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OBUDA UNIVERSITY
KELETI KÁROLY FACULTY OF BUSINESS AND MANAGEMENT

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SHARING SCIENTIFIC KNOWLEDGE WITHOUT BORDERS IN A MULTIDISCIPLINARY APPROACH

TUDOMÁNYOS TUDÁSMEGOSZTÁS HATÁROK NÉLKÜL MULTIDISZCIPLINÁRIS MEGKÖZELÍTÉSBEN

Joint conference of the International Society for Research in Education and Science and the Keleti Károly Faculty of Business and Management of Obuda University
International Society for Research in Education and Science és az Óbudai Egyetem Keleti Károly Gazdasági Karának közös konferenciája

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DESIGNING INTERACTIVE E-BOOKS: A FOCUS GROUP STUDY

Abstract: The design of digital learning resources for specialized domains such as Takaful (Islamic insurance) requires particular attention to usability, cultural sensitivity, and conceptual accessibility. While interactive e-books have gained popularity in education, their application in Islamic finance remains underexplored. This study investigates expert perspectives on the development of an interactive e-book tailored for Takaful education. Using a user-centered design approach, a high-fidelity prototype was evaluated through a focus group discussion with eight subject matter experts from Islamic finance and information communication technology (ICT). The findings revealed that effective content design must include multimedia elements—such as infographics, videos, and audio explanations to support comprehension of abstract concepts. Participants emphasized the importance of contextual relevance, recommending features such as clickable Quranic verses and glossary-linked definitions. Regarding interface design, users appreciated a layout that mirrors traditional reading formats, with consistent navigation and IIUM-aligned visual themes enhancing usability. In terms of interactivity, participants highlighted the value of quizzes with instant feedback, annotation tools, and embedded multimedia for fostering engagement and learner autonomy. These results align with existing literature emphasizing the role of digital glossaries, multimedia integration, and adaptive features in improving reading performance and knowledge retention. This paper contributes to the body of knowledge in educational technology by offering practical design recommendations for culturally responsive and pedagogically sound e-books in the Takaful domain. The insights gained can guide educators, designers, and policymakers in developing effective digital tools for Islamic finance education and public literacy.

Keywords: Interactive e-books, User-centered design, Digital learning

Introduction

The digital transformation of educational resources has significantly influenced how learners engage with content, particularly in specialized domains such as Islamic finance. Interactive e-books have emerged as a promising medium in modern education, that offers dynamic features like diverse multimedia components, interactive activities, quizzes, and feedback systems to enhance learner engagement, comprehension, as well as knowledge retention (Dahlan et al., 2024). These features align with principles of human-computer

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interaction (HCI), emphasizing user-centered design to create intuitive and effective learning tools (Panda, 2024).

Takaful education is characterized by complex terminologies and culturally specific concepts, which the design of interactive e-books presents unique challenges. Ensuring usability, cultural relevance, and accessibility is fundamental to facilitating effective learning experiences. On top of that, studies have highlighted the importance of using simplified language understood by general audience in interactive and multimedia-enhanced tools, which can go into supporting the integration of authentic and real-world materials to improve learning effectiveness. (Mısır, 2018). Despite the potential benefits, there is a lack of research focusing on the design and evaluation of interactive e-books tailored for takaful education. Existing literature predominantly addresses general educational contexts, leaving a gap in understanding how interactive e-books can be optimized for niche domains. This study aims to bridge this gap by exploring expert perspectives on the design considerations for content, interface, and interactivity in a takaful-focused interactive e-book.

Employing a qualitative methodology through focus group discussions with subject-matter experts in Islamic finance and information communication technology, this research seeks to uncover key design principles that enhance learner engagement and understanding. The findings aim to contribute practical guidelines for developing culturally responsive and pedagogically effective interactive e-books in the field of Islamic finance, thereby supporting better public understanding and informed decision-making in this sector.

Interactive E-Books in Education – Key Design Features Enhancing Learning

Interactive e-books have emerged as transformative tools in education, offering dynamic features that enhance learner engagement and comprehension. Their integration of multimedia elements such as videos, animations, infographics, quizzes, and hyperlinks cater to diverse learning styles and promotes active learning through user interaction and immediate feedback. These features align with Mayer's (2021) multimedia learning theory, which emphasizes that learning is improved when information is presented in both verbal and visual formats.

Recent studies underscore the effectiveness of interactive e-books in supporting complex learning processes. Cırakoglu et al. (2022) demonstrated that an interactive e-book developed using the Predict-

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Observe-Explain (POE) model significantly improved students' conceptual understanding in science education. Similarly, Franco and Bidarra (2022) emphasized that interactive e-books transform passive reading into a more immersive and participatory experience, leading to improved engagement and knowledge retention. These findings support the notion that interactivity through clickable definitions, assessments, embedded media, and personalized navigation enhances learners' control over their own learning process.

In the context of Islamic finance and Takaful education, interactive e-books fulfil a growing need for accessible, accurate, and engaging educational materials. The Islamic Development Bank Institute (2020) introduced a digital learning platform incorporating interactive content, including e-books, to enhance public understanding of Islamic financial instruments. This initiative was particularly effective in reaching global learners and explaining complex Shariah-compliant principles through real-world scenarios and case-based learning. Studies like Mısır (2018) have further argued that digital learning platforms must be tailored in such a way that supports learner inclusion, promotes intercultural sensitivities, as well as acknowledges the cultural differences in society, which would be possible by embracing a learner-centered pedagogy through these digital platforms.

The use of interactive e-books in education, especially in specialized domains like Islamic finance and Takaful, represents a valuable approach to democratizing knowledge. The integration of design features that promote comprehension, accessibility, and cultural relevance has the potential to bridge knowledge gaps and empower learners to make informed decisions in both academic and real-life contexts.

Interactive Elements and Design Features in Educational E-Books

Interactive e-books have become increasingly prominent in educational settings due to their ability to incorporate multimodal content, adaptive learning paths, and learner-controlled navigation. Unlike static PDF documents, interactive e-books leverage a variety of features such as digital glossaries, self-assessment tools, audiovisual elements, and problem-posing activities, to foster engagement and active learning (Clinton-Lisell et al., 2021). These features are not merely add-ons; when integrated coherently and aligned with pedagogical goals, they enhance comprehension, retention, and critical thinking (Craig et al., 2018; Sung et al., 2018).

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Multimedia components such as animations, hotspots, and interactive feedback have been found to boost engagement and improve targeted recall. For example, Zhou and Yadav (2017) observed that preschool learners interacting with visual and auditory hotspots demonstrated increased emotional engagement and specific recall, though overall comprehension gains were more modest. Similarly, Batoon et al. (2018) found that audiovisual content in high school e-books improved students' academic performance, although the potential for distraction remained a consideration. These findings suggest that interactivity can benefit learners across age groups and disciplines when thoughtfully implemented. The inclusion of digital glossaries and collaborative tools also showed strong positive effects. Clinton-Lisell et al. (2021), through a systematic review and meta-analysis, reported that digital glossaries significantly enhanced reading performance, especially when terms were embedded and accessible through hyperlinks. Collaborative features, such as annotation sharing and real-time discussions, supported social learning and deepened understanding particularly in hybrid or online environments. These tools align well with constructivist learning principles, encouraging learners to build and negotiate meaning actively.

Design principles such as adaptive feedback and combination of multiple interactive features are essential for maximizing educational outcomes. For instance, combining quizzes, video explanations, and glossary links allows for differentiated learning and reinforces self-regulated learning strategies (Ericson et al., 2016; Craig et al., 2018). However, studies also caution against overloading learners with too many features, which can lead to cognitive overload or disengagement (Lewin, 2000; Batoon et al., 2018). In the context of Islamic finance and Takaful education, where content often involves specialized vocabulary and ethical frameworks, such interactive features can bridge understanding gaps for public and academic audiences. Features like embedded Quranic verse explanations, audio-visual modeling of risk-sharing processes, and adaptive quizzes can describe complex Shariah-compliant principles, making financial education more accessible and culturally responsive.

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Method

This study employed a user-centered design (UCD) approach, aligning with the principles outlined in "ISO 9241" (2025), which emphasize involving users throughout the design and development process to ensure systems meet their needs and are usable and accessible. In e-book design, this approach involves understanding the reader's behaviour, preferences, and needs to create an intuitive and engaging reading experience (Panda, 2024). UCD is particularly effective in specialized domains like Islamic finance, where domain-specific knowledge is crucial for effective design. The research utilized a qualitative focus group method to evaluate a prototype of an interactive e-book designed for Takaful education. Focus groups are a well-established method in HCI research for gathering in-depth insights into user experiences and expectations, especially during the early stages of design.

Participants

Participants were selected using purposive sampling to ensure expertise relevant to the study. The focus group comprised eight subject matter experts, including four Islamic finance scholars and four information and communication technology (ICT) professionals with experience in educational technology design. This interdisciplinary composition facilitated comprehensive feedback on both the content and technical aspects of the e-book prototype.

Materials: Prototype

The primary material for evaluation was a high-fidelity prototype of the interactive e-book, developed using Kotobee. The prototype included features such as interactive quizzes, infographics, and real-world scenarios pertinent to Takaful concepts. These features were incorporated based on best practices in educational e-book design to enhance engagement and learning outcomes. Below are the examples of prototype interface design.

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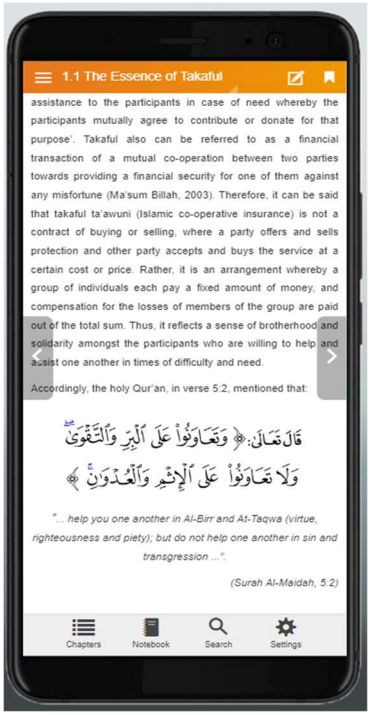

Figure 1. Prototype design for text and Quranic verse

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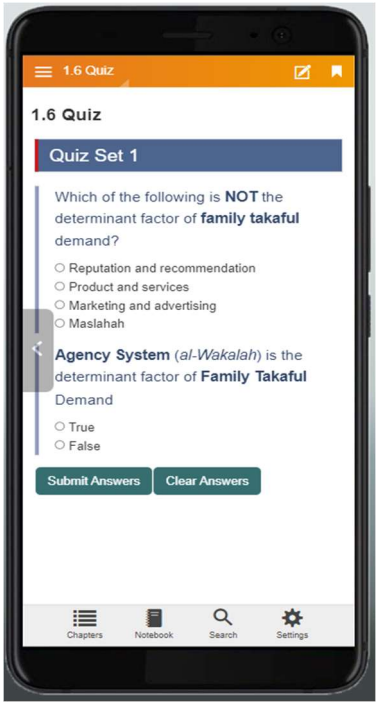

Figure 2. Prototype design quiz page at the end of each chapter

Procedures

The study was conducted in three phases:

1. *Prototype Review*: Participants were given access to the e-book prototype a day prior to the focus group session to allow for thorough review.

2. *Focus Group Discussion*: A 90-minute session was held, moderated by the lead researcher. The discussion was guided by a semi-structured interview protocol focusing on three key areas:

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Figure 3. Prototype design for Takaful model – clickable buttons

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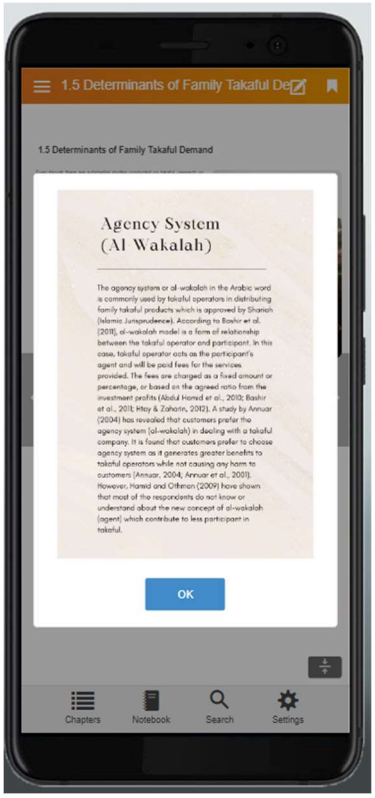

Figure 4. Prototype design for text explaination for the Takaful model – when it is clicked

A. Content Design (Cırakoglu et al.,2022; Dahlan et al., 2024; Mayer, 2021)

- Multimedia sufficiency (text, image, audio)
- Relevance of multimedia to Takaful models
- Attractiveness and suitability of content
- Readability of text
- Appropriateness of content structure (hierarchy)

B. Interface Design (Rogers et al.,2023; Nielsen, 2024; Panda, 2024)

- Ease of use
- Page layout (clean interface, simplicity, flow, spacing)
- Visual consistency (text, buttons, graphics)

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C. Interaction (Islamic Development Bank Institute, 2020; Cırakoglu et al., 2022; Dani, 2025)

- Availability of interactive elements (buttons, videos, hyperlinks)
- Assessment tool design (quizzes)
- Authoring support (highlighting, notes, search, bookmarking)

3. Data Collection: The session was audio-recorded and transcribed verbatim.

Data Analysis

The data collected from the focus group were analyzed using a thematic approach based on the interview questions, which were organized around three main design aspects: content design, interface design, and interactivity. Responses were reviewed and categorized according to recurring patterns within each theme, allowing the researchers to identify strengths, concerns, and recommendations expressed by the participants. This straightforward analysis method ensured that the evaluation remained aligned with the user-centered design focus of the study and highlighted key areas for improving the e-book prototype.

Results and Discussion

The evaluation of the interactive e-book for Takaful education highlighted three core areas influencing user experience and learning effectiveness: content design, interface design, and interactivity (Table 1).

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Table 1. Summary of findings from e-book prototype evaluation

Core areas	Findings
Content design	• Multimedia components are generally sufficient, but enhancements (e.g., clickable definitions, audio support) are recommended. • Infographics, video, and animated models are preferred to explain complex Takaful concepts. • Text readability is good, but improvements are needed in consistency (e.g., Arabic terms, Quranic verses). • Users suggested glossary links, hierarchical structure maintenance, and inclusion of institutional branding.
Interface design	• Interface is straightforward and easy to use. • Layout mirrors traditional books and supports cognitive flow. • Suggestions include glossary integration, quiz placement at chapter ends, and brand-aligned color schemes. • Design consistency for buttons, text, and images is an area for improvement.
Interaction	• Interactivity is adequate but should include more hyperlinks for terms, video/audio for models, and better assessment feedback. • Quizzes should show marks and guide users to relevant chapters. • Authoring tools (highlighting, notes, bookmarking) are positively received. • Suggestions include making content downloadable and publicly accessible.

Discussions

The study revealed that carefully designed content in an interactive e-book significantly enhances the learning experience for users engaging with complex subjects such as Takaful. Participants noted the usefulness of infographics, videos, and animated process models in explaining abstract concepts, which is consistent with Mayer's (2021) cognitive theory of multimedia learning. These multimedia elements reduce cognitive load and enable learners to construct mental models of the content more effectively. These findings are further supported by Batoon et al. (2018), who reported that audio-visual content in interactive e-books positively influenced student grades, particularly in secondary education. However, as noted in the same study and reinforced by Clinton-Lisell et al. (2021), multimedia must be carefully aligned with instructional goals to avoid cogni

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tive overload and distraction. Furthermore, recommendations to include hyperlinked definitions and audio-supported Quranic verses emphasize the importance of contextual relevance and cultural alignment in faith-based financial education. This aligns with Bozkurt and Bozkaya's (2015) criteria, which stress the need for domain-sensitive content structures and glossary functions in digital learning environments.

Interface design was also found to play a critical role in shaping user engagement and learning efficiency. Participants valued the straightforward and familiar layout that mimicked physical books, along with consistent visual elements and IIUM-themed color palettes. These preferences reflect the principles of user-centered design, particularly the importance of consistency, visual hierarchy, and minimal cognitive friction as outlined by Nielsen (2024) and Rogers et al. (2023). Maintaining interface consistency across pages especially in text formatting, button design, and navigation helps users develop predictable mental models of the e-book environment, reducing the time spent figuring out how to interact with content and allowing them to focus on learning instead.

Interactivity further contributed to improving user experience and learner motivation. The participants appreciated features such as clickable terms linked to a glossary, formative quizzes with instant feedback, and annotation tools. These findings align with research by Çırakoğlu et al. (2022), which demonstrated that interactive assessment and feedback mechanisms promote learner autonomy and retention. These preferences are confirmed in the findings of Clinton-Lisell et al. (2021), whose meta-analysis found digital glossaries and collaborative tools to significantly improve reading performance (effect size $g = 0.66$, $p < .001$). Moreover, studies by Craig et al. (2018) and Xu et al. (2020) emphasized that interactive quizzes, hotspots, and feedback mechanisms, when well-integrated, can improve both retention and learner autonomy, is the key to successful digital pedagogy. Similarly, Dani (2025) emphasizes that embedded features like bookmarking and highlighting transform passive reading into active learning.

In the context of Takaful education, where learners often encounter new legal, ethical, and financial frameworks, the combination of multimedia and interactive design allows for deeper conceptual engagement. When features are aligned with specific learning outcomes, as recommended by Sung et al. (2018), they promote critical thinking without increasing cognitive burden. The findings from this study, supported by the broader literature, affirm that a user-centered, culturally aware, and technically sound e-book can serve as a highly effective tool in disseminating Islamic finance knowledge, not only in formal education but also in public outreach and professional upskilling.

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Conclusion

This study set out to explore expert perspectives on designing an interactive e-book specifically tailored for Takaful education, with the aim of identifying key principles related to content, interface, and interaction design. Through a user-centered focus group approach, the findings demonstrated that multimedia elements such as infographics, videos, and audio-supported Quranic verses enhance learners' comprehension of abstract Islamic finance concepts. The study also revealed that clear content structure, consistent visual design, and embedded interactivity (quizzes, annotations, hyperlinks) are vital in improving usability, engagement, and learner autonomy—effectively fulfilling the study's objective of informing best practices for culturally responsive and pedagogically sound digital resource development.

These findings offer valuable contributions in educational technology and human-computer interaction, particularly within the niche context of Islamic finance. From an industry and policy perspective, the insights serve as a foundation for instructional designers, EdTech developers, and financial educators to adopt evidence-based strategies in creating digital learning materials that are both accessible and aligned with Islamic values. The e-book prototype developed in this study exemplifies how interactive technologies can democratize financial literacy and support capacity building in faith-based economic systems, potentially benefiting learners in academic, professional, and community education settings.

Nonetheless, the study has its limitations. The focus group was composed of a small and expert-driven sample, which may not represent the perspectives of general users or learners at various proficiency levels. Additionally, the study's findings are based on prototype evaluation rather than long-term user testing or learning outcome assessments. Future research should involve a broader demographic, including students and public users, and employ mixed-method evaluations to measure cognitive gains, behavioral engagement, and longitudinal impacts. Investigating adaptive learning technologies and personalized content delivery in Islamic financial education could further enrich the design of digital tools in this evolving field.

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Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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THE USE OF ARTIFICIAL INTELLIGENCE IN SCIENCE EDUCATION: A CASE STUDY

Abstract: This study aims to examine how a faculty member working at an education faculty in Türkiye integrates artificial intelligence (AI) tools into science education, as well as their views and experiences. Based on a qualitative case study design, data obtained from semi-structured interviews and notes taken by a participant observer who attended the faculty member's classes were analyzed thematically, revealing five main themes. These themes are commonly used AI tools, AI and information reliability, AI and ethics, AI and access to information, and perceptions of AI. The research findings reveal that the definition of AI is not yet fully established and can be perceived in different ways, that information obtained through AI is not very reliable in terms of science education, that it contains misconceptions and misinformation, that there are ethical issues in AI-based studies, and that although AI facilitates access to information, it carries risks in terms of developing thinking skills. In light of these findings, science educators are advised to educate themselves on subject matter knowledge and misconceptions, critically evaluate information obtained through AI, and adhere to ethical principles when using AI.

Keywords: Artificial intelligence, Science education, Technology integration

Introduction

In recent years, rapid developments in educational technology have been seen to have a significant impact on further improving teaching and learning experiences (Valtonen & Mäkinen, 2022). Artificial Intelligence (AI) stands out as a particularly notable advancement in educational technology (Mhlanga, 2023). The term AI was defined by McCarthy et al. (1955) and refers to a machine possessing human intelligence and capable of performing tasks considered intelligent (McCarthy et al., 1955). Kurzweil (1990) describes AI as the art of creating machines that can perform tasks done by human intelligence (Adıguzel et al., 2023). AI studies basically aim to develop computers and machines that are as intelligent as humans (Coppin, 2004), and with the achievement of this goal, various innovations and advances are taking place (Chen et al., 2020). AI is also defined as a field within computer science that uses algorithmic methods to study the fundamental structure of intelligence with the aim of producing intelligent entities that resemble human cognitive abilities

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(Dwivedia et al., 2021). The main aim of AI is to develop systems that can learn, demonstrate, explain, provide advice, understand, reason, and behave in a manner like humans. It also performs tasks such as speech recognition, acquiring new skills, strategy formation, and problem solving (Bozic & Poola, 2023). Thus, AI is profoundly influencing our learning processes (Chen et al., 2020).

By providing a learning environment that can be adapted to students' individual needs and encourages active participation, AI transcends the limitations of traditional methods to offer a more dynamic and interactive educational experience (Sevil & Gokoglu, 2024). From this perspective, the potential of AI tools to transform teaching processes is of great importance in terms of both enriching students' learning experiences and contributing to the development of more efficient strategies in education by teachers (Arugaslan, 2025). Huang et al. (2021) states that the use of AI technologies in education will enable teachers to improve the quality of teaching while making students' learning processes more diverse and personalized. This is thought to contribute to teachers making course content more flexible and tailored to student needs. However, the use of AI in education also brings with it certain difficulties and concerns. There are concerns that teachers' fundamental roles, such as guidance, assessment, and one-on-one interaction with students, may be transferred to technology, and that their traditional roles in the educational process may be reduced (Sevil & Gokoglu, 2024).

On the other hand, AI is increasingly transforming science education by enabling real-time performance monitoring, large-scale data analysis, and personalized feedback for learners. Beyond data-driven assessment, AI-powered simulations, visualizations, and creativity-based applications make abstract scientific concepts more accessible and foster deeper conceptual understanding (Yilmaz, 2024). As emphasized by Mazur (2009), the goal of science education is to promote meaningful learning by connecting new knowledge with prior understanding. In this context, AI does not only enhance scientific thinking and model-building skills but also redefines science education as an interactive and adaptive process, moving beyond rote memorization toward inquiry and creativity (Yasar et al., 2025).

