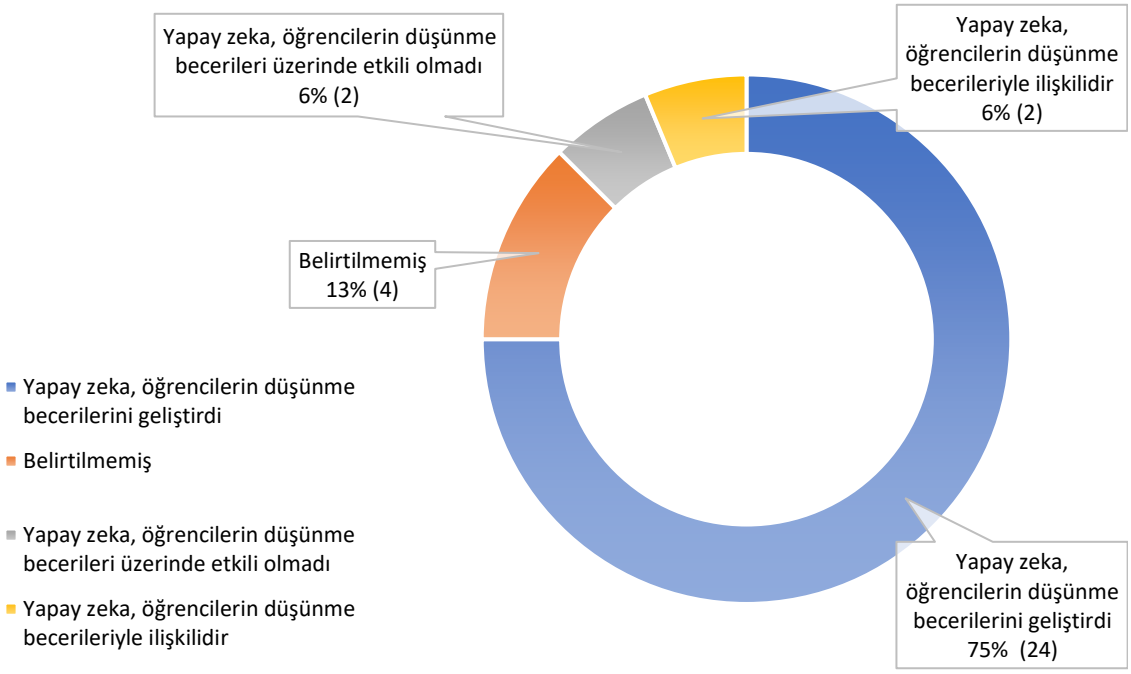
Çalışmalardaki konu dağılımları Tablo 6'da yer almaktadır. Tablo 6 incelendiğinde çalışmalarda eleştirel düşünme becerileri üzerinde chatgptnin etkileri (f=11) en fazla tercih edilen konu olmuştur. Buna ek olarak eleştirel düşünme becerilerini geliştirmek için yapay zekâ destekli bir çerçeve program geliştirme de (f=3) çalışmalarda konu olarak yer almıştır.

Tablo 6. Çalışmalardaki konuların dağılımları

Konu	f
Chatgpt'nin eleştirel düşünme becerileri üzerindeki etkileri	11
Yapay zekâ destekli öğrenmenin öğrencilerin eleştirel düşünme becerileri üzerindeki etkileri	4
Eleştirel düşünme becerilerini geliştirmek için yapay zekâ destekli bir çerçeve program geliştirme	3
Öğrencilerin bilgi işlemsel düşünme becerilerindeki değişim	3
Öğrencilerin üst düzey düşünme becerilerindeki değişim	1
Üretken yapay zekâ kullanılarak yapılan eğitimi alan öğrencilerin hesaplamalı düşünme becerilerindeki değişim	1
ChatGPT kullanılarak yapılan programlama eğitiminin öğrencilerin hesaplamalı düşünme becerileri üzerindeki etkisi	1
Öğrencilerin yaratıcı düşünme becerilerindeki değişim	1
Üretken yapay zekânın öğrencilerin yaratıcı düşünme becerileri üzerindeki etkisi	1
Öğrencilerin yansıtıcı düşünme becerilerindeki değişim	1
Chatgpt'nin öğrencilerin yansıtıcı yazma becerilerini geliştirme potansiyeli	1
Yapay zekâ destekli yazma ve eleştirel düşünme becerileri arasındaki ilişki	1
Öğrencilerin öğretim uygulamalarında Chatgpt kullanımına ilişkin deneyimleri, algıları ve düşünceleri	1
Yapay zekâ metin üreteçlerinin eleştirel düşünme becerilerindeki rolü	1
Yapay zekâ araçlarının bilgi işlemsel düşünme becerileri üzerindeki etkisi	1
Yapay zekâ uygulamalarının karmaşık düşünme becerileri üzerindeki etkisi	1
Yapay zekânın tartışmacı bir tarihsel metin geliştirmedeki potansiyeli	1
Eleştirel düşünme becerilerini geliştirmek için yapay zekâ destekli bir çerçeve program geliştirme	1
Öğrencilerin üst düzey düşünme becerilerindeki değişim	1

Eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerine etkileri

Çalışmalardaki yapay zekâ teknolojilerinin düşünme becerileri üzerindeki etkilerini gösteren bulgular Şekil 8'de sunulmuştur. Şekil 8 incelendiğinde eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirdiğini (%75) gösteren çalışma bulgularının çoğunlukta olduğu görülmektedir.



Şekil 8. Eğitimde kullanılan yapay zekâ teknolojilerini düşünme becerilerine etkileri

Eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirmedeki avantaj ve sınırlılıkları

Eğitimde yapay zekâ teknolojilerinin kullanımının öğrencilerin düşünme becerilerini geliştirmedeki avantajlarını gösteren çalışma bulguları Tablo 7'de sunulmuştur. Tablo 7'deki bulgular eğitimde yapay zekâ teknolojilerinin kullanılmasının öğrencilerin eleştirel düşünme becerilerinin geliştirilmesinde önemli avantajlar sağladığını göstermektedir. Aynı zamanda bulgulardan, eğitimde kullanılan yapay zekâ teknolojilerinin bilgi işlemsel, yansıtıcı, kompleks, yaratıcı, algoritmik ve farklı üst düzey düşünme becerilerini geliştirmede öğrencilere avantajlar sağladığı anlaşılmaktadır.

Tablo 7. Eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirmedeki avantajları

Avantajlar	Referans
Yapay zekâ eleştirel düşünmeyi potansiyel olarak geliştirebilir	(Essien vd., 2024)
Yapay zekâ eleştirel düşünmeyi potansiyel olarak geliştirebilir	(Almazrou vd., 2024)
Yapay zekâ eleştirel düşünme becerilerini artırır	(Muthmainnah vd., 2022)
Yapay zekâ araçları öğrencilerin eleştirel düşünme becerileri üzerinde olumlu bir etkiye sahiptir	(Liu & Wang, 2024)
Yapay zekâ destekli sınıflar öğrencilerin eleştirel düşünme becerilerini etkili bir şekilde geliştirebilir	(Wang vd., 2025)
Yapay zekâ eleştirel düşünmeyi geliştirebilir	(Gonsalves, 2024)
Yapay zekâ ile etkileşim, eleştirel düşünme performansı üzerinde önemli bir etkiye sahiptir	(Suriano vd., 2024)
Chatgpt kullanımı, öğrencilerin uzamsal olarak eleştirel düşünürler olmalarına yardımcı oldu	(Liang & Wu, 2024)
Chatgpt gibi yapay zekâ teknolojileri eleştirel düşünme becerilerini geliştirmek için kullanılabilir	(Guo & Lee, 2023)
Chatgpt yaratıcı ve eleştirel düşünmeyi teşvik eder	(Kartal, 2024)
Eleştirel düşünme becerilerini geliştirmek için geliştirilen çerçeve program etkili olmuştur	(Yusuf vd., 2024)

Eleştirel düşünme becerileri ve yapay zekâ destekli yazma arasında pozitif bir ilişki vardır	(Shen & Teng, 2024)
Yapay zekâ tarafından oluşturulan içerik araçlarını kullanırken eleştirel düşünme becerileri önemlidir	(Zou vd., 2024)
Yapay zekâ öğrencilerin üst düzey düşünme becerilerini geliştirir	(Almelweth, 2022)
Chatgpt destekli öğrenme aracı, öğrencilerin üst düzey düşünme becerilerini geliştirir	(Lee vd., 2024)
Yapay zekâ öğrencilerin bilgi işlemsel düşünme becerilerini geliştirir	(Huang & Qiao, 2024)
Nesnelerin yapay zekâsı, bilgi işlemsel düşünme becerilerini geliştirir	(Lin vd., 2021)
Öğrencilere tasarım yapmak için bir makine öğrenimi aracı öğretmek, öğrencilerin bilgi işlemsel düşünme becerileri ve algoritmik düşünme becerilerini geliştirir	(Wang & Wang, 2024)
Yapay zekâ öğrencilerin yansıtıcı düşünme becerilerini geliştirir	(Saritepeci & Yildiz Durak, 2024)
Yapay zekâ uygulamaları karmaşık düşünme becerilerini geliştirir	(George-Reyes vd., 2024)
ChatGPT metinleri tarihsel düşünmenin tüm boyutlarında daha yüksek puanlar almıştır	(Tirado-Olivares vd., 2023)
Yapay zekânın geleneksel öğrenme yaklaşımlarıyla birlikte kullanımı, öğrencilerin karar verme becerilerini geliştirmek ve kullandıkları bilgilerin güvenilirliğini sağlamak açısından büyük önem taşımaktadır	(Shin vd., 2024)
Yapay zekâ okuryazarlığı, sistematik düşünme, sezgisel düşünme ve karmaşık problem çözme becerilerini geliştirmede etkilidir	(Promma vd., 2025)
ChatGPT kullanımı öğrencilerin eleştirel düşünme becerilerini geliştirebilir	(Suriano vd., 2025)
ChatGPT ile ilgili daha fazla bilgi ve deneyim, daha yüksek dikkat seviyeleriyle birlikte, kullanıcıların karmaşık eleştirel düşünme becerilerindeki gelişmelerle ilişkilidir	(Fabio vd., 2024)
ChatGPT ile entegre somut biliş teorisi yöntemi, eleştirel düşünmeyi aktif olarak benimseme ve uygulama yoluyla analiz ve değerlendirme becerilerini geliştirir.	(Chang vd., 2025)
Yapay zekâ ve ChatGPT entegrasyonunun katkısı eleştirel düşünmeyi geliştirebilir.	(Naatonis, 2024)
Sohbet robotlarıyla birlikte kullanıldığında, yapay zekâ yakınsama müfredatı öğrencilerin eleştirel düşünmesini önemli ölçüde geliştirir.	(Hong vd., 2024)
Yapay zekâ, yaratıcı düşünmeyi önemli ölçüde destekleme potansiyeline sahiptir.	(Habib vd., 2024)
Chatgpt, öğrencilerin İngilizce eleştirel düşünme becerilerini önemli ölçüde geliştirebilir.	(You, 2024)
Chatgptnin programlama eğitiminde kullanımı, öğrencilerin bilgi işlemsel düşünme becerilerini önemli ölçüde artırır.	(Yilmaz & Yilmaz, 2023)

İncelenen çalışmalarda eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirmedeki sınırlılıklarını belirten bulgular Tablo 8'de yer almaktadır. Tablo 8'göre eğitimde kullanılan yapay zekâ teknolojileri eleştirel düşünmeyi zorlayarak, bu tür düşünme becerilerinde önemli değişimlere neden olmayabilir. Tablo 8'deki bulgular, eğitimde yapay zekâ teknolojileri kullanımı ile düşünme becerilerinin geliştirilmesi arasında hassas bir etkileşim olduğunu ve bu teknolojileri etkili bir şekilde kullanmak için zengin bir bilgi ve disiplinlerarası içerik bilgisine sahip olunması gerektiği yönünde sınırlılıklar olduğunu göstermiştir.

Tablo 8. Eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirmedeki sınırlılıkları

Sınılılıklar	Referans
Chatgpt kullanımı öğrencilerin eleştirel düşünme becerilerinde önemli değişikliklere neden olmayabilir	(Liang & Wu, 2024)
Yapay zekâ eleştirel düşünmeyi zorlayabilir	(Gonsalves, 2024)
Chatgpt kullanımı ile düşünme becerilerinin geliştirilmesi arasında hassas bir etkileşim vardır	(Kartal, 2024)
Yapay zekânın etkili kullanımı için zengin bilgi ve disiplinlerarası içerik bilgisine ihtiyaç vardır	(Huang & Qiao, 2024)
Eleştirel düşünme becerileri ile yapay zekâ destekli yazma arasında tek yönlü bir bağlantı vardır	(Shen & Teng, 2024)
Yapay zekâ sohbet robotlarına pasif bağımlılıktan kaçınılmalıdır	(Suriano vd., 2025)
Yapay zekânın yaratıcılık üzerinde olumsuz etkileri vardır	(Habib vd., 2024)

Tartışma ve Sonuç

Bu çalışmada, Web of Science ve Scopus veri tabanındaki SSCI indeksli dergilerde eğitim alanında kullanılan yapay zekâ teknolojilerinin düşünme becerileri üzerindeki etkilerini inceleyen bilimsel makalelerin araştırma eğilimleri ve temel bulguları analiz edilmiştir. Bu sistematik inceleme, 2024 yılında yapay zekâ teknolojilerinin düşünme becerilerine etkilerini inceleyen makalelerde artış olduğunu göstermiştir. 2024 yılından sonra artan çalışma sayısı, eğitimde kullanılan yapay zekâ teknoloji ve uygulamalarının öğrenciler tarafından daha kolay ulaşılabilir ve kullanılabilir olmasıyla açıklanabilir. Ayrıca, son yıllarda eğitim alanında yapay zekâ teknolojilerinin ön plana çıkmasıyla birlikte bu teknolojilerin öğrencilere ilişkin farklı değişkenlere olabilecek etkilerine yönelik ilginin artması da bu duruma etki etmiş olabilir. Bu bağlamda bu tür çalışmalara yönelik ilginin giderek artacağı söylenebilir. İncelenen çalışmalarda ağırlıklı olarak eleştirel düşünme becerilerinin konu edinildiği tespit edilmiştir. Eleştirel düşünme akıl yürütme, analiz ve değerlendirme gibi farklı süreçleri kapsayan birçok yönlü bir düşünme biçimidir. Bu nedenle son zamanlarda özellikle eğitim alanında öğrencilerin eleştirel düşünme becerilerini geliştirmeye etkisi olabilecek farklı teknolojilerin etkilerini inceleyen çalışma sayıları giderek artmaya devam etmektedir. Yapay zeka teknolojilerinin son yıllarda oldukça trend teknolojiler olarak yaşamın farklı alanlarında olduğu gibi eğitim alanında da çok yaygın bir şekilde kullanılmasının bu duruma etki ettiği düşünülebilir. Çalışmalarda en çok kullanılan anahtar kelimelerin eleştirel düşünme becerileri, chatgpt ve yapay zekâ olduğu belirlenmiştir. Eleştirel düşünme becerilerinin birçok çalışmaya konu edinilmesinin doğal sonucu olarak eleştirel düşünme becerileri çalışmalarda en çok kullanılan anahtar kelime olmuştur. ChatGPT çalışmalarda en çok kullanılan ikinci anahtar kelime olmuştur. ChatGPT'nin büyük ölçüde verinin analizi ile tutarlı ve kullanışlı yanıtlar sunan bir sohbet robutu olmasını (Gill vd., 2024) bu tür çalışmalarda diğer yapay zekâ teknolojilere göre daha fazla kullanılmasına sebep olmuş olabilir. Guo ve Lee'nin (2023) ChatGPT'nin öz algı, araştırıcı sorular sorma, değerlendirme ve mantıksal sonuçlar çıkarma ve karmaşık konuları anlama gibi eleştirel düşünme yeterliliklerine ilişkin alanlara olumlu katkılarının olduğunu gösteren çalışma sonuçları bu durumu desteklemektedir.

Çalışmalarda en çok tercih edilen araştırma yöntemlerinin yarı deneysel ve karma araştırma yöntemleri olduğu tespit edilmiştir. Bu tür araştırma yöntemleri ile bağımlı ve bağımsız değişkenler arasındaki nedensellik veya ilişkiler ortaya koyulabildiği (Rogers & Révész, 2019) için çalışmalarda daha fazla kullanılmış olabilir. Aynı zamanda bağımlı değişken veya değişkenlerdeki değişimlerin farklı sebeplerden değil bağımsız değişkenden kaynaklandığı yani nedensellik iddiasında bulunabilmek (Kardes & Herr, 2019; Viglia vd., 2021) için çalışmalarda bu araştırma yöntemleri tercih edilmiş olabilir. İncelenen çalışmalarda örneklem grubunun ağırlıklı olarak lisans ve lisansüstü öğrencilerden oluştuğu ve örneklem büyüklüğünün 0 ile 100 arasında olduğu belirlenmiştir. Bu durum yapay zekâ teknolojilerinin yükseköğretimde daha fazla kullanıldığının bir göstergesi olabilir. Yapay zekâ teknolojilerini kullanma ve geliştirme süreçlerine ilişkin altyapı imkânlarının yükseköğretim kurumlarında daha fazla olmasının da bu duruma etki ettiği söylenebilir. Bu sebeple, üniversite öğrencilerine daha fazla odaklanılmış olabilir. Çalışmaların önemli bir kısmında kullanılan ölçme araçları belirtilmemiştir. Çalışmalarda anketler ve eleştirel düşünme ile ilgili farklı ölçeklerin daha fazla kullanıldığı tespit edilmiştir. Kiss ve Józsa (2025) yaptıkları benzer bir sistematik inceleme çalışmasında anketlerin en sık kullanılan veri toplama araçları olduğu sonucuna ulaşmışlardır. Aynı şekilde Alsancak Sırakaya'da (2025) çalışmasında anket ve ölçeklerin veri toplama aracı olarak en çok tercih edilirken araçlar olduğunu ortaya koymuştur. Araştırmacıların çalışma sonuçlarına benzer şekilde çalışmalarda kullanılan, anket ve ölçeklerin, önceden hazırlanan mevcut araçlar veya bunların uyarlanmış

versiyonları (Kingsford-Smith & Evans, 2021; Venter & Panebianco, 2022) olduğu görülmüştür. Anket ve ölçeklerin, yönetim kolaylığı ve çok sayıda katılımcıya ulaşma imkânı sağlamasının (Ogbu & Excellence, 2025) bu tür çalışmalarda en yaygın kullanılan veri toplama araçları olarak yer almalarını sağlamış olabilir. Çalışmalarda anket ve ölçek kullanımının yüksek oranda olması nicel ölçümlere önem verildiğini göstermektedir.

Bu sistematik inceleme kapsamındaki çalışmalar, betimsel analiz, bağımlı ve bağımsız örneklem testleri gibi değişkenler arasındaki ilişkileri inceleyen analiz yöntemlerinin verilerin analizinde öncelikli olarak kullanıldığını ortaya koymuştur. Betimsel analizin her değişkeni ayrı ayrı inceleyerek, dağılım, merkezi eğilim ve değişkenlik gibi özellikleri özetlemesinin (O'Shaughnessy vd., 2025) bu durum üzerinde etkili olduğunu söylenebilir. İstatistiklerin hesaplanarak bunlar genellikle grafiksel olarak görselleştirilmesi (O'Shaughnessy vd., 2025) ile analiz sürecinin açık ve anlaşılır olmasının sağlanması bu analizlerin tercih edilmesini sağlamış olabilir. Çalışmalarda özellikle deney ve kontrol gruplarının olduğu yarı deneysel ön test son test kontrol gruplu desenlerin daha fazla kullanılmasına bağlı olarak veri analiz sürecinde bağımlı ve bağımsız örneklem t-testleri daha fazla kullanılmış olabilir. Öyleki eğitimde kullanılan yapay zekâ teknolojilerinin farklı gruplarda aynı değişken üzerindeki etkisini belirlemek için bağımsız örneklem t-testi kullanılmıştır. Grup içinde değişkenin ön ve son test puanları karşılaştırarak yapay zekâ teknolojilerinin bu değişkene olan etkisini ortaya koymak için de bağımlı örneklem t-testi kullanılmıştır. Bu sebeple, bu sonuç beklenen bir durumdur. Çalışmlarda en çok kullanılan veri kaynağı ölçek ve anketler olmuştur. Anket ve ölçeklerin veri toplamanın en basit yöntemlerinden (Younas & Porr, 2018) olması bu sonucu ortaya çıkarmış olabilir. Ölçeklerin belirlenen bir popülasyon ile anketler gerçekleştirilirken soyut bir veya birden fazla kavramı doğru bir şekilde ölçmenin en sağlam yolu (Younas & Porr, 2025) olarak görülmesinin elde edilen sonuçlar üzerindeki etkisi büyüktür.

Eleştirel düşünme becerilerine ilişkin veriler en çok kullanılan veri türleri olmuştur. Çalışmaların birçoğunda yapay zekâ teknolojilerinin eleştirel düşünme becerilerine etkilerinin incelenmesinin bu duruma kaynaklık ettiği söylenebilir. Anahtar kelimeler içerisinde eleştirel düşünme becerilerinin ağırlıklı olarak kullanılması da bu durumu desteklemektedir. Öyleki eleştirel düşünme becerileri çalışmalarda ağırlıklı olarak konu edinilmiştir. Buna bağlı olarak öğrencilerin eleştirel düşünme beceri düzeyleri çalışmalarda en çok test edilen değişken olmuştur. İncelenen çalışmalarda ChatGPT'nin eleştirel düşünme becerileri üzerindeki etkileri konu dağılımları arasında en başta yer almıştır. Suriano ve diğerlerinin (2025) yapay zekâ tabanlı ChatGPT gibi sohbet robotlarıyla etkileşimin sağlanmasının öğrencilerin eleştirel düşünme becerilerinin geliştirilmesi için değerli bir kaynak olabileceğini belirtmesi bu sonuçları destekler niteliklerdedir. Zafar ve diğerlerinin (2025) yapılandırılmış bir öğrenme ile stratejik olarak bütünleştirilen ChatGPT'nin eleştirel düşünmeyi geliştirebileceğine ilişkin çalışma sonucu da bu bağlamda değerlendirebilir. ChatGPT gibi yapay zekâ araçlarının kullanımı ile karmaşık problemler analiz edilebilir ve bu problemleri çözmek için bilişsel kaynaklar serbest bırakılabilir, bu sayede eleştirel düşünme süreci kolaylaştırabilir (Suriano vd., 2025; Avello vd., 2024). Çalışmalara ilişkin bulgu ve sonuçlara dayanarak ChatGPT'nin eleştirel düşünme becerileri üzerinde olumlu etkileri olduğu ve bu becerileri geliştirmede kullanılabileği söylenebilir.

İncelenen çalışmalardan elde edilen sonuçlar, eğitimde kullanılan yapay zekâ teknolojilerinin düşünme becerilerini geliştirdirdiğine ilişkin bulguların daha baskın olduğunu göstemiştir. Bu sonuçlar, yapay zeka teknolojilerinin düşünme becerilerine olumlu katkıları olduğunu gösteren çalışma sonuçları ile örtüşmektedir (Almelweth, 2022; George-Reyes vd., 2024; Liang & Wu, 2024; Promma vd., 2025). Gerçek olan şu ki yapay zekâ teknolojileri ile ilgili daha fazla bilgi ve deneyim, daha yüksek dikkat seviyeleriyle birlikte, kullanıcıların karmaşık eleştirel (Fabio vd., 2024), bilgi işlemsel (Huang & Qiao, 2024), yansıtıcı düşünme (Saritepeci & Yildiz Durak, 2024), yaratıcı (Habib vd., 2024) ve farklı üst düzey (Almelweth, 2022) düşünme becerilerinin gelişimleriyle ilişkilidir. Bu bağlamda farklı düşünme becerilerini geliştirmek için eğitim alanında farklı özeliklere sahip yapay zekâ teknolojilerinin kullanılmasının etkili bir yöntem olduğu söylenebilir. Çalışma sonuçlarından, eğitimde yapay zekâ kullanımının farklı düşünme becerilerini geliştirmede kullanıcılarına önemli avantajlar sağladığı anlaşılmıştır. Yapay zekânın eleştirel, bilgi işlemsel, yansıtıcı, yaratıcı, sistematik düşünme becerileri, sezgisel karar verme becerileri ve karmaşık problem çözme becerilerini geliştirdiğine ilişkin sağladığı avantajlar bunlardan bazılarıdır. Bunun yanında yapay zekâ teknolojilerinin eğitim alanında kullanımına ilişkin bazı sınırlılıklar bulunmaktadır. Örneğin Huang ve Qiao'ya (2024) göre yapay zekâ teknolojilerinin etkili kullanımı için zengin bilgi ve disiplinlerarası içerik bilgisine ihtiyaç vardır. Bazı durumlarda yapay zekâ eleştirel düşünmeyi zorlayabilir (Gonsalves, 2024). Yapay zekâ sohbet robotları pasif bağımlılığa (Suriano vd., 2025) sebep olabilir. Kartal'a göre (2024) chatGPT kullanımı ile düşünme becerilerinin geliştirilmesi arasında hassas bir etkileşim bulunmaktadır. Eğitim alanında farklı yapay zekâ teknolojilerinin etkili bir şekilde kullanarak düşünme becerilerilerini geliştirmek için bu sınırlılıkların dikkate alınması önerilebilir.

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Üniversite Öğrencilerinin Depreme Bağlı Acil Uzaktan Eğitim Sürecindeki Nomofobi Düzeyleri

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Özet

Bu araştırma, üniversite öğrencilerinin Türkiye'de 2023 yılında yaşanan Kahramanmaraş merkezli depreme bağlı olarak ivedilikle geçilen acil uzaktan eğitim sürecindeki nomofobi düzeylerini belirlemek amacıyla gerçekleştirilmiştir. Araştırma 2022-2023 akademik yılının bahar döneminde bir devlet üniversitesinin İngilizce hazırlık programında öğrenim görmekte olan öğrenciler ile gerçekleştirilmiştir. Durum çalışması deseninin uygulandığı araştırmanın verilerinin toplanmasında Nomofobi Ölçeği ile yapılandırılmış görüşme tekniğinden yararlanılmıştır. Araştırma sonuçlarına göre, nomofobiyi anlamlı şekilde öngören istatistiksel bir değişken bulunamamıştır. Kadın öğrenciler daha yüksek nomofobi düzeyine sahiptir ve öğrencilerin telefon kullanım sürelerinde artış olmasına rağmen bu süreler ile nomofobi düzeyleri arasında anlamlı bir ilişki bulunmamaktadır. Nitel veriler ise, öğrencilerin kaygı yönetimi, uzaktan eğitim ve gelişmelerin takibi sebebiyle mobil cihazlara olan bağımlılıklarının arttığını ortaya koymaktadır. Çalışma, kriz kaynaklı eğitim bağlamlarında teknoloji kullanımının psikolojik ve davranışsal boyutlarına dikkat çekmekte ve yükseköğretim kurumlarında dijital iyi oluşu desteklemeye yönelik müdahalelere ihtiyaç olduğunun altını çizmektedir.

Anahtar kelimeler: Nomofobi, acil uzaktan eğitim, üniversite öğrencileri.

Nomophobia Levels of University Students During The Emergency Remote Education Process Triggered By The Earthquake

Abstract

This study aims to determine the levels of nomophobia among university students during the emergency remote education process that was rapidly implemented in response to the earthquake centered in Kahramanmaraş, Turkey, in 2023. The research was conducted during the spring semester of the 2022–2023 academic year with students enrolled in the English preparatory program at a public university. Employing a case study design, data were collected using the Nomophobia Scale and a structured interview technique. The findings revealed no statistically significant variable that could meaningfully predict nomophobia. Female students exhibited higher levels of nomophobia, and although students' mobile phone usage times increased, no significant relationship was found between usage duration and nomophobia levels. Qualitative data indicated that students' dependence on mobile devices increased due to anxiety management, remote education, and the need to stay informed about ongoing developments. The study highlights the psychological and behavioral dimensions of technology use in crisis-driven educational contexts and underscores the need for interventions that support digital well-being in higher education institutions.

Keywords: Nomophobia, emergency remote education, university students.

Giriş

Acil uzaktan eğitim, pandemi ve doğal afetler gibi kriz durumlarında öğrenme-öğretme süreçlerinin durdurulmadan en az kesintiyle yürütülmeye devam edilebilmesini sağlayan ivedi bir çözüm olarak karşımıza çıkmaktadır. Önceden planlanan ve ayrıntılı olarak yapılandırılan çevrimiçi öğretimin aksine, eğitim kurumları acil uzaktan eğitime zorunlu koşullarda çoğunlukla zaman, kaynak ve yeterince hazırlıkları olmadan geçiş yapmak durumundadır. Bu tür eğitimin temel amacı, dijital ortamlara geçiş yaparak ve uzaktan öğretim metodolojisinden yararlanarak öğrenme-öğretme faaliyetlerinin tamamen durmasını ya da ertelenmesini önlemektir. Bu yaklaşımın öğretimin kesintisiz devam etmesi bakımından etkililiği Covid-19 pandemisi zamanında deneyimlenmiştir. Bu açıdan acil uzaktan eğitimin dünya genelinde eğitim sistemlerinin kriz yönetimindeki etkili bir bileşeni olduğu söylenebilir.

Covid-19'un eğitime yansımalarını inceleyen bazı araştırmalar (Pew Research Center, 2025; Fichten vd., 2022; OECD, 2023) bu süreçte geçilen acil uzaktan eğitim ile birlikte öğrencilerin teknoloji kullanımında bir artış olduğuna dikkat çekmektedir. Bu artışı etkileyen etmenler sadece öğrencilerin derslere uzaktan katılması ile ilgili değil, aynı zamanda ders dışı oyun ve sosyal medya gibi araçların kullanımında da yaşanan artışa işaret etmektedir. Özellikle akıllı telefon gibi mobil cihazların yoğun kullanımı nomofobiye yol açabilmektedir. İngilizce "no mobile phone phobia" ifadesinin kısaltmasından türetilen nomofobi kavramı, kabaca cep telefonundan uzak kalma korkusu olarak tanımlanan psikolojik bir durumdur. Nomofobi, özellikle öğrenenler üzerinde düşük konsantrasyon düzeyi, erteleme eğilimi, uyku sorunu ve ders çalışma alışkanlıklarında bozulma gibi etkiler yaratabilmektedir (Abukhanova vd., 2024; Rahman vd., 2024). Bu durum, öğrencilerin akademik başarı, bilişsel ve sosyal gelişim ve ruh sağlığını etkilemektedir (Kumar vd., 2025; Şahin ve Bülbüloğlu, 2021).

Bu araştırmada, Türkiye'de 2023 yılının 6 Şubat'ında Maraş merkezli yaşanan ve çok geniş bir bölgeyi etkileyen 7.8 şiddetli depremin ardından ivedilikle geçilen acil uzaktan eğitim sürecinde üniversite öğrencilerinin nomofobi düzeylerini incelemek amacıyla gerçekleştirilmiştir. Araştırmada, öğrencilerin uzaktan eğitim ve deprem felaketinden akıllı telefon kullanma alışkanlıklarının etkilenip etkilenmediği, etkilendiyse ne yönde etkilendiği ve bu tür değişkenlerin nomofobi düzeyleri ile ilişkisi araştırılmaya çalışılmıştır. Araştırmanın, deprem gibi kriz dönemlerinde öğrencilerin psikolojik iyilik halinin sağlanmasının önemine dikkat çekmesi, eğitim kurumlarının bu tür beklenmedik afet durumları için kriz yönetim mekanizmaları geliştirmeleri ve bunları sistemli bir şekilde işe koşmalarının gerekliliğini düşündürmesi bakımından alanyazına katkı sağlayacağı düşünülmektedir.

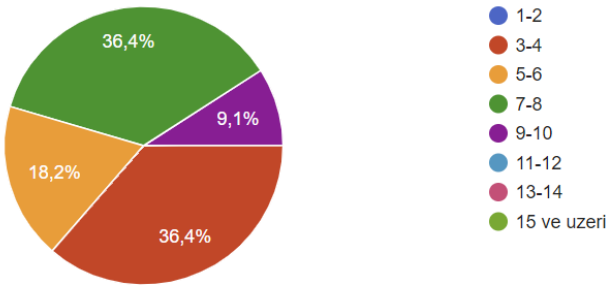
Yöntem

Depreme bağlı geçilen acilen uzaktan eğitim sürecinde üniversite öğrencilerinin nomofobi düzeylerinin belirlenmesi amacıyla gerçekleştirilen bu araştırmada, nitel araştırma desenlerinden durum çalışması deseni uygulanmıştır. Araştırma 2022-2023 akademik yılının bahar döneminde, acil uzaktan eğitim süreci henüz devam ederken gerçekleştirilmiştir. Katılımcı grubunu bir devlet üniversitesinin İngilizce Hazırlık Okulu'nda öğrenim görmekte olan öğrenciler oluşturmaktadır. Örneklem seçiminde kolayda örnekleme yaklaşımı benimsenmiş, söz konusu dönemde araştırmacının ders vermekle yükümlü olduğu sınıflardan birindeki öğrenciler çalışmaya dahil edilmiştir. Araştırmanın yapıldığı hazırlık sınıflarında daha etkili bir dil eğitimi sunulabilmesi için sınıf mevcutlarının yirmiyi geçmemesine özen gösterilmektedir. Nitekim, araştırma grubunu oluşturan öğrencilerin bulunduğu sınıfta toplamda 18 öğrenci bulunmaktadır. Bu öğrencilerden 2'si erkek 9'u kız olmak üzere toplam 11 kişi araştırmaya gönüllü olarak katılım sağlamıştır. Araştırma sürecinde katılımcıların tümü kendi memleketlerinde bulunmakta ve derslere çevrimiçi katılım sağlamaktadır.

Araştırmanın verileri nicel ve nitel olmak üzere iki türde toplanmıştır. Nicel veriler, Yıldırım ve Correira tarafından 2015 yılında geliştirilen ve Türkçe 'ye uyarlama çalışması yine Yıldırım ve arkadaşları (2016) tarafından yapılan Nomofobi Ölçeği kullanılmıştır. Ölçek 7'li likert tipi olup 20 maddeden oluşmaktadır. Bu maddelerin yanı sıra, ölçekte öğrencilerin yaş, cinsiyet, günlük akıllı telefon kullanma süresi ve akıllı telefon kullanma amaçlarından oluşan sorular da yer almaktadır. Ölçek Google Forms üzerinden hazırlanarak öğrenciler ile çevrimiçi ders sırasında ve elektronik posta ile paylaşılmıştır. Nitel veriler için ise yapılandırılmış görüşme formu kullanılmıştır. Yine görüşme verileri çevrimiçi ders sırasında yapılan ortak bir görüşme yoluyla toplanmıştır. Nicel verilerin analizinde SPSS programı kullanılmış olup, betimsel ve ilişkisel analiz yapılmıştır. Nitel veriler ise elle analiz edilmiştir. Buna göre, verilerin önce Word dokümanına transkripsiyonu yapılmış ve bu transkripsiyon üzerinde kodlamalar yapılmıştır. Kodlamalar frekansları ve araştırmanın amacı ve sorunsalı doğrultusunda gruplanarak kategoriler elde edilmiştir. Geçerlik ve güvenirliğin sağlanması için, analizler bir yöntem uzmanı tarafından bağımsız olarak yapılmış, sonra araştırmacının analizleri ile karşılaştırılarak farklı olan noktalar tespit edilmiştir. Bu farklılıklar üzerinde tekrar karşılıklı değerlendirmeler yapılmış ve ortak karara ulaşılmıştır.

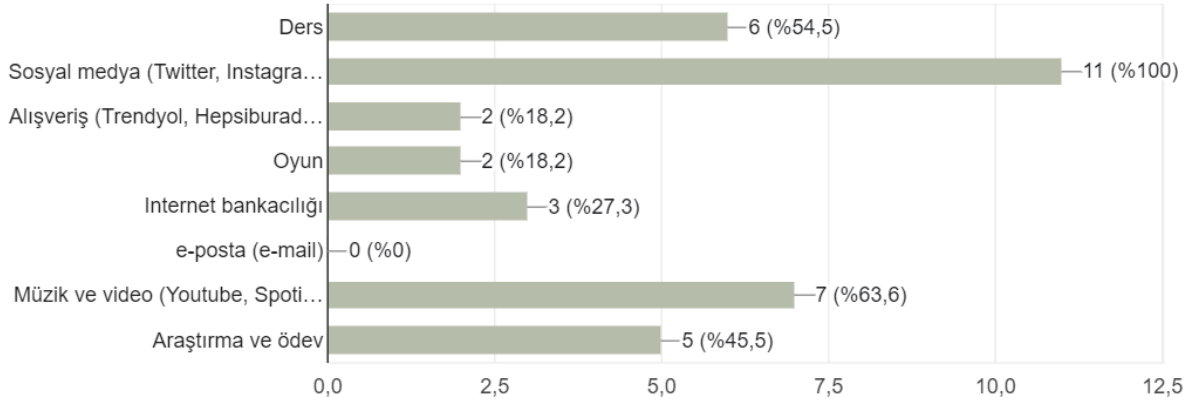
Bulgular

Katılımcılara öncelikle günlük olarak akıllı telefonlarını kullanma süreleri sorulmuştur. Bu süreler Şekil 1.de ayrıntılı olarak gösterilmiştir.



Şekil 1. Günlük akıllı telefon kullanma süreleri

Şekil 1'e göre katılımcıların üçte biri akıllı telefonunu ortalama 7-8 kullanırken, diğer üçte biri ise günde 3-4 saat kullanmaktadır. Katılımcılara ayrıca bu süre içinde akıllı telefonlarını hangi amaçlarla kullandıkları sorulmuştur. Şekil 2'de bu kullanım amaçları gösterilmiştir:



Şekil 2. Akıllı telefon kullanım amaçları

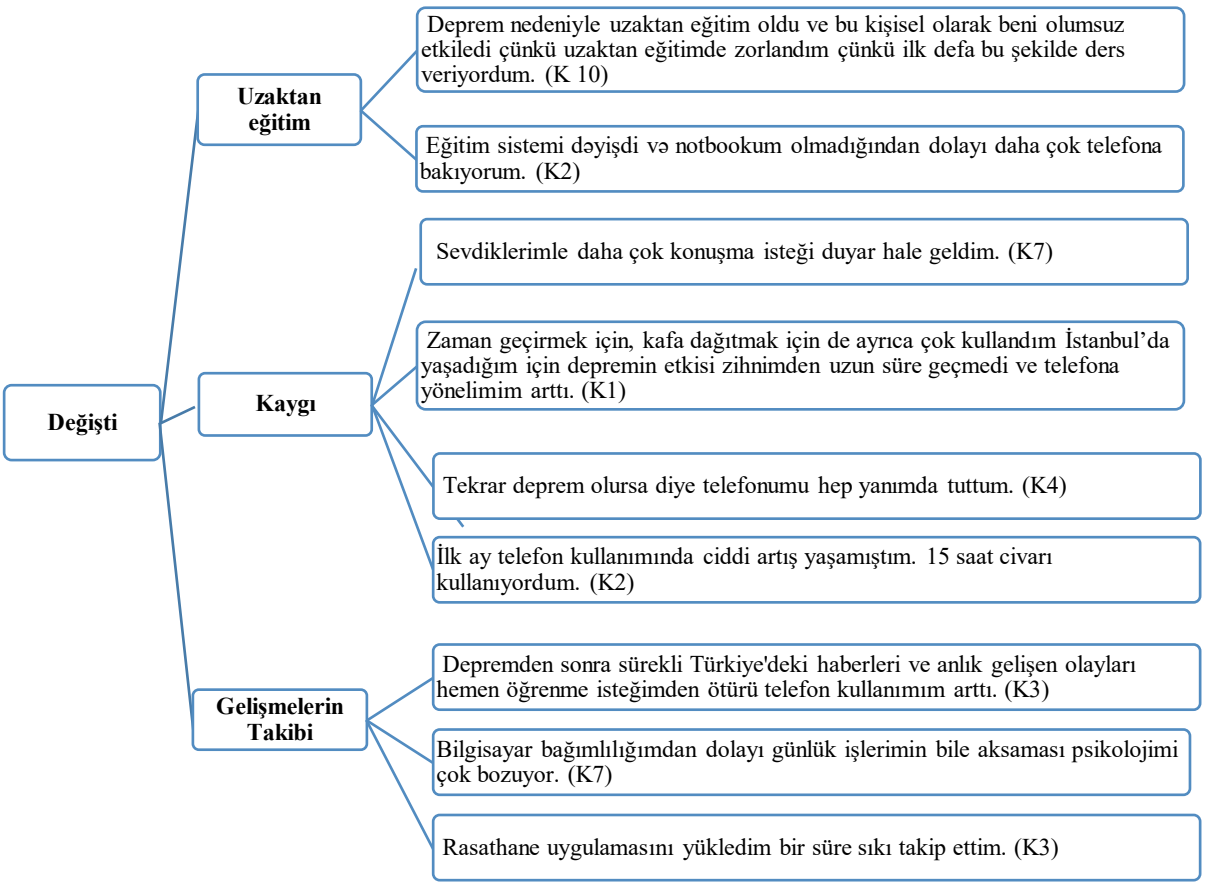
Katılımcıların tümü akıllı telefonlarını sosyal medyaya erişim için, yarısından fazlası ise müzik ve video kanalları ile çevrimiçi derslere katılmak amacıyla kullandığını belirtmiştir. Hiçbir öğrencinin telefonunu e-posta göndermek ya da okumak için kullanmaması dikkat çekicidir.

Nomofobi Ölçeğinden elde edilen bulgular ise şu şekildedir: Nomofobi skoru ($p=0.5541$) istatistiksel olarak anlamlı değildir. Etki düzeyi (Cohen $d=-0.52$) orta düzeyde ancak anlamlı değildir. Erkek ve kadın öğrenciler arasında nomofobi skoru ve günlük telefon kullanımı bakımından anlamlı bir fark bulunmamıştır. Kadın öğrenciler daha yüksek nomofobi skoruna sahip olmasına rağmen, fark anlamlı değildir. Bunun sebebi, örneklemi oluşturan erkek öğrencilerin sayısının çok az olmasından kaynaklı olabilir.

Katılımcıların yaşları 18 ile 35 arasında değişmektedir. 18-25 yaş arası katılımcılar 25-35 yaş arası katılımcılara göre anlamlı düzeyde daha fazla nomofobi skoruna sahiptir. Ancak yaş grupları arasında günlük telefon kullanımı bakımından anlamlı bir fark gözlenmemiştir.