When we look at literature, there are many studies on the use of AI in science education. Upon detailed examination of the literature, studies include science teacher candidates' views on sociological issues (Bayram & Celik, 2023), the effect of AI on primary school students' problem-solving and creative writing skills (Soydemir - Bor & Kucukaydin - Alkıs, 2021), increasing the awareness of science teacher candidates (Cam, Celik et al., 2021), science teachers' approaches to AI use in the distance education process (Erkoc,

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2023), the effect of AI on the scientific process skills of 8th grade gifted students in the topics of seasons, DNA, and pressure (Sarioglu, 2023), physics teacher candidates' perceptions of AI (Erdogan & Bozkurt, 2023), the use of Artificial Neural Networks (ANN) in classifying science teacher candidates' grade point averages (Yorganci & Isik, 2019), and an analysis of science teachers' use of AI in the distance learning process (Colak Yazici & Erkoc, 2023). Despite the increasing integration of AI in education, there is a lack of research on faculty members' perceptions and experiences with these technologies. This study aims to examine in depth how a faculty member uses AI tools in education, their experiences with these tools, and their perspectives on AI's potential and limitations. By exploring these individual assessments, the research contributes to understanding how AI is perceived in educational contexts, informs strategies for effectively integrating technology into teaching and learning, and addresses associated challenges, including ethical considerations, information reliability, and impacts on personal development. Overall, the study provides valuable insights into developing innovative educational practices and advancing literature on AI in education. Thus, the main research question of this study is 'What is the perspective of a faculty member in the field of science on artificial intelligence?'.

Method

This research was conducted with a faculty member with expertise in the field of science education at a university in Türkiye during the 2024–2025 academic year. In this study, a case study design, which is one of the qualitative research methods, was employed to conduct an in-depth analysis of a specific situation or practice and to systematically identify existing problems while offering potential solutions. According to Merriam (1998), the case study is a qualitative research approach well-suited for understanding real-life situations in education and for gaining in-depth insights into participants' perspectives and experiences.

Data Collection Instruments

Three different instruments were used to collect data in this study: Semi-structured interviews, participant observations, and document reviews.

Coding Procedure

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The participant was given a code name, Dr. Aysel, to ensure data confidentiality, and this name represented the participant's identity throughout the study. Also, she has conducted various academic studies on technology-supported teaching methods and actively integrates AI technologies into educational processes.

Interviews

The semi-structure interview was conducted face-to-face and during the interviews, Dr. Aysel's thoughts, experiences, and challenges regarding AI were discussed in detail.

Participant Observations

Observations were conducted to understand how the participant used AI-supported tools during the lesson process.

Document Reviews

The documents and the resources used by Dr. Aysel during the course were reviewed.

Reliability and Validity of Data Collection Instruments

To enhance inter-coder reliability, the dataset was independently examined by multiple researchers and common themes were established through consensus (Merriam, 2009). Researcher neutrality was maintained throughout the analysis to ensure trustworthiness, as emphasized by Lincoln and Guba (1985). Member checking was conducted by sharing observation and interview notes with participants, a strategy Merriam (2009) identifies as one of the most effective ways to strengthen credibility. In addition, findings were compared with relevant literature to ensure content consistency and theoretical grounding (Patton, 2015). Credibility was further supported through data triangulation, using observations, interviews, and document analysis, which Patton (2015) highlights as a key strategy for enhancing reliability.

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Data Analysis

The data obtained in this study were analyzed using thematic analysis, a method that enables the identification, organization, and interpretation of patterns of meaning (themes) within the data (Braun & Clarke, 2006). Themes were constructed to more accurately capture and represent Dr. Aysel's experiences. Data collected through interviews with Dr. Aysel, along with observation and field notes, were organized under specific themes. These themes included: commonly used AI tools, AI and information reliability, AI and ethics, AI and access to information, and perceptions of AI.

Findings

In this section, the findings obtained from the interviews with the participant are presented alongside their systematic analysis. The data collected from the faculty member were subjected to a process of thematic categorization, drawing on both interview transcripts and observer notes. Within each theme, the findings are triangulated by integrating insights from both the interview data and observational records, thereby enhancing the validity and depth of the analysis.

Theme 1: Commonly Used AI Tools

The findings indicate that Dr. Aysel primarily engages with ChatGPT due to its perceived ease of use as an AI tool. She further emphasizes that the capacity of AI applications to provide students with rapid and convenient access to information constitutes a key factor underlying their growing popularity in educational contexts. Moreover, Dr. Aysel utilizes widely adopted AI tools such as ChatGPT not only as a means of seeking solutions to specific problems but also as a supportive resource in areas where she encounters challenges or lacks prior expertise. This reflects her recognition of AI tools as facilitators of both problem-solving and self-directed learning. Dr. Aysel's opinion on this subject is given below.

"For me, the most important feature of AI tools is that they are practical to use and easy to access. The reason I prefer ChatGPT in particular is that it can provide quick and effective answers to my questions. It saves me time and allows me to access information immediately."

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"When I wanted to research collaborative learning in education, I was struck by how the content AI offered me emphasized that educational work is open to interpretation by each individual."

"...For assignments, I use ChatGPT not only to write texts and arrive at an initial solution, but also to quickly understand topics I occasionally struggle with. Teacher candidates use AI frequently. Especially in science classes, they ask AI tools like ChatGPT, Gemini, or Google Assistant directly for the answer to a question they encounter."

In her lessons, Dr. Aysel uses AI-supported Web 2.0 tools, examples of which are shown in Figures 1, 2, 3, and 4 below. The notes taken by an observer who attended Dr. Aysel's lessons and screenshots of the AI-supported applications used in the lessons are provided below.

Participant Observer Note: Dr. Aysel introduced Web 2.0 tools in her lessons with us. She asked us to thoroughly examine the AI-powered features, automatic design suggestions, visualization options, and simple interfaces of Web 2.0 tools such as Canva, Animaker, and Visme that we use in science education, and to create projects. She reviewed the projects we created and told us that using this technology to design presentations and infographic texts would save us time; she also said that since the designs were visual and fun, students would be able to focus better on their lessons. She stated that it offered significant benefits for students learning in science education and would contribute to the integration of educational technology. We also used GitMind, one of the Web 2.0 tools, in Dr. Aysel's class. Dr. Aysel said that GitMind is easy to use and has many advantages because it is AI-supported. (May 12, 2025)

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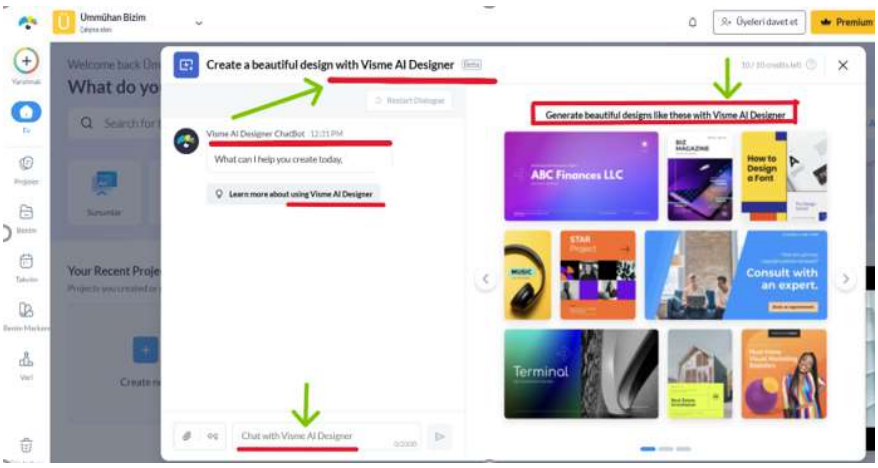

Figure 1. Visme's AI-powered interface

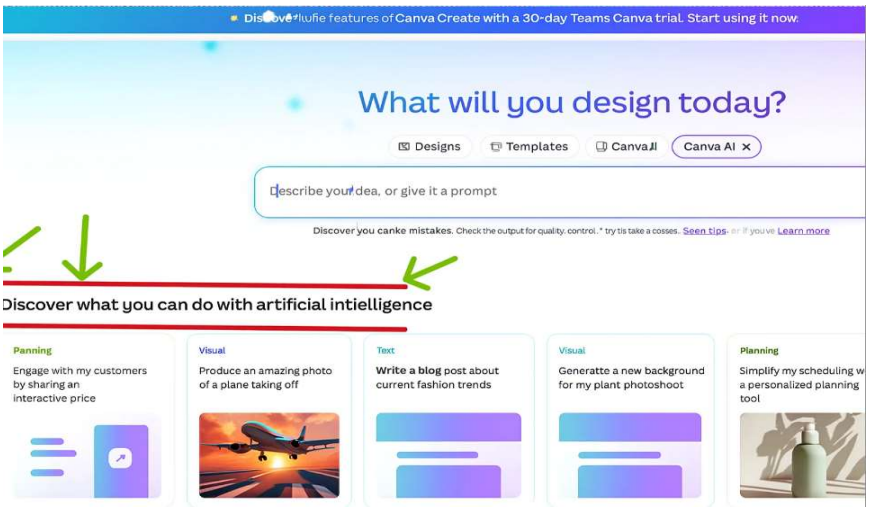

Figure 2. Canva's AI-powered interface

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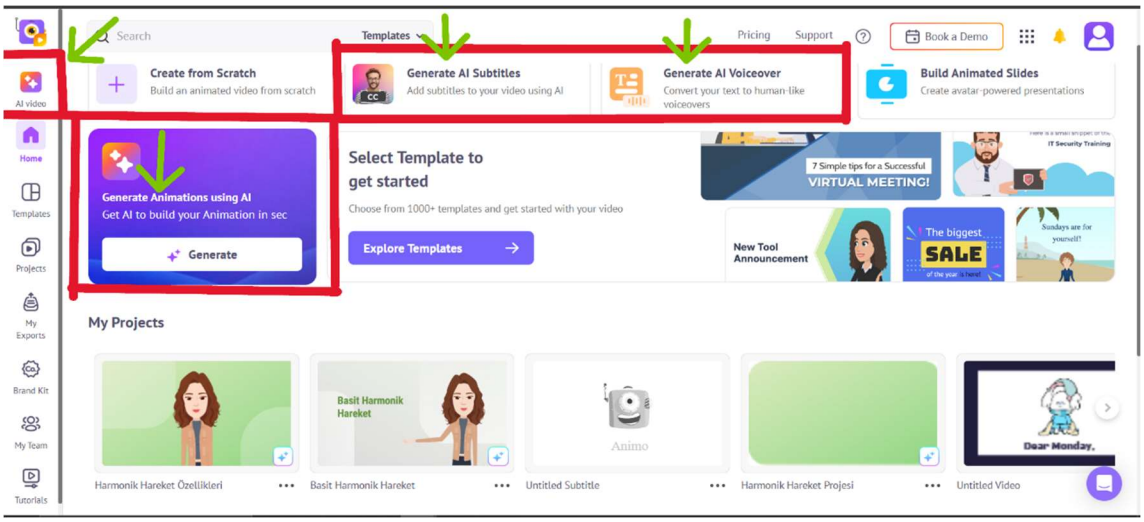

Figure 3. Animaker's AI-powered interface

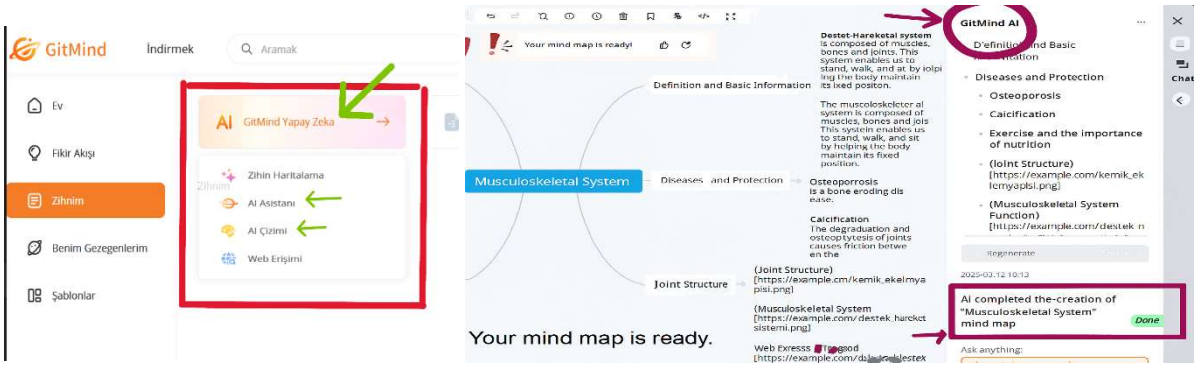

Figure 4. Gitmind's AI-powered interface and example

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Theme 2: AI and Information Reliability

The findings indicate that Dr. Aysel acknowledges the potential fallibility of AI-generated information and stresses the need for cautious engagement with such outputs. While she perceives the use of AI tools by preservice teachers as beneficial, she also highlights the risk of overreliance on these technologies. In her view, the uncritical acceptance of AI outputs may undermine learner autonomy, impede personal development, and weaken critical thinking skills. Dr. Aysel's perspectives on this issue are presented below.

"I asked these tools some questions related to my project and used the content they provided without verifying its accuracy. Later, during my research, I realizem that some parts were incorrect... It's great for teacher candidates to ask AI about things they are curious about, but being so confident about the accuracy of information they get from a single source can negatively affect their development. Because the thought that it might not be correct is where a person really begins to learn."

Participant Observer Note: In our lesson with Dr. Aysel, we sent a Physics question on Force and Motion to Chat GPT, an AI tool, to solve. The actual correct answer to the question we sent was A) Alone-II. The AI initially misunderstood the question and solved it incorrectly, finding option B. Later, lacking confidence, it continuously changed its answer based on Dr. Aysel's messages. Despite changing it, it misinterpreted this and tried to explain the question. If we hadn't known the correct answer and hadn't been skeptical, we would have allowed the AI to mislead us. Dr. Aysel told us that while we can naturally use AI tools to improve ourselves, information accepted without question is not always correct. (May 23, 2025)

The classroom application shown in the example in Figure 5 demonstrates that artificial intelligence-based tools (e.g., ChatGPT) can produce misconceptions in some cases and show inconsistencies in their responses. This highlights the risk of misguiding students in learning environments where critical inquiry skills are not developed.

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Figure 5. ChatGPT's response to the force-motion question

Theme 3: AI and Ethics

Dr. Aysel highlights that referencing information generated by AI tools without ensuring its reliability may pose significant risks to academic integrity and ethical scholarship. She stresses that such practices could undermine responsible citation practices and weaken the principles of scholarly accountability. Accordingly, her perspective draws attention once again to the necessity of cultivating critical thinking as a safeguard against the uncritical use of AI-generated content. Dr. Aysel's views on this matter are presented below.

"The accuracy of some of the information provided by AI is not always certain. For example, while preparing the discussion section for a research article, I noticed that some of the articles suggested by AI had incorrect citation sections or that such articles did not actually exist. This situation demonstrates the need to always verify information obtained from artificial intelligence."

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"I think artificial intelligence is very problematic in terms of ethical issues. In particular, I think it will cause an increase in plagiarism rates in its own field, and beyond that, I think there will always be the suspicion, 'Was this really done? Are the studies or research in literature really there?' Therefore, I can say that it is not ethically appropriate to do academic work with artificial intelligence."

Participant Observer Note: In our lessons, Dr. Aysel mentioned that AI could violate ethical values. In line with the research, AI made a mistake in the thesis/article proposal we requested from her and proposed a doctoral thesis that did not exist. In fact, this doctoral thesis covered galactic regions that do not even exist in the world. Dr. Aysel wanted us to search for this thesis in official sources such as YOKTEZ and Google Scholar and find that it really existed, but there was no such thesis in any official publications. Even though AI made the wrong thesis proposal, she made detailed explanations as if it existed and even prepared an abstract accordingly. Dr. Aysel said that if we used this thesis as a source without researching it, we would very likely make a big mistake. For this reason, she told us to conduct our literature research from official sources, to pay attention to reliability, that she had encountered such a problem before, and that she did not make a mistake because she thought critically (May 24, 2025).

The situation described in Figure 6 reveals that artificial intelligence tools have the potential to mislead researchers by generating academic studies that do not actually exist. The findings demonstrate that relying solely on verifiable and reliable sources in academic research is indispensable in terms of scientific ethics and validity.

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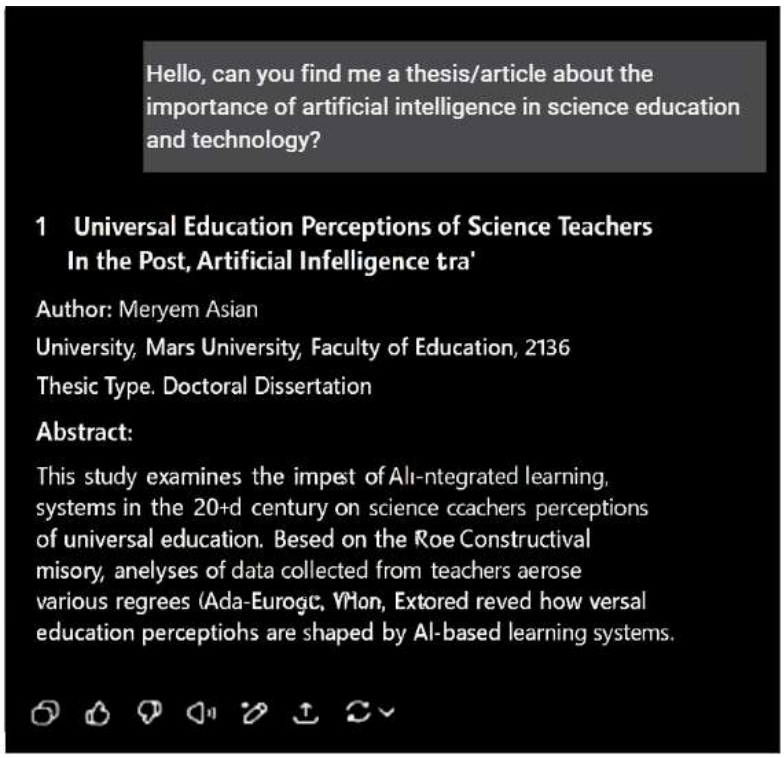

Figure 6. ChatGPT thesis proposal

Theme 4: AI and Access to Information

Dr. Aysel highlighted that, although AI tools can enhance students' rapid access to information and support efficient information retrieval, they simultaneously pose potential risks to the development of critical thinking and cognitive skills. She further emphasized that unmediated reliance on AI outputs may hinder the cultivation of information literacy and critical analytical abilities, underscoring important pedagogical implications for the responsible integration of AI in educational contexts. Her perspectives on this issue are presented below.

"Using AI tools for student development is great, but I think it's problematic that they are so confident about the accuracy of the information they get from a single source. Education is a system that concerns people, so when we work with artificial intelligence in education, there is no single answer to the questions we ask. AI only provides us with support. It helps us create a plan that will continue with a different

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perspective and new questions, but the data and content it provides cannot be the main content of our work. AI does not give us concrete answers; it is designed to help us and suggests that we stay on our own path. Although AI has positive aspects, students using these tools only to quickly finish their homework or assignments can hinder their development."

Participant Observer Note: After my conversation with Dr. Aysel, she said that her students needed to be flexible in their use of AI. I then wanted to test the AI myself and asked her to prepare an assignment for me as an example. The AI prepared a 500-word assignment exactly as instructed. Dr. Aysel said that AI can be used in many ways and that whether this is good or bad is up to us. She said she pays close attention to these issues and wants us to find ways to always push ourselves forward, rather than getting used to ready-made solutions.

As shown in Figure 7, the findings indicate that while artificial intelligence tools can be used as flexible and versatile support tools in educational processes, viewing them solely as a source of information may limit students' critical thinking and independent learning skills. The findings reveal that the educational contribution of AI should be evaluated as a complementary tool that supports student development but does not replace the primary learning process.

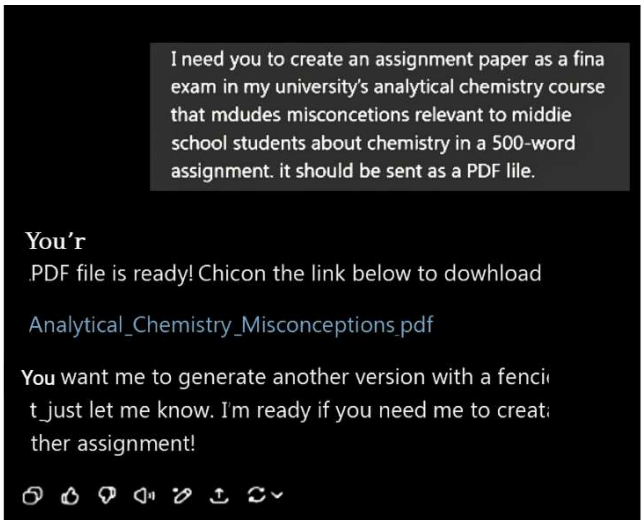

Figure 7. ChatGPT homework answer

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Theme 5: Perceptions of AI

Dr. Aysel emphasizes that the concept of AI can be perceived and defined differently by various users. She notes that AI may be understood not merely as a data-processing tool, but as an expansive knowledge network that integrates multidimensional data sources and broadens students' cognitive frameworks. In this context, AI has the potential to support students' conceptual thinking skills by facilitating the construction of mental maps, thereby extending its role beyond simple information processing. Her perspectives on this matter are presented below.

"When I hear AI, what comes to mind is technology. Technology is a system that brings me whatever relates to my field or education. We can also think of AI as a data collection tool or a research-based library. To me, AI is like a mind map. It seems like a mind map that brings together not only my knowledge but all the knowledge in the world. We can also think of it as a data collection tool or a research-based library. In projects related to AI-supported materials, I see studies investigating the impact of these tools. I am also considering working on the question of artificial intelligence versus natural intelligence."

Participant Observer Note: Figure 8 shows the visual we created with Dr. Aysel using the command "Create visuals that show AI as a massive mind map and library using students, other people, data, and information" in the Sora version of Chat GPT.

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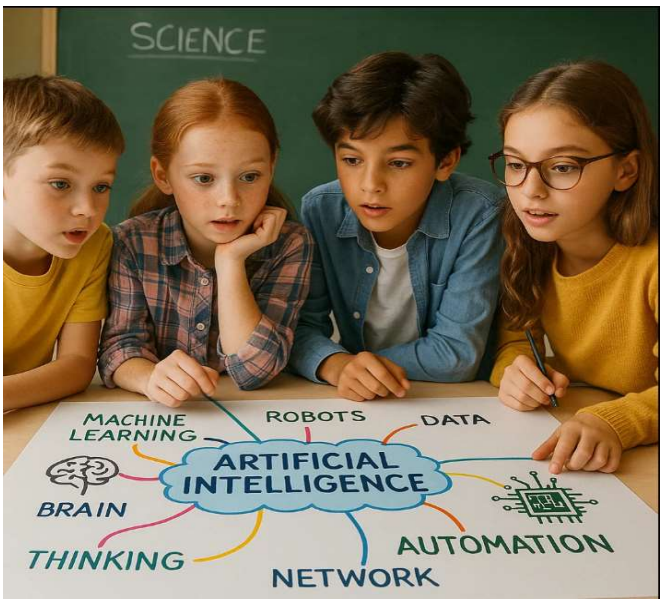

Figure 8. ChatGPT Sora version mind map visual

Discussion

In this study, the experiences and opinions of a faculty member regarding the use of artificial intelligence tools in education were examined, and the opportunities, challenges, ethical and reliability dimensions, and effects on access to information of these technologies in teaching processes were evaluated.

The research findings reveal that artificial intelligence (AI) tools are used in science education due to their ease of use and ability to provide quick access to information. Additionally, it demonstrates that AI-supported Web 2.0 applications are effectively utilized to support students' visual, creative, and collaborative learning processes. This is consistent with previous studies in the literature that AI tools enrich the learning experience and increase students' analytical thinking skills (Luckin et al., 2016; Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

On the other hand, it should be kept in mind that the accuracy of the information provided by AI tools cannot always be guaranteed and that using it without verification may pose risks in terms of academic ethics. Ethical issues related to artificial intelligence constitute one of the most important problems today, as stated

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in Ozturk's (2025) article. As noted in the findings of this study, relying solely on AI may limit students' independent learning and critical thinking skills (Nabiyev & Erumit, 2020; Holmes, Bialik, & Fadel, 2021). Therefore, it can be said that those who use AI for educational purposes should not forget to view AI outputs with a critical eye. Research findings indicate that AI has not yet been fully defined. This finding is consistent with the work of Bedir et al. (2025), which shows that gifted students perceive AI differently. It can be said that the diversity of perceptions in the minds of teachers and faculty members is reflected in students as well.

Conclusion

This study also revealed that artificial intelligence has not yet been fully defined, and that its use in science education has not yet been ideally trained, resulting in conceptual misconceptions and incorrect answers to science questions. It was noted that ethical problems may arise in the information obtained through artificial intelligence, and that artificial intelligence should be used without abandoning critical thinking.

Recommendations

Based on the findings of this study, it is recommended that AI tools and AI-supported applications be used cautiously in educational settings. Particular attention should be paid to the potential risk that AI tools, when applied in science education, may present misconceptions or incorrect solutions as if they were accurate. Therefore, information provided by AI should be cross-checked with established sources and fundamental references in science education. Moreover, given that the boundaries of AI ethics are not yet clearly defined, educators are advised to act with careful consideration of ethical principles when employing such tools. For future research in science education, it is further recommended that researchers train AI systems specifically with respect to common misconceptions and subject-matter knowledge in science, thereby enabling more reliable and pedagogically meaningful applications.

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Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

* This study has received ethics committee approval from Necmettin Erbakan University. Date: 26.05.2025. Meeting Number: 13 Decision Number: 2025/633

Conflict of Interest

* The authors declare that they have no conflicts of interest

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DIGITAL SELF-EFFICACY, TECHNOLOGY ADOPTION PRACTICES AND TECHNOLOGY INTEGRATION SKILLS: A STRUCTURAL EQUATION MODEL FRAMEWORK FOR FACULTY DIGITAL COMPETENCY DEVELOPMENT

Abstract: This study investigated the intricate interplay among digital self-efficacy, technology integration, and technology adoption practices within higher education institutions, examining their influence on faculty behaviors and overall productivity. Employing a quantitative approach utilizing Structural Equation Modeling (SEM), the research assessed various facets of digital competency. Findings revealed faculty possess a commendable level of digital self-efficacy, particularly in safety (composite mean=3.34) and communication. While strong confidence exists in technology's potential to enhance student learning (highest performance expectancy=3.67), significant barriers were identified in facilitating conditions, notably unreliable internet connectivity (lowest=2.35) and institutional support. Regarding technology integration, faculty generally demonstrate an agreeable level of skill, valuing its role in career advancement (highest=3.30), though expressing least contentment with digital content quality (lowest=2.75). Crucially, the analysis confirmed robust interconnections: digital self-efficacy directly and substantially influences both technology adoption practices (estimate=0.782) and technology integration skills (estimate=0.782). Furthermore, technology adoption practices directly and positively affect technology integration skills (estimate=0.252), establishing a significant mediating role for adoption in the self-efficacy-integration relationship (indirect effect=0.129). The proposed model demonstrated a good fit (cfi=0.938, tli=0.916). In conclusion, faculty digital self-efficacy is a pivotal driver of technology engagement and integration.

Keywords: Digital self-efficacy, Technology adoption, Technology integration

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Introduction

Higher education stands at a crossroads, facing the urgent imperative to embrace sustainable practices while simultaneously navigating a period of rapid technological advancement. The introduction of digital technologies is no longer an option, it has become a reality and affects each aspect of life at the university, from learning and teaching to administration and science. However, this shift raises an important question: how can higher education institutions use technology more effectively to progress beyond operational efficiency and towards the kind of desired technology adoption practices that are a cornerstone of innovative societies?

A crucial skill from today's digital literacy is the concept of digital self-efficacy, which means to have believe in own ability to search through technology and take advantage of their benefits. This multi-faceted domain covers a range of dimensions which include information and data literacy, communication and collaboration, digital content creation, safety problem-solving. (Aslan, 2020). In terms of media education, effective technology integration means using technological tools with educational goals; promoting skills related to digital literacy; and fostering critical thinking and creativity through activities mediated by technology. (Eden et al., 2024) This includes many facets, including comfort with simple digital tools; confidence to infuse technologies into instructional designs and procedures (e.g., technology-enhanced learning methodologies); troubleshooting capabilities These various dimensions, including information and data literacy, communication and collaboration, digital content creation, safety, health and wellbeing as well as problems solving are indicative of the multi-faceted nature of digital self-efficacy Secondly: Technology integration skills refer to practical abilities required for the effective use of technology in teaching and learning. The successful incorporation of digital tools and resources into teaching and learning is technology integration. The intentional use of technology to improve the quality and efficiency of educational programs. (Karkouti, 2021) Factors associated with the three skills – basic technology literacy, access to online channels and digital content, ability and comfort in using technology. In addition, the research covers technology adoption habits that present the behaviors and trends of using technology in teaching practice. Sits within The Unified Theory of Acceptance and Use of Technology (UTAUT) — a determinative model on the acceptance of technology based on the constructs such as performance expectancy, effort expectancy, social influence and facilitating conditions. (Marikyan and Papagiannidis, 2023). The endnote looks at how these aspects can influence faculty integrating technology.

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This research focuses on the faculty members of provincial local colleges. While those colleges are committed to advancing technology adoption practices, variations in employees' digital self-efficacy and the effective integration of technology present potential challenges. Specific challenges that may be facing organizations, some of the main ones indicated in prior research include an employee digital divide with respect to technology proficiency between staff members, likely resistance to blend technologies into work groups and their practices, resource limitations related to accessing the necessary tools for driving technological adoption and how effectively this can be managed, differences in current levels of awareness with regard to tech integration among task groups. This study will approach these problems and investigate how they affect the bond amid digital self-efficacy, technology appropriation, as well as faculty-based levels involving the acceptance of various kinds of technologies.

There has been a notable gap in the literature with respect to integrated models that investigate the relationships between the digital self-efficacy of higher education faculty, technology adoption practices and development of their technology integration skills. In the provinces, such as in Batangas, this gap is especially important where digital advancements are often not followed through on due to literal problems — facing issues with traditional class cards and non-functional equipment; they rely still on aged technology. This study directly addresses this gap by examining the nuanced intersections of these issues at the level of faculty members and suggests an evidence-based model to guide interventions made by institutions. The implications also provide tangible strategies, a practicality that is frequently absent in entirely theoretical explorations.

This research aims to improve the understanding on how promoting digital self-efficacy and increased communication skills can act as an agent of change in developing more successful, sustainable technology initiatives at a local college level. This study has potential to provide an empirical structural equation model that demonstrates a relationship between digital self-efficacy, technology integration skills and technology adoption best practices -all of which are needed by faculty. With this framework, local colleges in the province of Batangas and elsewhere can have access to a data-driven validated model for formulating specific digital competency programs — all leading to a stronger yet more inclusive digital transformation that is continuously actualized across their system.

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Related Literature

Digital Self-Efficacy: A Foundational Belief

The review of the literature positions digital self-efficacy in the center of its conceptualization, and it is defined as an individual's self-assessment capability to use digital technologies for accomplishing particular purposes (Coles et al., 2020). This fundamental belief acts as a potent predictor of pre-service teacher educators and higher education instructors regarding how they see and consequently use technology in their teaching work (Aslan, 2020). It becomes a question of whether they perceive technology more of an empowering device or a producer of technostress. Aslan et., al (2020) have expanded this idea defining it as an independent core competence; digital self-efficacy is essential for blundering through the digital landscape, and one element of one's professional growth.

This digital self-efficacy is no monolithic concept but rather is built up by a number of sub-dimensions. Literature disaggregates these elements to generate a better understanding of the digital competence of an individual. These factors are comprised of sub-dimensions found in information and data literacy, which is characteristic of the effective searching, evaluation, and use of digital information. Content generation is also a key element-comment which refers to the ability to create and develop digital content for teaching. Lastly, digital communication and collaboration skills include competency in using various digital tools to interact with students and peers (Adalar, 2021). These specific skills in combination together make the overall digital self-efficacy of an educator.

Technology Adoption Practices

The review includes an analysis of technology adoption practices as a separate, but related, variable. Adoption describes the decision and behavior that take place first and during the first few attempts to accept and adopt new digital tools (Marikyan & Papagiannidis, 2023). The paper focuses on the Unified Theory of Acceptance and Use of Technology (UTAUT) as a theoretical foundation to help unravel this process. According to the UTAUT model performance expectancy (perceived usefulness), effort expectancy (perceived ease of use), social influence, and facilitating conditions are the factors that directly impact individual's behavioral intention toward using the technology. Among faculty, digital self-efficacy has a

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significant positive effect on perceived usefulness and perceived ease of use of technology, which in turn determines their intention to use it. It's a critical first step that should come before assimilation.

Technology Integration Skills

Differently, technology integration competencies refer to the pedagogical utilization and deliberate use of digital resources within instructional processes, and this is different from adoption. It is more than just using, it is a set of sophisticated skills necessary to select, apply and to assess digital resources for the purpose of improving student learning (Karkouti, 2021). The need to distinguish the "what" of adoption from the "how" of integrated use (skilled and effective use in curriculum) is part of the point of the literature. Someone may be using the group but not really seeing themselves as using it (e.g., a teacher uses a learning management system but only a person who is already high on the integration scale would primarily use it to do a flipped classroom or collaborative projects). The literature clearly states that there is a strong and positive relationship between digital self-efficacy and technology integration (Warsen & Vandermolen, 2020), thus indicating that the confidence of an educator is essential to the competent and effective use of technology in teaching.

Effects of the Variables

The review of literature documents the important impacts of these variables on both students and faculty. The impact of strong digital self-efficacy on the student, pairing with right technology adoption and integration, will bring about favorable result (Wallace & Tovey, 2022). Faculty that feels proficient with technology can bring a more engaging and interactive learning experience to their students. For the faculty, the development of these competences highly contributes to the overall digital competence increase. This can lead to heightened professional fulfillment as teachers perceive themselves to be more effective. The literature indicates that the acquisition of these skills could also translate into vocational advantages, including job security, funding for “techie” projects, and recognition as an innovative leader in their own institution. Such variables are reciprocally related in a model where a positive system of beliefs triggers purposeful actions, resulting in better teaching practice and increased professional competence.

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It states a few hypotheses for testing the relationships among these variables in relation to your research title. It proposes a positive significant correlation between lecturer digital self-efficacy and technological adoption behavior. A second hypothesis suggests such a positive association between faculty's digital self-efficacy and their technology integration abilities. These assumptions are central to the conceptual framework developed in this paper, which posits that a teacher's self-efficacy of digital skills is a key influencer on how they use technology in their educational practice. The examination of these more intricately-ordered relationships, we concluded from the literature, may be testable using the broader SEM (Structural Equation Model) paradigm. Possibly, it is here that SEM is shown to be particularly well suited as a statistical model to assess direct and indirect associations amongst a range of multiple variables simultaneously. The framework permits analyzing how digital self-efficacy affects technology adoption and integration not just directly, but can go through other variables, such as professional development or institutional support (Zhao et al., 2025). This method is a good method that gives) you a great way to test if your variables are interconnected in any strong way.

Method

Research Design

Descriptive research was used to detect the characteristics, frequencies and the relationships between the variables without interferences. It used a mixed-methods design of integrating quantitative survey data with additional qualitative interviews in order to obtain fuller coverage of the faculty while delving deeper into their perspectives. The data were triangulated between the two techniques to increase the validity and reliability of the study results.

Participants of the Study

The subjects of the study were 309 faculty members of provincial Locally Funded City Colleges in Batangas Province out of the 334 total population. A priori power was calculated with G*Power software to determine

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the sample size required in order to have adequate power to avoid Type II error, and this recommended a sample size of 309. Stratified random sampling was applied in order to reflect equal weightage in each college and department. The participant profile indicated a female dominated faculty (54.4%), perhaps young (28-43 years), mostly Guest Lecturers/Part-Timers (77.7%) and Bachelor's (45.3%) degree qualifiers. An overwhelming 90.0% had received digital or computer-related training earlier.

Instruments

The main instrument used was a well-structured questionnaire survey that consisted of two sections: the demographic profile and the questions on the study's variables. Member checks were performed in the subsequent interviews to confirm and to enrich quantitative sources of information. The questionnaire's internal consistency and validity was tested in a pilot study (3o participants) and Cronbach's alpha was performed. The results showed that the internal consistency between the scales was very high for all the constructs, namely, Digital Self-Efficacy ($\alpha = 0.922$), Technology Integration ($\alpha = 0.908$), and Technology Adoption Practices ($\alpha = 0.963$), proving high reliability and reducing the measurement error.

Procedure

To develop the survey, we conducted a comprehensive literature review to inform data collection. It was tested in a pilot post-approval study following approval of both the expert and agency. The original intent to use Google Form to distribute the survey was unsuccessful as faculty response rate was low, and survey was skipped over as faculty were too busy. In turn, the researchers shifted tactics to an in-person, hand-delivered survey approach. This change permitted physically interacting with participants, which reduced initial reticence and allowed for a smoother collection of data. The printed questionnaires were collected at different days for the convenience of the faculty members' tight schedule.

Ethical Considerations

The research was performed in compliance with ethical guidelines. The investigator received formal permission with the use of letters of intent and a formal orientation. All participants were informed of the right not to answer any questions they were uncomfortable with, and all personally identifying data were treated as nonmandatory for the purpose of privacy. Integrity of data collection and analysis was maintained,

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and no recordings or pictures were snapped during the process. Research was also presented to an Ethics Committee.

Data Analysis

Structural Equation Modeling (SEM) was used to analyze data (IBM SPSS Amos). This powerful multivariate technique was applied to examine the overall theoretical framework as a unified model. Path coefficients that measured the strength and significance of the relationships among the constructs were provided by the analysis. For instance, the direct impact of DSE to TIS is 0.87. The analysis also verified the important mediating effect of Technology Adoption Practices, showing an indirect effect of 0.129, and a p-value under 0.001. The approach offered a deep and sophisticated insight into the joint impact of faculty confidence and adoption behavior on their digital capabilities.

Results and Discussion

Digital Self-Efficacy: The overall level of digital self-efficacy among respondents was assessed as agreeable, with a composite mean of 3.13. Faculty demonstrated the highest confidence in Digital Self-Efficacy in terms of Safety, achieving a mean of 3.34 and interpreted as "Agree," specifically in protecting data and privacy with a mean of 3.45. Conversely, areas needing improvement included Problem-Solving, which had a mean of 3.00, with the lowest weighted mean for applying design thinking principles at 2.77. Additionally, within Communication and Collaboration, effectively using various institutional digital platforms showed lower confidence, with a mean of 2.80.

Technology Adoption Practices: The extent of technology adoption practices was strongly agreeable, indicated by a composite mean of 3.29. Faculty highly anticipated that technology would significantly improve student learning outcomes, reflected by the highest mean of 3.67 for Performance Expectancy, interpreted as "Strongly Agree." However, a critical area for development was facilitating conditions, where respondents disagreed on their ability to connect to the Internet reliably, with the lowest mean of 2.35. Perceived organizational support for technology use also presented a challenge, with a mean of 2.75.

Technology Integration Skills: The level of technology integration skills was agreeable, showing a composite mean of 3.23. Faculty expressed high agreement that technology integration skills are important for

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advancing their career in the institution, achieving the highest mean of 3.43. Despite this, areas needing improvement included contentment with the quality of available digital content resources, which had a mean of 2.75, and effectively using institutional online portals, with a mean of 2.71.

Direct Effect of Digital Self-Efficacy: A substantial and statistically significant direct positive effect of digital self-efficacy on technology adoption practices was found, with an estimate of 0.782. Similarly, digital self-efficacy exhibited a strong and statistically significant direct positive effect on technology integration skills, with an estimate of 0.782.

Direct Effect of Technology Adoption Practices: A statistically significant direct positive effect of technology adoption practices on technology integration skills was observed, with an estimate of 0.252.

Mediating Role of Technology Adoption Practices: The study confirmed a statistically significant indirect effect of digital self-efficacy on technology integration skills, indicating that technology adoption practices significantly mediate this relationship, with an estimate of 0.129.

Proposed Model for Faculty Digital Competency Development: The proposed Structural Equation Model Framework demonstrated a good fit with the collected data, as evidenced by acceptable fit indices such as CFI at 0.938, TLI at 0.916, and SRMR at 0.057. This confirms the model's validity in representing the interplay among the key constructs.

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Proposed Model

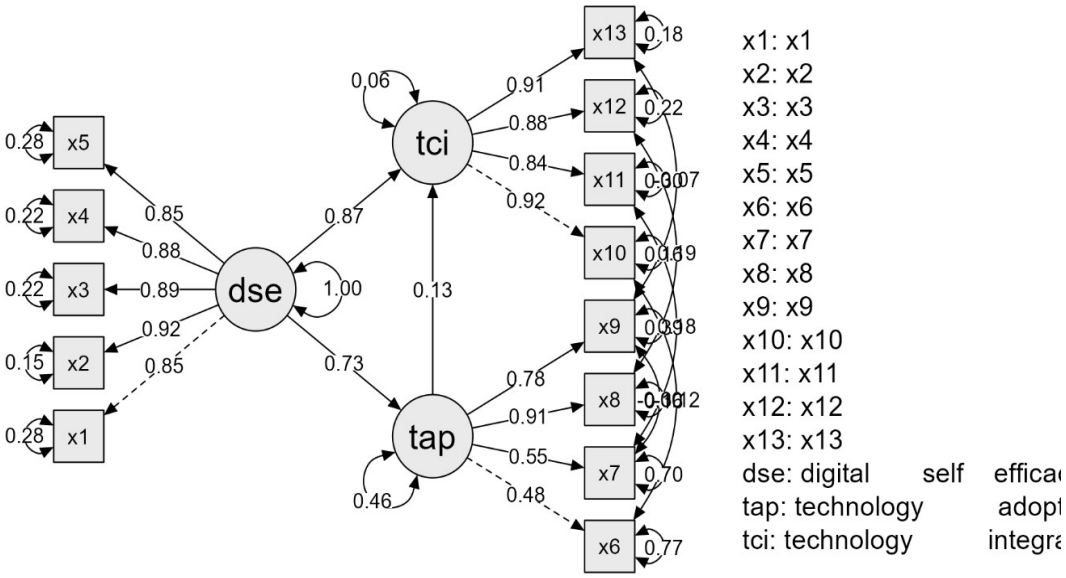

Figure 1. SEM path diagram of digital self-efficacy, technology adoption, and technology integration

Figure 1 shows SEM Path Diagram of Digital Self-Efficacy, Technology Adoption, and Technology Integration.

The above-described Structural Equation Model (SEM) diagram is a representation of the study´s empirical results, i.e., it tested whether the theoretical blueprint was supported by collected data or not. The circles (dse, tap, tci) represent the 'big ideas' of Digital Self-Efficacy, Technology Adoption Practices and Technology Integration Skills in this model. The squares (x1 through x13) and the observed variables, which are questions on a specific survey that is used to operationalize each of those latent variables. The arrows point from circles to squares and their values represent the factor loadings, which describing the degree with which each survey question believes it is measuring its latent variable (the ellipsoid) The SEM Diagram (Structural Equation Model) describes the empirical output of our study where the theoretical blueprint is confronted with our data. The small circles in the common factor model represents the latent variables. Circles that are DSE, TAP and TCI was in our model. The latent variables are the 'big ideas' of Digital Self-Efficacy, Technology Adoption Practices, and Technology Integration Skills. The squares for instance when I say x1 through x13 the observed variables these are the specific survey questions that were used to measure

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those latent variables. Factor loadings — The values on the arrows pointing from the circles to the squares are factor loadings, which show how well each survey question measured its corresponding latent variable.

Most crucial findings are the direct causal effects itself (denoted between latent variables below) expressed by the single-headed arrows The next strongest direct effect in our model was a positive one from DSE to tci, of value 0.87. However, the level of fear of failure seems to be one of the highest predictors that caused a professor to say he was not using technology (p. 11). There was also a remarkably strong positive direct effect of Digit Self-Efficacy (dse) on Technology Adoption Practices (tap), having insect 0.73. More confidence = better faculty adoption of new tech. A positive, albeit weak path from TAP to TCI ($\beta = 0.13$) indicated that adopting new tools slightly catalyzed the learning of integration skills but had a much smaller effect than self-efficacy.

The small circles on TCI and TAP stand for the residual variances of the latent variables themselves. A residual variance of 0.06 on TCI is very low, which means that our model explains 94% of the variance faculty's Technology Integration Skills. This indicates that the joint impact of Digital Self-Efficacy and Technology Adoption Practices powerfully account for why faculty members use technology. By contrast, the 0.46 residual variance of TAP implies that our model explains only 54% of the variance in Technology Adoption Practices, and unspecified other determinants are likely to be important. The double-headed arrows linking the error terms of certain manifest variables (x6 and x10, as well as x7 and x11) indicate that those two survey questions have disturbed some amount of unspecific variance over which most empirical models do not adequately fit to.

The mediation analysis using SEM diagram has shown that Technology Adoption Practices (TAP) mediate the relationship between Digital Self-Efficacy (DSE) and Technology Integration (TCI-Partial Mediation). Results reveal a high and direct effect of DSE on TCI with a beta coefficient standardized at 0.87, meaning that participants showing higher scores for computer self-efficacy cope significantly better in the use of technologies within their professional practices. Another important fact is that DSE is also influencing TCI indirectly throughout the mediating role of TAP, with an indirect effect of 0.0949 (through multiplication by: 0.73×0.13). This indirect effect is small in magnitude at a statistical level, but still demonstrates that TAP works to bolster the influence of DSE on technology integration. Taken together, the overall effect of DSE on TCI is 0.965 and only approximately 9.8% of this effect is mediated through TAP. These results reflect a moderate mediation, with TAP enhancing the DSE-TCI effect somewhat, but most of the influence

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occurring as a direct effect. This suggests that while promoting behaviors of technology adoption is good, building digital self-efficacy individually contributes more in fostering the successful integration of technologies in organizations or educational sectors.

Proposed Framework

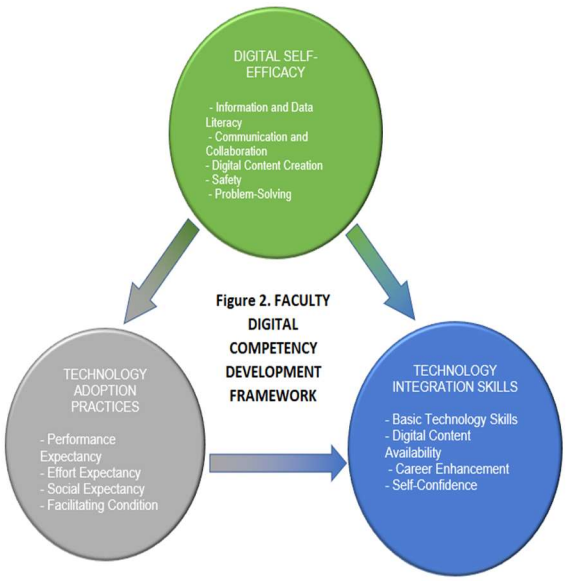

Figure 2. Shows structural equation model framework of faculty digital competency development

This framework is a visual representation of the key causal pathways supported by the statistical analysis. It is drawn with a top-down flow to illustrate the hierarchy of influence found in the model. This has the main three pillars highlighted as circles in color, colored due to a conceptual analogy. The top logo, which is the green circle represents Digital Self-Efficacy (the center core existence of faculty as if they are sustained or energized with) Technology Adoption Practices (The grey circle, lower left): this represents an unthreatening and practical approach to adopting new tools. The broader, thicker, farther to the right blue circle on the bottom represents Technology Integration Skills because it shows a greater depth of technology skills as well.