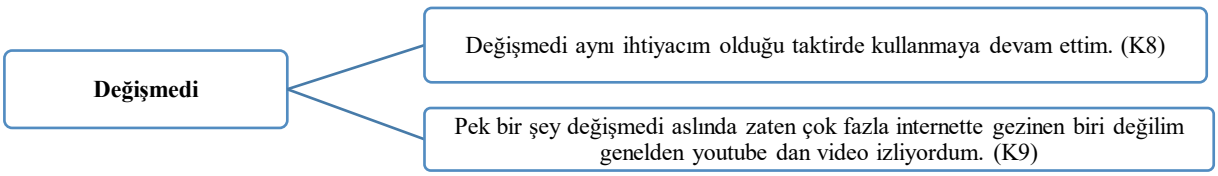
Nitel Verilerden Elde Edilen Bulgular

Araştırmada nomofobi düzeylerinin tespit edilmesinin yanı sıra, öğrencilerin akıllı telefon kullanma alışkanlıklarının depreme bağlı olarak değişip değişmediğinin de tespit edilmesi amaçlanmıştır. Bu doğrultuda katılımcılardan elde edilen veriler "değişti" ve "değişmedi" olmak üzere iki ana temada toplanmıştır. "Değişti" teması ve buna bağlı alt temalar ile bu temalara ilişkin öğrencilerin ifadeleri doğrudan alıntı olarak aşağıdaki şekilde gösterilmiştir:



Şekil 3. "Depremle birlikte akıllı telefon kullanma alışkanlığım değişti" temasına bağlı alt tema ve doğrudan alıntılar

Katılımcılar arasında depreme bağlı olarak akıllı telefon kullanma alışkanlıklarında bir değişiklik oluşmadığını dile getiren az sayıda katılımcı vardır. Bu bulguya ilişkin tema, alt tema ve bulguları destekleyici doğrudan alıntılar Şekil 4'te gösterilmiştir:



Şekil 4. "Depremle birlikte akıllı telefon kullanma alışkanlığım değişmedi" temasına bağlı doğrudan alıntılar

Tartışma ve Sonuç

2023 yılında Kahramanmaraş merkezli gerçekleşen deprem sonucu geçilen acil uzaktan eğitim sürecinde üniversite öğrencilerinin akıllı telefon kullanma alışkanlıklarının değişip değişmediği ve nomofobi düzeylerinin belirlenmesi amacıyla gerçekleştirilen bu araştırmaya göre, katılımcıların çoğunun deprem sebebi ile akıllı telefon kullanma alışkanlıkları değişmiştir. Bunun sebepleri arasında, uzaktan eğitim, kaygı yönetimi ve gelişmelerin takibi yer almaktadır. Benzer şekilde, araştırmalar deprem gibi acil uzaktan eğitime geçmenin bir diğer sebebi olan Covid-19 pandemisi sırasında öğrencilerde akıllı telefon kullanımının büyük oranda arttığını göstermektedir

(Vargo vd., 2021; Yang ve Shigeno, 2021; Chemnad vd., 2022). Öte yandan, nomofobiyi anlamlı şekilde öngören istatistiksel bir değişken bulunamamıştır. Bu durum, örneklem büyüklüğünün küçük olması veya ölçülmemiş başka faktörlerden kaynaklanıyor olabilir. Ayrıca, kadınlar ve 19–25 yaş grubu katılımcılar daha yüksek nomofobi ortalamasına sahiptir. Ancak bu farklar istatistiksel olarak anlamlı değildir. Bunun nedeni, örneklem içerisinde erkek katılımcıların çok az kişi tarafından temsil ediliyor olması olabilir. Afacan ve Muhametjanova (2024) araştırmalarında hem Azerbaycan hem de Kırgızistan'daki kadın öğrencilerin erkek öğrencilere kıyasla daha yüksek nomofobi düzeyine sahip olduklarını belirlemiştir. Buna karşın, Taş ve Eker (2021) cinsiyet ve kaygının nomofobinin anlamlı yordayıcıları olduğunu, lakin yaşın anlamlı bir yordayıcı olmadığını ortaya koymuşlardır. Bunun yanı sıra, günlük telefon kullanma süresi ile nomofobi düzeyleri arasında bir ilişki bulunmamıştır. Ancak alanyazında bunun tam tersine işaret eden araştırmalar çoğunluktadır. Örneğin, Kara, Baydemir ve İnceman-Kara (2021) günlük akıllı telefon kullanımı ile nomofobi arasında anlamlı ve güçlü bir ilişki olduğunu belirlemiştir. Benzer şekilde, Jahrami ve arkadaşlarının (2023) araştırmasına göre nomofobi ile ekran süresi ve telefonun yakınında olma doğrudan ilişkilidir. Sonuç olarak, yükseköğretim kurumlarında özellikle kriz durumlarında dijital iyi oluşu desteklemeye yönelik müdahalelerin planlanması ve uygulanması önem arz etmektedir. Nomofobi yalnızca telefon kullanım süresi veya temel demografik özelliklerden değil, bunların dışındaki başka faktörlerden etkilenebilmektedir. Bu sebeple, daha büyük ve çeşitli örneklemler içeren ve psikolojik ve sosyal değişkenleri de dikkate alan benzer araştırmaların yapılmasına ihtiyaç vardır.

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Yaşamak istiyoruz. Sessiz kirleticilerin elinden bir kurtulabilirsek!

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Özet

Geçmişten günümüze kadar insanlar kendi yaşamına ve yaşadığı doğal çevreye zarar vermiştir**.** Bu verdiği zararlardan birisi de dünyamızı ve çevremizi en çok etkileyen sesiz kirleticiler olarak adlandırdığımız hava kirliliğidir. Hava kirliliğini en çok etkileyen etmenler ise fabrika bacalarından çıkan gazlar, dizelli motorlu taşıtlar, kömür kullanımı şeklinde sıralanabilir. Diğer taraftan bu kirleticilerin önemli bir bölümü küresel ısınmaya da neden olmasından dolayı iklim eylemleri açısından dikkat edilmesi gereken konular arasında yer almaktadır. Bu çalışmada amacımız, kanıt temelli öğrenme yaklaşımı ile ortaokul düzeyindeki öğrencilerin sessiz kirleticilere karşı farkındalığını oluşturmaktır. Çalışma 2023-2024 Akademik Yılında, Rize 'de MEB'e bağlı bir ortaokulda yürütülmüştür. Çalışmaya 19 öğrenci katılmıştır. Çalışma, nicel ve nitel yaklaşımların bir arada yürütüldüğü karma bir yöntem ile gerçekleştirilmiştir. Araştırmada sessiz kirletici ön test ve son test başarı testi uygulanmıştır. Araştırma süresince ortaokul seviyesine uygun, konferans, drama ve eğitsel oyun teknikleri uygulanmıştır. Daha sonra bu etkinlikleri yarı yapılandırılmış görüşme formu ile öğrencilerin görüşleri alınarak nitel veri toplama aracı ile de değerlendirilmiştir.

Anahtar Kelimeler: Sessiz kirletici, ortaokul, öğrenci, kanıt temelli öğrenme, iklim eylemi

Abstract

From the past to the present, humans have harmed their own lives and the natural environment they inhabit. One of these harms is air pollution, which we call silent pollutants, which most significantly impact our world and environment. The factors that most significantly impact air pollution include exhaust gases from factory chimneys, diesel-powered vehicles, and coal consumption. Furthermore, because a significant portion of these pollutants contribute to global warming, they are among the issues requiring attention in climate action. In this study, our aim is to raise awareness of silent pollutants among middle school students using an evidence-based learning approach. The study was conducted in a middle school affiliated with the Ministry of National Education in Rize during the 2023-2024 academic year. Nineteen students participated. The study employed a mixed methodology combining quantitative and qualitative approaches. A pre-test and post-test achievement test for silent pollutants were administered. Throughout the study, conference, drama, and educational game techniques appropriate for the middle school level were employed. These activities were then evaluated using a semi-structured interview form and qualitative data collection tool, gathering student opinions.

Keywords: Silent pollutant, middle school, student, evidence-based learning, climate action

1. Giriş

Çevre sorunları her geçen gün belirgin bir şekilde gün yüzüne çıkarken sorunların temelinde birçok farklı bakış açısı eğitim ve özelinde çevre, eğitimini ön plana çıkarmaktadır (Sönmez, Yerlikaya (2017). Çevre eğitimi; bütün yönleri ile ele alınması gereken, diğer disiplinlerle etkileşimini göz ardı etmeden ve problemlerin çözüm metodolojisinin öğretimini esas alan bir yaklaşımdır. Çevre ile ilk etkileşim erken yaşta başladığı için çevre eğitimine ilköğretimde başlanması bireylerin ilerleyen yaşlardaki tutumunu olumlu yönde geliştirmesi açısından önemlidir. Bu nedenle ortaokullarda çevre eğitiminin önemi giderek artmaktadır (Yücel,1999).

Çevre sorunlarına dönük bir eğitimde çevre sorunlarının niteliklerinin bilinmesi oldukça önemlidir. Konuya bu açıdan baktığımızda pek çok çevre sorunları olduğu görülmektedir. Bunların ayrı bir şekilde ele alınıp eğitiminin o çerçevede verilmesi konunun daha iyi şekilde öğrenilmesine önemli katkılar sağlayacaktır. Bu kapsamda hava kirliliği bu çalışmanın özünü oluşturmaktadır. Hava kirlilikleri son zamanlarda dikkat çekme amacına dönük olarak sessiz kirleticiler olarak kullanmaya başlanmış ve bu kavram Çevre, Şehircilik ve İklim Değişikliği Bakanlığı (2023) tarafından da benimsenmiştir.

Sessiz Kirletici (Hava kirliliği), endüstri devrimiyle birlikte özellikle Batı ülkelerinde önemli bir halk sağlığı sorunu olmaya başlamıştır. Yirminci yüzyılın başlarında geleneksel fosil yakıtların aşırı kullanımı sonucu, atmosferde sülfür dioksit (SO2) ve partikül artışına bağlı olarak solunum hastalıklarına bağlı ölümlerde ciddi artışlar görülmüştür. Bu yıllarda, Belçika ve Amerika Birleşik Devletleri (ABD)'nin çeşitli bölgelerinde, Londra'da dramatik hava kirliliği görülmüş, ölüm oranları beklenenin birkaç misli üzerine çıkmıştır (Bayram, Dikensoy, 2006)

Bir halk sağlığı sorunu olarak hava kirliliği, kentsel bölgeler için giderek ön sıralara yükselen bir sağlık sorunudur. 2015 yılı için dünya genelinde genel olarak çevre kirliliğinin 9 milyon erken ölüm nedeni olduğu bu rakamın yaklaşık 4.5 milyonunun, diğer bir deyişle yaklaşık yarısının dış ortam hava kirliliği nedenli olduğu tahmin edilmektedir (Landrigan 2018, akt. Yavuz 2020). Dünya Sağlık Örgütü (DSÖ) değerlendirmelerine göre hava kirliliği akciğer kanserine bağlı ölümlerin yaklaşık üçte birinin, kalp hastalıklarına bağlı ölümlerin dörtte birinin hava kirliliği nedenli olduğunu vurgulamaktadır (Yavuz 2020). Hava kirliliğine yol açan çok sayıda kirletici bulunmaktadır. Bu kirleticiler kimyasal yapılarına göre farklı özellikler taşımakta ve etkiler oluşturmaktadırlar EPA (2023). Dış ortam hava kirliliğine yol açan etkenler çok çeşitlidir ve farklı maddelerin karışımı biçimindedir, bu maddeler gaz, sıvı ya da katı olabilirler. Yüzlerce sayıda sıralanabilen bu kirleticilerden bazıları çeşitli çevre kuruluşları ve kurumları tarafından seçilen bazıları "çekirdek kirletici seti" olarak belirlenmiş ve hava kalitesi göstergesi olarak ele alınmıştır. Bu çekirdek kirleticiler çoğu ülkede düzenli olarak izlenen kirleticilerden oluşmaktadır (Örneğin ABD Çevre Koruma Örgütü EPA altı kirleticiyi kriter kirleticiler olarak belirlenmiştir. Bu kirleticiler: Karbonmonoksit (CO), Partiküler Madde (PM), Ozon (O3), Kükürt dioksit (SO2) ve nitrojen dioksit (NO2) olarak belirlenmiştir (Yavuz, 2020).

Belli başlı sessiz kirleticilerin çeşitleri ve etkileri şunlardır (Yılmaz, 2021).

a) Partikül Maddeler (PM10, PM2.5), Ana Kaynağı: Sanayi, yakıt yanması, tarım ve ikincil kimyasal reaksiyonlar. Sağlık Etkisi: Kanser, kalp problemleri, solunum yolu hastalıkları, bebek ölüm oranlarında artış.

b) Azotoksitler, Ana Kaynağı: Taşıt emisyonları, yüksek sıcaklıkta yakma prosesleri. Sağlık Etkisi: Göz ve solunum yolu hastalıkları, asit yağmurları. Karbon monoksit ve siyah karbon ikincil kirleticilerdir. Kükürt dioksit, fosil yakıt yanması (ve yangınlar) sonucu dumanda kalır ve asit yağmurlarına sebebiyet verir. Ozon, trafikten kaynaklanan azot oksitler ve uçucu organik bileşiklerin güneş ışığıyla değişimi sonucu oluşur ve solunum sistemi problemleri, göz ve burunda kaşıntı, astım, vücut direncinde azalmaya sebebiyet verir.

Karbon monoksit ve siyah karbon ise ikincil kirleticilerdir. Kükürt dioksit, fosil yakıt yanması (ve yangınlar) sonucu dumanda kalır ve asit yağmurlarına sebebiyet verir. Ozon, trafikten kaynaklanan azot oksitler ve uçucu organik bileşiklerin güneş ışığıyla değişimi sonucu oluşur ve solunum sistemi problemleri, göz ve burunda kaşıntı, astım, vücut direncinde azalmaya sebebiyet verir (Yılmaz, 2021). EPA (Çevre Koruma Ajansı (2023), ülkelerin ekonomik büyümesi ile hava kirliliği eksenli ölümler arasında enteresan bir ilişki vermiştir. Başlangıçta az gelişmiş ekonomiler, çevre ve hava kirliliği yüklü ekonomik büyüme gösterirler. Bu ülkeler, ekonomileri büyürken çevreyi çok kirletirler ve hava kirliliği eksenli ölüm oranları da yüksektir. Çocuklar hava kirliliğinin olumsuz etkilerine erişkinlere göre daha duyarlıdır. Çünkü alveollerin %80'i postnatal olarak oluşur ve akciğerin tam gelişimi 6-8 yaşına dek devam eder. Çocukların dakikadaki solunum sayılarının daha hızlı olması ve fiziksel aktivitelerinin daha çok olması nedeniyle erişkinlere kıyasla daha fazla solunumsal toksik maddeyle karşılaşırlar. İç havada yüksek seviyede bulunan ajanların astım ataklarını tetiklemesi nedeniyle çocuklar arasında astım riski artar. EPA'nın verilerine göre okul çağındaki hemen hemen her 13 çocuktan birinde astım görülmekte ve bu oran okul öncesi çağdaki çocuklarda diğer gruplara göre daha hızlı artış göstermektedir (Öztürk, Düzovalı, 2011).

Sessiz kirleticilerin neden olduğu bir diğer durum ise küresel ısınmadır. Sessiz kirleticilerin pek çoğu sera etkisi yaparak küresel ısınmaya neden olmakta bu durum ise küresel ölçekte pek çok canlının yaşam alanlarını daraltarak onların yaşamlarını tehdit etmektedir (İlkılıç, Behçet 2006). Bilhassa son 30 yıllık süreçte başta teknolojik gelişmelerin, aşırı yakıt tüketimi ve nüfus artışının da tetiklemesiyle atmosfere sera gazları salınımın da bir artış söz konusudur (Akın 2006).

İnsan, yaşamı boyunca farklı olaylarla karşılaşır. Öğrencilere okulda yaşamları boyunca ihtiyaç duyabilecekleri her şeyi öğretmenin mümkün olamayabileceği düşünülebilir. Öğretilenlerden bir kısmının da kısa zamanda geçerliğini kaybetmesi mümkün olabilmektedir. Bu sebeple öğrencilere ihtiyaç duyabilecekleri temel becerileri kazandırarak hayata hazırlanmalarına katkıda bulunmanın iyi bir tercih olabileceği (Yanpar, 2009) ifade edilmektedir. Öğrencilere kanıt kullanmayı öğreterek işe başlanabilir. Öğrencilerin kanıtlardan yararlanarak karşılaştıkları olayları yorumlamaları, doğru bilgiye ulaşmaları mümkün olabilir (Sağlam, Bilgiç, 2018). Diğer

taraftan Acar (2013), öğrencilerin çoğunlukla kanıt kullanma becerisinin akademik başarılarına etkisi olduğuna inandıklarını, kanıta dayalı derslerin daha kalıcı öğrenmeler sağladığını ve öğrencilerin başarılarını artırdığını belirlemiştir. Cooper ve Dilek (2004) ilköğretim öğrencilerinin tarih derslerinde düşünmeleri ile ilişkili olarak öğrencilerin birincil kaynaklardan yararlanıldığında, onların motivasyonlarının, meraklarının ve yaratıcılıklarının arttığı sonucuna ulaşmışlardır.

1.1 Araştırmanın Önemi

Çevre eğitimine katkı sağlamak amacıyla yapılan araştırmalarda ülkemizde Okul öncesi, İlköğretim ve Orta öğretim programı içerisinde ele alınan çevre konularının çevre bilincini geliştirme açısından yeterli olmadığı belirtilmektedir (Ünal vd. 1999, Şimşekli 2004). Yapılacak bu araştırma bu yönü ile değerlendirildiğinde özellikle erken yaşlardan itibaren öğrencilerde sağlıklı bir yaşam için çoğu öldürücü olan sessiz kirleticilere karşı öğrencilerde sistemli bir duyarlılık oluşturabilecektir.

1.2 Çalışmanın Amacı

Bu çalışmada, sessiz kirletici olarak adlandırılan hava kirliliği hakkında 5.sınıf ortaokul öğrencilerinin bilinçlendirilmesi hedeflenmiştir. Bunun iki önemli nedeni bulunmaktadır. Bunlardan birincisi küçük yaştaki çocukların hava kirliliğinden daha olumsuz etkilenmeleri diğeri ise, küçük yaşta elde edilen hava kirliliği ve çevre bilincine dönük duyarlılığın gelecekteki yaşamında da pozitif bir etkiye sahip olacağı inancıdır. Diğer taraftan MEB Sosyal Bilgiler öğretim programında, çevre okuryazarlığı ortaokul öğrencilerinde geliştirilmesi gereken temel beceriler arasında yer almaktadır. Ayrıca, 5.Sınıf sosyal bilgiler kazanımları arasında, "SB.5.3.4. Yaşadığı çevredeki afetlerin ve çevre sorunlarının oluşum nedenlerini sorgular." kazanımı yer almaktadır. Bu çerçevede sosyal bilgiler dersi kapsamında konferans, eğitsel oyun ve drama teknikleri ile öğrencilerin sessiz kirletici olarak adlandırılan hava kirliliğine karşı bilinci artırılmak istenmiştir.

Kanıt temelli öğrenme yaklaşımı ile sesiz kirleticilerin öğretimi bu çalışmanın özünü oluşturmaktadır. Çalışma konusu olan sessiz kirleticiler insan ve diğer canlıların yaşamlarını tehdit ettiğinden dolayı da projeyi daha dikkat çekici hale getirmek için proje başlığı "Yaşamak istiyoruz. Sessiz kirleticilerin elinden bir kurtulabilirsek!" şeklinde adlandırılmıştır.

Bu kapsamda aşağıdaki sorulara cevap aranmıştır.

1) Kanıt temelli öğrenme yaklaşımı ile yapılan "sessiz kirletici" öğretiminin öğrencilerin akademik başarı ön ve son testlerinde anlamlı bir fark oluşturmuş mudur?

2) Kanıt temelli öğrenme yaklaşımı ile oluşturulan sessiz kirletici etkinlikleri ile ilgili olarak öğrencilerin görüşleri nelerdir?

YÖNTEM

Araştırmanın modeli:

Bu çalışmada, Araştırmada nicel ve nitel araştırma yöntemlerinin bir arada değerlendirildiği karma model kullanılmıştır. Nitel ve nicel olarak her iki araştırma yönteminin kullanıldığı çalışma sonucunda daha çok veri çeşitlemesi elde edilmiştir. Çeşitleme (triangulation) farklı veri toplama ve analiz yöntemleri kullanarak araştırma sonuçlarının inandırıcılığını arttırmaya yönelik çabaların bütünüdür (Yıldırım, A., Şimşek, H. (2006).

Projenin Çalışma Grubu:

Projenin çalışma grubunu Rize'de bir devlet okulunda öğrenim gören 19 kişilik 5.sınıf öğrencileri oluşturacaktır. Velilerden gerekli iznin alındığı ve MEB'den alındığı çalışmada araştırma grubu için öğrenci seçiminde amaçlı örneklem olarak belirlenmiştir. Amaçlı örneklem analitik çalışmalar için uygun bir grubudur (Yin, 1984; aktaran: Yıldırım, Şimşek, 1999).

Araştırmanın Uygulama Aşamaları:

Araştırma Millî Eğitim Bakanlığı ve Okul Müdürlüğü'nden alınan izne bağlı olarak sınıf içi ve sınıf dışı

etkinliklerle gerçekleştirilmiştir. Araştırma kapsamında yapılan uygulamalar aşağıda belirtilmiştir.

1)Tanışma ve öğrencilere uygulama aşamaları, çalışma yaprakları ve öğrenci günlüklerinin tutulması ile ilgili bilgiler

2) Sessiz kirletici başarı testi ön test uygulaması

3) Sessiz kirletici olarak adlandırılan hava kirliliğinin insan hayatına dönük etkileri konusunda öğrencilere konferans verildi.

4) Sessiz kirleticiler ile ilgili drama çalışması fakültemiz drama öğretim elemanının önderliğinde gerçekleştirilecektir. Öğrencilerin gözlemlediği sessiz kirletici olaylarından hareket edilerek drama gerçekleştirildi.

5) Kanıt temelli öğrenmeye dönük sesiz kirleticileri içeren eğitsel oyunlar oynatıldı

7) Kanıt temelli öğrenim bağlamında gazete ve internet haberlerinden yola çıkılarak sınıf bülten tahtası hazırlandı.

6) Sessiz kirletici başarı son testinin uygulaması yapıldı

7) Son olarak öğrencilerle sessiz kirleticilere yönelik yapılan etkinliklerle ilgili öğrencilerin görüşleri alındı

Verilerin Toplanması:

Araştırmada elde edilecek veriler, öğrenci günlükleri, öntest ve sontest sessiz kirleticiler başarı testi ve yarı yapılandırılmış mülakat sorularından elde edilmiştir.

SORULAR**:**

1.Sessiz kirleticilerin insan sağlığı üzerine etkileri hakkında ne düşünüyorsunuz?

2.Sessiz kirleticilerin tehlikelerini önlemek için neler yapılabilir?

3) Sessiz kirleticiler ile ilgili verilen konferansın üzerinizdeki etkisi nasıldır?

4) Sessiz kirleticiler ile ilgili gerçekleştirilen eğitsel oyunların üzerinizdeki etkisi nasıldır?

5)Sessiz kirleticiler ile ilgili gerçekleştirilen drama etkinliklerinin üzerinizdeki etkisi nasıldır?