Each panel depicts single-headed arrows to indicate the direct causal relationships among the pillars. From the center green circle (Digital Self-Efficacy) to the grey one (Technology Adoption Practices), a single-

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headed arrow is used to indicate how a faculty member's confidence influences adoption behaviors directly. In this figure, we also see the second single-headed arrow from the Digital Self-Efficacy (green) circle to Technology Integration Skills (blue), that indicates a high direct effect from self-efficacy on technology integration ability. The third single-headed arrow is drawn pointing from the Technology Adoption Practices (grey) circle to the Technology Integration Skills (blue) circle, illustrating that practice itself contributes directly to skill development. This elegant model, displaying as it does a hierarchy of stretchability and its one-way progression via single-headed arrows is statistically significant.

In a nutshell and according to the exhaustive examination of SEM, we have strong evidence that digital Self-Efficacy acts as a powerful driver in supporting faculty adoption of technology. In online safety and communication at least, and faculty typically are confident in their digital skills based on a pretty solid understanding. A greater fleece enters into how colleges approach change, though: confidence — both in technology and their ability to learn how to use it. Nevertheless, one of the key obstacles remains to be hidden in facilitating conditions — a powerful practical force in perceived lack of reliable internet connectivity and perceived sufficiency of institutional support.

But though they find difficulty, technology skills are seen as critical to their professional careers and career and personal development, which contributes to the generally high levels of actual integration. Even within integration, however, and especially towards higher quality in digital content, additional confidence to navigate specific institutional online portals and real-time troubleshooting during class. In the end, this model provides strong evidence that digital self-efficacy both pushes faculty to adopt new technologies and, more significantly still, hoists them up another level in terms of their integration with these tools — with adoption itself further cementing this deeper connection. To truly enable faculty and to fully realize the potential of technology, therefore, it is necessary that we do not only hand tools over to a user group but accompany them with capacity building efforts (confidence), an adoption model build upon usable and reliable infrastructure (stability), interesting use cases with high-quality resources (resource stability) as well as targeted follow-up on institutional solutions/platforms and requests by faculty for shared problem solving.

Conclusion

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Findings revealed that faculty demonstrate a solid foundation in digital self-efficacy, particularly concerning digital safety, which bodes well for their continued engagement with technology. However, there's a clear opportunity for targeted development to boost their confidence in complex digital problem-solving and in maximizing the utility of institutional platforms.

Faculty exhibit a high propensity for technology adoption, driven by a strong belief in its benefits for student learning. However, pervasive practical barriers, notably unreliable internet connectivity and inadequate perceived organizational support, significantly hinder the comprehensive implementation of these adoption practices. Faculty exhibit an agreeable level of technology integration skills, primarily driven by its perceived importance for career advancement. To foster deeper and more effective integration, it is crucial to enhance the quality of available digital content and improve the usability and support for institutional online portals.

Findings revealed that digital self-efficacy serves as a powerful and direct catalyst, substantially influencing both the adoption of new technologies and their deeper integration into faculty's professional practices. The statistical analysis showed that active engagement in technology adoption practices directly and positively contributes to enhancing faculty's technology integration skills. The results imply that technology adoption practices play a crucial mediating role, signifying that digital self-efficacy not only directly fosters technology integration but also significantly influences it by first promoting greater technology adoption. The developed Structural Equation Model effectively and reliably depicts the intricate, interconnected relationships between digital self-efficacy, technology adoption practices, and technology integration skills, validating its utility as a robust framework for understanding faculty digital competency development.

Recommendations

To the Local Colleges Administration and IT Department: They may prioritize substantial investment in improving and ensuring highly reliable internet connectivity across all campus facilities and for remote access. The finding that faculty members disagree (mean 2.35) with their ability to connect to the internet reliably indicates this is the most critical practical barrier hindering effective technology adoption and integration.

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To the IT Department, Library Services, and Academic Support Units: It is recommended that they may conduct a comprehensive usability review of all existing institutional digital platforms, including communication tools and online library resources. Also, they may provide targeted, hands-on training sessions and easily accessible, user-friendly support guides specifically for these platforms. This addresses the lower perceived effectiveness in using institutional communication platforms (mean 2.80) and finding/evaluating scholarly articles through institutional library resources (mean 2.50).

To the Academic Development Center and Curriculum Development Units: They may develop and curate a centralized repository of high-quality, pedagogically sound digital content tailored to various disciplines. Concurrently, they may offer specialized workshops focusing on advanced digital content creation skills such as digital storytelling and sophisticated multimedia integration. This directly responds to the lower satisfaction with the quality of available digital content (mean 2.75) and the lower self-efficacy in using digital tools for storytelling and narrative design (mean 2.70).

To Human Resources, Academic Affairs, and Professional Development Offices: They may establish clear pathways and dedicated professional development programs that explicitly link the development of technology integration skills to career advancement opportunities, promotions, and leadership roles within the institution. This addresses the finding that while faculty strongly believe technology integration skills advance their careers, they report lower agreement regarding adequate institutional training and support specifically for career-driven technology skill development (mean 2.94).

To the Local Colleges Administration and Academic Planning Committee (Regarding Framework Adoption): They may formally adopt and systematically utilize the investigated framework, which encompasses Digital Self-Efficacy, Technology Adoption Practices (including Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions), and Technology Integration, as a guiding model for strategic planning, resource allocation, and continuous program development related to digital learning and faculty professional development. This framework provides a holistic, data-driven lens to understand and intervene across the multifaceted dimensions influencing faculty's engagement with educational technology

To Future Researchers: Future research may employ qualitative methodologies, such as in-depth interviews or focus group discussions, to further explore the specific underlying reasons for faculty's lower agreement

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with internet reliability and contentment with digital content quality. Additionally, subsequent studies may expand the current framework to investigate the influence of institutional culture, specific disciplinary needs, and the long-term impact of technology adoption on student learning outcomes and faculty well-being.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

* This research has ethics committee approval: LPU-B-Research Ethics Review Committee RERC Code: A1-2025-144

Conflict of Interest

* The authors declare that they have no conflicts of interest

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ARTIFICIAL INTELLIGENCE ROLE IN AVOIDING AMBIGUOUS VOCABULAR

Abstract: Artificial Intelligence has undergone extraordinary development and progress in recent years and as such it has significantly influenced almost every domain or field of life, including education and learning. The purpose of this study is to investigate the use of AI to understand ambiguous words in English and to avoid the ambiguity caused by them during learning English as a second language. Given the somehow limited number of studies that have been focused on the effectiveness of using AI to learn vocabulary in general and ambiguous English vocabulary as one of the most common difficulties encountered during learning English as a second language, the paper aims to highlight precisely the advantages and effectiveness that the use of AI brings in this aspect. This paper aims to present key and effective elements of the use of AI to avoid the ambiguities created by ambiguous words and to better understand and acquire this ambiguous vocabulary in conversation and to correctly interpret the intended meaning of the speaker. The study highlights the considerable values of the use of AI both in education and in the process of learning the English language if used correctly and with the appropriate instructions. Regarding the methodology used, a number of questionnaires were designed and distributed where the questions focus on the impacts, facilities and benefits that AI brings to the acquisition of ambiguous vocabulary.

Keywords: Artificial intelligence, Technology, Ambiguity, Effectiveness, Facilities.

Introduction

The extraordinary development of artificial intelligence has brought a new era not only in technology but in every aspect of life (Kessler, 2018; Xia, 2022). Having such impressive efficiency and easy-to-use features enabled AI to gain immediate popularity as well as success in almost every domain. If we refer to how artificial intelligence has been defined by several scholars, we understand that AI is nothing less than the computerization of human intelligence in technological applications in order to perform various commands or given operations (Hassani et al., 2020). Despite the doubts or skepticism often encountered among different teachers or scholars about its use for studying purposes, the development of technology and AI is significantly affecting as well as extremely revolutionizing education specifically the acquisition of foreign

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languages (Kessler, 2018; Xia, 2022). Neither education, nor the learning of English language is left out of the impact and influence of AI as well as technology. Artificial Intelligence (AI), thanks to its outstanding progress, is also transforming the methods of education, learning in general, learning of foreign languages and especially vocabulary. Technology and AI offer the students of English as a Second Language the opportunity not only to access the relevant vocabulary but also to refine communicative language abilities as well as skills, enabling them to improve their language competence considerably and appropriately (De La Vall & Araya, 2023).

The difficulties that students encounter when learning English as a second language are often evidenced due to the uncertainty that arises during the acquisition of ambiguous vocabulary. The use of these words in sentences and conversations often lead to confusion, ambiguity, misunderstanding as well as misinterpretations. The resent rapid and significant development of AI has proven that the future will be closely connected to AI, so the education, the learning of ambiguous vocabulary, as well as the avoidance of the ambiguity that these words carry are no exception to this trend (Kim & Kim, 2022). AI and technology enable a variety of applications to provide word translation, different explanations of the meaning of a word, alternatives associated with the relevant context, etc. It is now a fact that different AI tools such as: Natural Language Processing (NLP) applications, Chat GTP, etc. are playing an increasingly important role in learning the new vocabulary of English as a foreign language. It is high time that AI and technology are used even in the process of learning ambiguous vocabulary, avoiding and clarifying ambiguities, improving comprehension when using ambiguous vocabulary (**Liu & Chen, 2023).** It is essential that AI to be effectively and appropriately included in various activities about the acquisition of the ambiguous vocabulary and in the most efficient techniques that enable SLL of English to avoid the ambiguity encountered when using ambiguous vocabulary. The inclusion of AI in education has absolutely had a significant impact, therefore there are continuous efforts for a better and more effective integration of AI into teaching and learning process (Kim & Kim, 2022).

Integrating AI in the process of learning foreign languages and especially in the acquisition of ambiguous vocabulary and semantic ambiguity resolution brings about a number of advantages. The use of AI as well as other technological applications offer students effective tools to improve their linguistic skills and boost their vocabulary (Kessler, 2018). İf used appropriately, AI might assist the teaching process, revolutionize the convenctional methods of learning, therefore facilitate the acquisition of the ambguous vocabulary by giving effective solutions to a number of tasks (De La Vall & Araya, 2023). Adequate integration of AI in

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the proces of learning English as second language results in positive outcomes refering understanding appropriately the ambiguous vocabulary. First of all, it improves considerably English language learning and offers personalised explanations and appropriate examples to the students according to the given situation or context (Lee et al., 2022). Furthermore, AI offers students opportunity to access the right word that fits the given context and provide them with the right alternatives for understanding possible mistakes. Likewise, AI provides students instantly with the adequate materials or explanations for different exams and assessments since it offers immediate access to the required information as well as individual feedback (Lee et al., 2022). Integration of technology and AI in education as well as English language learning improves and enhances lingustic competences as well as English proficiency (Kruger, 2023). Autonomous as well as individual learning is provided by AI and computer assistance language learning thanks to the growing use of computers in education (Siemens, 2005). It offers a new perspective about self-directed learning of vocabulary which has increasingly become common in computer-assisted language learning (Xodabande & Atai, 2022). The appropriate integration of AI in learning ambiguous vocabulary obviously revolutionize the traditional methods of learning vocabulary making this process easier to access, really effective, profitable and convenient. (Chen et al., 2021; Semerikov et al., 2021).

On the other hand, the involvement of AI and technology in SL learning results in a number of disadvantages as well. One of the greatest concers of the implication of technology and AI in the acquisition of the ambiguous vocabulary is plagiarism. Students not always respect the ethical rules and deliver a totally copied work as it was compiled by them (Alharbi& Khalil, 2023). Moreover, the use of AI in certain tasks put at risk students creativity or critical thinking abilities leading them toward a complete passivity in the process of learning. These experiences make teachers more skeptical regarding the use of AI and technological tools in the proces of learning in general, and acquisition of the ambiguous vocabulary (**Nazaretsky et al., 2022)**. İn addition, neither teachers have gained enough qualifications nor students have been fully instructed how to use AI correctly and ethically in the process of English language learning and specifically in acquiring ambiguous vocabulary. This gap of appropriate knowledge and expertise regarding technology and AI make some of them doubtful toward the integration of AI in the proces of teaching and learning as well. (Alharbi, K., & Khalil, L. 2023)

Despite the drawbacks mentioned above the benefits of the involvement of AI tools in the process of learning in general and specifically in the acquisition of ambiguous vocabulary obviously prevail. The integration of AI in the process of teaching and learning of the ambiguous vocabulary not only facilitates

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students' performance but also it fulfills better students' needs, offers personalized learning and improves teaching methodologies (Zhang & Cao, 2022). Furthermore, this implication in education and vocabulary acquisition improves learning skills as well as extends its benefits and convenience globally (Fitria, 2021).

Method

The aim of this paper is to investigate the role of using AI in understanding and learning the meaning of ambiguous words in English as well as avoiding the ambiguity caused by them during learning English as a second language. It is concentrated in giving response to the following research questions:

1. Does the use of AI facilitate the process of learning of the ambiguous words by SLL of English?
2. Does the use of AI help SLL of English to avoid ambiguity caused by the ambiguous words in English?

The answers to these questions support the hypothesis that the use of AI in the process of learning English as second language facilitate the acquisition of the ambiguous vocabulary and clarify the meaning of the ambiguous words and avoid ambiguity caused by them. In order to conduct this research, it is used an integrated approach between quantitative and qualitative methods. According to Thomas (2003), the combination of quantitative and qualitative methods constitutes an integrated approach that gives a deeper insight and a better analysis of the study. The quantitative data are collected through two types of questionnaires: one questionnaire designed for students and the other for teachers, while the qualitative data were gathered by conducting semi-structured interviews and discussions in focus groups. The questionnaires, compiled and delivered by means of Google form, consisted of 10 questions each. The sample of the research consisted of 100 students from F.S. Noli university in Albania and 30 English teachers. The sampling of the research was done by a random selection of students but taking into consideration the representation at different levels: both in terms of the ability and mastery of the English language, as well as from different academic fields of study.

The students who participated in the study ranged in age from 19 to 24 years old, while the teachers ranged from 35 to 50. Questionnaires and focus group discussions were used to investigate the role of the use of AI tools in the avoidance of ambiguity caused by ambiguous words. The structured questionnaires were

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designed to assess students' and teachers' perceptions about ambiguity in English communication and their appreciation of the use of AI to understand, explain the meaning of the ambiguous words and resolve ambiguity. The questionnaires consisted of 10 questions with multiple-choice Likert-scale alternatives, focusing on how often students / teachers access or rely on AI to understand, explain and interpret ambiguous words when they are uncertain about their meaning or find difficulty to interpret them accurately. Focus group discussions provide us with qualitative data about students' experiences to avoid the ambiguity created as a result of the use of ambiguous words in discourse. Discussions were held in 2 focus groups, one of them consisted of students from the sample and the other consisted of teachers from the sample. Each focus group consisted of 7 students and 7 teachers who discussed and answered semi-structured interview questions. Discussions explored students' and teachers' experiences regarding the use of AI in resolving ambiguity created as a result of ambiguous words.

The research procedure was carried out in two stages. During the first phase, there were questionnaire surveys administered to students and to teachers as well. Participants completed the structured questionnaire independently and individually. This procedure aimed to collect the necessary data on students' and teachers' perceptions about the use of AI tools to understand, explain and avoid semantic ambiguity. During the second phase, there were conducted focus group discussions which provided deeper insights into how students and teachers try to make use of AI to avoid ambiguity and the effectiveness of using AI in clarifying the meaning of ambiguous words. Responses from the questionnaires were analyzed using descriptive statistics to summarize students' and teachers' perceptions as well as attitudes regarding using AI in understanding ambiguous vocabulary. In the same way, the qualitative data obtained from the focus group discussions regarding the students' as well as teachers' experiences in relation to ambiguous words and the use of AI to avoid this ambiguity were also analyzed. Descriptive statistics were used to analyze the questionnaire responses. Analysis of focus group discussions included analyzing responses, gathering data from students' experiences to understand how students make use of AI tools to avoid ambiguity. There are also scrutinized students' and teachers' perceptions of the effectiveness of using AI to understand and acquire correctly the ambiguous vocabulary. The data gathered from the responses of the teachers and students' interviews offered qualitative information about their opinion regarding the use of AI in avoiding ambiguity caused by the ambiguous words.

To collect further, more detailed and analytical data, it was thought to conduct a test on 39 Albanian students who actually study at F.S. Noli University and belong to the intermediate level of language

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acquisition. The students participating in this study were selected to belong to the same level of language acquisition and were randomly divided into two groups: an experimental group which consisted of 20 students and a control group of 19 students. In the experimental group, ambiguous vocabulary was taught and learned by using different AI applications, while in the students of the control group, the ambiguous words were taught through the traditional methods. In order to fulfil the aim of this research, there were carried out the following tests to students of both groups: Diagnostic Test for balancing students based on their overall knowledge of English before the experiment. (2) Achievement test in order to measure the achievements of both groups of students, experimental group and the control group in the end of the experiment.

At the beginning of the experimental period, the students of both groups were given a Diagnostic English Test so that the English language level of participants of both groups to be similar at start of the study. The ages of the participants ranged from 18 to 20. The diagnostic test consists of general exercises that reveal the general level of test takers in English. The evaluation of the test was done by the researcher herself together with one of her colleagues. Taking into consideration the goal of the research, there were used 10 exercises of 10 items each of them which consisted of ambiguous word acquisition and the language of the test was at the students' ability level.

The students of the experimental group were taught the ambiguous words along making use of technology and AI applications, such as automatic translation, NLP, Chat GTP etc. while in the control group the ambiguous words were taught just in the traditional way. The lessons were held by the researcher to limit the impact of teacher changeability during the classes that took place for 3 months (three sessions a week). At the end of the experimental period that lasted a semester, or 15 weeks, the experimental test was administered to each group. The tests contained 10 exercises of 10 items each that tested the acquisition of ambiguous words after the experimental period. Comparing the results will confirm or not the hypothesis of the study and will provide an answer to the research question.

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Results and Discussion

The data gathered from the questionnaires delivered to 100 students and 30 teachers as well as the responses to the semi-structured interviews in the focus group discussions will provide us with the relevant information for analyzing the role of AI and technology in learning ambiguous vocabulary. Based on the statistical data collected by the questionnaire and the interviews conducted during the focus group discussion, we can analyze the experiences of the students and teachers regarding the use of AI during learning ambiguous vocabulary in English as second language learner. With regard to the responses of the questionnaire's questions organized with Likert-scale alternatives we can interpret the findings about the benefits of using AI in the process of learning ambiguous vocabulary. In order to create a better qualitative interpretation of the study, there are analyzed the responses of students and teachers from the semi-structured interviews conducted in the focus group discussion. The statistical results that are collected by the responses of the students to the questions of the questionnaires delivered are shown in Table.1 as well as bar-chart 1, while the responses of the teachers to the questionnaire compiled for them are displayed in Table. 2 as well as bar-chart 2. So, Table 1 shows the number of students out of the sample of 100 students for each response (never, seldom, often, usually, always) to the questionnaire questions while the bar-chart 1 shows the percentage of students for each response given to the questions. As for Table 2, it shows the number of teachers out of the sample of 30 teachers for each response (never, seldom, often, usually, always) to the questionnaire questions while the bar-chart 2 shows the percentage of teachers for each response given to the questions.

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Table 1. The number of students for each Likert scale response to the questions of students questionnaire.

Questionnaire Questions for students	Never	Seldom	Often	Usually	Always
Do you come across ambiguous vocabulary while learning English?	5	9	13	31	42
Do you find it difficult to understand ambiguous vocabulary?	8	12	11	32	37
Do you use AI In learning ambiguous vocabulary?	7	6	12	31	44
Do you find it useful to use AI in understanding ambiguous vocabulary?	9	8	14	30	39
Do you use AI when you find difficulty with ambiguous vocabulary?	5	8	11	35	41
Do you use AI to resolve ambiguity when using ambiguous vocabulary?	4	7	9	34	46
Do you consider AI as a facility in understanding the meaning of an ambiguous word?	6	12	10	24	48
Do you find AI more beneficial than traditional methods in ambiguous vocabulary acquisition?	8	6	13	28	43
Do you consider AI reliable in understanding the meaning of an ambiguous word?	9	11	11	32	37
Would you consider AI tools as highly useful techniques for resolving semantic ambiguity?	5	8	9	34	44

Source: Data collected by the students' response to the questionnaire

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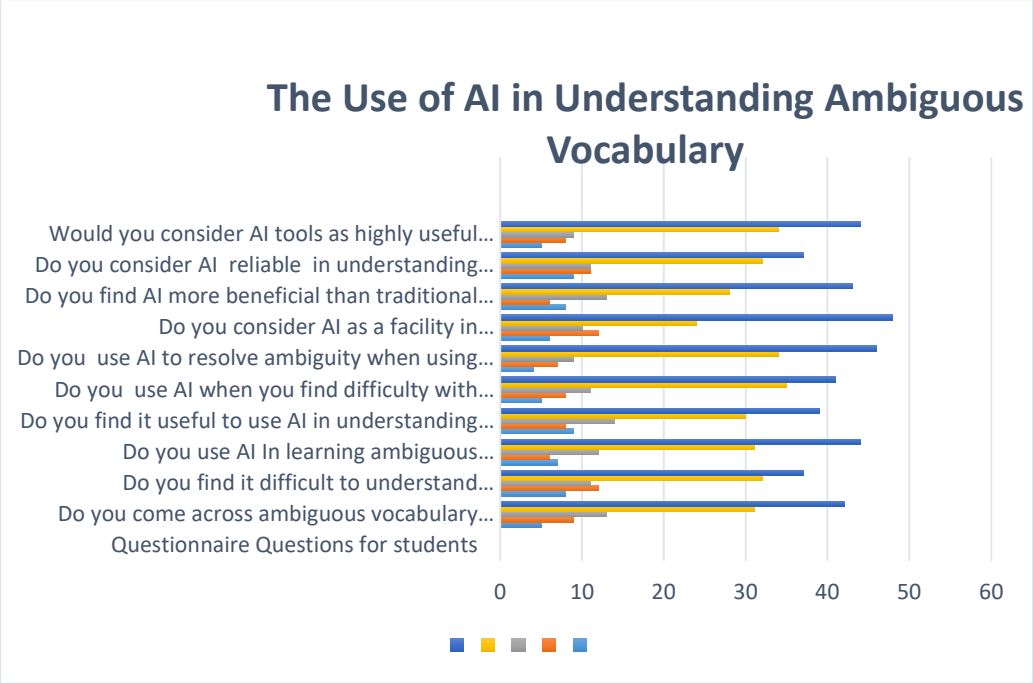

Figure 1. The percentage of students' response to each question of the student's questionnaire

Source: Data collected by the students' response to the questionnaire

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Table 2. The number of teachers for each Likert scale response to the teacher's questionnaire

Questionnaire Questions for teachers	Never	Seldom	Often	Usually	Always
Do you come across ambiguous vocabulary while teaching English?	3	4	5	8	10
Do you find it difficult to make ambiguous vocabulary clear to students?	3	4	6	9	8
Do you use AI while teaching ambiguous vocabulary?	4	5	9	7	5
Do you find it useful to use AI in explaining ambiguous vocabulary?	4	5	8	5	7
Do you use AI when your students find difficulty in understanding ambiguous vocabulary?	5	6	7	5	7
Do you use AI to resolve ambiguity when you deal with explanations of ambiguous vocabulary?	4	5	7	8	6
Do you consider AI as a facility in explaining the meaning of an ambiguous word?	5	7	5	6	7
Do you find AI more beneficial than traditional methods in teaching ambiguous vocabulary?	5	4	6	8	7
Do you consider AI reliable in explaining and understanding the meaning of an ambiguous words?	4	5	6	7	6
Would you consider AI tools as highly useful techniques for resolving semantic ambiguity?	5	6	6	6	7

Source: Data collected by the teachers' response to the questionnaire

Analyzing the data collected from the questionnaire, it is obvious that most of the students of the sample use AI in learning ambiguous words. As much as 31% of the sample use it usually while as much as 44% use it always compared to 12 % who use it often, 6% who use AI seldom and only 7% who never use it in learning and understanding ambiguous vocabulary. Regarding the usefulness of the use of AI in understanding the meaning of the ambiguous words, 30 % of the students that participated in the survey consider AI usually useful in understanding ambiguous vocabulary and 39 % responded that they find the use of AI always useful in learning ambiguous vocabulary, only 14 percent often find AI useful in acquisition of ambiguous vocabulary compared to 8% that seldom consider AI useful in understanding ambiguous words and 9% who never find AI a useful tool in understanding ambiguous words.