6) Daha yaşanabilir bir dünya için sessiz kirleticiler farkındalığı kazanmanın önem hakkında ne düşünüyorsunuz?

7) Biz gençler sessiz kirleticilerin tehlikelerine karşı neler yapabiliriz?

Veri Analizi:

Bu çalışma, karma desenli olduğu için hem nicel hem de nitel yöntem ve teknikleri göz önüne alınarak analiz edilmiştir. Nicel olarak deneme modellerinden "çalışmada tek grup ön test-son test, kontrol grupsuz deney deseni kullanılmıştır. Bu desende deneysel işlemler tek bir grup üzerinde yapılan çalışmalar üzerinden test edilir. Çalışma grubundakilerin bağımsız değişkene yönelik ölçümleri uygulanacak olan programın öncesinde ön test ve sonrasında da son test olarak aynı kişilere aynı ölçme araçları kullanılarak elde edilir (Aslan, 2018). Kanıt temelli öğrenme yaklaşım çerçevesinde "sessiz kirleticiler ile ilgili oluşturulmuş etkinlikler ile ilgili yarı yapılandırılmış görüşme soruları öğrencilere sorulmuştur. Bunlar tema ve kodlar oluşturularak analiz edilecektir. Öğrenci günlükleri ve çalışma yaprakları doküman incelemesi yolu ile analiz edilmiştir. Öğrencilerden alınan görüşler ise kod ve temalar ışığında nitel olarak içerik analizine tabi tutulmuştur. Nitel verilerin analizinde

Miles & Huberman (1994) güvenirlik formülü (Güvenirlik = Görüş Birliği / (Görüş Birliği + Görüş Ayrılığı) kullanılmıştır.

2.1 Çalışma Grubu:

Araştırmamızın Çalışma grubunu; Rize Çayeli'nde bir okulda görev yapan 20 öğrenci oluşturmaktadır. Çalışma grubu seçiminde kolay ulaşabilirlik ön planda tutulmuştur.

Bulgular ve Yorum

İlk olarak sürdürülebilir kalkınma bağlamında yapılan etkinliklerin çevre okuryazarlığı artırıp artırılmadığına bakılmıştır**.** Bunun içinde öğrencilere Sessiz kirletici başarı testi uygulaması ön test ve son test uygulamaları yapılmıştır. Yapılan istatistik sonucuna göre ön testin aritmetik ortalamasının X=11,473 son testin aritmetik ortalamasının ise X= testin aritmetik saptanmıştır. Öntest- sontest puan ortalamaları arasında anlamlı bir farkın olup olmadığı Wilcoxon işaretli sıralar testi ile analiz edilmiş, Sonuçlar Tablo 1'de verilmiştir. Katılımcıların öntest - sontest puanları arasında anlamlı bir farklılaşma olduğu bulunmuştur (z=,-2,804 p<.05). Katılımcıların yani öğrencilerin sessiz kirleticilere dönük etkinliklerden memnun olduğu böylelikle anlaşılmıştır.

Tablo 1: Sessiz kirletici başarı testi uygulama

	N	X	Ss	
Ön test	19	11,473	3,564	
Son test	19	15.578	3,834	

	Sıra işaretleri	Sıra ortalaması	Sıra toplamı	Z	p
Başarı	Negatif sıra	6,38	25,50	-2,804	,005
	Pozitif sıra	10,97	164,50		
	Eşit	0			

2. alt problemde uygulamalar nitel veri yolu ile ele alınmıştır.

Öğrencilerin nitel bulgularına yönelik vermiş olduğu cevaplar şunlardır. Öğrencilere ilk olarak sorulan "Sessiz kirleticilerin insan sağlığı üzerine etkileri hakkında ne düşünüyorsunuz? sorusuna verdiği cevaplar değerlendirildiğinde (Tablo 2), insan sağlığı teması altında, 8 kategori oluşturulmuştur. Bu kategoriler, Zarar verir 4; Hasta olur 4; Akciğer rahatsızlığı 2; Sessizce vücudu kirletir 1; Etki yapmaz 3; Kötü olur 3; Kulaklarımıza iyi gelir 1; İnsanları öldürür 1 biçiminde olup en fazla zarar verir ve hasta olur kategorisinde gerçekleşmiştir.

Tablo 2: Sessiz kirleticilerin insan sağlığı üzerine etkileri hakkında ne düşünüyorsunuz? Sorularına öğrencilerin verdiği cevaplar

Tema	Kategoriler	f	Öğrenciler
İnsan sağlığı	Zarar verir	4	(Ö1), (Ö9), (Ö10), (Ö17)
	Hasta olur	4	(Ö3), (Ö11), (Ö12), (Ö14)
	Akciğer rahatsızlığı	2	(Ö5), (Ö6)
	Sessizce vücudu kirletir	1	(Ö7)
	Etki yapmaz	3	(Ö2), (Ö4), (Ö8)
	Kötü olur	3	(Ö13), (Ö16), (Ö18)
	Kulaklarımıza iyi gelir	1	(Ö15)
	İnsanları öldürür	1	(Ö19)

Öğrenci cevaplarından örnekler.

İnsanlar üzerinde hiçbir etki yapmaz Ö2.
İnsanlığı üzerinde kötü olacağını düşünüyorum Ö18.
İnsanları öldürür Ö19.

"Sessiz kirleticilerin tehlikelerini önlemek için neler yapılabilir? Sorusuna öğrencilerin verdiği cevaplar?" Sorusuna öğrencilerin verdiği cevaplar irdelendiğinde (Tablo 3), tehlike için önlem temasında 12 kategori oluşturmuşlardır. Bunlar içinde en fazla frekansın olduğu kategoriler toplu taşıma (3) ve fabrika bacalarına filtre takma (4) ve dikkatli olunmalı (3) kategorileridir.
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Tablo 3. Sessiz kirleticilerin tehlikelerini önlemek için neler yapılabilir? Sorusuna öğrencilerin verdiği cevaplar

Tema	Kategoriler	f	Öğrenci cevapları
	Afiş asılmalı	2	(Ö19), (Ö2)

Tehlike için önlem	Yerdeki çöp alınmalı	1	(Ö18)
	Toplu taşıma kullanımı	3	(Ö17), (Ö3), (Ö5)
	Sesli olması sağlanmalı	1	(Ö16)
	Fabrika bacalarına filtre	4	(Ö14), (Ö6), (Ö5), (Ö16)
	Ateşte yakılmalı	1	(Ö15)
	Fikri olmayan	1	(Ö13)
	Dikkatli olmalı	3	(Ö12), (Ö9), (Ö1)
	Eğitim yapılmalı	1	(Ö11)
	Kirlilik azaltılmalı	1	(Ö10)
	Sessiz kirleticiler dünyadan atılmalı	1	(Ö8)
	Onları Uyarmalıyız	2	(Ö7), (Ö2)

Öğrenci cevaplarından örnekler

Kendisini sessiz kirleticilerden koruması için çaba sarf etmeli (Ö5).
Toplu taşıma araçları kullanılmalı (Ö2).
Bu konuda insanları eğitmeliyiz (Ö10).

"Sessiz kirleticiler ile ilgili verilen konferansın üzerinizdeki etkisi nasıldır?" sorusuna öğrencilerin verdiği cevaplar irdelendiğinde (Tablo 4) Bu temada öğrencilerin konferansı ileri düzeyde etkili bulduğu kategorisinde (10) yoğunlaştığı görülmektedir. Tek bir öğrenci ise iyi bulmadığını beyan etmiştir.

Tablo 4. "Sessiz kirleticiler ile ilgili verilen konferansın üzerinizdeki etkisi nasıldır?" sorusuna öğrencilerin verdiği cevaplar

Tema	**Kategoriler**	**f**	**Öğrenci cevapları**
Konferansın etkisi	**Orta düzeyde**	4	(Ö1), (Ö2), (Ö4), (Ö19)
	İleri düzeyde	10	(Ö3), (Ö8), (Ö9), (Ö11), (Ö13), (Ö14), (Ö16), (Ö18), (Ö5), (Ö6), (Ö7)
	Çok iyi bulmadım	1	(Ö10)
	Yorum yok	3	(Ö12), (Ö15), (Ö18)

Öğrenci cevaplarından örnekler

Sessiz kirleticiler ile ilgili iyi şeyler öğrendim. Ö8.
Konferansı iyi anlayamadım çıkar Ö10.
Kirleticiler ile ilgili kapsamlı bilgi edindim. Ö18.

"Sessiz kirleticiler ile ilgili gerçekleştirilen eğitsel oyunların üzerinizdeki etkisi nasıldır? sorusuna öğrencilerin verdiği cevaplar irdelendiğinde (Tablo 5) öğrencilerin yarıdan fazlası çok etkileyici olarak eğitsel oyunları (10) değerlendirmişler. Buna karşılık 5 öğrenci ise herhangi bir yorum yapmamayı tercih etmişlerdir. Buna karşılık 5 öğrencide herhangi bir yorumda bulunmamıştır.

Tablo 5. Sessiz kirleticiler ile ilgili gerçekleştirilen eğitsel oyunların üzerinizdeki etkisi nasıldır? Sorusuna öğrencilerin verdiği cevaplar

Tema	**Kategoriler**	**f**	**Öğrenci cevapları**
Eğitsel oyunun etkisi	Sessiz kirleticileri kavrama	1	(Ö19)
	Yorum yok	5	(Ö12), (Ö15), (Ö16), (Ö18), (Ö3)
	Çok etkileyici	10	(Ö13), (Ö14), (Ö15),(Ö10), (Ö9), (Ö8), (Ö4), (Ö6),(Ö5),(Ö1)
	Normal düzeyde	1	(Ö5),
	Anlamadım	2	(Ö4), (Ö2)

Öğrenci cevaplarından örnekler

Çok güzel ve öğretici idi Ö8

Üzerimde eğitim için bir etki yapmadı. Ö4

Eğitsel oyunların etkileyici yönü vardı. Ö14.

"Sessiz kirleticiler ile ilgili gerçekleştirilen drama etkinliklerinin üzerinizdeki etkisi nasıldır? "Sorusuna öğrencilerin verdiği cevaplar irdelendiğinde (Tablo 6). En fazla çok etkileyici kategorisine öğrencilerin yoğunlaştığı (10) görülmektedir. Anlamadım kategorisinde ise sadece 1 öğrenci bulunmaktadır.

Tablo 6. "Sessiz kirleticiler ile ilgili gerçekleştirilen drama etkinliklerinin üzerinizdeki etkisi nasıldır?" Sorusuna öğrencilerin verdiği cevaplar

Tema	**Kategoriler**	**f**	**Öğrenci cevapları**
Dramanın etkisi	Sesiz kirleticileri kavrama	3	(Ö19), (Ö18), (Ö12)
	Yorum yok	2	(Ö15), (Ö16),)
	Çok etkileyici	10	(Ö13), (Ö14), (Ö15),(Ö10), (Ö9), (Ö8), (Ö4), (Ö6),(Ö5),(Ö1), (Ö3)
	Normal düzeyde	2	(Ö5), (Ö2)
	Anlamadım	1	(Ö4),

Öğrenci cevaplarından örnekler

Kavrama kolaylığı sağladı. Ö12

Drama ile iyi bir eğitim gerçekleştirdik Ö5 .

Yıl içerisinde tasarruf yapabiliriz Ö4.

"Daha yaşanabilir bir dünya için sessiz kirleticiler farkındalığı kazanmanın önem hakkında ne düşünüyorsunuz? Sorusuna öğrencilerin verdiği cevaplar incelendiğinde"

Tablo 7. "Daha yaşanabilir bir dünya için sessiz kirleticiler farkındalığı kazanmanın önem hakkında ne düşünüyorsunuz?" Sorusuna öğrencilerin verdiği cevaplar incelendiğinde öğrencilerin hayatı bilinçli yaşama kategorisine yoğunlaştığı (10) görülmektedir. Bu kapsamda dikkat çeken diğer kapsam ise önlem alma (5) kategorisidir.

Tablo 7. "Daha yaşanabilir bir dünya için sessiz kirleticiler farkındalığı kazanmanın önem hakkında ne düşünüyorsunuz?" Sorusuna öğrencilerin verdiği cevaplar

Tema	**Kategoriler**	**f**	**Öğrenci cevapları**
farkındalık	Önlem almada etkili	5	(Ö13), (Ö6), (Ö7), (Ö11), (Ö2)
	Hayatı bilinçli yaşama	10	(Ö10), (Ö17), (Ö8), (Ö9), (Ö5), (Ö18), (Ö16). (Ö3), (Ö1), (Ö4)
	Fikri yok	2	(Ö19),(Ö15)
	Gereksiz	1	(Ö14)

Bu kapsamda öğrencilerin verdiği cevaplardan örnekler şunlardır.

Sessiz kirleticileri doğaya salmayın bırakın yaşayalım (Ö17).
Bir fikir oluşturamadım (Ö19).
Yaşamak için önlem almada etkilidir (Ö13).

Bu kapsamda öğrencilere sorulan son soru ise "Biz gençler sessiz kirleticilerin tehlikelerine karşı neler yapabiliriz?" sorusudur. Bu sorunun cevabı incelendiğinde (Tablo 8) sessiz kirleticilere karşı önlem alma (7) ilk sırada olmuştur. İkinci sırada ise kirliliği azaltma (3) ve çevreyi (3) koruma bulunmaktadır.

Tablo 8. "Biz gençler sessiz kirleticilerin tehlikelerine karşı neler yapabiliriz?" Sorusuna öğrencilerin verdiği cevaplar

Tema	**Kategoriler**	**f**	**Öğrenci cevapları**
Neler yapılmalı?	Çevreyi koruma	3	(Ö18), (Ö15), (Ö11)
	Kirletenleri uyarma	3	(Ö19), (Ö1), (Ö7)
	Önlem alma	7	(Ö2), (Ö3), (Ö16), (Ö9), (Ö8), (Ö14), (Ö13)
	Azaltma	3	(Ö4), (Ö10), (Ö19)
	Fikrim yok	4	(Ö5), (Ö6), (Ö12), (Ö18),
	Mücadele	1	(Ö17)

Öğrenci cevaplarından örnekler

Bilinçli kullanım yapalım Ö12.

Petrol, nükleer enerji, gibi şeylerin yerine doğaya zarar vermeyecek şeyleri kullanalım Ö2 .

Yıl içerisinde tasarruf yapabiliriz Ö4.

TARTIŞMA VE SONUÇ

"Yaşamak istiyoruz. Sessiz kirleticilerin elinden bir kurtulabilirsek!" adlı bu çalışma alın yazın tarandığında eğitim dünyasında sessiz kirleticiler adında ilk çalışma olması ile oldukça özgün bir çalışmadır. Zira sessiz kirleticiler hava kirliliğini temel olarak alsa da bilim dünyasında hava kirliliğinden daha öte bir kavramı içine almaktadır. Burada sessiz kirletici olarak kullanılmasındaki temel nokta insan sağlığına olan zararı sinsi bir şekilde gerçekleştirmesidir. Yavuz, (2020) sessiz kirleticileri aynı zamanda sessiz katil olarak nitelendirerek hava kirliğinin günümüzde en fazla halk sağlığını tehdit eden unsurlardan biri olduğunu ortaya koymuştur.

Garson 'un 1962 de ele aldığı "sessiz bahar" adlı kitabında aslında eğitim dünyasına dönük mesajlar verilmesine karşın bu mesaj eğitim dünyasında yeterince yer edinememiştir. Bu çalışma kirliliğin boyutlarını öğrencilere çarpıcı bir şekilde verilmiş olup başarı testinde ve öğrenci görüşlerinde önemli bir bilinçlilik gösterdiği görülmektedir. Özdağ (2011), çevre sağlık konusunda dikkat çekerken çevreci eleştirilerin iyi anlaşılabilmesi gerektiğini belirtmektedir.

Konu hava kirliği bağlamında düşünüldüğünde bu çalışma hava kirliliği konusunda eğitim ile ilgili yapılan çalışmalar ile de önemli ölçüde paralellik göstermektedir. Bu çalışmada olduğu gibi Yalçınkaya (2012), öğrencilerin büyük bir kısmı (%70) hava kirliliğini ciddi bir sorun olarak görmektedir.

Kanıt temelli yaklaşım yöntemi ile ortaya konan bu araştırma raporu öğrencilerde etkili bilgi dağarcığı geliştirme yanında daha da önemlisi öğrenci zihninde güçlü bir farkındalık geliştirilmesinde büyük bir yarar sağlamıştır.

Öneriler:

1. Sessiz kirleticilere dönük uygulamalarda öğrenci memnuniyeti yüksektir. Bu tür etkinlikleri ilkokul öğretimine ve lise öğretiminde de yapılması bilinçlendirme açısından faydalı olacaktır.

Sessiz kirleticiler ile ilgili etkinlikleri kanıt temelli olarak alınmıştır. Daha farklı etkinlikler de denenebilir

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Sosyal Bilgiler Öğretmen ve Sosyal Bilgiler Öğretmen Adaylarının Dijital Yetkinlikler İle İlgili Görüşleri

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Özet

Çağın teknolojik yapı ve gelişim ve değişiminde önemli bir öğe olarak dijital yetkin insanlara daha çok ihtiyaç hissedilecektir. Bu çalışmada dijital yetkinlik sosyal bilgiler öğretmenleri ve öğretmen adayları tarafından nasıl anlamlandırıldığı ve nasıl değerlendirildiği çalışmanın özlerini oluşturmaktadır. Bu kapsamda dijital yetkinliklerin nasıl öğretilmesi gerektiği, öğretim sürecinde karşılaşılabilecek sorunlar ve çözüm önerileri araştırmada yer almıştır. Sosyal Bilgileri öğretmen ve sosyal bilgiler öğretmen adaylarının dijital yetkinlikleri ile ilgili görüşlerinin alındığı bu çalışma nitel bir araştırma olarak tasarlanan olgu bilimsel bir çalışmadır. Olgu bilim çalışmaları, farkında olunan ancak ayrıntılı ve derinlemesine bilgi sahibi olmadığımız olgular dikkat çeken çalışmalardır. Bu olgular, tamamı ile yabancı olmadığımız ve aynı zamanda tam olarak kavrayamadığımız olgulardır Bu araştırmanın çalışma grubunu oluşturan öğretmenleri ve öğretmen adayları oluşturmaktadır. Çalışma grubunu oluşturan öğretmen ve öğretmen adayları kolay ulaşabilir şekilde Rize de görev yapan öğretmenler ve Recep Tayyip Erdoğan Üniversitesi Eğitim Fakültesi sosyal bilgiler öğretmen adaylarından oluşmuştur. Çalışmaya 10 sosyal bilgiler öğretmeni 10 da sosyal bilgiler öğretmen adayı katılacaktır. Veriler yarı yapılandırılmış görüşme formu hazırlanıp uzman görüşü desteği ve pilot uygulama sonrasında hazırlanmıştır. Verilerin analizinde veri toplama için hazırlanan yarı yapılandırılmış görüşme formu nitel araştırma kuram ve ilkelerin göre analiz edilmiş bu kapsamda görüşme formunda verilen cevaplardan yola çıkarak, geçerlik ve güvenirliğe dikkat edilerek tema ve kodlar oluşturularak veriler analiz edilerek bulgular yorumlanmıştır. Araştırma sonuçları öğretmen ve öğretmen adaylarının genel olarak dijital yetkinlik konusunda gerekli bilgi ve donanıma sahip olduklarını göstermiştir.

Anahtar Sözcükler: Sosyal bilgiler, dijital yetkinlik, 21.yüzyıl, teknoloji

Abstract

As a key element in the technological structure, development, and change of our age, the need for digitally competent individuals will increase. This study focuses on how social studies teachers and prospective teachers interpret and evaluate digital competence. In this context, the research examines how digital competence should be taught, potential problems encountered in the teaching process, and proposed solutions. This study, designed as a qualitative research, seeks the opinions of social studies teachers and prospective social studies teachers regarding their digital competence. Phenomenological studies are studies that draw attention to phenomena we are aware of but lack detailed and in-depth knowledge about. These phenomena are not entirely unfamiliar to us, and at the same time, they are not fully comprehended. The study group consists of teachers and prospective teachers. The study group consisted of teachers working in Rize and prospective social studies teachers from the Faculty of Education at Recep Tayyip Erdoğan University, within easy reach. Ten social studies teachers and ten prospective social studies teachers will participate in the study. The data were compiled using a semi-structured interview form, expert opinion support, and a pilot application. In the data analysis, the semi-structured interview form prepared for data collection was analyzed according to qualitative research theories and principles. Based on the answers provided in the interview form, themes and codes were created, paying attention to validity and reliability. The data were analyzed and the findings were interpreted. The research results showed that teachers and prospective teachers generally possess the necessary knowledge and skills regarding digital competence.

Keywords: Social studies, digital competence, 21st century, technology

Giriş

Çağımızda teknolojinin çok hızlı geliştiği ve toplum hayatını birçok yönden etkilediği inkâr edilemez bir gerçektir. Teknolojinin toplumsal yaşama girmesi ile birlikte toplumlar bir taraftan teknolojinin nimetlerinden faydalanırken diğer taraftan bu fayda daha etkili bir şekilde kullanmak için yoğun bir çaba içine girmektedir. Bundan dolayı dijital yetkinliğin önemi günümüzde giderek artmaktadır. Günümüz dünyasında toplumlar, insanlar bilgiye bilgisayar, internet ve çoğu kez bunların bileşimini barındıran mobil kaynakları kullanarak bilgiye ulaşmaktadır. Global Dijital Raporu'na (2020), bütün dünyada 4,54 milyar insan internet kullanmakta 3.80 milyar insan sosyal

medyayı kullanmakta ve 5.19 milyar insan da cep telefonuna sahip durumdadır (Fundalina, 2020).Kişiden kişiye değişmekle birlikte insanlarımız günün önemli bir bölümünü internete bağlı veya onu kullanarak geçirmektedir.

Kelime anlamı olarak yetkinlik Türk Dil Sözlüğü'ne göre (2021) "Yetkin olma durumu, olgunluk, kemal, mükemmeliyet" olarak tanımlanmaktadır. Günümüz dijital çağı yaşadığından dolayı dijital yetkinlik kavramının da bilim dünyası literatürüne girmesi kaçınılmaz olmuştur. (Kurudayıoğlu ,Soysal 2020). Durum böyle olunca "dijital yeterlilik bağlamında insanların ne tür yetkinliklerinin olması gerektiğini araştırmak kaçınılmaz olmuştur. (Ilomäki, L., Kantosalo, A., & Lakkala, M., 2011). Çünkü teknolojinin gittikçe artan bir hız ile gelişmesi, insanların da bu konu belli bir beceriye sahip olmasını zorunlu hale getirmiştir. Diğer taraftan günümüz çağına ayak uydurmak isteyen insanlar 21. Yüzyıl becerileri ile kendilerini donatmak zorundadır. Bu kapsamda düşünüldüğünde dijital yetkinlik toplum içinde varlık olarak kendini göstermek isteyen insanların temel ihtiyaçlarından biri durumundadır.

Avrupa Parlamentosu Konseyi dijital yetkinliği tanımlarken oldukça geniş bir yelpazede toplum ve kişiler arası ilişkileri göz önüne alarak geniş bir yelpazede tanımlamaya çalışmıştır. European Council, 2006). Avrupa Birliği'nin dijital yetkinliğe verdiği önem sonucunda Avrupa dijital yetkinlik çerçevesinin oluşmasına ortam hazırlamıştır. Avrupa Birliği'nin dijital yetkinlik kavramına verdiği önemi DigComp 2.0 adıyla açıklıkla görülebilmektedir. 2017 yılında DigComp 2.1 adıyla yeniden güncellenme yeniden yapılmıştır (European Commission, 2017). Avrupa Birliğinin dijital yetkinlik ile ilgili kararları Türkiye'de de yankısını kısa sürede hissettirmiştir. Zaman içerisinde Türkiye'de dijital yetkinlik düşüncelerine olumlu baktığını çeşitli platformlarda dile getirmiştir. Böylelikle Digital yetkinlik MEB öğretim programlarına da dahil edilmiştir. Böylece dijital yetkinlik sosyal bilgiler öğretim programında da yer almıştır (Bilasa, Taşpınar,2017; MEB 2018).

2018 Sosyal Bilgiler Programı (1, 2, 3, 4, 5, 6, 7 ve 8. Sınıflar) incelendiğinde görülmektedir ki programın Avrupa Yeterlilikler Çerçevesi (AYÇ) dikkate alınarak Türkiye Yeterlilikler Çerçevesi 'ne (TYÇ) göre planlanıp hazırlandığı ortaya çıkmaktadır. Türkiye Yeterlilikler Çerçevesi'nde sekiz anahtar yetkinlik bulunmaktadır, Bunlar aşağıda belirtilmiştir.

1.Ana Dilde Öğretim

2. Yabancı Dillerde Öğretim

3. Matematiksel Yetkinlik ve Bilim/Teknolojide Temel Yetkinlikler

4. Dijital Yetkinlik

5. Öğrenmeyi Öğrenme

6. Sosyal ve Vatandaşlıkla ilgili Yetkinlikler

7. İnsiyatif Alma ve Girişimcilik

8. Kültürel Farkındalık ve ifade (MEB, 2018, s. 4-5).

Burada görüldüğü gibi dijital yetkinlik TYÇ'de de yer almaktadır. Bu durum MEB 2018 programında şu ifadeler ile belirtilmiştir. "Eğitim sistemimiz yetkinliklerde bütünleşmiş bilgi, beceri ve davranışlara sahip karakterde bireyler yetiştirmeyi amaçlar. Öğrencilerin hem ulusal hem de uluslararası düzeyde; kişisel, sosyal, akademik ve iş hayatlarında ihtiyaç duyacakları beceri yelpazeleri olan yetkinlikler Türkiye Yeterlilikler Çerçevesi'nde (TYÇ) belirlenmiştir".

Dijital yetkinliğin önemli bir faydası öğrencilere teknolojiyi verimli bir şekilde kullanmasını öğretmesidir. Diğer taraftan eğitim dünyasında fırsat eşitliği yaratmasında önemli bir etkiye sahiptir. Dijital yetkinliğin eğitim dünyasında böyle şekilde bir yer edinmesi programda yer alacak kazanımların kazandırılması dijital yetkinler göz önüne alınarak yapılması gerekir (Kurudayıoğlu, Soysal 2020).Buradan hareketle sosyal bilgiler öğretmen adaylarının dijital yetkinliklerinin iyi olması onların sosyal bilgiler öğretimine etkisini ve katkısını artıracaktır. Sosyal Bilgiler bireylere, toplumun değerlerini benimsetmek amacıyla hak ve özgürlükler ve temel vatandaşlık bilgilerinin farklı sosyal bilim disiplinleri ile öğrencilere sunulduğu bir ilkokul ve ortaokul dersi olarak tanımlanabilir (Keskin Yazar,2015; Turan, Avcı:2018). sosyal bilgiler dersi etkin vatandaş yetiştirmeyi amaçlamakta olup çağın gelişim sürecine ayak uydurabilen öğrenciler yetiştirebilmek için öğrencilerin dijital teknolojilerden haberdar olması ve öğretmenlerin de dijital teknolojiyi rahatlıkla kullanabilmeleri gerekir (Yeşiltaş ve Sönmez, 2009). Sosyal bilgiler dersi öğretim programları dikkate alındığında teknoloji ve teknolojiye ilişkin beceriler ilk kez 2005 sosyal bilgiler dersi öğretim programında yer tutmuş, 2018 yılında beceri, kavram ve yetkinlikler güncellenmiştir. (Yeşiltaş Gez,2020).

Teknolojik anlamda yaşanan gelişmeler insanların dijital anlamda kendilerini geliştirmelerine zorunlu kılmaktadır. Bu da insanların dijital yetkinliklerinin yeniliklere açık bir şekilde kendilerini geliştirmelerine bağlıdır (Canbek Sağıroğlu 2007; Akkoyunlu ve Soylu, 2010;Işık 2011).

"Dijital Yetkinlik" konusunun tüm derslerde verilmesi gerekli önemli bir yetkinlik olduğu günümüzdeki teknolojik gelişimler dikkate alındığında açıkça ortaya çıkmaktadır (Ekmen, Bakar,2018;Erişen vd 2018). bir diğer önemli nokta da toplumsal yaşamı oldukça fazla bir şekilde etkileyen dijital teknolojilerin sürekli değişim ve gelişme göstermesi dijital anlamda etkinliklerin de değişmesini zorunlu hale getirmektedir (Bayrakçı,2020) Bu bağlamda çağın teknolojik yapı ve gelişim ve değişiminde önemli bir öğe olarak dijital yetkin insanlara daha çok ihtiyaç hissedilecektir. Bu çalışmada dijital yetkinlik sosyal bilgiler öğretmenleri ve öğretmen adayları tarafından nasıl anlamlandırıldığı ve nasıl değerlendirildiği çalışmanın özlerini oluşturmaktadır. Bu kapsamda dijital yetkinliklerin nasıl öğretilmesi gerektiği, öğretim sürecinde karşılaşılabilecek sorunlar ve çözüm önerileri araştırmada yer almıştır.

Araştırma sorusu: Sosyal Bilgiler öğretmen ve öğretmen adaylarının dijital yetkinlikler ile ilgili görüşleri neler olduğu bu araştırmamızın temel sorudur.

1.2 Araştırmanın Önemi

Literatür incelendiğinde çevre ile ilgili öğrenci, davranış ve düşüncelerinin buna ilaveten geri dönüşümle ilgili yapılan çalışmaların daha çok ortaokulların normal eğitim kademelerinde çalışıldığı görülmektedir. Bu bağlamda yapılan bu çalışma ortaokul öğrencilerinin çevreye ve geri dönüşüme bakış açısını belirleme açısından literatüre önemli katkılar sağlayacağı düşünülmektedir. Öğrencilerin geri dönüşümle ilgili çevreye duyarlı bir birey olmaları ve farkındalık yaratmaları amaçlanmıştır.

1.3 Çalışmanın Amacı

Bu araştırmada 21 yüzyıl becerileri kazandırma çerçevesinde Millî Eğitim Bakanlığınca benimsenen 10 yetkinlikten biri olan dijital yetkinlikle ilgili sosyal bilgiler öğretmeni ve sosyal bilgiler öğretmen adaylarının görüşlerinin öğrenilmesi çalışmamızın ana konusunu oluşturmaktadır. Bu kapsamda aşağıdaki sorulara cevap aranmıştır.

1. Dijital yetkinlik deyince ne anlıyorsunuz
2. Digital yetkinliğin insanlar için önemi hakkında ne düşünüyorsunuz
3. Dijital yetkinliğin sosyal bilgiler eğitiminde öğrenciler açısından önemi hakkında ne düşünüyorsunuz
4. Dijital yetkinliğin sosyal bilgiler eğitiminde öğretmenler açısından önemi hakkında ne düşünüyorsunuz
5. Dijital yetkinlik okul içi ortamlarda nasıl öğrenilmelidir?
6. Dijital yetkinlik okul dışı ortamlarda nasıl öğrenilmelidir?
7. Dijital yetkinlikte sosyal bilgiler öğretmenlerinin karşılaşacağı sorunlar nelerdir?
8. Dijital yetkinlikte karşılaşılan sorunlara dönük ne tür çözüm önerileri getirebilirsiniz.

Yöntem

2.1Araştırma Deseni

Sosyal Bilgileri öğretmen ve sosyal bilgiler öğretmen adaylarının dijital yetkinlikleri ile ilgili görüşlerinin alındığı bu çalışma nitel bir araştırma olarak tasarlanan olgu bilimsel bir çalışmadır. Olgu bilim çalışmaları, farkında olunan ancak ayrıntılı ve derinlemesine bilgi sahibi olmadığımız olgular dikkat çeken çalışmalardır. Bu olgular, tamamı ile yabancı olmadığımız ve aynı zamanda tam olarak kavrayamadığımız olgulardır (Yıldırım ve Şimşek, 2008).

2.2 Çalışma Grubu:

Araştırmanın çalışma grubunu; Rize de eğitim fakültesindeki sosyal bilgiler öğretmen adayları, Rize de görev yapan sosyal bilgiler öğretmeni (Tablo 1) Çalışma grubu seçiminde kolay ulaşabilirlik ön planda tutulmuştur.

Tablo 1: Araştırmaya katılan öğretmen ve öğrencilerin demografik özellikleri

ÖĞRETMEN	**f**	**%**
1.Cinsiyet		
Kız	6	60
Erkek	4	40
TOPLAM	10	100
SOSYAL BİLGİLER ÖĞRETMEN ADAYI		
Kız	5	50
Erkek	5	50
TOPLAM	10	100

Rize çevresinde okullarda görev yapan 10 sosyal bilgiler öğretmeni ile Recep Tayyip Erdoğan Tayyip Erdoğan Sınıfta okuyan ve öğretmenlik uygulaması I ve II yi alan ve almakta olan 10 sosyal bilgiler öğretmen bilgiler öğretmeni araştırmanın grubunu oluşturmuş olup bu öğrenciler seçkisiz örnek yöntemi ve gönüllülük esasına bağlı olarak seçilmiştir.

2.3 Veri toplama:

Araştırmada verilerin toplanması görüşme yolu ile belirlenmiştir. Görüşme yöntemi sosyal bilimlerde sıkça kullanılan bir yöntem nitel araştırmalarda sıkça kullanılan bir yöntem olması ile dikkat çeker (Yıldırım, Şimşek 2008). Araştırmada amaç bağlamında oluşturulan alt problemleri analiz edebilmek için dijital yetkinliklere ilişkin hazırlanan yarı yapılandırılmış görüşme soruları hazırlanmış ve bu soru 3 uzman görüşüne başvurularak son şeklini almıştır. 5 öğrenci ile gerçekleştirilen pilot uygulama sonrasında proje önerisi için hazır hale getirilmiştir.

2.4 Verilerin Analizi

Bu araştırmada kullanılan görüşme formu iki bölümden oluşmaktadır. Birinci bölümde kişisel veriler, ikinci bölümde ise sekiz adet açık uçlu soru yer almaktadır. Veriler nitel araştırma yöntemleri çerçevesinde analiz edilmiştir. Bu kapsamda geçerlik ve güvenirlik durumu ele alınacaktır. Geçerlilik için görüşme ortam koşulları nitel araştırma sonuçları için uygun hale getirilmiş ve 2 uzman görüşüne baş vurulmuştur. Güvenirlikte, Miles & Huberman (1994)'ın güvenirlik formülü (Güvenirlik formülü=görüş birliği/(görüş birliği + görüş ayrılığı) x 100) kullanılmıştır.

Bulgular Ve Yorum

Sosyal bilgiler öğretmen ve öğretmen adaylarına ilişkin nitel olarak alınan verilerin çözümünden elde edilen bulgular aşağıda verilmiştir.

Öğretmen ve öğretmen adaylarına açık uçlu soru olarak ilk olarak "Dijital yetkinlik deyince ne anlıyorsunuz? sorusu sorulmuştur.

Sosyal bilgiler öğretmenlerin verdiği cevaplar ele alındığında, öğretmenlerin vermiş olduğu cevaplar 5 kategoride değerlendirilmiştir. (Ağdaki yenilik 2; Çağdaş uygulama 2; Teknolojinin eğitime entegre olma durumu 2; Dijital araçları kullanma becerisi 5; Medyayı analiz 1. Öğretmenler en fazla dijital yetkinliği anlamada dijital araçları kullanma becerisine (5) dikkat çekmişlerdir (Tablo 2). Öğretmenlerin cevaplarından bazı örnekler aşağıda sunulmuştur.

Dijital yetkinlik deyince genel ağ üzerindeki yenilikleri takip edebilmek olarak anlıyorum Ö1.

Teknolojik aletlerin çağdaş uygulamalara uyarlanabilmesi Ö2.

21.yy. çağdaş bir eğitim sisteminde ilkokul ve ortaokullarda bireyin, hayatını kolaylaştıracak dijital okuryazarlıklara ağırlık verilmelidir Ö7.

Sosyal bilgiler öğretmen adaylarının verdiği cevaplar incelendiğinde, Sosyal katılım 1; Medyayı analiz 1; İleri teknoloji 3; Gelişen teknolojiyi kullanma 3; Dijital iletişim 1; Bilgiyi kullanma 2 olmak üzere toplam 6 kategori oluşturmuşlardır. Öğretmen adayları en çok ileri teknoloji ve gelişen teknolojiyi (3) kullanma kategorisine katılım göstermişlerdir (3) (Tablo 2). Öğretmen adaylarının verdiği cevaplardan örneklerden aşağıda sunulmuştur.

Dijital yetkinlik deyince genel ağ üzerindeki yenilikleri takip edebilmek olarak anlıyorum ÖA1.

Teknolojik aletlerin çağdaş uygulamalara uyarlanabilmesi ÖA2.

Bilgi arama ve elde edilen bilgi ile eleştirel olarak, çeşitli araç ve gereçleri (dijital) ve uygulamaları kullanarak (mobil, internet) başkalarıyla iletişim kurma becerisini ifade eder ÖA5.

Tablo 2: Dijital yetkinlik deyince ne anlıyorsunuz? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	**Dijital yetkinlik**	1.Ağdaki yenilik	2	Ö1, Ö5
		2.Çağdaş uygulama	2	Ö2, Ö10
		3.Teknolojinin eğitime entegre olma durumu	2	Ö3, Ö6,
		4.Dijital araçları kullanma becerisi	5	Ö4, Ö7, Ö8, Ö9, Ö10
		5.Medyayı Analiz	1	Ö9
TOPLAM		**5**	**12**	
Öğretmen Adayları		1.Sosyal katılım	1	ÖA1
		2.Medyayı analiz	1	ÖA1
		3.İleri teknoloji	3	ÖA2, ÖA3, ÖA9
		4.Gelişen teknolojiyi kullanma	3	ÖA4, ÖA6, ÖA8
		5.Dijital iletişim	1	ÖA5
		6.Bilgiyi kullanma	2	ÖA7,ÖA10
TOPLAM		**6**	**11**	

Sosyal bilgiler öğretmenlerine 2.alt problemin gereği olarak "Dijital yetkinliğin insanlar için önemi hakkında ne düşünüyorsunuz?" sorusu sorulmuştur. Sosyal bilgiler öğretmenlerinin bu soruya verdikleri cevaplar 6 kategoride toplanmıştır. İşleri kolaylaştırma 4; Çağdaşlık için gerekli 4; Olmazsa olmaz 1; Zamandan tasarruf 2; Dijital vatandaşlık 1 ve Haberdar olma 1 (Tablo 3). Öğretmenlerin verdiği cevaplardan örnekler şunlardır.

Hizmete ulaşmada hayatını kolaylaştırabilmesi için dijital yetkinlik gereklidir Ö7.

Çağın gerisinde kalmamak ve sürekli yenilenen gelişmelere ayak uydurabilmek günümüzde önemli bir beceri Ö10.

İçinde bulunduğumuz yüzyılda dünya hızlıca değişiyor. Bu değişimin önemli bir kolunu da dijitalleşme oluşturuyor Ö7.

Sosyal bilgiler öğretmen adaylarının cevapları değerlendirildiğinde ise, Haberdar olma 2; Kamuoyu oluşturma 1; Coğrafi alan 1; Medya okuryazarı 1; Hayatın merkezi 5; Çağdaşlık için gerekli 2 ve Zamandan tasarruf 1 olmak üzere 6 kategoride toplamak mümkündür. Toplam 6 kategoride toplanan görüşlerde öğretmen adayları en çok "Hayatın merkezi" kategorisine (5) görüşle katılmışlardır. Bu alt kategoriye ilişkin öğretmen adaylarının görüşleri şunlardır (Tablo 3).

Kamuoyu oluşturmaya yardımcı olan medyanın doğru kullanılması gerekir ÖA1.

Doğru bilgiye ulaşma ve bunları diğer insanlara iletebilme açısından büyük önem taşıyor ÖA2.

Günümüzde dijital yetkinlik hayatımızın merkezindedir ÖA3.

Tablo 3: "Dijital yetkinliğin insanlar için önemi hakkında ne düşünüyorsunuz?" Sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	**Dijital yetkinliğin İnsanlar için önemi**	1.İşleri kolaylaştırma	4	Ö1,Ö3,Ö5,Ö7
		2.Çağdaşlık için gerekli	4	Ö2,Ö3,Ö4,Ö10
		3.Olmazsa olmaz	1	Ö6,
		4.Zamandan tasarruf	2	Ö7,Ö8
		5.Dijital vatandaşlık	1	Ö7
		6.Haberdar olma	1	Ö9
TOPLAM			13	
Öğretmen Adayları		1.Haberdar olma	2	ÖA1,ÖA2
		2.Kamuoyu oluşturma	1	ÖA1
		3.Coğrafi alan	1	ÖA1
		4.Medya okuryazarı	1	ÖA2
		5.Hayatın merkezi	5	ÖA3,ÖA5;ÖA6,ÖA7,ÖA9
		6.Çağdaşlık için gerekli	2	ÖA4, ÖA10
		7.Zamandan tasarruf	1	ÖA8
TOPLAM		7	13	

Üçüncü alt problem olan "Dijital yetkinliğin sosyal bilgiler dersi öğrencileri için önemi hakkında ne düşünüyorsunuz? sorusuna ilişkin öğretmenlerin görüşleri 7 kategoride toplanmıştır (Tablo 4). Bunlar İlgi oluşturma 1; Kolaylık sağlama 2; Sosyal bilgiler öğrenimi için 4; Dijital araçları doğru kullanma 1; Dijital içeriği takip 2; Kazanımları kazandırmada 1; Çeşitli okuryazarlıkların öğretimi 1dir. Bu alt problemde öğretmen en çok "Sosyal bilgiler öğrenimi için kategorisine" (4) görüşle katılım göstermişlerdir. Öğretmenin görüşlerinden örnekler şunlardır.

Dersin gereği ve amacı zaten değişen dünyaya uyum ile şekilleniyor. Sosyal bilgiler bu değişimde lokomotif olabilir Ö4.

İnternet ağı üzerinden derslere destek amaçlı farklı sayfalarda, farklı adreslerden yardımcı kaynaklardan yararlanılır Ö5.

İnternet ağı üzerinden derslere destek amaçlı farklı sayfalarda, farklı adreslerden yardımcı kaynaklardan yararlanılır Ö8.

Bu alt probleme ilişkin sosyal bilgiler öğretmen adaylarının görüşleri ise toplam 9 kategoride ele alınmıştır Bunlar şunlardır. Dijital araçları doğru kullanma 2; Dijital içeriği takip 1; Kazanımları kazandırmada 2; İlgi Oluşturma 1; Öğrencilerin akıllı tahtayı kullanması 1; Dijital oyun 1; Sosyal bilgilerin amaçları için 3; Dijital vatandaşlık öğrenimi için 2 Dijital medyayı doğru kullanım 1. Öğretmen adayları bu alt problemde en çok Sosyal bilgilerin amaçları için 3 kategorisine katılım göstermiştir (Tablo 4). Öğretmen adaylarının görüşlerden bazıları şunlardır.

Öğretmenlerin teknolojiyi kullanmasını, bu doğrultuda da dersin işleyişine yeni bir bakış açısı kazanılmasını sağlar ÖA4.

Tablo 4: Dijital yetkinliğin sosyal bilgiler dersi öğrencileri için önemi hakkında ne düşünüyorsunuz? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	**Dijital yetkinliğin Öğrenciler için Önemi**	1. İlgi oluşturma	1	Ö1
		2.Kolaylık sağlama	2	Ö1, Ö10
		3.Sosyal bilgiler öğrenimi için	4	Ö2, Ö4, Ö5, Ö8, Ö9
		4.Dijital araçları doğru kullanma	1	Ö3
		5.Dijital içeriği takip	2	Ö3, Ö4
		6.Kazanımları kazandırmada	1	Ö6
		7.Çeşitli okuryazarlıkların öğretimi	1	Ö7
TOPLAM		7	12	
		1.Dijital araçları doğru kullanma	2	ÖA1, ÖA8
		2.Dijital içeriği takip	1	ÖA1

Öğretmen Adayları		3.Kazanınları kazandırmada	2	ÖA1, ÖA6
		4.İlgi Oluşturma	1	ÖA3
		5.Öğrencilerin akıllı tahtayı kullanması	1	ÖA2
		6.Dijital oyun	1	ÖA2
		7.Sosyal bilgilerin amaçları için	3	ÖA4, ÖA9, ÖA3
		8.Dijital vatandaşlık öğrenimi için	2	ÖA5, ÖA10
		9.Dijital medyayı doğru kullanım	1	ÖA7
TOPLAM		9	14	

4. Alt problem olan "Dijital yetkinliğin sosyal bilgiler öğretmeni için önemi hakkında ne düşünüyorsunuz? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar şu şekilde analiz edilmiştir.