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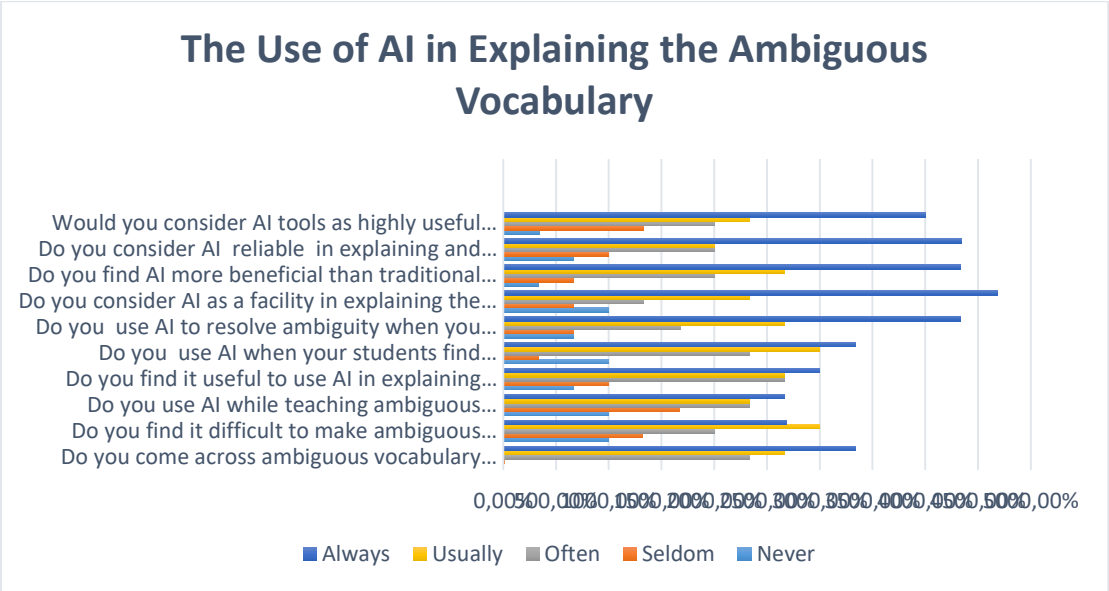

Figure 2. The percentage of teachers to each question of teachers' questionnaire according to Likert scale

Source: Data collected by the students' response to the questionnaire

Regarding the question if they consider AI a facility in understanding ambiguous words, the data collected proved that 48% of the students always find AI a facility in understanding ambiguous vocabulary, compared to 24% who usually consider AI a facility, 10% who responded that they seldom consider AI a facility and 12 % who seldom consider AI a facility while only 6% never consider AI a facility in understanding ambiguous vocabulary. Compared to the traditional ways of the acquisition of the ambiguous vocabulary, AI is considered by 43% of the students to be always more beneficial and by 28% of the students to be usually more beneficial, only 13 % of the students responded that they often considered AI more beneficial that the traditional methods in the acquisition of the ambiguous vocabulary, while 8% never and 6% seldom considered AI beneficial for the acquisition of the ambiguous words. As much as 69 % of the students find AI a reliable tool for understanding ambiguous words respectively 37% who find AI always reliable, 32% who usually find it reliable, in relation to 11% of the students who often considered AI reliable, while 9% never and 11% seldom consider AI as a reliable tool for understanding and learning ambiguous words. The majority of students involved in the study responded that they consider AI tools as highly useful techniques in resolving semantic ambiguity, out of whom 44% find AI always useful, 34 % usually useful, in the neutral

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zone there are as much as 9% who often find AI a useful technique in resolving ambiguity in comparison to 8% seldom and 5% that never find AI a useful technique in resolving ambiguity.

As far as the teachers' questionnaire is concerned, the data collected demonstrate that teachers are less enthusiastic about the use of AI in the acquisition of ambiguous vocabulary. Referring to the response of the teachers, only 40% of teachers use technology and AI in explaining the meaning of ambiguous words out of whom 23.3% use it usually and 16.7 % use it always in comparison to the 30% who are positioned in the neutral zone responding that they use it often, 16.7 % who seldom use it, and 13.3% who never use it. The teacher's skepticism is clear even regarding the question if they find AI more beneficial than traditional methods in teaching ambiguous vocabulary, as 26.7 % of them usually find AI more beneficial than the traditional methods and the same percentage always find AI more beneficial than traditional methods of acquiring ambiguous vocabulary. Similar results are evidenced from the data collected from the question if they consider AI reliable in explaining and understanding the meaning of an ambiguous word. So, only 20 % of the teachers always consider AI a reliable tool in explaining ambiguous vocabulary, compared to 26.7% of them who usually consider it reliable, as much as 23.3 % of often find AI a reliable tool, while 13.3% and 16.7% respectively never and seldom consider AI a reliable tool for explaining and understanding ambiguous vocabulary. Similarly, the data collected from the teachers' responses to the question if they consider AI tools as highly useful techniques for resolving semantic ambiguity show that 20% and 23.3 % of teachers responded usually and always to this question, as well as those who responded often and seldom comprise the same percentage of 20% in contrast with 16.7% of the teachers who never consider AI a highly useful technique for resolving ambiguity.

In order to get a qualitative view of the study, there are going to be analyzed the responses of the interviews in the focus group discussion. Both the students and the teachers were asked open-ended questions about the use of AI in understanding and acquiring ambiguous vocabulary. Most of the students consider AI tools very useful and efficient applications for learning English in general and acquisition of ambiguous words. They find them very helpful in any kind of situation when you don't really understand a word or its nuances of meaning properly. According to them, AI applications are easily accessible and easy to use as well. The students believe that thanks to AI tools, they are provided with all the necessary information about the given vocabulary instantly. Students admitted that they lacked the necessary training for using AI tools in order that they use these appliances more appropriately and to avoid ethical violations. The students were very enthusiastic about benefits that AI tools have in learning English as second language and especially in the

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acquisition of the ambiguous vocabulary as AI has facilitated and simplified this process. They highlight the effectiveness, reliability and comfort over the traditional ways of learning ambiguous vocabulary.

The teachers' responses to the open-ended questions interviews give us a different view. Summarizing their response to the questions about using AI tools in teaching ambiguous vocabulary, it is obvious that most of the teachers are skeptical and suspicious about its use. They think that it may make students passive in the process of learning, less motivated, less creative and less productive. They question the possibility of damaging their critical thinking and problem-solving skills. They absolutely expressed their concern about the violation of the ethical rules. Teachers highlighted the risk of facing addiction to technology and being totally dependent on it. They fear the complete loss of creativity and imagination. According to them, what makes them hesitant was that pretty soon we will hardly find individualistic features in anybody's work as everything will be done on AI applications. Being accustomed to the traditional way of teaching, it is neither easy for most of the teachers to integrate AI in the process of teaching ambiguous vocabulary, nor acceptable to consider AI a facilitator in the process of explanation and acquisition of the ambiguous vocabulary. Obviously, the lack of relevant training and instructions about how and to what extend to integrate AI in teaching plays its own role in their skepticism. Nevertheless, there are a number of activities about understanding ambiguous vocabulary for which AI tools are very helpful and effective. If trained and instructed appropriately, the integration of AI in the process of teaching and learning ambiguous vocabulary will be a considerably effective way. Regarding the analysis of the data gained from the experimental test, they considered and then studied the following variables:

- Pre-test, the total points obtained in the diagnostic test/before
- Post-test, the total points obtained in the experimental test/after.

Table 3. The results from the experimental group and control group

Group	Variable	N	Minimum	Maximum	Average	Std. Deviation
Experimental group	Pre- Test	20	33	90	58.85	17.775
	Post- Test	20	51	91	75.10	12.155
	Valid N	20				
Control group	Pre- Test	19	31	90	57.58	17.795
	Post- Test	19	40	90	62.68	16.695
	Valid N	19				

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The groups studied were designed as follows:

- The experimental group (n=20, 9m, 11f) used technology and AI applications in understanding ambiguous words.
- The control group (n=19, 7m, 12f) worked only with vocabulary in the traditional way

The comparison of these 2 groups was carried out through parametric statistical tests Independent Sample t-test and Paired Samples t test. As a prerequisite for the application of these statistical tests, the data were tested for normal distribution using the Shapiro–Wilk test. Then, to ensure the initial equality between the experimental and control groups, an independent sample T-Test was applied to the diagnostic test results. To assess the effect of using AI and technological appliances in ambiguous vocabulary acquisition within each group, a paired sample T-Test was used to compare the results of the pre- and post-tests, for each group separately. To compare the results of the experimental test, as well as to more accurately measure the effect of the method used, the experimental test and the new variable Difference (Difference = After – Before) were compared using the Independent Sample T-Test. This approach allows for a full assessment of the impact of context use on the acquisition of ambiguous vocabulary.

The results showed that the variables Pre-test, Post-test (for both groups) and Difference did not deviate significantly from normal distribution ($p > 0.05$), thus fulfilling the prerequisite for the use of parametric tests.A T-Test for independent samples was performed to compare the mean preliminary results of the experimental group (M experimental= 58.9, SD = 17.8) and the control group (M control= 57.6, SD = 17.8). The results did not show any statistically significant difference between the two groups on the diagnostic test ($t(37) = -0.22$, $p = .826>0.05$). This indicates that the groups were comparable at baseline and any subsequent changes can be attributed to the experimental intervention (i.e., the use of AI and technology in the acquisition of ambiguous vocabulary.

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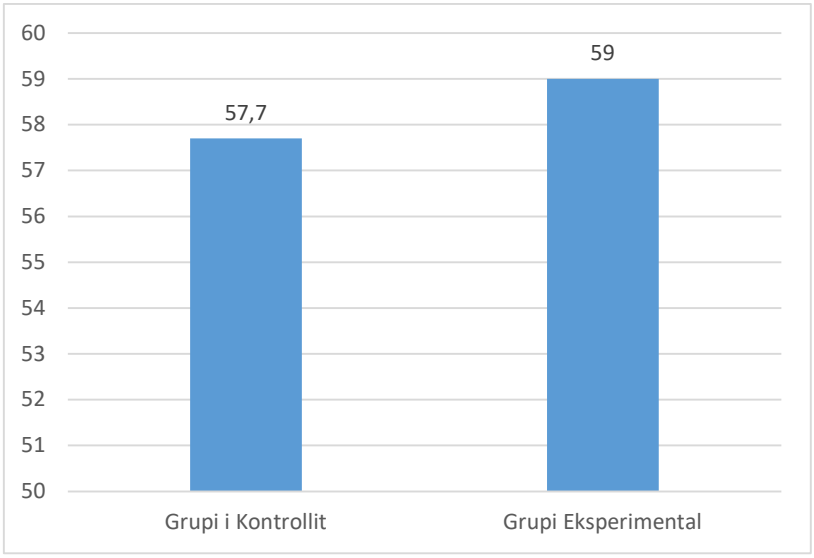

Figure 3. Comparison of the results of diagnostic tests for each group

Differences within each group. To assess whether there was a difference in students' scores on the two tests, a paired t-test was applied to each group.

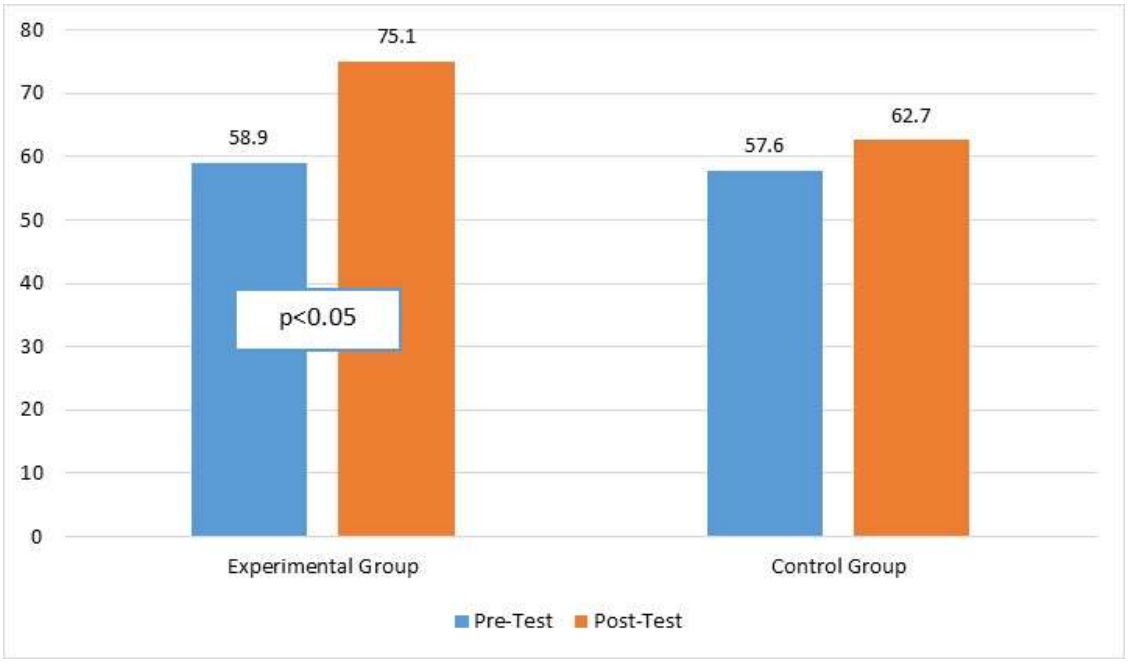

Figure 4. Comparison of ambiguous words acquisition before-after the experimental stage for each group

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The experimental group showed a statistically significant improvement in the results after the intervention (MPost-Test = 75.1, SD = 12.2) compared to those before the intervention (MPre-Test = 58.9, SD = 17.9, t (19) = -7.04, p =0< 0.05.). This result shows that the use of technology and various AI applications have had a strong effect on the experimental group and as a result ambiguous vocabulary acquisition has improved considerably at the end of the experimental period.

The control group also showed a moderate improvement, also statistically significant (M Post-Test = 62.7, SD = 16.7; M Pre-Test = 57.6, SD = 17.8, t (18) = -2.93, p = .009<0.05). This change is natural as a result of the usual learning process or perhaps also due to the second exposure to the test model. Even at first glance, it seems that the improvement observed here is lower compared to the experimental group.

Conclusion

The aim of this study is to look into the use of AI in a better understanding and acquisition of the ambiguous words in English in order to avoid the ambiguity caused by them during learning English as a second language. It points out the benefits and facilities that the use of AI brings in the process of learning of the ambiguous vocabulary as a very important part of learning English as second language and how its use helps to avoid the ambiguities created by these words.

Integrating AI in the process of learning foreign languages, especially ambiguous vocabulary acquisition brings about a number of advantages to students and teachers as well. So, the use of AI and other technological applications offer students effective tools to improve their linguistic competences, boost and enhance their vocabulary (Kessler, 2018). İf used appropriately, AI might facilitate both the learning as well as the teaching process, revolutionize the traditional methods of teaching and learning, therefore facilitate the acquisition of the ambiguous vocabulary by giving effective solutions to a number of tasks (De La Vall & Araya, 2023). Adequate involvement of AI in the proces of learning English as second language results in positive outcomes refering learning and understanding appropriately nuances of meaning of the ambiguous vocabury, the ones that best fits to the given situation or context. Furthermore, it advances and refines considerably the learning process and offers students individualized explanations as well as appropriate examples according to the students necessities or given situation (Lee et al., 2022). Last but not

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least, AI offers students opportunity to access the right word that fits the given context and make out possible mistakes.

Likewise, AI provides students with the adequate materials or explanations for different exams or assessments regarding the acquisition of the ambiguous vocabulary since it offers immediate access to the required information as well as individual feedback (Lee et al., 2022). Integration of technology and AI in education facilitate English language learning, enhance students skills and upgrade their English proficiency (M. Krüger 2023). Autonomous as well as individualized learning is provided by AI and computer assistance language learning thanks to the growing use of computers in education (Siemens, 2005). It offers a new perspective to self-directed learning of vocabulary which has increasingly become common in computer-assisted language learning **(Nong et al.,2021).**

İn spite of benefits mentioned, the use of AI in Education, specifically English language learning causes some disadvantages as well. One of the drawbacks as a result of the implication of technology and AI in the acquisition of the ambiguous vocabulary, which was highlighed even by the teachers who took part in the study, is plagiarism. There are rare cases when students respect the ethical rules and in a considerable number of cases they copy the entire task pretending to be theirs (Alharbi & Khalil, 2023) These experiences make teachers more doubtful and skeptical regarding the use of AI and technological tools in the proces of learning in general, as well as in the ambiguous vocabulary acquisition. In addition, neither teachers have gained enough qualifications nor students have been fully instructed how to use AI correctly and ethically in the process of learning and specifically in the acquisition of the ambiguous vocabulary. This gap of appropriate knowledge and expertise regarding technology and AI make some of them hesitant toward the integration of AI in the proces of teaching and learning as well. (Alharbi & Khalil, 2023)

However, the role of AI has absolutely become an important element in the process of learning of English as a second language and especially in the acquision of ambiguous vocabulary as it obviously helps significantly in resolving students' problems about ambiguity caused as a result of them. It clearly facilitate and enhance the process of learning of the ambiguous vocabulary and upgrade the learning results. İf students and teachers get trained and instructed appropriately, the benefits of AI in the process of learning of the ambiguous vocabulary will be even greater and maybe undisputable. Education and English language learning definitely must keep up with the development of technology therefore this advancement implies the appropriate integration of AI in this process.

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Recommendations

It goes without saying that technology and AI occupy a great part of our life and has taken its important fields by storm. Education and training cannot be left behind this successful development. As any other kind of development, the use of technology and AI in the acquisition of ambiguous vocabulary can neither be taken for granted, nor can be underestimated. It must be considered seriously its role in education in general, and specifically in the proper understanding of the sematic ambiguity. What should we as teachers do, is to look at *the bright side and its advantages* rather than *pointing out just its disadvantages*.

We should get rid of the scepticism and embrace science, development, technology and AI as well. Instead of prejudicing AI's disadvantages, for which we of course are aware and cannot deny, we must train ourselves and then our students about its proper use in Learning English as SL and particularly vocabulary acquisition in order to get the best use of it. We must lead our studentst to the correct and proper use of AI in vocabulary acquisition and instruct them in order to avoid ethical issues, plagiarism or "lazziness". As several studies prove that AI facilitate students learning and resolves semantic ambiguity easier and faster than traditional methods, let's not hesitate but include it in the teaching of English as a second language and in the proper acquisition of ambiguous vocabulary.

Scientific Ethics Declaration

* The author declares that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the author.

Conflict of Interest

* The author declares that she has no conflict of interest

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THE UTILIZATION OF ARTIFICIAL INTELLIGENCE IN HUNGARIAN HIGHER EDUCATION: A META-SUMMARY OF RECENT STUDIES

Abstract: The rapid spread of artificial intelligence (AI) is transforming higher education environments around the world – and Hungary is no exception. Over the past three years (2023–2025), several empirical studies have examined the attitudes of students and teachers toward AI, its uses, and the challenges of integrating the technology into Hungarian higher education institutions. The aim of this paper is to provide a comparative overview of these studies, i.e., to produce a meta-summary of the latest data and trends and to formulate recommendations for future AI strategies in Hungarian higher education. The analysis is based on four thematic categories: knowledge and use of AI tools, educational integration, ethical and pedagogical challenges, and institutional support and guidelines. Surveys show that artificial intelligence is no longer a marginal phenomenon in Hungarian higher education, but part of everyday practice. At the same time, the development of critical digital literacy, the clarification of ethical guidelines, and the establishment of institutional support systems are essential for the integration of technology into education. Based on the results, Hungarian students widely use AI tools for information retrieval and text creation, while teachers primarily use them for curriculum development and assessment purposes. In both groups, the integration of ethical and critical considerations appears to be a significant challenge. The study makes recommendations for the development of institutional policies, pedagogical practices, and ethical regulations.

Keywords: Artificial intelligence, Higher education, Attitude, Challenges

Introduction

Artificial intelligence (AI) is playing an increasingly important role in the digital ecosystem of higher education. The explosive emergence of artificial intelligence (AI) from 2022 onwards will have a significant impact on higher education practices (Figure 1). Students are increasingly turning to AI tools for learning purposes, while educators are often uncertain about the pedagogical and ethical implications of technology.

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The aim of this study is to map AI usage trends in Hungarian higher education based on empirical research conducted over the past three years. The aim of the research is to identify patterns of AI-based tool use, pedagogical opportunities, and ethical and didactic challenges along thematic categories.

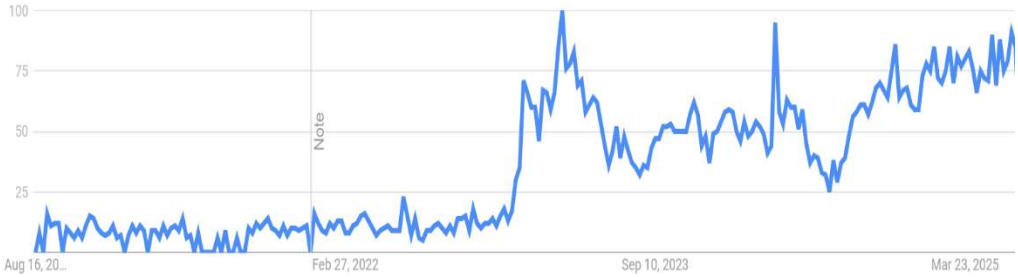

Figure 1. Google Trends searches in Hungary for the keyword: Mesterséges intelligencia

In recent years, AI has become a central topic of discourse in higher education. In Hungary, too, more and more research is examining how students and teachers integrate artificial intelligence into their everyday learning and teaching practices (Folmeg et al., 2024; Rajki et al., 2024). While students tend to adapt quickly and focus on practical applications (e.g., text composition, information retrieval), teachers are more concerned about methodological uncertainty and ethical issues (Szűts, 2024).