Sosyal Bilgiler öğretmenlerin verdiği cevaplardan 7 kategori oluşturulmuştur. Bunlar Öğrencide İlgi oluşturma 1; Kolaylık sağlama, sosyal bilgiler öğretimi 4; dijital araçları doğru kullanma 1; Dijital içeriği takip 2; Kazanımları kazandırmada 1; ve Çeşitli okuryazarlıkların öğretimi 1 olup, öğretmenler en çok sosyal bilgiler öğrenimi için kategorisinde (4) görüş bildirmişlerdir (Tablo 5). Öğretmenin görüşlerinden örnekler şunlardır.

Okul içi eğitimde özellikle akıllı tahta, tablet ve bilgisayarlardan yaralanarak öğrencileri yaparak yaşayarak eğitmeli ve bu konuda bilgilendirmeliyiz Ö8.

Öğretmenin derslerinde etkin bir şekilde öğretim teknolojilerini kullanmasıyla, öğrencilere dijital yetkinlik konusunda örnek olmasıyla öğretilebilir Ö4.

Öğretmen rehberliğinde sınıfın dışında öğrencilere belli örnek olaylar verilerek bunları çeşitli medya araçlarından doğruluğunu ve güvenirliğini buldurmaya çalışabilir Ö7.

Sosyal bilgiler öğretmen adaylarının verdiği cevaplar incelendiğinde ise bu alt problemde 8 kategori oluşturulmuştur. Dijital araçları doğru kullanma 1; Dijital içeriği takip 1; Kazanımları kazandırmada 1; Daha iyi öğretmen 1; Öğretimde kolaylık 1; Dijital Dünyaya uyum sağlayan öğretmen 1; Yeni nesil öğretmen 1; Zamandan tasarruf 1; Öğretmen adayları en çok Öğretimde kolaylık ve (2) Yeni nesil (2) öğretmen kategorisine görüş bildirmişlerdir (Tablo 5). Öğretmen adaylarından örnekler şunlardır.

Öğretmen rehberliğinde sınıfın dışında öğrencilere belli örnek olaylar verilerek bunları çeşitli medya araçlarından doğruluğunu ve güvenirliğini buldurmaya çalışabilir ÖA4.

İnsan içselleştirdiği hayatında kullandığı her ögeyi anlatırken daha kolay ve güzel anlatır bir sosyal bilgiler öğretmeni aynı zamanda çok iyi bir dijital okuryazardır ÖA6.

Bir öğretmenin bu yetkinliğe sahip olması öğrenciyi elinde tutmasına yarar ÖA4.

Tablo 5: Dijital yetkinliğin sosyal bilgiler öğretmeni için önemi hakkında ne düşünüyorsunuz? sorusuna öğretmeni için öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	Dijital yetkinliğin Öğretmenler için önemi	1. Öğrencide İlgi oluşturma	1	Ö1
		2.Kolaylık sağlama	2	Ö1, Ö10
		3.Sosyal bilgiler öğrenimi için	4	Ö2, Ö5, Ö8, Ö9
		4.Dijital araçları doğru kullanma	1	Ö3
		5.Dijital içeriği takip	2	Ö3, Ö4
		6.Kazanınları kazandırmada	1	Ö6
		7.Çeşitli okuryazarlıkların öğretimi	1	Ö7
TOPLAM		7	12	
Öğretmen Adayları		1.Dijital araçları doğru kullanma	1	ÖA1
		2.Dijital içeriği takip	1	ÖA2
		3.Kazanımları kazandırmada	1	ÖA1
		4.Daha iyi öğretmen	3	ÖA3, ÖA4, ÖA10
		5.Öğretimde kolaylık	2	ÖA2, ÖA6
		6.Dijital Dünyaya uyum sağlayan öğretmen	1	ÖA5
		7.Yeni nesil öğretmen	2	ÖA7, ÖA9
		8.Zamandan tasarruf	1	ÖA8
TOPLAM		8	12	

Diğer bir alt problem olan Dijital yetkinlik okul içi ortamlarda nasıl öğretilmelidir? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar bu aşamada analiz edilmiştir. Öğretmenlerin görüşleri 7 kategoride toplanmıştır. Öğrencilere gösterilmeli 1; Gerekli yerlere konulmalı 1; Ders içi Etkinlikler 5; Teknolojik alt yapı geliştirme 1; Eğitim içi bilgilendirme 2; Öğrenciler arasında bilgi paylaşımı 1; Dijital yeterlik dersi 1. Bu problemde en çok ders içi etkinlikler (5) kategorisinde öğretmenler görüş bildirmişlerdir (Tablo 6). Sosyal bilgiler öğretmenlerinden örnek görüşler şunlardır.

Teknolojik alt yapı iyileştirilebilir Ö3.

Bilişim teknoloji derslerinde ve diğer derslerde ayrıca kodlama atölyelerinde dijital yetkinlik kazanılabilir Ö7.

Dijital yetkinlik için ayrı bir ders açılmalı Ö9.

Bu kategoride öğretmen adaylarının görüşleri 4 kategoride toplanmıştır. Bunlar Ders içi etkinlikler 6; Aktif Öğrenci oluşturma 2; Örnek Olaylarla 2; Ayrı ders olmalı 1 şeklindedir. Bu problemde en çok ders içi etkinlikler kategorisinde öğretmen adayları görüş bildirmişlerdir (Tablo 6). Sosyal bilgiler öğretmen adaylarından örnek görüşler şunlardır.

Tablo 6: Dijital yetkinlik okul içi öğrencileri ortamlarda nasıl öğretilmelidir? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	Okul içi Dijital yetkinlik	1.Öğrencilere gösterilmeli	1	Ö1
		2.Gerekli yerlere konulmalı	1	Ö1
		3.Ders içi etkinlikler	5	Ö2, Ö3,Ö4, Ö8, Ö10
		4.Teknolojik alt yapı geliştirme	1	Ö3
		5.Eğitim içi bilgilendirme	2	Ö5, Ö7
		6.Öğrenciler arasında bilgi paylaşımı	1	Ö6
		7.Dijital yeterlik dersi	1	Ö9
TOPLAM		7	12	
Öğretmen Adayları		1.Ders içi etkinlikler	6	ÖA1, ÖA2, ÖA4, ÖA5, ÖA7, ÖA10
		2.Aktif Öğrenci oluşturma	2	ÖA3, ÖA6
		3.Örnek Olaylarla	2	ÖA6, ÖA9
		4.Ayrı ders olmalı	1	ÖA8
TOPLAM		4	11	

Dijital yetkinlik okul dışı ortamlarda nasıl öğretilmelidir? Alt problemine ilişkin sorusuna öğretmenlerin verdiği cevaplar incelendiğinde 12 kategori oluştuğu görülmektedir. Medya takibi 1; Aile kontrolü ve eğitimi 3; Halk içi kurslar 1; Özel kurslar 2; Öğrencilere kurs açılması 1; Kamu spotu kullanma 1; Gençlik merkezlerden yararlanma 1; Uzaktan eğitim 1; Öğrencinin kendini geliştirmesi 2; Halk eğitim merkezleri 1; Bilim merkezleri 1; Ödev 1 dir. Bu alt problemde öğretmenler en çok Aile eğitimi ve kontrolü (3) kategorisinde görüş bildirmişlerdir (Tablo 7).

Özel sertifikalı kurslara katılınabilir Ö3.

Bilim merkezlerindeki aletlerin kullanımını öğrenmek Ö5.

Dijital yetkinlik okul dışı ortamlarda kamu spotlarıyla, aile içi eğitim etkinlikleriyle Ö4.

Bu alt problem için sosyal bilgiler öğretmen adaylarının verdiği cevaplar incelendiğinde görüşlerin 7 kategoride toplandığı görülmektedir. Bunlar Fikrim yok 1; Aile Desteği 2; Kalıcı öğrenme etkinlikleri 1; Dijital ödev 1; Dijital ödev 1; Bilim merkezleri 1; Günlük hayatta kullanımını teşvik 1; Kendisini geliştirmesi ile 3tür. Bu alt problemde öğretmen adayları en çok kendini geliştirme (3) kategorisinde görüş bildirmişlerdir (Tablo 7).

Bu konu ile ilgili fikrim yok ÖA1.

Okul dışı ortamlarda ailelerin desteği ile öğrencilere verilebilir ÖA2.

Ayrı bir ders kadar gerekli bir konudur ÖA7.

Tablo 7: Dijital yetkinlik okul dışı ortamlarda nasıl öğretilmelidir? Sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	Okul dışı Dijital yetkinlik	1.medya takibi	1	Ö1
		2.Aile kontrolü ve eğitimi	3	Ö1, Ö4, Ö10
		3.Halk içi kurslar	1	Ö2
		4.Özel kurslar	2	Ö2, Ö7
		5.Öğrencilere kurs açılması	1	Ö3
		6.Kamu spotu kullanma	1	Ö4
		7.Gençlik merkezlerden yararlanma	1	Ö4
		8.Uzaktan eğitim	1	Ö5
		9.Öğrencinin kendini geliştirmesi	2	Ö6, Ö8
		10.Halk eğitim merkezleri	1	Ö7
		11.Bilim merkezleri	1	Ö9
		12.Ödev	1	Ö10
TOPLAM		12	16	
Öğretmen Adayları		1.Fikrim yok	1	ÖA1
		2.Aile Desteği	2	ÖA2, ÖA8
		3.Kalıcı öğrenme etkinlikleri	1	ÖA3
		4.Dijital ödev	1	ÖA4
		5.Bilim merkezleri	1	ÖA5
		6.Günlük hayatta kullanımını teşvik	1	ÖA6
		7.Kendisini geliştirmesi ile	3	ÖA7, ÖA9, ÖA10
TOPLAM		7	10	

Dijital yetkinlikte sosyal bilgiler öğretmenlerinin karşılaşacağı sorunlara dönük alt problemde toplamda 8 kategori oluşturulmuştur. Bunlar, Dijital yetersizlik 1; İçeriğin araştırılması 2; Güncelliği olmayan konu 1; Bazı öğretmenler dijital bilgide yetersiz 5; Cihazlara erişmede sorunlar 1; Dijital kaynakların bulunmasında zorluklar 1;Yeterince pratik değil 1; Öğrenci dijital beceri yetersizliği 2dir. Bu alt problemde öğretmenler en çok "Bazı öğretmenler dijital bilgide yetersiz." (5) kategorisinde görüş bildirilmiştir (Tablo 8).

10 yıl üstü öğretmenlerde uyum sorunu Ö3.

Öğrencilere doğru ve yanlış bilgiyi öğretmeye çalışırken kavram yanılgıları ortaya çıkabilir.Ö9

Öğrenme ortamının teknolojik olarak dijital etkinliklere hazır olmaması Ö4

Sosyal bilgiler öğretmen adaylarının verdiği cevaplar ele alındığında, 9 kategori oluşturulduğu görülmektedir. Bunlar, Dijital beceri 1; Kendini geliştirme 1; Sorunu anlama 1; Okulların alt yapı yetersizliği 1; Öğretmen dijital yetersizliği 2; Program içerik fazlalığı 1; Programda dijital etkinlik azlığı 2; Öğrenci dijital yetersizliği ve Bilgi kirliliği 3 tür. Bu alt problemde en çok öğrenci dijital yetersizliği ve bilgi kirliliği 3 kategorisinde öğretmen adayları görüş bildirmişlerdir (Tablo 8).

Öğrencilerin çok fazla teknolojik alet kullanarak yanlış şekilde dijital ortamda olduğunu göz önünde bulundurursak öğrencileri bu karmaşık ortamdan doğruya ve güzelle çekmek oldukça zor ve güçlük verici olacaktır ÖA8.

Karşı tarafın yeterince bu konuda bilgi sahibi olmaması iletilmek istenen şeyin sağlıklı şekilde verilmesini zorlaştırabilir ÖA7.

Eğitimde medya araçlarına ayak uyduramamak sorunların başında yer alır ÖA4.

Okullarda sosyal bilgiler sınıflarının olmaması ÖA5.

Tablo 8: Dijital yetkinlikte sosyal bilgiler öğretmenlerinin karşılaşacağı sorunlar nelerdir? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	**Dijital yetkinlikte sorunlar**	1.Dijital yetersizlik	1	Ö1
		2.Güvenirliğin testi,içeriğin araştırılması	2	Ö2, Ö8
		3.Güncelliği olmayan konu	1	Ö2
		4.Bazı öğretmenler dijital bilgide yetersiz.	5	Ö2, Ö4, Ö7, Ö9, Ö10
		5.Cihazlara erişmede sorunlar	1	Ö3
		6.Dijital kaynakların bulunmasında zorluklar	1	Ö5
		7.Yeterince pratik değil	1	Ö6
		8.Öğrenci dijital beceri yetersizliği	2	Ö7, Ö9
TOPLAM		**8**	**14**	
		1.Dijital beceri	1	ÖA1

Öğretmen Adayları		2.Kendini geliştirme	2	ÖA1, ÖA2
		3.Sorunu anlama	1	ÖA1
		4.Okulların alt yapı yetersizliği	2	ÖA3, ÖA10
		5.Öğretmen dijital yetersizliği	2	ÖA3, ÖA9
		6.Program içerik fazlalığı	1	ÖA5
		7.Programda dijital etkinlik azlığı	1	ÖA5
		8.Öğrenci dijital yetersizlik	1	ÖA6
		9. Bilgi kirliliği	3	ÖA4, ÖA7, ÖA8
TOPLAM		**9**	**13**	

Bu araştırmanın son alt problemi olan "Dijital yetkinlikte sosyal bilgiler öğretmenlerinin karşılaşacağı sorunlara çözüm önerilerinde öğretmenler 9 kategori oluşturmuşlardır. Bunlar İyi Eğitim 3; İçeriğin bilinmesi 1; Test edilme 1; Okulların alt yapı sorununun çözümü 1; Dijital eğitim hizmetlerine ulaşılabilirlik 1; Uzman kişilerce eğitim almak 1; Kendini geliştirme 2; Aile desteği 2 ve Dijital yetkinlik dersi 1 dir. Öğretmenler bu kapsamda en çok iyi eğitim (3) kategorisinde görüş bildirmişlerdir *(Tablo 9).*

Dijital becerileri sunacak eğitim vermeliyiz. Üniversite sayısını artırmadan önce temel eğitimin niteliğini ve kalitesini artırmaya önem vermeliyiz Ö7.

Okulların altyapısının tamamlanması Ö4.

Halk eğitim merkezleri ve diğer özel kurs merkezlerinin bu konuda açmış olduğu eğitimlere katılarak, uzaktan eğitimini alarak dijital yetkinlik kazanılabilir Ö6.

Bu kategoride öğretmen adayları 8 kategori oluşturmuşlardır. Bunlar, Kendini geliştirme 1; Karşı tarafından dijital yetkinliğe sahip olmaması 1; İçeriğin sadeleştirilmesi 1; Yanlışın bulunması ile 1; Doğru bilgilendirmeler 1; Uzman desteği 1; Bilgi kirliliğinin önlenmesi 1; Yeni proje geliştirme 1. Bu kategoride öğretmen adayları en fazla görüşü "Doğru bilgilendirmeler 3" kategorisinde oluşturmuşlardır (Tablo 9).

Ayrı bir ders saati oluşturulmalı ÖA5.

Öğrencilere öncelikle doğru bilinen yanlışları ve neden yanlış olduğunu örneklerle detaylı bir şekilde anlatmak bu konuda bize çözüm sağlayabilir diye düşünüyorum. ÖA6

Bilgiyi ve bu ortamı kişi kendi iyiliğine yönelik kullanmayı öğrenmeli öyle kullanmalıdır ÖA7.

Tablo 9: Dijital yetkinlikte sosyal bilgiler öğretmenlerinin karşılaşacağı sorunlar nelerdir? sorusuna öğretmen ve öğretmen adaylarının verdiği cevaplar

	Temalar	**Kategoriler**	**f**	
Öğretmenler	Dijital yetkinlik	1.İyi Eğitim	3	Ö1, Ö4, Ö7, Ö9
		2.İçeriğin bilinmesi	1	Ö1,
		3.Test edilme	1	Ö2
		4.Okulların alt yapı sorununun çözümü	2	Ö4, Ö9

	Çözüm önerileri	5.Dijital eğitim hizmetlerine ulaşılabilirlik	1	Ö4
		6.Uzman kişilerce eğitim almak	1	Ö5
		7.Kendini geliştirme	2	Ö6, Ö7
		8.Aile desteği	2	Ö8, Ö10
		9. Dijital yetkinlik dersi	1	Ö9
TOPLAM		**Üğ-şp*0o9**	**13**	
Öğretmen Adayları		1.Kendini geliştirme	1	ÖA1
		2. Karşı tarafından dijital yetkinliğe sahip olmaması	1	ÖA2
		3i.çeriğin sadeleştirilmesi	1	ÖA5
		4.Yanlışın bulunması ile	1	ÖA6
		5.Doğru Bilgilendirmeler	1	ÖA7, ÖA3, ÖA4
		6.Uzman desteği	1	ÖA8
		7.Bilgi kirliliğinin önlenmesi	1	ÖA9
		8.Yeni proje geliştirme	1	ÖA10
TOPLAM		8	8	

TARTIŞMA VE SONUÇ

Bilimsel ve teknolojik gelişmelere bağlı olarak son yıllarda dijital araç ve gereçlerin kullanımları giderek artmaktadır. Bu araçlar özellikle bilgi edinme bağlamında önem kazanırken kullanım alanları da giderek yaygınlaşmaktadır. Artık dünyada öğrenciler bu araç ve gereçler ile iç içe yaşamak zorunda kalmışlardır. Bu kapsamda değerlendirildiğinde çocukların teknolojiyi doğru anlayıp kullanmaları bir ihtiyaçtan öte bir zorunluluk haline gelmiştir (Ekmen, Bakar 2018). Bu projede gelecekte çocukların zaman zaman dijital dünyasına hükmedecek; onları çeşitli konularda dijital kaynaklarla bilgilendirecek, gerekirse onları, dijital kaynakların kullanımına yönlendirecek olan sosyal bilgiler öğretmenlerinin ve sosyal bilgiler öğretmen adaylarının dijital yetkinliklere ilişkin görüşleri ele alınmıştır.

Gerek sosyal bilgiler öğretmenler ve gerekse öğretmen adayları dijital yetkinliklerle ilgili tanımlarda dijital yetkinliğin çağımızdaki önemden yola çıkarak bir tanım gerçekleştirdiği görülmektedir. Sosyal bilgiler öğretmen ve sosyal bilgiler öğretmen adaylarının dijital yeterliliklere karşı gösterdiği önem Ekmen ve Bakar (2018) tarafından yapılan çalışma ile bir tutarlılık göstermektedir. Ekmen ve Bakar (2018), çalışmalarında sosyal bilgiler öğretmenlerinin dijital yeterlikle ilgili belli bir birikimlerinin olduğunu ortaya koymuştur. Bu çalışma ile örtüşen bir diğer çalışmada, Geçgel vd (2020) de yaptığı çalışmadır. Öğretmen dijital yetkinliğe sahip olduklarını bu çalışmada belirtmişlerdir.

Gerek sosyal bilgiler öğretmeni ve gerekse sosyal bilgiler öğretmeni adaylar önemli bir sorun olarak dijital yetkinlikle ilgili olarak bazı kıdemli sosyal bilgiler öğretmenlerinin gerekli donanıma sahip olmadığını belirtmişlerdir. Öğretmenlerin ve öğretmen adaylarının bu konudaki görüşleri ile Fidan ve Yeleğen (2022)

görüşleri önemli ölçüde paralellik göstermektedir. Fidan ve Yeleğen (2022) yapmış oldukları çalışmada kıdemli öğretmenlerin gerekli dijital yeterliliğe sahip olmadıklarını belirtmiştir. Diğer taraftan benzer bir bulgu Gökbulut (2021) ve arkadaşları tarafından ortaya konmuştur.

Öğretmen ve öğretmen adayları dijital yetkinliklerini geliştirmek için seminer kurs gibi çeşitli faaliyetlere katılmak istediklerini belirtmişlerdir. Bu görüşte Fidan ve Yeleğen (2022) görüşleri ile bir paralellik göstermektedir.

Öğretmenlerin dikkat çektiği bir konuda alt yapı yetersizliği bazı öğretmenler ve öğretmen adayları bazı okullarda alt yapı yetersizliği söz konusu olduğunu bunların da çalışmalarını aksattığını belirtmişlerdir. Fakat bu görüşte olan öğretmen ve öğretmen adaylarının sayısı düşük sayıdadır. Benzer bulgular Pala 2023'ün çalışmasında da yer almaktadır.

Yine bazı öğretmenler dijital cihazlara erişime sorunları yaşadıklarını belirtmişlerdir. Dijital yetersizlik durumunda uzman öğretmenlerden bilgi almanın gerekliliğine dikkat çekmişlerdir. Bu bulgular Fidan ve Yeleğen 2022 bulguları ile örtüşmektedir.

ÖNERİLER

Bu çalışmada ortaya çıkan bulgular bağlamında şu öneriler getirilebilir.

1.Sosyal bilgiler öğretmenler ve öğretmen adaylarına dijital yetkinlik dönük olarak hizmet içi seminer verilebilir.

2. Okullarda dijital yetkinlik bağlamında alt yapı eksiklerinin giderilmesine dönük çalışmalar yapılabilir.

3. Dijital yetkinlik bağlamında ders içerikleri oluşturulabilir.

TEŞEKKÜR

Bu çalışma 2209-A Üniversite Öğrencileri Araştırma Projeleri çerçevesinde gerçekleştirildiği için TÜBİTAK'a teşekkür ederiz.