Several studies have already examined the integration of AI into education in the context of higher education in Hungary. Analyses by the OECD (2021, 2023) pointed out early on that digital transformation and AI integration are strategic issues for quality assurance in Hungarian higher education. According to the latest international comparative survey on the use of AI (Daskalaki et al., 2024), Hungarian teachers and students alike show considerable openness to AI tools, but institutional frameworks are lacking. At the national level, Folmeg et al. (2024) examined the components of student AI literacy and pointed out that awareness and critical thinking are limited. The international survey of KPMG (2025) has shown that Hungary is at the very last place within the 47 countries examined when it comes to AI knowledge, efficacy, and training. Several studies examine the impact of AI in specific areas of higher education: Molnár (2024) in measurement and evaluation, Tolner et al. (2023) in online examinations, and Lengyel, Felvégi, and Füzesi (2024) in agricultural higher education have presented the new opportunities and risks. In social science higher education, Marciniak and Baksa (2024) and Szűts (2024) highlighted the problems of fears, dilemmas, and regulatory gaps.

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In their detailed exploration of the student perspective, Jäckel and Garai-Fodor (2024) shed light on the specific attitudes of Generation Z, while Pető and Kovács (2023) interpreted the transformation of Hungarian higher education in a broader social context. Tick's (2023, 2024) domestic and international research examines the educational effects of ChatGPT and the dilemmas faced by educators, while Bokor (2023) discusses the long-term consequences of technological disruption. According to Lu and Harris (2018), there are four main areas where AI can be used particularly effectively for educational purposes:

1) Teaching with intelligent tutoring systems (ITS).
2) Personalizing the learning process
3) Assessment and examination
4) Automation of educational administration tasks.

The aim of this study is to provide a comprehensive overview and synthesis of recent empirical studies in order to explore trends, challenges, and directions for development in Hungarian higher education.

Method

Research Objective

The aim of this study is to provide a comprehensive overview of the use of artificial intelligence in Hungarian higher education, with a particular focus on the attitudes and usage habits of students and teachers, as well as the challenges of educational integration. To this end, we conducted a meta-analysis of the empirical studies published between 2023 and 2025.

Methodological Approach

The research is a qualitative study in the form of a meta-summary (narrative review) based on document analysis. Its purpose is not to produce a statistical meta-analysis, but rather to synthesize, contextualize, and thematically map the results.

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Source Selection Criteria

The included studies were selected based on the following criteria:

- Time limit: empirical studies published between January 2023 and June 2025.
- Geographical focus: studies conducted in Hungary or involving Hungarian participants.
- Target group: students and teachers in higher education.
- Content focus: Educational aspects of AI use – attitudes, forms of use, challenges.
- Publication type: Professional study, article, or report based on completed research (not preliminary research or blog posts).

The initial search resulted in a total of 15,900 English language and a significantly lower amount of (811) Hungarian language results on Google scholar for this period for the keywords "artificial intelligence", "higher education", "student" and "teacher" (or their Hungarian equivalent).

Coding

The aim is to create a qualitative coding framework that can be used to perform content analysis or comparative analysis on the textual results of various empirical studies. Articles were analyzed along the following four topics:

- Knowledge and use of AI tools
- Integration into education
- Ethical and pedagogical challenges
- Institutional support and guidelines

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Table 1. Coding outline based on thematic categories

Main theme	Code category	Description	Example/indicator
Knowledge and use of MI tools	tool_type	Name and type of AI tool used	ChatGPT, Grammarly, Copilot, text translator, AI note-taker
	frequency_of_use	Regularity of use	Daily, weekly, occasionally
	purpose_of_use	What the user uses it for	Writing, brainstorming, learning, research, writing papers
	depth_of_knowledge	Awareness of use, accompanied by reflection	Automated vs. interpreted use
Integration into education	learning_support	Use of AI in student learning	Note-taking, summary generation, question answering
	educational_content	Application of AI to curriculum development	Course outline creation, illustration generation
	assessment_automation	Automation of assessment	AI tool for essay assessment, test correction
	interaction_reorganization	Impact of AI on teacher-student communication	AI tutor, automated responders
Ethical and pedagogical challenges	plagiarism_concern	Fear that content created with the help of AI is plagiarism	Secret use by students, lack of "AI-generated" labeling
	critical_thinking	The impact of AI on students' independent thinking	Mechanical copying, formulaic reasoning
	transparency	The comprehensibility of AI's functioning or decision-making	Criticism of "black box" algorithms
	data_protection	Security of personal or educational data	Papers uploaded to AI tools, teaching materials uploaded with names
Institutional support and guidelines	institutional_guidance	Are there internal regulations on the use of AI?	Code of ethics for AI use, rector's recommendation

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methodological_training	Preparing teachers for the integration of AI pedagogy	Workshops, internal training, support for curriculum development
technological_access	Is access to AI tools provided?	Institutional license, internal integration of AI platform
student_information	Information for students on proper use	Teaching aids, case studies

Results and Discussion

Below, based on the studies examined, we present the characteristics of AI use in Hungarian higher education in a thematic breakdown, interpreting the perspectives of students and teachers separately.

Knowledge and use of MI Tools

Student Usage and Attitudes

The national survey conducted by Rajki et al. (2025) based on a sample of 1,027 students shows that nearly 90% of students use some form of AI-based tool, primarily for text creation, translation, and information retrieval. At the same time, the level of conscious and critical use varies greatly, and pedagogical use is still in its infancy. The most common tool is ChatGPT (83%), followed by Grammarly and various AI-based note-taking tools. The purpose of use was typically information retrieval, text composition, and exam preparation. Approximately 64% of respondents use AI tools on a weekly basis (Rajki et al., 2025).

The focus group study by Folmeg et al., 2024 confirms these patterns, but also points out that students often use AI "based on intuition" rather than reflectively or consciously. Use is mainly limited to generating and searching for academic texts. The results show that students typically use the tools in an experimental manner, while rarely reflecting on their ethical or methodological implications.

Jäckel and Garai-Fodor (2024) specifically demonstrated that the demand for fast and efficient information retrieval among Generation Z led to intensive experimentation with AI tools. According to a pilot study by

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Tick et al. (2023), students rated ChatGPT positively, but its long-term learning effects are uncertain. It must be noted that although students turn more and more towards digital learning, mainly using smart tools but, at the same time, they require an occasional, personal, face-to-face contact.

Educational Perspectives

On the teaching side, tool use is much more heterogeneous: many are familiar with it, but conscious, systematic integration is only observed in a small circle (Daskalaki et al., 2024). This Navigating the Future of Education survey provides an opportunity for international comparison, asking 1,754 educators in five countries, including Hungary, about the integration of artificial intelligence. 63% of Hungarian teachers have tried some kind of AI tool for educational purposes, but only 21% use it regularly. Among Hungarian respondents (17%), the most common areas of use were curriculum development and student performance assessment, but there were significant concerns about algorithmic bias, transparency, and a decline in students' critical thinking skills. From the perspective of educators, Tick (2024) and Marciniak and Baksa (2024) argue that teachers are often ambivalent: although they recognize the innovative potential of AI, they fear misuse by students. Placing this in a broader context, Bokor (2023) draws attention to technology-invariant challenges.

Integration into Education

Based on feedback from both students and teachers, it is clear that AI is rarely used to reorganize interactive processes (e.g., tutoring, feedback) – this is not yet typical in Hungarian higher education culture. Students mainly use AI to support learning, especially when quick information or simple explanations are needed. At the same time, several students reported that the generated content is formulaic and therefore unreliable without critical evaluation. The use of AI is typically informal, often without the knowledge of teachers (Rajki et al., 2025). Tick stresses (2019) that more attention must be paid to security awareness trainings and courses for the students of the Z generation within Hungarian higher education. Although teachers are open to AI tools, many are unable to integrate them into their courses. The Navigating survey shows that while the assessment of lesson preparation is mostly positive, the application of AI to automate assessment is still in its infancy, mainly due to mistrust and data protection issues (Daskalaki et al., 2024).

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The practical aspects of integration are presented in several field-specific studies. Molnár (2024) emphasizes the automation potential of AI in assessment processes, while Tolner et al. (2023) identify immediate benefits but also serious ethical risks in online testing. Lengyel et al. (2024) see the support of research processes and the alleviation of the shortage of teaching staff in agricultural higher education as feasible.

The OECD (2023) highlights that integration among Hungarian higher education institutions is uneven, and in many places there is a lack of organizational-level strategy. This is consistent with the international survey by Daskalaki et al. (2024), which found that the majority of Hungarian educators use AI in an experimental manner but do not receive institutional support for it. Experimentation has begun, but a comprehensive methodological framework is lacking.

Ethical and Pedagogical Challenges

Almost all of the studies examined highlight the existence of ethical dilemmas. The phenomenon of "secret AI use" is common among students: although they use the tools, they do not always admit to it. The line between plagiarism and non-plagiarism becomes blurred, especially when the text is only partially generated. Students often view generative AI as a "co-author," which generates strong ethical debates.

The problems of plagiarism, authorship, and evaluation appear as central dilemmas (Szűts, 2024; Folmeg et al., 2024). Among educators, the greatest uncertainty can be observed in determining ethical and supportive forms of application. The Navigating survey (Daskalaki et al., 2024) also highlights that 62% of Hungarian educators believe that the lack of ethical regulations hinders implementation. The dilemmas faced by students are detailed by Rajki et al. (2024); many students are uncertain whether the use of AI tools is compatible with academic integrity. Marciniak and Baksa (2024) point out that in social science education, teachers fear that text-generating AI weakens critical thinking. Szűts (2024) also highlights broader ethical and social concerns, such as the issues of autonomy and responsibility. Teachers are very concerned that students' independent thinking is being pushed into the background. According to the studies, teachers receive little support on how to teach students to use AI critically. According to Tick (2024), educators are particularly concerned about plagiarism and assessment bias. Pető and Kovács (2023) identified the risk of increased social inequality, as the use of AI tools is highly dependent on students' digital competence.

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Institutional Support and Guidelines

Based on OECD reports from 2020 and 2023, the digital transformation of Hungarian higher education institutions is progressing slowly but surely. Specific strategies for artificial intelligence are still rare, but demands from students and teachers are putting increasing pressure on the administrative sphere. All studies indicate that institutional regulation and support are lacking. According to Rajki et al (2025), 78% of students did not receive any information from their university on how to use AI responsibly. The Navigating survey (2024) reveals that 87% of teachers believe that institutional guidelines and internal AI ethics are needed.

Research consistently points to a lack of institutional regulation (Rajki et al., 2025; OECD 2021, 2023). Only a few Hungarian universities have explicit AI regulations, while most institutions leave it up to teachers to establish the framework. Institutional support for the digital transformation of Hungarian higher education is fragmented, and regulations on AI are only partially in place (OECD 2021, 2023).

Methodological training is also lacking: there is no systematic development or training program tailored to Hungarian higher education for the integration of AI pedagogy, either for students or teachers. European comparative research (Daskalaki et al., 2024) confirms this picture: 60% of Hungarian teachers have tried AI, but there is little official training or guidance available.

The example of Lengyel et al. (2024) from agricultural higher education shows that innovation at the institutional level is successful when AI is treated not only as a teaching aid but also as a research aid. Bokor (2023) also highlights the lack of institutional-level strategy, which may reinforce the fragmentation of applications in the long term.

Recommendations

1. Development of institutional guidelines

Higher education institutions should establish transparent, accessible protocols for the use of AI. These should cover issues such as plagiarism thresholds, source usage, independent work, and AI support.

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2. Methodological and ethical training

Courses and training sessions should be launched both for students and teachers on the conscious and critical use of AI tools. Digital competencies should be integrated into basic training.

3. Development-focused assessment practices

An assessment reform—such as project-based, reflective, or process-focused assessments—can help control and support the use of AI-based content.

4. Supportive infrastructure

The development of internal AI platforms, such as education-specific chatbots or university AI assistants, is recommended. In addition, the integration of administrative AI tools (e.g., automatic feedback, timetable management) can reduce the workload of teachers.

Conclusion

Surveys show that artificial intelligence is no longer a marginal phenomenon in Hungarian higher education, but part of everyday practice. AI is spreading rapidly in Hungarian higher education, but its integration is unregulated and raises significant ethical questions. The development of critical digital literacy, the clarification of ethical guidelines, and the establishment of institutional support systems are essential for the integration of technology into education. The lack of institutional support appears to be a key obstacle. This meta-summary offers a starting point from which future training policy and research directions can be mapped out. The main findings of the study are as follows:

- Student use of AI is widespread but informal and unreflective.
- Teacher integration of AI is sporadic and cautious, often ad hoc.
- The lack of critical thinking and ethical frameworks carries risks.

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- There is a strong demand for structured institutional responses and training.

The study's recommendations could contribute to strengthening future regulatory and methodological frameworks.

Scientific Ethics Declaration

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DEVELOPMENT OF 3D VISUALIZATION MEDIA USING ASSEMBLR STUDIO FOR LEARNING POLYHEDRAL GEOMETRY

Abstract: The integration of technology in education has significantly transformed the teaching and learning process, especially in subjects like geometry, which heavily rely on spatial visualization. Students' understanding of polyhedral geometry concepts is often hindered by the limitations of two-dimensional representations found in textbooks. Recent technological advancements have enabled 3D visualization to become an innovative solution for enhancing conceptual understanding in geometry. This study employs the Plomp development model, which consists of three phases. In the preliminary research phase, it was found that students struggle to understand polyhedral geometry due to limitations in visual representation. In the prototyping phase, an interactive and engaging 3D visualization medium was developed. In the assessment phase, media feasibility testing was conducted, focusing on expert validation and practical testing with students. The validation was carried out by three experts: a media expert, a subject matter expert, and an educational expert. The validation results indicated that the developed 3D visualization media achieved a very high level of validity, with an average score of 90.7%. Furthermore, the average practicality score was 79%, categorized as practical. The findings of this study demonstrate that the use of 3D visualization media based on Assemblr Studio is feasible for teaching polyhedral geometry.

Keywords: 3D visualization, Assemblr Studio, Polyhedral geometry, Media development, Plomp model

Introduction

The integration of technology in education has significantly transformed the teaching and learning process, especially in subjects that heavily rely on spatial visualization, such as geometry (Dalgarno & Lee, 2010; Hwang & Tsai, 2011; Fowler, 2015; Jian & Abu Bakar, 2024). Geometry plays a crucial role in developing students' spatial reasoning and problem-solving skills. However, many students struggle to understand three-dimensional (3D) geometry concepts due to the limitations of two-dimensional (2D) representations in textbooks that are not supported by interactive media (Lowrie et al., 2016; Fujita et al., 2017; Rich & Brendefur, 2019; Fujita et al., 2020).

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Advancements in digital technology, such as Augmented Reality (AR), have emerged as an innovative solutions to enhance students' understanding of geometric concepts in mathematics education, one of the core components of STEM education (Bacca et al., 2014; Ibáñez & Delgado-Kloos, 2018; Gargrish et al., 2020; Wang et al., 2024; Jiang et al., 2025). One AR-based platform that can be used in learning is Assemblr Studio, which allows students to interact with 3D models to improve their spatial understanding (Huang & Lin, 2017; Šafhalter et al., 2020; Surynkova, 2020).

Several studies have shown that students continue to struggle with polyhedral geometry, highlighting the need for learning aids and the integration of interactive technology (Yegambaram, 2013; Jones & Tzekaki, 2016; Fazira & Qohar, 2021; Izzati et al., 2023; Nuratiqoh & Qohar, 2024). Traditional teaching methods that rely on static 3D represebtations in textbooks often fail to provide the dynamic and immersive learning experiences needed to enhance students' spatial ability (Kinshuk et al., 2016; Chikha et al., 2021). Moreover, technology-based learning media must address the complexity of usage and ensure user-friendliness for students while aligning with curriculum standards in this digital age (Scanlon, 2021; Twining et al., 2021). Therefore, there is a need for 3D visualization media that is not only easily accessible and student-friendly but also designed to meet the learning objectives of polyhedral geometry.

A growing body of research has explored the role of technology in geometry learning. For instance, research has shown that AR-based geometry applications can significantly enhance students' spatial abilities (Gecü-Parmaksız, 2017; Gun & Atasoy, 2017; Danakorn Nincarean et al., 2019; del Cerro Velázquez & Morales Méndez, 2021; Ozcakir & Cakiroglu, 2021; Supli & Yan, 2024). Additionally, other studies have indicated that interactive 3D models are more effective in helping students grasp complex geometric relationships compared to traditional teaching methods that lack 3D visualization (Ng et al., 2020; Schmid & Korenova, 2024). The novelty of this research is lies in its bibliometric analysis using VOSviewer on internationally recognized journals, focusing on the keywords 3D Visualization, Assemblr Studio, Polyhedral Geometry, and Media Development. The network visualization resulting from this bibliometric analysis is presented in Figure 1.

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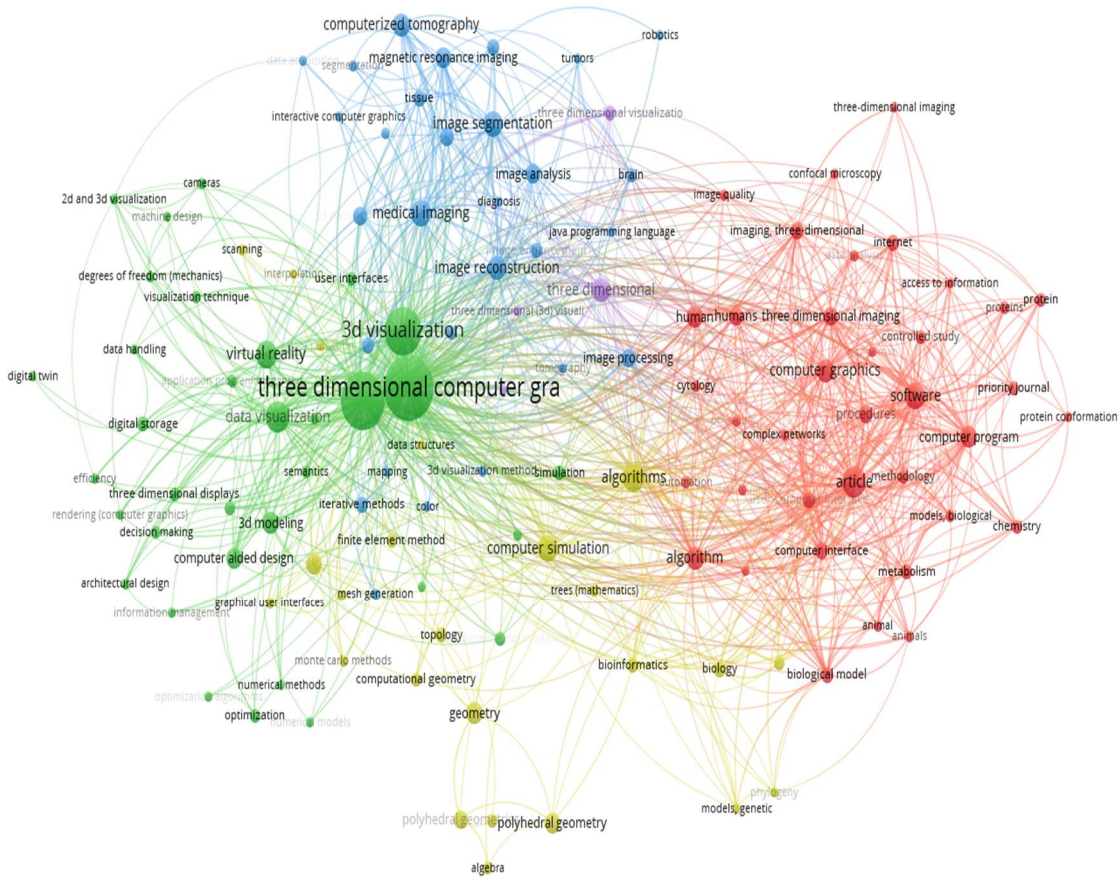

Figure 1. Network visualization

Based on the bibliometric analysis in the network visualization, the keyword "polyhedral geometry" has not yet been linked to "3D visualization". Additionally, there are no existing connections to the keywords "Assemblr Studio" and "media development'. While numerous studies have discussed the benefits of digital visualization in geometry learning, no research has systematically investigated the development process of 3D visualization media using Assemblr Studio for learning polyhedral geometry, particularly through the Plomp development model.

Moreover, there are still limitations in research that examines this development with validation and practicality tests in polyhedral geometry. Most 3D visualization or modeling-based learning media that have been developed either lack empirical validation from experts and practicality test. This study addresses these

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gaps by applying the Plomp development model to design and evaluate 3D visualization media using Assemblr Studio for learning polyhedral geometry.

Additionally, this study provides empirical validation from experts to ensure the feasibility of the developed media for classroom use. Recognizing the importance of 3D visualization media, this study aims to: 1) design 3D visualization media using Assemblr Studio based on the Plomp development model for learning polyhedral geometry; 2) evaluate the validity of the developed media through expert validation; 3) evaluate the practicality of the developed media through practicality tests to students.

Method

This study employs developmental research, focusing on the design, validation (Tracey, 2009), and practicality testing of 3D visualization media for learning polyhedral geometry. This media is designed to support the understanding of shapes, dimensions, and relationships between different parts of polyhedral geometry. The Plomp development model is used, with its phase modified into three main phases: preliminary research, prototyping phase, and assessment phase (Nieveen & Folmer, 2013).

Subjects (Participants)

The participants in this study include three experts responsible for media validation: a media expert who evaluates the technical aspects of 3D visualization, a subject matter expert who evaluates content alignment with geometry learning objectives, and an educational expert who evaluates the instructional aspects of the developed media. The research subjects consist of a small group of 25 junior high school students from Indonesia. These students participated in the needs analysis and practicality testing to assess the usability of the media.

Data Collection Techniques

Data collection was conducted through several activities: 1) a literature review to analyze previous studies on the use of digital media, challenges in geometry learning, and the potential of 3D visualization media; 2)

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interviews and observations with teachers and students to identify challenges and learning needs in polyhedral geometry; 3) validation by three experts, who evaluated the media based on feasibility of materials, feasibility of media, feasibility of instruction manual language using validation sheets. Practicality testing was conducted with a small group of students using the developed media, followed by a questionnaire to evaluate its practicality in learning.

Data Analysis Techniques

The data analysis techniques used in this study include: 1) needs analysis, processed through coding using MAXQDA 24; 2) media validation, analyzed based on the percentage score to determine its level of validity; 3) media practicality testing, assessed using the percentage score to determine the practicality level. The analysis follows a Likert scale (1-5). The validity criteria in this study are based on a minimum validity score of $4 \leq Va < 5$ on the Likert scale or $80\% \leq Va < 100\%$, indicating that the developed media is feasible for use (Mustami et al., 2019). The validation score criteria for all validators are presented in Table 1.

Table 1. Validity criteria

Validity score	Category
85,01-100,00%	Very valid
70,01-85,00%	Valid
55,01-70,00%	Moderately valid
37,01-55,00%	Less valid
20,00-37,00%	Not valid

Criteria for determining the practicality test score for all students based on the percentage of their assessment (Dahal et al., 2023) are presented in Table 2.

Table 2. Practicality criteria

Practicality score	Category
0 – 59 %	Not practical
60 – 65 %	Little practical
66 – 70%	Pretty practical
71 – 81 %	Practical
82 – 100%	Very practical

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Results and Discussion

Preliminary Research

The needs analysis was conducted by identifying challenges in learning polyhedral geometry and exploring potential solutions. During the preliminary research phase, interviews and classroom observations were carried out. The needs analysis of qualitative data from interviews and observations was analyzed using creative coding with MAXQDA 24 application and are presented in Figure 2.

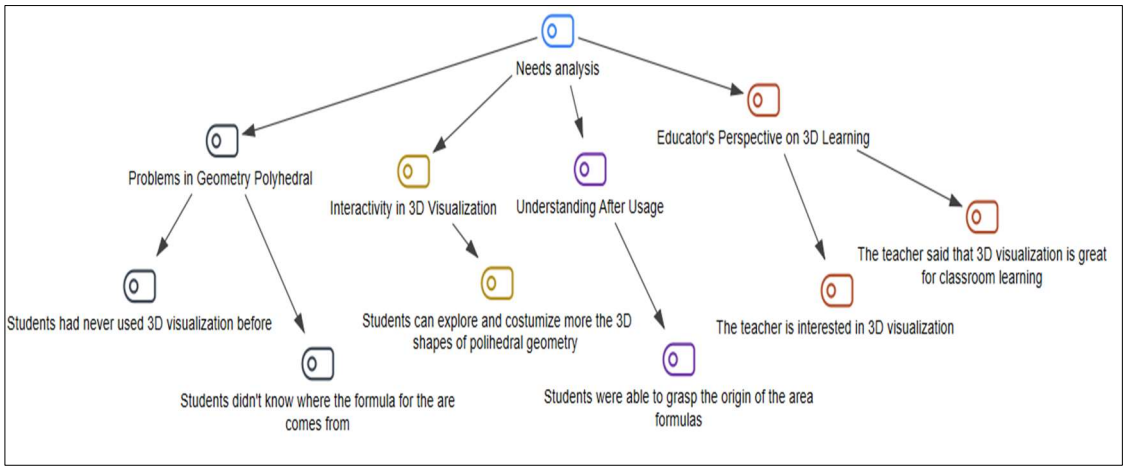

Figure 2. Needs analysis through creative coding

Based on the coding of interview and observation results, as shown in Figure 2, it was found that students had never used 3D visualization media in polyhedral geometry learning in the classroom. Additionally, students struggled to understand polyhedral geometry concepts, such as the derivation of surface area formulas they had learned. This difficulty was caused by the limited visual representations available in textbooks and two-dimensional images. These findings align with previous research by Lowrie et al. (2016), Fujita et al. (2017), Rich and Brendefur (2019), and Fujita et al. (2020). Discussions with the teacher revealed that she was interested in 3D visualization media for polyhedral geometry because she had never used such media in her classroom instruction. According to the teacher, using this media could make students more active in learning and help them better understand polyhedral geometry concepts. A literature review of previous studies has shown that technology-based visualization can aid in understanding geometry concepts (Žakelj & Klancar, 2022; Mjenda, 2023; Schoenherr et al., 2024; Suparman et al., 2024; Medina Herrera et

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al., 2024). Furthermore, interactive and digital learning media have the potential to enhance students' learning motivation and engagement in the learning process (Liu & Moeller, 2019; Li et al., 2024). The findings from this preliminary research serve as the foundation for designing 3D visualization media tailored to students' learning needs.

Prototyping Phase

In the prototyping phase, the 3D visualization media was designed with an interactive and engaging interface to enhance students' learning experiences. This media was developed using the Assemblr Studio platform, which allows students to view and interact with 3D models. The development process involved designing the initial layout and creating visualizations that support the learning of polyhedral geometry concepts. An example of a polyhedral geometry concept that has been visualized is a prism. Figure 3 illustrates the 3D visualization of triangular prism.

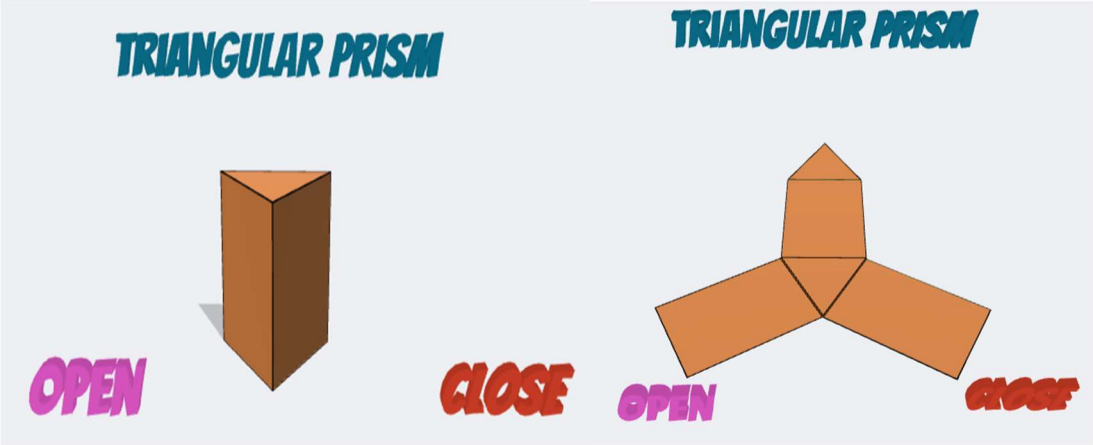

Figure 3. 3D visualization of a triangular prism

The 3D visualization of the triangular prism in Figure 3 displays both the front view and the internal structure of the shape. This visualization allows students to explore the 3D form from various angles. Students can rotate, zoom in, zoom out, and view the nets of the polyhedral geometric shapes. Other polyhedral geometry included in the media are cubes, rectangular prism, and triangular pyramid. Each 3D shape can be explored by scanning its respective barcode. These barcodes can be scanned using a mobile phone. The barcodes for the 3D visualization are shown in Figure 4.

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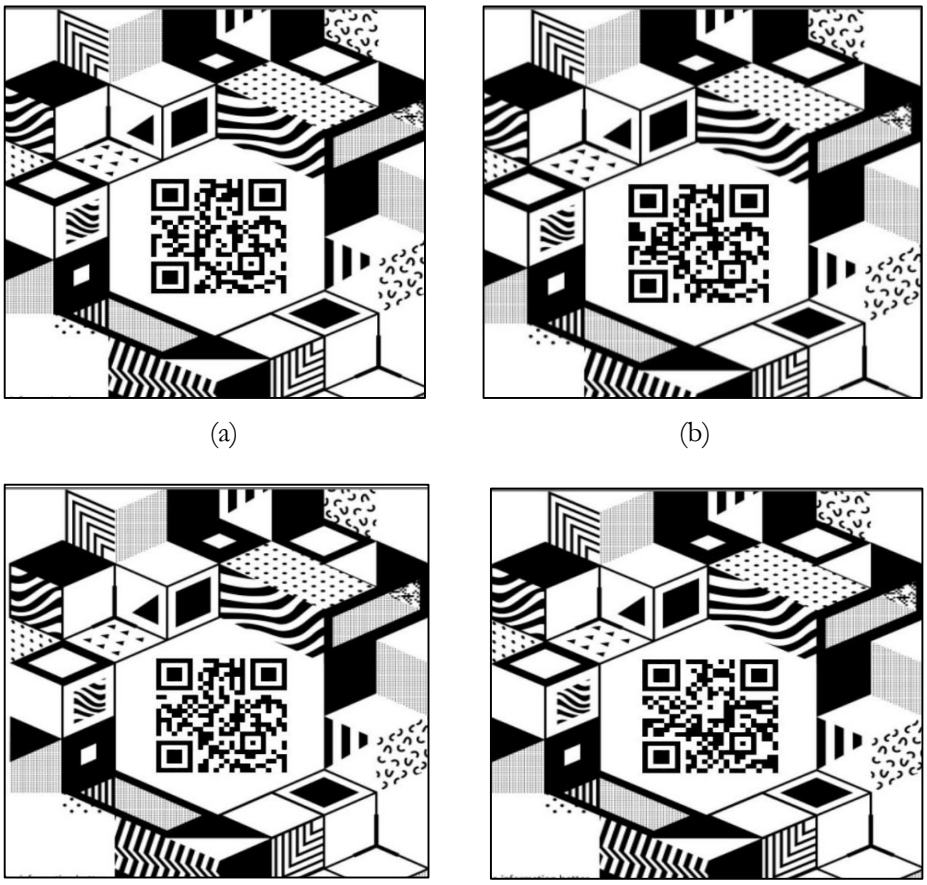

(a) (b)

(c) (d)

Figure 4. (a), (b), (c), (d) Barcodes for each polyhedral geometric shape

Each barcode in Figure 4 represents the 3D visualization of different polyhedral geometry shapes. Figure 2(a) corresponds to a triangular prism, Figure 2(b) to a triangular pyramid, Figure 2(c) to a cube, and Figure 2(d) to a cuboid.

Some of the most suitable topics for using this 3D visualization include: 1) understanding the characteristics of polyhedral shapes, such as identifying the number of faces, edges, and vertices, as well as recognizing the shapes of their constituent faces; 2) exploring the nets of polyhedral geometric shapes and relating them to their 3D counterparts to better understand their construction; 3) helping students grasp that surface area is the sum of all face areas by exploring the nets of polyhedral geometric shapes.

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Assessment Phase

At the assessment phase, the developed media was evaluated by three experts: a media expert, a subject matter expert, and an educational expert. The validation test was conducted to evaluate the feasibility of the media. The validation results from the three experts for each assessment aspect are presented in Table 3.

Table 3. Validity test

Aspect	Number of indicators	Total score	Maximum score	Percentage	Criteria
Feasibility of materials	5	68	75	90,7	Very valid
Feasibility of media	11	149	165	90,3	Very valid
Feasibility of instruction manual language	2	28	30	93,3	Very valid
Total	18	245	270	90,7	Very valid

The expert validation results indicate that the media has a very high level of validity, with an average validation score of 90.7%. This percentage demonstrates that the 3D visualization media for learning polyhedral geometry meets feasibility standards in terms of content, visual presentation, and the appropriateness of instructional language for learning.

Table 4. Practicality test

Aspect	Number of indicators	Total score	Maximum score	Percentage	Criteria
Usefulness	3	60,204	75	80,272%	Practical
Convenience	5	106	125	84,8%	Practical
Satisfication	2	35,8	50	71,6%	Practical
Total	10	245	270	78,891%	Practical

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In addition to expert validation, the practicality test was carried out on students to find out the extent to which this media can be implemented properly in learning. The results of the practicality test for each assessment aspect by students are presented in Table 4. The practicality test results in Table 4 indicate that the media obtained an average score of 79%, categorized as practical. This score indicates that the developed 3D visualization media is practically applicable for classroom learning.

The findings of this study show that the use of 3D visualization media based on Assemblr Studio is feasible for use in learning polyhedral geometry, as evidenced by validity and practicality tests. This aligns with the studies of Schindler et al. (2017), and D'Angelo (2018). With clearer and more interactive visual representations, students can more easily grasp geometric concepts that were previously difficult to understand without using this media. This is consistent with the research of Schoenherr et al. (2024), Parame-Decin (2023), Medina Herrera et al. (2024); and Žakelj and Klancar (2022), which highlight visualization as a powerful tool to support mathematics learning.

Conclusion

The integration of 3D visualization media in mathematics education has demonstrated its potential to enhance students' understanding of polyhedral geometry. This study, which employs the Plomp development model, has produced 3D visualization media using Assemblr Studio that have been validated and tested for practicality. Expert validation results indicate that the developed 3D visualization media have a very high validity level, with an average score of 90.7%. Additionally, student practicality testing yielded an average score of 79%, categorizing the media as practical. The findings reveal that students often struggle with understanding polyhedral geometry due to the limitations of two-dimensional representations in textbooks, which are presented without the aid of media. The developed media addresses these challenges by providing interactive and engaging visualizations that support polyhedral geometry learning.

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Recommendations

This study has the advantage of providing a strong foundation for the development of technology-based learning media through expert validation and practicality testing. Although it has not yet included an effectiveness test on student learning outcomes, the validation conducted ensures that this media meets quality standards for use. To maximize its benefits, further research can focus on testing its effectiveness in significantly improving students' understanding. Additionally, further development is needed to make this media more flexible and adaptive, allowing it to be used in various learning scenarios.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in the EPESS journal belongs to the authors. This study does not require ethics committee approval as it focuses on the development of 3D visualization media without involving human subjects in experimental research.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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ADOLESCENCE AS A CRITICAL PERIOD: GENDER DIFFERENCES IN NUTRITION, PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR

Abstract: The study, conducted with a sample of 177 male students and 89 female students from the final grades of high schools in Zagreb, examined physical activity, sedentary behavior, and dietary habits among adolescents. The results show that the majority of male students (67%) regularly engage in sports, with most having been involved in sports for over five years (44.65%), while the majority of female students (52.27%) are inactive. Among those who participate in sports, a larger percentage of both genders engage in individual sports (39.55% of male athletes and 42.05% of female athletes).Regarding sedentary behavior, both genders spend a similar amount of time using mobile devices and applications (2-3 hours daily), with a higher percentage of male students (37.29%) spending more time playing video games compared to female students (79.55%).In terms of dietary habits, the majority of students from both genders report having prior knowledge of nutrition, with male students being slightly more informed about weight loss and weight gain advice. While they are aware of the importance of proper nutrition, there are noticeable deficiencies in their dietary habits, especially in the consumption of fruits, vegetables, and fish. Females generally consume more fruits and dairy products, while males consume more meat and meat products. The study highlights the need for further educational and health interventions to promote a more balanced diet and greater engagement in physical activity among adolescents.

Keywords: Secondary school students, Physical activity, Eating habits, Nutrition

Introduction

Adolescence is a pivotal period in life, marked by rapid and profound changes across physical, emotional, social, and cognitive domains. It is a time when the foundations for adult habits are established, including behaviors related to nutrition, physical activity, and mental health (National Academies of Sciences, Engineering, and Medicine [NASEM], 2019; Mastorci et al., 2024). This stage, which spans from ages 10 to

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19, presents young people with numerous challenges arising from pubertal changes, social pressures, and the drive for independence and identity formation (Steinberg, 2005; Arnett, 2007).

One of the most prominent characteristics of adolescence is the emergence of gender differences, which are evident across various aspects of adolescent life—from biological and physical traits to social roles and psychological needs (De Bolle et al., 2015). Boys and girls often adopt different approaches when it comes to diet, physical activity, sedentary behavior, and mental health (Harter, 2012; Harris & O'Neil, 2017). For instance, boys are generally more likely to engage in high-intensity physical activities and meet recommended physical activity guidelines, while girls more frequently report higher levels of sedentary behavior (Brazo-Sayavera et al., 2021; Aubert et al., 2018). Similarly, dietary habits also vary significantly between genders. Girls tend to be more concerned with body weight control, which often leads to an increased risk of disordered eating and unhealthy weight-loss strategies (Gibson, Hunt & Sallis, 2016; Mikkilä, Räsänen & Räsänen, 2004). In contrast, boys are more likely to consume larger quantities of fast food and sugary beverages, raising their risk of obesity and related health problems (Harris & O'Neil, 2017; Gibson et al., 2016; Mikkilä et al., 2004). These differences are not superficial—they deeply affect adolescents' physical and mental health and lay the groundwork for potential health issues in adulthood (Berge et al., 2017).

The issue of gender differences in dietary habits and physical activity is also evident in research conducted in Croatia. Peršun (2021), in a study among high school students in Zagreb, found that girls more frequently choose healthier foods and vegetables, while boys consume more processed food, sugary drinks, and fast food. Similar studies conducted in Osijek and Split suggest that girls tend to maintain more balanced diets, whereas boys show a preference for fast food and carbonated drinks (Peršun, 2017). In a study by Uršulin-Trstenjak, Miler & Ferenčak (2016), carried out in secondary schools in Zagreb and Varaždin, a significant gender gap in physical activity levels was highlighted: boys were more involved in high-intensity activities, while girls more often opted for lighter forms of exercise, such as walking or cycling. Similarly, Peršun (2021) analyzed adolescents' dietary habits in Zagreb and found that boys often fail to meet the recommended daily intake of fruits and vegetables.

In recent years, global research has revealed alarming trends in sedentary behavior and low levels of physical activity among adolescents worldwide (Guthold et al., 2019; van Sluijs et al., 2021). Global studies consistently show that only a minority of adolescents meet WHO physical activity guidelines—over 80 % globally fall short of the 60-minute daily recommendation (Guthold et al., 2019), with only around 20 %

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achieving daily physical activity even in large multi-country samples (Pengpid & Peltzer, 2020). Simultaneously, increased technology use and screen time have become serious concerns, contributing to negative mental health outcomes and obesity (Carson et al., 2016; Poitras et al., 2016). These trends underscore the need for further research to better understand the specific needs of boys and girls and to support the development of targeted interventions aimed at reducing these negative outcomes (Aubert et al., 2018). In Croatia, according to Mikulić et al. (2018), the majority of adolescents do not meet the recommended levels of physical activity, and a significant number spend most of their day sitting, which can lead to adverse health consequences. Similarly, research by Vranić et al. (2019) shows that Croatian adolescents spend a high percentage of their time being sedentary—up to 8 to 9 hours a day—mostly on mobile phones and computers.

This paper aims to explore gender differences in dietary habits, physical activity, and sedentary behavior among Croatian adolescents. Understanding these differences is crucial for designing specific programs and policies aimed at improving young people's health, taking into account the unique needs of both boys and girls (Berge et al., 2017; Harris & O'Neil, 2017).

Method

Sample of Respondents

The sample consisted of students from the 3rd and 4th grades of the I. Technical School Tesla in Zagreb (n = 177), aged 16 to 19 (M = 17.59), and female students from the All-Girls General Gymnasium of the Sisters of Mercy (F = 89), aged 16 to 19 (M = 17.41). All participants were informed about the purpose of the study and were made aware that participation was voluntary and they could withdraw at any time.

Variables Sampled

An online questionnaire was created using Google Forms, consisting of 51 questions related to daily activity, sedentary behavior, and dietary habits (Questionnaire link). Each nominal variable (i.e., the response options for a given question) was coded from 1 to 6, depending on the number of answers offered.

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Data Analysis Methods

Descriptive statistical analyses were performed. Mode and mode frequency were calculated using the Statistica software, version 14.0 (StatSoft, Inc., Tulsa, USA).

Data Collection

Physical and health education teachers distributed the questionnaire link to students during class time.

Results and Discussion

Table 1 presents the values of descriptive parameters for indicators of activity, sedentary behavior, and dietary habits among upper secondary school students.

Table 1. Descriptive indicators of physical activity, sedentary behavior, and dietary habits among upper secondary school students

	Boys (n=177)			Girls (n=89)		
Question	Mode	Freq	%	Mode	Freq.	%
How old are you?	18	88	49.7%	17	48	53.9%
Highest level of education completed	4	75	42.3%	3	50	56.8%
When you are alone, do you get bored?	3	91	51.4%	1	60	68.1%
Do you play any sports?	1 (Yes)	119	67.2%	3 (No)	46	52.2%
If you play sports, which sport group does your sport belong to?	2	70	39.5%	5	37	42.0%
How many years have you been playing sports?	6	79	44.6%	3	42	47.7%
How many days per week do you train?	Multiple (varied)	44	24.8%	6	24	27.2%
Do you earn any income from playing sports?	2 (No)	152	85.8%	8 (No)	75	85.2%
How many hours per day do you watch TV?	1	100	56.5%	0	48	54.5%
How many hours per day do you play computer games?	1	66	37.2%	9	70	79.5%

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How many hours per day do you spend browsing social media/apps?	3	93	52.5%	4	37	42.0%
How many times per week do you do other leisure activities (foreign language, music, hobbies, etc.)?	3	67	37.8%	5	33	37.5%
Do you have prior knowledge about nutrition?	1 (Yes)	141	79.6%	6 (Yes)	64	72.7%
Have you ever received advice about nutrition to lose/gain weight?	1 (Yes)	112	63.2%	8 (Yes)	62	70.4%
Do you work with a nutritionist?	2 (No)	164	92.6%	6 (No)	83	94.3%
Are you currently on a special diet?	2 (No)	155	87.5%	7 (No)	73	82.9%
Most often I eat when:	1	112	63.2%	8	57	64.7%
Usually when I eat:	1	119	67.2%	3	57	64.7%
To what extent does the statement apply: I eat standing up	2	61	34.4%	6	35	39.7%
To what extent does the statement apply: I eat from a bowl	3	76	42.9%	4	36	40.9%
To what extent does the statement apply: I eat while watching TV, reading, or working	3	60	33.9%	0	36	40.9%
To what extent does the statement apply: I eat when I'm bored	3	60	33.9%	0	34	38.6%
To what extent does the statement apply: I eat when I'm angry or in a bad mood	1	93	52.5%	4	26	29.5%
To what extent does the statement apply: I eat unorganized between meals	3	58	32.7%	7	28	3

Based on the results obtained, it is evident that the majority of male students engage in sports (67%), while the majority of female students do not (52.27%). Among both genders, those who engage in sports predominantly participate in individual sports (such as athletics, gymnastics, boxing, etc.; 39.55% of male athletes and 42.05% of female athletes). This result contradicts the findings of Ivković, Hordov and Miodrag (2021), which show that Croatian high school students most often participate in team sports (football, basketball, volleyball), followed by individual sports (athletics, swimming, boxing, and rowing). Similar patterns were observed in other populations: in an Israeli sample, gymnastics, athletics, and tennis were among the most frequent individual sports, while basketball, football, and volleyball were dominant team sports (Lidor et al., 2022). U.S. data likewise demonstrate that athletics and other individual sports rank among the most common extracurricular activities among adolescents, in some cases even surpassing team

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sports such as football and basketball (National Federation of State High School Associations [NFHS], 2019; Pate et al., 2000).

Regarding the length of time spent practicing sports, it was found that the majority of male athletes have been practicing sports for more than five years (44.65%), while female athletes predominantly selected the option "I do not engage in sports" (47.73%), which resulted in the data on the duration of female athletes' involvement in sports not being recorded as dominant. The number of training days per week among male athletes is highly variable (ranging from 1-2 times a week to 6 times a week), while female athletes predominantly train 3 times a week (27.27%). Male and female athletes alike report no income from their sports activities (85.88% of male athletes and 85.23% of female athletes). The level of sports activity among the participants in this study is significantly higher than the results from Ivković et al. (2021), where only 40.05% of Croatian high school students engage in sports regularly, as well as compared to data from the Global Matrix 4.0 report (Pedišić et al., 2023), which shows that only 30% of high school students participate in organized sports activities.

In terms of time spent watching TV and (presumably) using mobile devices, the data from both genders are quite similar: both genders predominantly do not spend time watching television (56.60% of male athletes and 54.55% of female athletes), but they mostly spend 2-3 hours a day browsing content on various applications (52.54% of male athletes and 42.05% of female athletes). The time spent browsing different applications corresponds with the findings in the study by Jokić et al. (2024), also with global research findings which indicate that a significant portion of adolescents engage in extensive screen time, particularly through mobile devices (Dai & Ouyang, 2025). Such trends reflect the growing role of digital media in adolescents' daily lives and highlight the importance of monitoring screen exposure in this population.

While both genders predominantly chose the response "I do not spend time playing computer games" to the question, "How many hours a day do you spend playing video games?", the percentage of male athletes giving this response (37.29%) is significantly lower than that of female athletes (79.55%). This data aligns with numerous studies that confirm adolescents, especially boys, spend significantly more time playing video games than girls (Desai et al., 2010; Gómez-Gonzalvo et al. 2020; Leonhardt & Overå, 2021). Despite the inability to determine statistical significance for these differences, the result indicates notable gender differences in video game-related behavior among adolescents.