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Digital Transformation in Note-Taking Strategies in Class: A Field Research

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Abstract

Analyzing note-taking strategies in the classroom is anticipated to provide an in-depth understanding of university students' individual learning styles. This study focuses on how university students take notes in the classroom and how digital tools can support notetaking. The purpose of this study is to identify university students' note-taking strategies in class. This research was designed using qualitative research design and a case study model. Detailed steps were planned for determining participant demographics and preparing semi-structured interview questions. Ethics committee approval was obtained from the university where the primary researcher was based to conduct the research. In keeping with the nature of the qualitative research design, a semi-structured interview form was used to collect data. To develop the data collection tool, national and international literature was reviewed, and a detailed literature review was conducted on the subject. The participants were 24 students enrolled in the education faculties of two different universities during the 2024-2025 academic year. Data collection began in the Fall semester of the 2024-2025 academic year and continued into the Spring semester. An online survey was conducted to determine participants' attitudes toward digital note-taking and artificial intelligence systems, how they take notes in class, and their opinions about the methods they use. Data analysis was conducted using Nvivo 14, a computer-aided qualitative data analysis program. Data analysis was conducted using thematic content analysis. The themes and subthemes resulting from the analysis are presented.

Keywords: Note-taking, Digital Transformation, Field Research, Case Study.

Introduction

Note-taking is a necessary strategy due to the limitations of the information processing system. Because this limited capacity prevents the processing of all the information received by the information processing system, note-taking is employed. Note-taking serves the purpose of structuring information and helping it be retained for longer periods of time. Note-taking, used in various daily situations, is a strategy frequently employed by individuals in both their academic and personal lives. It can be argued that using note-taking strategies while listening or reading is a key factor in enhancing academic success. However, the most crucial aspect is employing effective note-taking strategies. Numerous studies in literature have identified the effectiveness of note-taking strategies in academic and daily life. Piolat, Olive, and Kellogg (2005) emphasize that note-taking strategies activate individuals' cognitive processes, providing the opportunity to process information in depth. Research by Kiewra (1989) revealed that note-taking strategies implemented in class stimulate skills such as listening, selective attention, information filtering, and restructuring. Note-taking is currently evaluated under two basic strategies: digital note-taking and hand-written notetaking. Hand-written notetaking stands out for its strengths in processing information in depth and making sense of it. Research by Piolat, Olive, and Kellogg (2005) found that handwriting combines motor skills with mental processing, thus leaving more lasting impressions in memory. A study on digital notetaking conducted by Bui, Myerson, and Hale (2013) revealed that features such as speed, organization, and ease of access are prominent. Based on this result, it can be argued that digital tools enrich the learning process by allowing users to archive, categorize, and add multimedia elements to their notes. Research by Pam, Mueller, and Oppenheimer (2014) suggested that digital note-taking tools provide students with opportunities to access, classify, visualize, and share information, while also transforming the note-taking process into a technological skill rather than a cognitive one.

Research on handwritten and digital notetaking has shown that, while digital notetaking reduces the cognitive load of writing and allows for more in-depth processing of information, it is not always more effective. A study by Peverly, Vekaria, Reddington, Sumowski, Johnson, and Ramsay (2013) found that while digital notes have a more superficial effect on information processing, taking handwritten notes still provides an advantage in subjects requiring in-depth learning. Research by Pam, Mueller, and Oppenheimer (2014) demonstrated that taking handwritten notes has a stronger effect on information recall compared to digital media. Pam, Mueller, and

Oppenheimer demonstrated that university students who took handwritten notes had higher conceptual learning levels than students who took notes on laptops. The study concluded that slower typing speed supports learning by triggering the process of filtering and rephrasing information (2014). Today, the popularity of mobile learning is increasing. Despite this popularity, not all university students own mobile devices. In other words, a form of digital inequality exists in this regard. Addressing digital inequality in the educational context is not limited to the mere possession of technological equipment. Warschauer (2003) considers digital inequality not merely a technical deficiency, but a multilayered problem with sociocultural, economic, and pedagogical dimensions. Therefore, focusing solely on device and internet access is insufficient to understand the barriers created by the deepening digital divide during the COVID-19 pandemic in accessing quality education in Turkey. Among the factors that determine students' active participation in online learning, digital literacy levels, parental support, teachers' online pedagogical competencies, and educational institutions' technology adoption strategies also play a critical role (Selwyn, 2016; Van Dijk, 2020).

With online education during the Covid-19 pandemic, the popularity of digital learning has increased, and taking notes via tablets, iPads, computers, or mobile phones has become a necessity rather than a choice. However, due to socioeconomic inequalities among students, it is known that not all university students have mobile devices that can support digital learning. The researchers of this study observed that taking notes by hand has evolved into taking notes with digital tools at the universities they work at. This research focuses on how university students take notes in class and how digital tools can support notetaking. In this sense, the aim of the study is to determine university students' note-taking strategies in class. To this end, the following questions were sought:

1. What are the participants' preferred strategies for taking notes in class?
2. What are the participants' attitudes and behaviors regarding notetaking in class?
3. What digital note-taking techniques do participants use?
4. When and how do participants review their notes in class?
5. How do participants evaluate the contribution of taking notes in class to learning?
6. What materials do participants use in classes?

Methodology

This research is designed as a qualitative research and case study. To best achieve the research objective, this research will attempt to reveal the reflection of university students' classroom note-taking strategies in Turkey. It is anticipated that analyzing university students' classroom note-taking strategies will provide an in-depth understanding of individual learning styles. Within the scope of the research, the steps to be followed in determining the demographic characteristics of the participants and preparing semi-structured interview questions were carefully planned. Semi-structured interview forms were used in accordance with the nature of qualitative design.

Study Group

The study participants were 24 students enrolled in the education faculties of two different universities during the 2024-2025 academic year. Data collection began in the fall semester of the 2024-2025 academic year and continued into the spring semester. An online survey was conducted to determine the methods participants use for taking notes, their opinions on how they take notes in class, and their attitudes toward digital note-taking and artificial intelligence systems.

Data Collection

Ethics committee approval was obtained from the university where the primary researcher works to conduct the study. In keeping with the nature of the qualitative research design, a semi-structured interview form was used to collect data. To develop the data collection tool, national and international publications were reviewed, and a detailed literature review was conducted. University students' opinions on note-taking methods, how they take notes in class, and their attitudes toward digital note-taking and artificial intelligence systems were collected via online interviews.

Data Analysis

In the study, the computer-assisted qualitative data analysis program Nvivo 14 was used to transcribe and analyze the qualitative data. Interview data were transcribed into written format. Transcriptions were double-checked for accuracy and validity. Data was analyzed using the thematic content analysis technique of Braun and Clark (2016).

The stages of the process:

1. Data identification
2. Creation of initial codes
3. Creation of themes
4. Review of themes
5. Identification and naming of themes
6. Preparation of the report

Validity and Reliability

To ensure the validity of the research, the theoretical framework for the study was established by conducting a comprehensive literature review on the subject. The development of the qualitative design and data collection tool used in the study, the selection of the participant group that constituted the research sample, the number of participants, and participant information were explained in detail. To enhance the credibility of the research, a comprehensive question pool was created, and care was taken to provide a rich dataset from two different universities for in-depth analysis (Yıldırım & Şimşek, 2015). Participants' views were provided directly. Due to the principle of confidentiality, the participants' real names were coded.

To ensure the reliability of the research, the researchers repeatedly read the research questions and interview transcripts, and coding was performed based on concepts extracted from the data. To ensure the reliability of the content analysis, inter-coder consistency was ensured by coding the data by field experts. To ensure verifiability, the notes, data, and coding obtained from the study were stored electronically for later review (Miles & Huberman, 1994; Silverman, 2016).

Findings

The findings obtained because of the thematic content analysis are given below under headings.

1. Note-Taking Preferences

Most participants still prefer the traditional note-taking method (pen, paper, and notebook). Despite this finding, there has been an increase in the number of students using digital note-taking devices (laptops, tablets, mobile phones, etc.). It was observed that a small number of students do not actively take notes in lectures, preferring instead to take notes from friends or simply listen to lectures. Some participants reported occasionally borrowing notes from friends. These students typically photocopy sections they consider important or transcribe notes verbatim. In some classes, sharing lecture notes digitally through a class representative is a common practice.

2. Note-Taking Behaviors in Class

Most participants reported that they only take notes of what they consider important from what the instructor says or writes during class. The percentage of students who prefer to take full notes is relatively low. One group of students considered audio recordings during class as part of the note-taking process. Students reported that they often take notes by drawing or photographing graphical content such as diagrams. Especially in digitally transmitted courses, taking screenshots of such content and adding them to PDFs or note-taking programs is a common method.

3. Digital Note-Taking Techniques

The most used digital note-taking techniques are taking notes on PDFs and the Cornell Note-Taking Technique. Mind maps and software like Notion are more common among students who use technology effectively. Audio-to-text technology is used relatively less frequently.

4. When and How to Review Notes

Most participants prefer to review their lecture notes before exams or immediately after class. It was found that few students regularly review their notes daily. Participants typically review their notes sequentially or by skipping topics. Some prefer to review only the material covered in class.

5. The Contribution of Notetaking to Learning

A group of participants noted that it was sometimes difficult to access specific information when reviewing notes. Disorganized or lacking in detail notes were noted as a hindrance to the review process. However, most participants stated that taking notes or borrowing notes from friends contributed positively to learning.

6. Use of Course Materials

Most participants purchase subject-specific textbooks, especially for reference when preparing for exams. However, a relatively high number of students also consult digital resources in addition to textbooks. Students

widely believe that having audio or video recordings of lectures is beneficial. Furthermore, open note-sharing platforms with a larger number of students have been found to support learning.

The results of the study reveal that some students enrich their notes with content from different sources, while others incorporate information learned from assignments into their lecture notes. Most students maintain a strong belief that taking written notes makes knowledge more permanent. They emphasized the need to expand the use of drawings, symbols, and linking indicators when taking notes. The study's findings provide important data for understanding university students' note-taking behaviors and preferences. This study found that participating university students are moving toward a hybrid note-taking culture, where both traditional and digital methods are used together.

Analysis of the data revealed participants' experiences transitioning to digital note-taking tools, the factors influencing their strategy choices, and the effects of digital notetaking on learning. Therefore, the study aims to provide recommendations for both instructors and educational technology developers on effective note-taking practices that support learning in the digital age.

Conclusion and Discussion

This research examines the effects of manual and digital note-taking strategies on students' learning experiences and cognitive processes from a multidimensional perspective. Findings indicate that while manual notetaking supports conceptual learning and in-depth processing, digital notetaking offers advantages in terms of speed, organization, sharing, and accessibility. However, the fact that digital note-taking tools can also introduce distractions can negatively impact learning quality. The proliferation of digital learning tools, particularly in the post-COVID-19 pandemic era, has made digital note-taking strategies essential for many students. During this period, students' note-taking strategies have been shaped not only by individual preferences and course content, but also by digital inequality, digital literacy levels, and distance learning conditions. In this context, hybrid note-taking strategies offer an increasingly functional alternative in today's educational environments, providing both in-depth learning and digital flexibility. Therefore, developing appropriate and flexible note-taking strategies for students plays a crucial role in enhancing learning outcomes.

The results revealed that among note-taking strategies, taking notes by hand supports conceptual learning, while taking digital notes supports speed and flexibility. Similarly, a study by Luo, Kiewra, and Samuelson (2022) found that effective notetaking significantly impacts learning outcomes, stating that how students' structure and use their notes is more important than the type of note-taking strategy. Therefore, when designing effective learning environments, attention should be paid to students' individual preferences, course content, and unequal digital access conditions. Pedagogical approaches that encourage students to consciously use both methods can be developed to maximize learning outcomes. Neuroscientific studies conducted in recent decades indicate that both note-taking methods activate different cognitive processes. A study by Van der Weel, F., Audrey, L. H., & Van der Meer, A. (2024) found that handwriting establishes greater connections between memory, language processing, and motor coordination regions of the brain, while writing on a tablet or computer is associated more with visuospatial processing. Research by Bui and Myerson (2022) revealed that taking notes by hand requires more cognitive effort, resulting in better mental processing of the content. In this context, the advantages and limitations of digital notetaking should be evaluated in conjunction with the technological tool used, the student's digital literacy level, and learning goals. Therefore, hybrid note-taking strategies that blend both strategies may have the potential to offer both deep learning and digital practicality.

A study by Barrot, Llenares, and del Rosario (2021) indicated that with the proliferation of online education platforms in the post-COVID-19 era, digital note-taking has become not only a preference but also a necessity for many students. A study by Pam, Mueller, and Oppenheimer (2014) found that students who take notes on a keyboard tend to transfer information verbatim, thus limiting their in-depth processing. A study by Ravizza, Uitvlugt, and Fenn (2017) revealed that digital devices provide simultaneous access to different stimuli (notifications, social media, the internet) and can lead to distractions and negatively impact learning quality. Studies by Kiewra (2022) and Swart and Busstra (2024) indicated that factors such as notifications or internet connection during digital note-taking reduce learning performance. It was determined that most students unknowingly encounter distractions while using digital tools. Research from the past decade has shown that digital notetaking (tablets, laptops, note-taking apps, mobile phones) has both advantages and limitations. Research by Arden, Norris, Cole, and Gamble (2024) found that while digital tools provide significant convenience in archiving, organizing, and sharing information, the effects of digital notetaking on learning outcomes are heterogeneous due to risks such as superficial transfer, reduced productivity, a tendency to rephrase, and distraction. Some studies have found that digital notetaking reduces cognitive load, while others find that handwriting provides an advantage in conceptual processing.

The results of the study reveal that the popularity of digital learning has increased with online education during the COVID-19 pandemic. Digitalization, accelerated by the COVID-19 pandemic, has transformed note-taking behaviors not only in terms of material use but also at cognitive and pedagogical levels. The attention, motivation, and interaction challenges students encountered while adapting to online course environments directly impacted their note-taking strategies. Studies during the pandemic have reported that students adjusted their note-taking strategies due to technology-based challenges and resource access issues during online learning. A study by Aguilar-Rodríguez, González-Calero, and Padrón (2023) found that hybrid strategies offer flexible and in-depth learning by meeting both personal preferences and course content requirements. In this context, a multidimensional structure has emerged that affects students' personal and environmental preferences, particularly with the increased digitalization of distance education following the pandemic. Therefore, this research aims to evaluate the effects of social inequalities, digital tool access, individual learning styles and pedagogical requirements on note-taking strategies from a holistic perspective.

Suggestions

Pedagogical Design: Note-taking strategies should consider students' individual learning styles and preferences; challenging, uniform practices should be avoided. Educators should design hybrid learning environments that support both handwritten and digital note-taking tools. Students should be guided in determining which note-taking method is appropriate for each learning objective.

Digital Literacy Education: To effectively use digital note-taking strategies, students should be equipped with fundamental digital literacy skills. This should include skills and ethical principles such as managing distractions, data archiving, and secure file sharing. To counter the potential distractions of digital devices, students can be taught mental self-regulation and focus strategies.

Equitable Access: Inequalities in access to digital tools negatively impact the learning process. Therefore, it is important for institutions to provide students with the necessary hardware and software support.

Research and Development: To increase the effectiveness of hybrid note-taking strategies, new digital tools and applications should be developed, and the cognitive processes that influence learning outcomes should be more thoroughly investigated.

Acknowledgements

This work was supported by the TÜBİTAK 2224-B Domestic Scientific Events Participation Support Program.

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Introducing pre-service primary school teachers to physical computing by means of Arduino and Raspberry Pi. A case study.

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Abstract

Physical computing is a powerful tool for the creation of interactive objects and constructions, introducing theoretical and technical aspects of technology to children, making it a promising tool for them to learn fundamental concepts in computer science, engineering, science and literacy as well as to cultivate collaboration and communication skills using technology as a means for personal expression. Research has shown that physical computing activities, among others, materialize students' computational concepts through computational practices, and improve their computational perspectives using authentic contexts. Despite the positive impact, there is a lack of such educational activities and opportunities for primary school students as teachers are not familiarized with the use of such tools in educational frameworks. Following the trend worldwide, the motivation and training of pre-service primary school teachers emerging crucial, as they need to have computing content, technological knowledge and pedagogical content knowledge to utilize physical computing learning activities in their classrooms. This study discusses the results of a short workshop that offered to twelve (12) pre-service teachers to introduce them to physical computing by means of Arduino and Raspberry Pi platforms and Scratch for Arduino (S4A) and Python programming environments. A diagnostic questionnaire, an evaluation questionnaire, specific designed worksheets, focus group discussion and participatory observation were used to collect data. The presented results are documented by the description of two indicative activities of the workshop and the analysis of the data collected. Results discuss participants' perceived usefulness, perceived ease of use, knowledge gain, performance, feelings, challenges, needs for support, perceived opportunities and intention to utilize physical computing activities in their classroom.

Keywords: educational robotics, physical computing, Arduino, Raspberry Pi, primary education, pre-service teachers, authentic learning activities, STEM education.

Introduction

Tools for Physical computing are powerful tools for the creation of interactive objects and constructions, introducing theoretical and technical aspects of technology to children, making it a promising tool to teach and learn fundamental concepts in computer science, engineering, science and literacy as well as to cultivate collaboration and communication skills using technology as a means for personal expression. Physical computing activities can materialize students' computational concepts through computational practices and improve their computational perspectives using authentic contexts (Park et al., 2018). Despite the positive impact, there is a lack of such educational activities and opportunities for primary school students as teachers are not familiarized with the use of such tools in educational frameworks (Balaouras et al., 2022; Michalopoulos et al., 2022). Following the trend worldwide, the motivation and training of pre-service primary school teachers emerging crucial, as they need to have computing content technological knowledge and pedagogical content knowledge to utilize physical computing learning activities in their classrooms.

Physical Computing in education

Nowadays technological development inevitably challenges educational approaches in terms of the future demand for knowledge, skills and attitudes that need to be taught. The ability to operate and communicate effectively in multidisciplinary fields is considered important. Educational robotics and Physical computing provide a suitable framework for developing such competence. Competences such as computational thinking and design thinking have also been identified as necessary for adapting to the future. The core of these competences consists of developing basic coding skills and transferring them to the physical world (Dochshanov & Tramonti, 2020). Research has shown that physical computing can materialize students' computational concepts through computational practices and improve their computational perspectives through the utilization of authentic learning activities (Gayathri, 2021; Schätz et al., 2024). There are many educational robots and physical computing devices and teachers at all levels of education support that the utilization of such devices increases both student motivation

and performance. However, there are many obstacles for teachers who want to utilize such devices in their classroom. The stronger challenges for using educational robots and physical computing devices at schools are the lack of hardware and the maintenance of the hardware that is available, and the higher workload for teachers demanding (Bungert & Bruckschen, 2022). The implementation of such activities in schools requires enthusiastic and dedicated teachers with IT knowledge, pedagogical and technical skills, able to attract their students' interest. (Von Wangenheim et al., 2017).

The integration of physical computing into school curricula leads to an urgent need for appropriate tools, lesson plans, best practice reports, and detailed descriptions and manuals. The creative design of interactive objects and systems using programmable hardware can enhance students' motivation, creativity, and learning. Literature worldwide focuses on extracurricular activities that cannot be easily transferred to regular school lessons. Thus, it is important to explore possibilities to integrate physical computing into schools achieving the goals of school curricula (Gerstein, 2016; Grillenberger & Romeike, 2017; Kim & Min, 2021). Developing Children s computational thinking through Physical Computing demands in-service and pre-service teachers training and support to help them technologically and pedagogically to achieve learning objectives in order to cultivate the citizens of the 21st century.

Aim and Research Questions

The study discusses the results of a short workshop that offered to twelve (12) pre-service teachers to introduce them to physical computing by means of Arduino and Raspberry Pi platforms and Scratch for Arduino (S4A) and Python programming environments. Results discuss participants' perceived usefulness, perceived ease of use, knowledge gain, performance, feelings, challenges, needs for support, perceived opportunities and intention to utilize physical computing activities in their classroom. The research questions can be formulated as:

- What is pre-service teachers' acceptance of Physical computing for primary education students in terms of *perceived usefulness, perceived ease of use, knowledge gain, performance, feelings, challenges, needs for support, perceived opportunities and intention to utilize physical computing activities in their classroom?*
- What do they consider to be the educational value of Physical computing tools and applications in Primary Education?

Methodology

The study was qualitative research and as research tools used: *paired questionnaires* before and after the course (A diagnostic questionnaire before the course and an evaluation one after the course), the *worksheets* per activity, *participatory observation* by the researchers and a *focus-group discussion*.

The participants were pre-service primary school teachers/university students attending the 4th year of their studies at the department of 'Educational Sciences and Social Work' of University of Patras in Greece. The study can be considered as a case study as the sampling of the research was convenient and twelve (12) pre-service teachers participated, attending a short course to introduce them to physical computing by means of Arduino and Raspberry Pi platforms and Scratch for Arduino (S4A) and Python programming environments.

Research tools

The research tools were:

- Diagnostic questionnaire before the course: Eleven (11) questions including *gender, age, skills of computer use, attendance of courses in ICT use, attendance of courses in educational robotics or coding, knowledge concerning control, selection, repetition structures and variables in coding, awareness of Physical Computing (asked to describe or imagine what it could be, where it is used, to describe an example)*.
- Evaluation one after the course: Thirteen (13) feedback questions related to *how much participants enjoyed the activities, how easy, useful, understandable they found activities, whether they would like to engage in such activities again in the future, knowledge gain concerning control, selection, repetition structures and variables in coding, what they liked or dislike, difficulties they faced, knowledge needs to carry out the activities, usefulness of Physical computing.*
- Worksheets per activity: The way participants worked on the worksheets of each activity and their answers on them were analysed.
- Participatory observation: During participatory observation, the two researchers observed the discussions, activities, and reactions of the participants and intervened when they needed help or encouragement to carry out the activities.
- Focus group discussion based on twelve (12) questions concerning:

- *perceived usefulness, perceived ease of use and intention to utilize physical computing activities in their classroom* (based on the Technology Acceptance Model 2 (TAM 2) (Teo, 2011; Teo et al., 2019)
- *challenges, needs for support* (based on the work of Nikolopoulou, K., & Gialamas, V. (2016)
- *knowledge gain, performance, feelings, perceived opportunities.*

In order to ensure the validity and reliability of the research tools and the research, the back-translation procedure (Brislin, 1970) followed for the translation and adaptation of the questions of TAM 2, two experts (one expert in Pedagogy in primary education and one expert in Physical computing) reviewed all the questions to ensure the content validity as well as the diagnostic questionnaire, the evaluation questionnaire and the learning activity worksheets to ensure their suitability for the purposes of the study. Furthermore, a pilot implementation of the learning activities and the research tools with a group of three (3) participants to ensure face validity of both worksheets and the research tools. Code reproducibility was measured with the participation of three coders (Krippendorff, 2004) to ensure the reliability of the content analysis. A pilot content analysis of discussion at the pilot phase was conducted by all three coders and then the percentage of agreement among the coders was used to measure reliability that was calculated equal to 0.93, a value that considered satisfactory.

Data analysis

Descriptive statistical analysis was used to analyse the data from the two questionnaires, and a thematic analysis was applied to participants answers per question. Brief analysis was also applied to the worksheets and the notes of the observation.

The procedure

Twelve pre-service primary school teachers participated in a short course on "*Physical Computing in education*" that included six (6) project-based activities for their introduction to Physical Computing fundamentals and be able to teach them to their students. The workshop had a duration of 30 hours. used for this purpose. Arduino and Raspberry Pi platforms and Scratch for Arduino (S4A) and Python programming environments were utilized for the purposes of the course and the study.

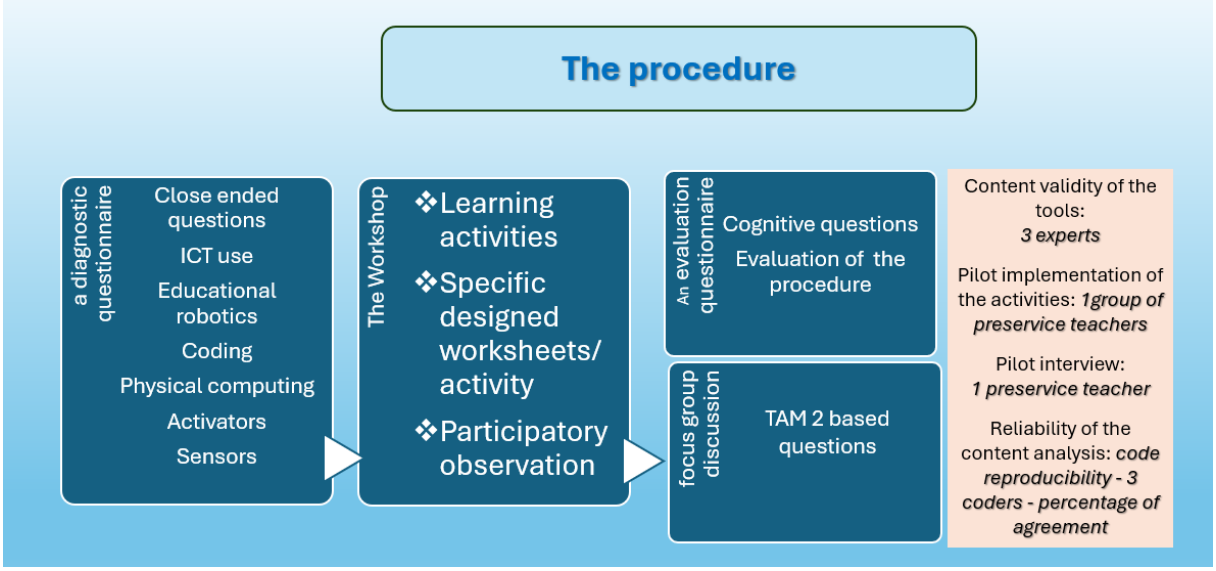

Figure 1. The research procedure.

The participants

Five (5) of the participants were women and seven (7) were men. All participants attended courses on the use of ICT, had attended short courses on coding during their studies at the university (especially on scratch) and short courses on educational robotics during their studies at the university (especially on Lego Mindstorms kits).

Physical Computing Learning activities

Six (6) project-based learning activities (three (3) utilizing Arduino and Scratch for Arduino (S4A) and three (3) utilizing Raspberry Pi and Python) composed the content and learning activities of the course. In this paper tow (2) of them are briefly described:

The treasure chest

The treasure chest activity utilized the basic Arduino kit and Scratch for Arduino (S4A) coding environment, had a duration of six (6) hours and based on six (6) worksheets. Participants were asked to design, build, and program a treasure chest so that *pressing a switch the system is activated to, with the appropriate code (knocks on the piezo sensor) the motor unlocks the door of treasure chest and allows them to take the treasure before it lock again.* The participants worked in groups of there (3) persons and two (2) researchers observed the discussions, activities, and reactions of the participants and intervened when they needed help or encouragement to carry out the activities. Figure 2 describes briefly the content of the activity.

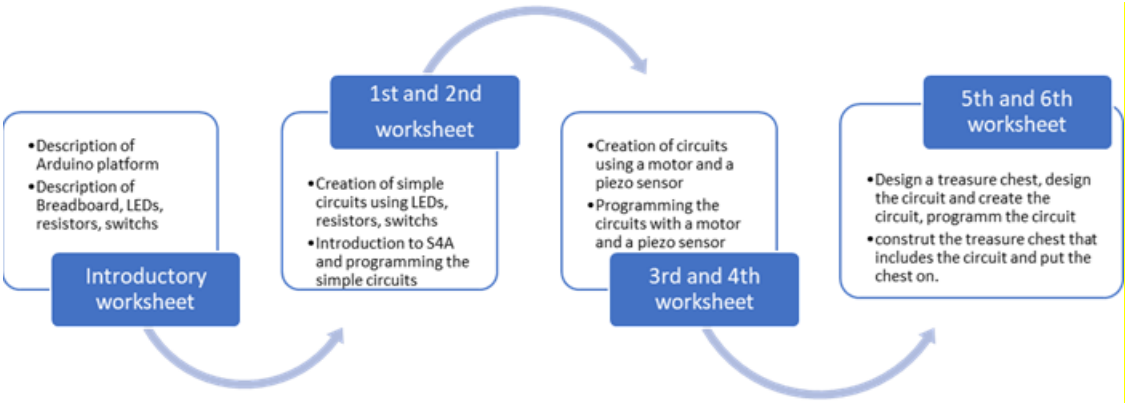

Figure 2. A graphically presentation of the phases of the activity with Arduino and S4A.

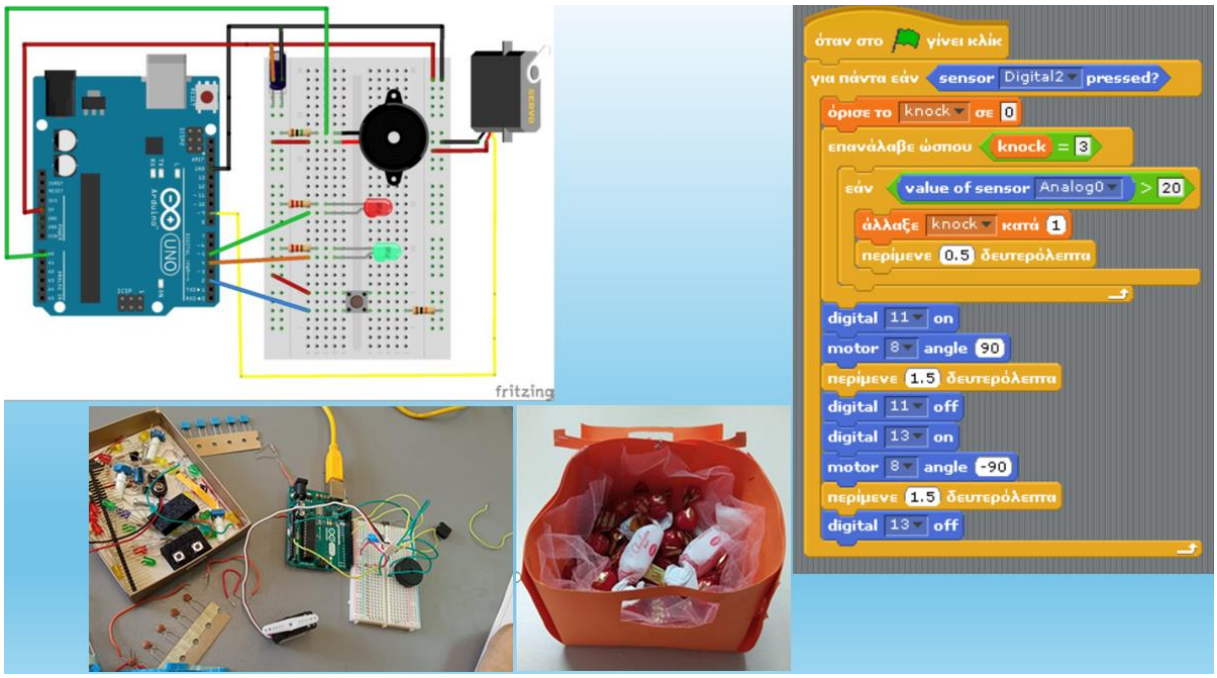

Figure 3. The circuit in Tinkercad, the real circuit during construction, the program and the treasure chest.

The video treasure chest presents the product of the activity.

The smart house

The smart house activity utilized the Raspberry Pi platform and Python programming environment, had a duration of six (6) hours and based on six (6) worksheets. The participants had *to create a system that simulates a smart house. This system would automatically activate a fan inside the house depending on the ambient temperature and light intensity. To achieve this, they are asked to work a motor, a light sensor, a temperature sensor, the Raspberry Pi platform to build the necessary circuits and program them by creating simple programs in Python*. The participants worked in groups of there (3) persons and two (2) researchers observed the discussions, activities, and reactions of the participants and intervened when they needed help or encouragement to carry out the activities. Figure 4 describes briefly the content of the activity.

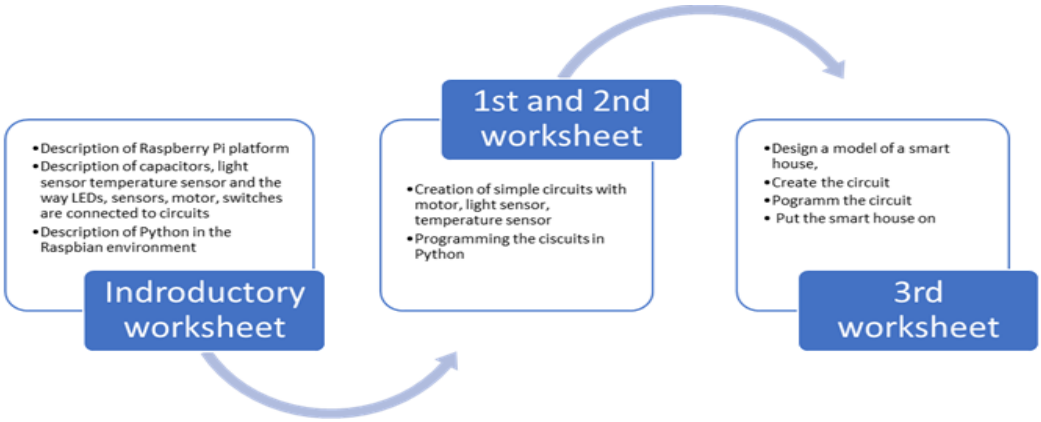

Figure 4. A graphically presentation of the phases of the activity with Raspberry Pi platform and Python programming environment.

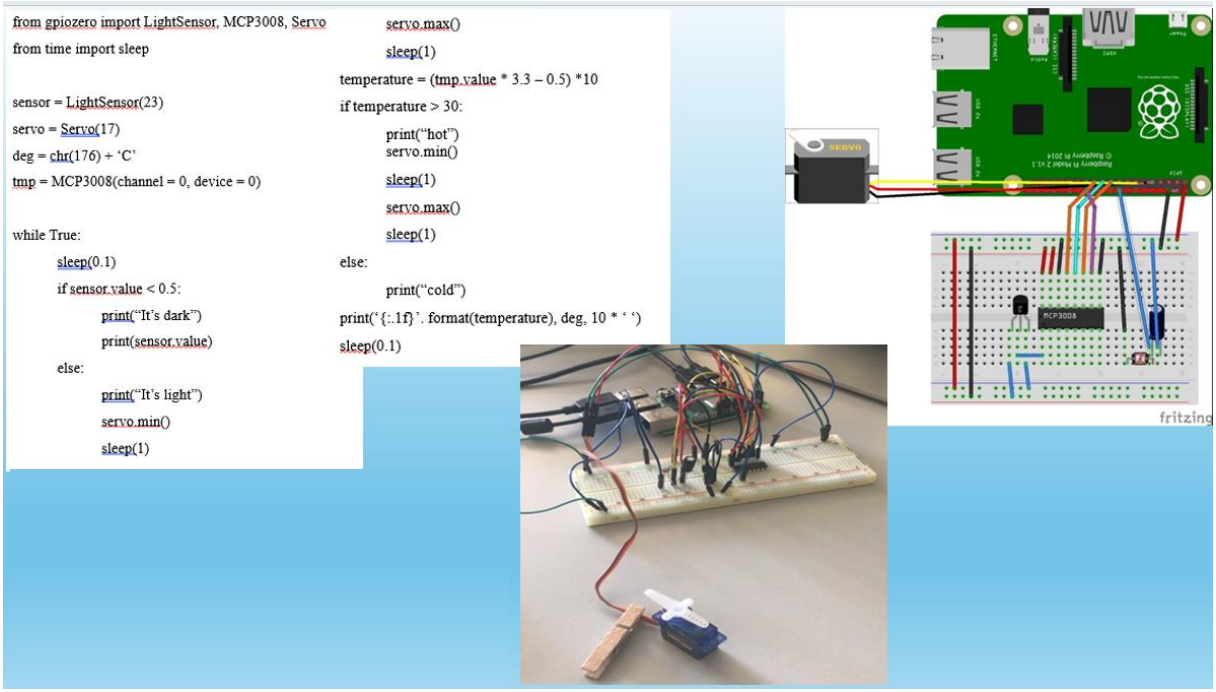

Figure 5. The circuit in Tinkercad, the real circuit during construction and the program of the smart house.

The video smart house presents the product of the activity.

Results

The results of the study are presented per research tool.

Diagnostic questionnaire

Nine (9) participants were able to correctly describe *selection* and *repetition structures* in coding, while seven (7) participants seemed to know what a *variable* is in coding. All participants knew what a *light sensor*, a *temperature sensor*, and a *motor* are, while eight (8) participants knew what a *capacitor* is. Seven (7) participants had not heard the term *Physical Computing* before, but five (5) participants were aware of the term and could link it to everyday activities.

Indicative answers from whom do not were aware of Physical computing: "*It aims to program physical objects using a specific programming language or maybe it refers to 3D models", "It may be the combination and study of physical objects through programming or the existence of objects for executing certain commands*".

Indicative answers from whom stated that they were aware of Physical computing: "*It relates to programming physical objects to perform actions that are relevant to people's lives, it engages with physics, mathematics, and other subjects beyond robotics and programming*".

Five participants gave an example of where Physical computing can be used: "*for mathematics, physics, etc. and in programming and using computers*", "*Maybe in displaying 3D objects for a variety of purposes, such as showing a building at the size it will be built*", "*It could be used in education or for solving everyday problems, such as using electronic circuits*."

Evaluation questionnaire

All participants expressed that they enjoyed the six learning activities. Most participants (9) claimed that they did not experience any major difficulties with the Arduino and Raspberry Pi platforms or the S4A and Python programming environments, but three (3) participants reported that they faced some difficulty constructing the circuits and creating the final programs. Furthermore, they expressed interest in engaging in similar learning activities in the future. Most participants (11) were able to understand and describe the programming structures they used. It's worth noting that even participants who didn't know the programming structures before the activities were able to describe them in the evaluation questionnaire. Most participants (10) reported that they were impressed by the results of each activity. All but one of the participants seemed understand the role of a capacitor in an electrical circuit and answered the questions about the light sensor, the temperature sensor, and the motor correctly and completely. They answered that they need knowledge concerning *Mathematics*, *Physics*, *Robotics*, and *Computer Science* to carry out the activities.

They seemed to understand the concept and role of Physical Computing in the new era. Indicatively, students' answers are: "*Physical Computing is a process by which we can program specific procedures to be carried out automatically. Such applications are useful in our daily life because they make it easier*.", "*It is the programming for the creation of objects that are useful in their daily lives*", "*it is the application of programming to physical objects, yielding results from simple things*", "*It is when we program various devices in our daily life to operate automatically without human intervention*", "*It is the study of physical phenomena with the help of robotics through computer tools*", "*These are useful applications for solving problems with specific procedures*".

As examples of applications in everyday life, they mentioned *automatic air conditioning adjustment, remote control of the television, automatic plant watering, and alarm creation, the creation of security systems, lighting with a detection sensor, photocells operation, electric doors, and temperature control.*

Finally, they stated that they learned new things but also remembered and applied existing knowledge. Indicative answers are: "*Yes, today I learned new things and viewed coding from a different perspective because, as it was taught in school, it was not interesting to me, and I could not understand how to code and why*", "*I understood how to use logic to programme objects that interact with their environment*".

Worksheets per activity and Participatory observation

According to the notes of the two researchers, during the participatory observation: Participants, divided into groups of three persons (in each group both boys and girls participated), carefully read the information and guidelines on the worksheets and carefully designed, created and programming the circuits. They worked collaboratively perfectly throughout the activities. Whenever they faced a difficulty, they firstly were trying to solve it into their group and if they couldn't, they asked the researchers for help. To answer the questions on the worksheets, they discussed them with their entire group. They did not face strong difficulties, but when they had to combine the function of servo motor, light sensor, and temperature sensor for the first time, they find it difficult to create the circuits. The circuits with the temperature sensor and the Analog to Digital Converter (ADC) caused the most questions to the researchers. All groups managed to solve the problems they were given and they successfully answered all the questions on the worksheets. Their enthusiasm and willingness to experiment until they found the solution for each problem was evident throughout the process of all activities.

Indicative students' description of their products:

"Each one of us can hide our own treasure in a treasure chest! Only we can access it using a secret code! For our a treasure chest, pressing a switch the system is activated, we knock three times on the piezo sensor (the three knocks is our code), the motor unlocks the door of treasure chest, we can take the treasure and after a while it locks again".

"*The smart house was designed so that the cooling fan operates automatically depending on the light and temperature in the room. More specifically, in the case of light, when the light sensor detects light >0.5, the cooling fan starts operating but when the light sensor detects darkness in the house <0.5, the cooling fan stops. The same applies to temperature, e.g. if we place an ice cube next to the temperature sensor, the cooling fan will stop operating, while if we place a hair dryer with hot air towards it, the cooling fan will start* operating."

It is worth mentioning that during the activities, the participants discussed among themselves how interesting it would be for their students to design similar projects in their future careers as teachers.

Focus group

All participants expressed that the utilization of educational robotics and physical object programming activities would be beneficial to their teaching career because it could enhance the effectiveness of their teaching in many subjects (*perceived usefulness).*

They think that they have understood how to use such activities in their teaching, and they do not find it difficult to use simple activities in their future classrooms. They feel that they have enough knowledge to use educational robotics and physical computing activities in their classroom. However, they will probably need help from the computer science teacher or a science teacher or a teacher with experience in experiments (*perceived ease of use).*

However, they believe that the curriculum will make it difficult to use physical computing during their teaching, because these activities are interdisciplinary and may require collaboration between classroom teachers and subject teachers. Additionally, the curriculum does not clearly support collaboration among students. A strong challenge is the lack of such equipment in schools (*challenges)*.

Training in educational robotics and physical computing is required concerning both the design and creation of circuits and the coding of circuits and objects. Advanced training concerning pedagogical approaches to be followed is needed (*needs for support*).

Students could deeply learn about mathematics, physics, computer science, and the environment. They also cultivate skills concerning cooperation, solution design, and construction. In this way, they could be taught practical knowledge of mathematics, natural sciences, and computer science (*knowledge gain)*.

They believe that educational robotics and physical object programming activities will be enjoyable for their students and will stimulate their curiosity, while also being quite entertaining. They themselves felt satisfaction every time they created the final product of the activity and pleasure during the course (*feelings).*

Participants indicated high performance by collaboration and distribution of roles during their work on the learning activities (*performance*) and felt that they were offered innovative tools for their students, motivation to study sciences and coding and triggering to work with new tools for authentic learning activities (*perceived opportunities).*

All participants would use Physical computing activities in their classrooms, even though some circuits look difficult to build. They would utilize such activities but with the appropriate training, suitable support, enough equipment and strong collaboration among teachers (*intention to utilize physical computing activities in their classroom).*

Conclusions

All participants (pre-service teachers, university students to be primary school teachers) enjoyed the six learning activities and understood the concept and role of Physical Computing in the new era, describing examples of applications in everyday life. They stated that they learned new things but also remembered and applied existing knowledge. All participants managed to solve the problems they were given and they successfully answered all the questions on the worksheets. They expressed enthusiasm and willingness to experiment with each problem given. During the activities they discussed among themselves how interesting it would be for their students to design similar projects in their future careers as teachers.

Their *perceived usefulness* was high; their *perceived ease of use* was moderate to high. They faced *challenges* concerning the curriculum and the equipment in schools. They *need support* and training in educational robotics, physical computing and in pedagogical approaches to be utilized. Their students could learn about mathematics, physics, computer science, and the environment as well as cultivate skills concerning cooperation, solution design, and construction (*knowledge gain)*. They *felt* satisfaction and pleasure during the course, and they believe that such activities would be enjoyable for their students and would stimulate their curiosity. Participants indicated high *performance* by collaboration and distribution of roles during their work on the learning activities and felt that they were offered *opportunities* related to innovative tools for their students, motivation to study sciences and coding and triggering to work with new tools for authentic learning activities.

All participants expressed their *intention to utilize physical computing activities in their classroom)* with the appropriate training, suitable support, enough equipment and strong collaboration among teachers.

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