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Aside from sports, the majority of both male students (37.85%) and female students (37.50%) engage in other activities during their free time (such as learning a foreign language, music, or hobbies like art) 2-3 times a week. This percentage aligns with the findings of Jokić et al. (2022), who reported that 71.7% of third-year high school students in Croatia do not participate in any extracurricular activities other than sports. Recent international studies confirm that extracurricular activities positively impact adolescent development. Participation in sports, arts, and other activities enhances physical activity (Nagata et al., 2025), improves mental health by reducing depression and anxiety (O'Flaherty et al., 2022), and promotes healthier behaviors and risk awareness (Szapary et al., 2025). Together with the current study, these findings highlight the important role of extracurricular engagement in supporting social, cognitive, and emotional growth, as well as healthy lifestyle habits.

Regarding nutrition knowledge, an exceptionally high percentage of male students (79.66%) and female students (72.73%) reported having prior knowledge of nutrition and having received advice on nutrition (such as how to lose or gain weight: 63.28% of male students and 70.45% of female students). However, male (92.66%) and female students (94.32%) do not collaborate with a nutritionist, nor are they following any special diet regime (87.57% of male students and 82.95% of female students). These results regarding the participants' knowledge of nutrition are consistent with the findings from studies conducted on high school seniors at the Medical School in Rijeka (Gudeljević & Jovanović, 2021) and at the Health School in Split (Kendeš, 2021). These studies showed that students have a positive attitude and relatively good knowledge about nutrition and are aware of the importance of a healthy diet for maintaining good health. Among students who reported following a specific diet, protein- and carbohydrate-rich diets were most frequently mentioned, while female students primarily mentioned attempts to follow a healthier diet and a calorie-deficit diet.

International studies confirm these gender-specific dietary patterns. Girls are more likely to consume fruit, vegetables, and healthy foods, while boys prefer fast food and meat (Askovic & Kirchengast, 2012). Girls also more often engage in dieting due to body-image concerns, as supported by a systematic review (Deslippe et al., 2023). Similar findings in Costa Rica show girls linked to nutritious foods, while boys favor energy-dense meals (Salazar et al., 2014).

The eating habits of the students show that, in most cases, they eat when they are hungry and it is time for a meal (63.28% of male students and 64.77% of female students), and when they have requested and

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received food (67.23% of male students and 64.77% of female students). Gender differences are observed in responses related to the ways and places of meal consumption. Male students almost never eat standing up (34%), while female students do so occasionally (39.77%); male students occasionally eat from a bowl (42.94%), while female students do so frequently (40.91%); male students occasionally eat while watching TV, reading, or working (33.90%), while female students do so frequently (40.91%); and both male students (33.90%) and female students (38.64%) occasionally eat when they are bored (34%). Male students never eat when they are angry or in a bad mood (52.54%), while a dominant percentage of female students do so frequently (29.55%). The dynamics, organization, and locations of student meals show that the highest frequency of responses is recorded for "I sometimes eat unorganized meals between meals" (32.77% of male students and 31.82% of female students). Both genders sometimes eat late in the evening or at night (35.59% of male students and 34.09% of female students). Gender differences are present in the frequency of meals outside the dining room: male students sometimes eat in the living or working room (28.81%), while female students do so frequently (32.95%). Male students sometimes eat in the bedroom (30.51%), while female students do so frequently (28.41%). Both genders only sometimes take a second serving of food (36.72% of male students and 45.45% of female students). The findings of this study regarding adolescents' eating habits are consistent with international research. Female students were more likely than males to eat in response to emotions or while multitasking, such as watching TV or reading, whereas male students showed more structured eating patterns (Herle et al., 2017; Lombardo, Giusti & Fabbri, 2024). These results highlight that emotional states and meal contexts significantly influence adolescents' eating behaviors. Compared to their generation, the majority of male students (49.72%) and female students (56.82%) believe they eat at an average speed. Once or twice a week, they participate in a family meal with the majority of family members present (40.68% of male students and 47.73% of female students), and their families eat in a restaurant or order fast food less than once a month (63.28% of male students and 62.50% of female students).

In the homes of male students (69.93%) and female students (71.59%), snacks and sweets are easily accessible, and the most common types found include 2-3 types of savory snacks (44.63% of male students and 39.77% of female students), 2-3 types of nuts (51.95% of male students and 45.45% of female students), 1 type of chocolate (48.59% of male students and 53.41% of female students), and no types of chocolate bars (44.63% of male students and 53.41% of female students). Gender differences are visible in the number of types of candy and carbonated drinks in students' homes: male students predominantly have 1 type of candy (40.68%), while female students have none (37.50%); male students predominantly have 1 type of

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carbonated drink (36.72%), while female students have none (39.77%). In both genders' homes, the same situation exists for dry cookies and filled cookies (usually 1 type is available), while ice creams and lollipops are mostly unavailable. Most male (47.46%) and female students (48.86%) do not consume additional snacks and sweets over the weekend compared to the week. These findings indicate that both male and female students have easy access to various types of snacks and sweets at home, with gender differences in the types and quantities available. This is consistent with the study by Savige et al. (2007), which found that adolescent snacking behaviors, often occurring after school or while watching TV, are influenced by gender and household context, highlighting the role of home availability in shaping eating habits.

Male and female students consume similar amounts of cereals, legumes, fresh vegetables, fish and seafood, and olive oil: the majority consume 1 portion of cereals and cereal products daily (54.24% of male students and 70.45% of female students), 1 portion of legumes weekly (46.89% of male students and 48.86% of female students), 1-2.5 portions of fresh vegetables daily (49.15% of male students and 54.55% of female students), less than 1 portion of fish and seafood weekly (48.59% of male students and 54.55% of female students), and occasionally consume olive oil (less than 5 tablespoons per day; 54.24% of male students and 57.95% of female students). Gender differences are observed in the consumption of fresh fruit, milk and dairy products, and meat and meat products. Male students consume less than 1 serving of fresh fruit daily (39.55%), while female students consume 1-2 servings of fresh fruit daily (50.00%). Male students consume less than 1 serving of milk and dairy products daily (39.95%), while female students consume 1-1.5 servings of milk and dairy products daily (43.18%). Male students consume more than 1.5 servings of meat and meat products daily (44.63%), while female students consume 1-1.5 servings of meat and meat products daily (52.27%). As previously noted, these results are consistent with the findings of Nagata et al. (2025), which found that among the early adolescent population in the United States, the male sex was associated with lower intake of fruits, vegetables, and whole grains, but higher consumption of meat, added sugars, and fats — all indicating poorer dietary quality compared to girls.

Conclusion

This study examined gender differences in physical activity, sedentary behavior, and dietary habits among Croatian high school students. The results indicate that the majority of male students actively participate in

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sports, mostly in individual disciplines, while female students are less involved in organized sports. Male students show more variable training frequency and intensity, whereas female students tend to have more structured, moderate activity patterns. Both genders spend limited time watching TV or playing video games, but boys engage in gaming significantly more than girls. Meanwhile, both genders spend 2–3 hours daily browsing social media or other digital applications, reflecting the increasing role of technology in adolescents' daily routines.

Although students demonstrated high levels of nutritional knowledge, this did not consistently translate into healthy eating behaviors. Female students consumed more fruits, vegetables, and dairy products, while male students consumed more meat, fast food, and high-calorie snacks. Special diets were more common among females and generally aimed at calorie restriction, whereas males followed protein-focused diets. Eating contexts and behaviors also differed by gender: female students were more likely to eat in response to emotions or while multitasking, whereas male students maintained more structured eating patterns.

The study also highlighted the home food environment, showing that snacks and sweets are easily accessible to both genders, but both genders do not show a frequent consumption of these items. Overall, the findings reveal a gap between knowledge and practice regarding healthy lifestyles, underlining the importance of targeted interventions to improve physical activity engagement, limit excessive screen time, and foster healthier dietary behaviors. Gender-specific strategies may be particularly beneficial, addressing the unique needs, habits, and preferences of boys and girls to promote lifelong healthy habits.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

* Ethics committee permission no. 2181-205-02-05-25-008 of University of Split Faculty of Kinesiology.

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Conflict of Interest

* The authors declare that they have no conflicts of interest

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ASSESSING SCIENTIFIC THINKING IN EARLY CHILDHOOD: DEVELOPMENT AND VALIDATION OF THE SCIENTIFIC THINKING SKILLS ASSESSMENT TOOL (STS-AT)

Abstract This study reports the development and validation of the Scientific Thinking Skills Assessment Tool (STS-AT), designed to measure scientific thinking in children aged 5–8 years. The STS-AT assesses four domains: critical inquiry, hypothesis testing, analytical interpretation, and metacognitive awareness. Item development was guided by theoretical frameworks and expert review, followed by pilot testing with 72 children, which demonstrated clarity and inter-rater reliability (Cohen's $\varkappa = 0.88$). The final instrument comprised 12 open-ended tasks supported with visual aids and scored on a four-point rubric. The main study involved 282 children from Turkish kindergartens and primary schools. Reliability analyses indicated strong internal consistency (Cronbach's $\alpha = .87$) and high test–retest stability ($r = .91$). Exploratory and confirmatory factor analyses supported a four-factor structure with excellent fit (RMSEA = .04, CFI = .95, TLI = .93, SRMR = .06). Results showed significant improvements in scientific thinking with age ($F(3,278) = 18.81$, $p < .001$, $\eta^2 = 0.17$), while no gender differences were observed ($t = -1.01$, $p = 0.315$). These findings suggest that the STS-AT is a valid, reliable, and developmentally appropriate tool for assessing scientific thinking in early childhood.

Keywords: Scientific thinking, Early childhood, Assessment, Scale development, Validity, Reliability

Introduction

Scientific thinking has long been recognized as a cornerstone of cognitive development in early childhood, encompassing the skills of questioning, predicting, hypothesizing, testing ideas, interpreting evidence, and reflecting on one's reasoning (Kuhn, 2010; Zimmerman, 2007). Classic developmental theories position this period as critical: Piaget (1972) described the transition from preoperational to concrete operational thought as a time when children increasingly coordinate evidence and reasoning, while Vygotsky (1978) emphasized the role of social interaction and scaffolding in fostering inquiry and reflection.

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In recent decades, researchers have conceptualized young children as "little scientists" who actively generate and test explanations about the natural and social world (Gopnik et al., 2000). More recent empirical work confirms that children as young as five can design simple experiments, differentiate between confounded and unconfounded evidence, and modify their explanations based on feedback (Koerber et al., 2015; Köksal, 2022). These findings highlight not only the presence of early competencies but also the importance of providing structured opportunities to nurture them.

The global emphasis on STEM education has further reinforced the importance of fostering scientific thinking in early years (Bybee, 2013; OECD, 2017). Early scientific reasoning is associated with later academic achievement, problem-solving, and civic scientific literacy (National Research Council [NRC], 2012). Moreover, cultivating inquiry and reflective skills in childhood contributes to the development of critical 21st-century competencies such as creativity, resilience, and informed decision-making (NGSS Lead States, 2013).

Despite this recognition, assessment practices in early childhood education remain limited. Existing tools often measure isolated skills—such as observation or prediction—rather than capturing the multidimensional nature of scientific thinking (Zimmerman, 2007; Koerber & Osterhaus, 2020). The Work Sampling System (WSS) includes a "scientific thinking" domain but does not provide fine-grained psychometric evidence and treats science as a subset of general learning (Meisels et al., 1995). More recently, Koerber and Osterhaus (2020) developed the Science-K Inventory**,** a Rasch-scaled assessment for preschoolers, focusing on experimentation and nature-of-science concepts. While valuable, such instruments remain relatively rare and often lack integration of metacognitive elements—such as children's awareness of their own thinking—which are known to be crucial even in early development (Flavell, 1979; Schraw & Dennison, 1994).

Therefore, there is a pressing need for a valid and reliable instrument that conceptualizes scientific thinking holistically, integrating critical inquiry**,** hypothesis testing**,** analytical reasoning**,** and metacognitive awareness in a developmentally appropriate framework. Addressing this gap, the present study introduces the Scientific Thinking Skills Assessment Tool (STS-AT), specifically designed for children aged 5–8 years. Drawing on constructivist theories and contemporary evidence, the STS-AT provides a child-centered, play-based, and psychometrically robust measure.

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The purpose of this paper is to describe the conceptualization, development, and validation of the STS-AT. We present evidence of internal consistency, test–retest reliability, item-level performance, and factorial validity (via exploratory and confirmatory factor analyses). Additionally, developmental validity is examined through age comparisons, and potential gender differences are explored. By establishing a rigorous foundation, this study aims to contribute a novel and reliable tool to the field of early childhood science education.

Theoretical Background

Scientific thinking in early childhood is a multidimensional construct that emerges through the interaction of cognitive development, social context, and instructional opportunities. The STS-AT was designed to reflect four interrelated domains—critical inquiry, hypothesis testing, analytical interpretation, and metacognitive awareness—each grounded in established theoretical and empirical literature.

Critical Inquiry

Critical inquiry refers to children's capacity to generate questions, attend to observations, and identify meaningful problems for investigation. Piaget (1972) emphasized that during the transition from preoperational to concrete operational stages, children begin to coordinate their observations with logical operations. Vygotsky's (1978) sociocultural theory further highlighted that inquiry skills are fostered when children are guided by more knowledgeable peers or adults within the zone of proximal development. Contemporary research shows that preschool and early primary students are capable of posing causal questions and noticing patterns in phenomena when supported with scaffolding (Eshach & Fried, 2005; Köksal, 2022). Inquiry is also positioned as a central scientific practice in the Next Generation Science Standards (NGSS Lead States, 2013), underlining its educational relevance.

Hypothesis Testing

The ability to generate predictions and verify them through observation or experimentation is central to scientific reasoning. Kuhn (2010) describes hypothesis testing as a critical shift from intuitive explanations to evidence-based thinking. Empirical studies demonstrate that children as young as five can engage in simple experimental designs and revise their hypotheses in light of outcomes (Koerber et al., 2015).

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According to Zimmerman (2007), children's competence in controlling variables and recognizing unconfounded evidence increases markedly between ages 5 and 8. The National Research Council (2012) also identifies prediction and verification as key practices in developing scientific literacy from early schooling.

Analytical Interpretation

Analytical interpretation involves drawing inferences, recognizing cause–effect relations, and applying logical reasoning to data. Research shows that children develop the ability to distinguish correlation from causation during the early school years, although scaffolding is often needed (Sodian et al., 1991). Koerber and Osterhaus (2020) argue that analytic reasoning is a separate yet related dimension of scientific thinking, requiring both domain-general skills and specific knowledge. Developmental psychology suggests that such reasoning is not merely about generating correct answers but about cultivating explanatory frameworks that integrate evidence and logic (Zimmerman, 2007).

Metacognitive Awareness

Metacognitive awareness is the ability to reflect on and regulate one's own thinking. Flavell (1979) introduced metacognition as a crucial developmental process, while Schraw and Dennison (1994) demonstrated that even young learners exhibit early forms of metacognitive awareness when asked to evaluate their understanding. Recent studies confirm that children can monitor their confidence, recognize uncertainty, and adjust strategies accordingly (Kuhn, 2000; Whitebread et al., 2009). Incorporating metacognition into assessments provides richer insight into children's scientific reasoning, as it captures not only what they know but how they know it.

Together, these four domains reflect a comprehensive approach to scientific thinking in early childhood. By grounding the STS-AT in both classic developmental theories and contemporary frameworks, the instrument ensures ecological and educational validity. Moreover, this multidimensional model aligns with international policy calls for integrating inquiry, reasoning, and reflection into early STEM education (OECD, 2017; NGSS Lead States, 2013).

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Method

Participants

The study was conducted in two phases: a pilot study and a main validation study. In the pilot study, seventy-two children (35 girls, 37 boys; *M* age = 6.4 years) from two public kindergartens in Türkiye participated. The pilot aimed to examine item clarity, engagement, and scoring feasibility. The main study included 282 children (138 girls, 144 boys) aged between 5 and 8 years, recruited from both urban and rural schools in northern Türkiye. Parental consent and children's assent were obtained prior to participation. The distribution of participants across age groups is presented in Table 1.

Table 1. Demographic characteristics of the main study sample

Age (years)	Girls (n)	Boys (n)	Total (n)	Mean Age (SD)
5	34	37	71	5.2 (0.4)
6	48	50	98	6.3 (0.5)
7	34	33	67	7.2 (0.4)
8	22	24	46	8.1 (0.5)
Total	138	144	282	6.5 (1.1)

Instrument Development

The Scientific Thinking Skills Assessment Tool (STS-AT) was developed to capture four theoretically and empirically grounded domains: critical inquiry, hypothesis testing, analytical interpretation, and metacognitive awareness. Item generation was informed by constructivist and sociocultural theories (Piaget, 1972; Vygotsky, 1978) as well as empirical literature on scientific reasoning in early childhood (Zimmerman, 2007; Koerber et al., 2015). Twelve open-ended items were created, with three items representing each domain. The items were reviewed by eight experts in early childhood education, developmental psychology, and science education using a Delphi procedure. The Content Validity Index (CVI) across items was .91, indicating high agreement regarding the relevance and clarity of the items.

Following expert review, the instrument was piloted with seventy-two children. Pilot results supported both feasibility and reliability, with inter-rater agreement between two independent coders reaching $\varkappa = .88$.

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Based on pilot feedback, items were revised to enhance concreteness and engagement. For instance, abstract prompts such as "What do you think happens next?" were replaced with developmentally appropriate tasks like "What happens if we add more blocks to the tower?" Table 2 presents example items from the STS-AT along with the associated scoring rubric.

Table 2. Example Items from the STS-AT

Domain	Example Item	Scoring Rubric (1–4)
Critical Inquiry	What questions would you ask if you found a new bug?	1 = vague → 4 = specific scientific question
Hypothesis Testing	What do you think will happen if we put the paper boat in water?	1 = no prediction → 4 = clear testable prediction
Analytical Interpretation	Why do you think the block tower fell down?	1 = irrelevant → 4 = logical causal explanation
Metacognitive Awareness	How did you decide your answer?	1 = no reflection → 4 = explicit self-reflection

Procedure

The STS-AT was administered individually in quiet classroom settings by trained facilitators. Each session lasted approximately twenty minutes per child. Standardized administration protocols were followed, including scripted instructions, visual prompts, and scoring guidelines, to minimize assessor bias. To increase accessibility, visual aids and manipulatives such as blocks, paper boats, and picture cards were used to scaffold children's responses. Ethical approval was obtained from the university's ethics committee (Ref. No. 2025/04-12). Written parental consent and verbal assent from the children were required for participation. Inter-rater reliability was reassessed in a randomly selected 25% of the main sample, yielding strong agreement ($\varkappa$ = .91).

Data Analysis

Analyses were conducted using SPSS 29 and AMOS 27 and followed established guidelines for scale development (DeVellis, 2017; Tabachnick & Fidell, 2019). Item analysis included computation of means, standard deviations, corrected item–total correlations, and Cronbach's alpha if item deleted. Reliability evidence included Cronbach's alpha coefficients for the total scale and subscales, inter-rater reliability, and test–retest reliability over a two-week interval with a subsample of fifty children.

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Construct validity was examined in two stages. First, exploratory factor analysis (EFA) with principal axis factoring and oblique rotation was conducted to explore underlying factor structure. Second, confirmatory factor analysis (CFA) using maximum likelihood estimation tested the hypothesized four-factor model, with model fit evaluated using χ^2/df, RMSEA, CFI, TLI, and SRMR. Convergent and discriminant validity were examined through intercorrelations among the subscales.

Developmental validity was evaluated by comparing total STS-AT scores across age groups using one-way ANOVA. Post hoc analyses were performed to identify significant group differences, with eta-squared (η^2) reported as an effect size measure. Gender comparisons were conducted using independent samples *t*-tests, with Cohen's *d* reported to indicate the magnitude of differences. Table 3 summarizes the analytic procedures used in this study.

Table 3. Overview of analytic procedures

Analysis Type	Purpose	Indicators Reported
Item Analysis	Evaluate item quality	Mean, SD, corrected r, α if deleted
Reliability	Internal consistency and stability	Cronbach's α, test–retest, ϰ
Construct Validity (EFA, CFA)	Confirm factor structure	Variance explained, loadings, fit indices
Developmental Validity	Age-related progression	ANOVA, η^2, post hoc contrasts
Gender Differences	Gender fairness	t-test, Cohen's d

Following the analytic framework summarized in Table 3, the study applied a systematic and multi-step validation process to establish the psychometric quality of the STS-AT. Item analyses ensured that each task functioned as intended, while reliability testing provided evidence of both internal consistency and temporal stability. The combination of exploratory and confirmatory factor analyses allowed for a robust evaluation of construct validity, confirming the four-domain model hypothesized on theoretical grounds. Finally, developmental and gender-based comparisons offered additional insights into the sensitivity and fairness of the instrument across subgroups. Together, these analyses created a comprehensive foundation for interpreting the results reported in the following section.

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Results

Descriptive Statistics

The initial analysis focused on descriptive statistics of the STS-AT. Across the main sample (N = 282), the mean total score was 24.82 (SD = 4.91), indicating a moderate level of scientific thinking skills in children aged 5–8 years. Examination of the four domains revealed comparable distributions, although some variation was observed in the relative strengths of subdomains.

Table 4 presents the descriptive statistics and Cronbach's alpha reliability coefficients for each subscale. Analytical interpretation showed the highest mean score, suggesting that children were relatively adept at recognizing cause–effect relationships and drawing logical inferences. In contrast, metacognitive awareness yielded the lowest mean, consistent with the notion that reflective thinking develops later than direct reasoning skills.

Table 4. Descriptive statistics and reliability of STS-AT Subscales

Subscale	Mean	SD	Cronbach's α
Critical Inquiry	6.48	1.80	.78
Hypothesis Testing	5.99	1.90	.79
Analytical Interpretation	6.65	1.70	.82
Metacognitive Awareness	5.72	1.60	.79
Total Scale	24.82	4.91	.87

The total scale reliability coefficient of α = .87 suggests strong internal consistency. Overall, the descriptive statistics support the internal coherence of the instrument and provide preliminary evidence that the four domains function as theoretically expected.

Item Analysis

Item-level analysis was conducted to evaluate the functioning of each of the twelve items. Mean scores ranged between 1.98 and 2.41, demonstrating variability across items and indicating that the tasks provided an appropriate level of challenge for children. Corrected item–total correlations varied between .35 and .52,

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all exceeding the recommended threshold of .30. This suggests that each item contributed meaningfully to the construct being measured. Cronbach's alpha if item deleted ranged from .85 to .87, showing that no single item significantly weakened the overall reliability of the scale. Table 5 summarizes these findings in detail.

Table 5. Item means, standard deviations, corrected item–total correlations, and alpha if deleted

Item	Mean	SD	Corrected r	α if deleted
ESM1	2.15	0.82	.38	.86
ESM2	2.07	0.79	.41	.85
ESM3	2.23	0.81	.42	.85
H1	2.31	0.84	.35	.86
H2	1.98	0.77	.37	.86
H3	2.16	0.80	.40	.85
AY1	2.39	0.85	.52	.85
AY2	2.41	0.82	.47	.85
AY3	2.28	0.80	.45	.85
MF1	2.04	0.79	.36	.86
MF2	2.11	0.77	.39	.85
MF3	2.08	0.81	.40	.85

The overall pattern suggests that items were well balanced in terms of difficulty and discrimination. Importantly, the relatively higher correlations for analytical interpretation items (AY1–AY3) reinforce the robustness of this subscale.

Reliability

Reliability analyses provided strong evidence of measurement consistency. The total scale demonstrated high internal consistency (α = .87), while subscale reliabilities ranged from .78 to .82. These values are well above the commonly accepted threshold of .70. Test–retest reliability assessed with fifty children over a two-week interval yielded $r = .91$, confirming excellent temporal stability. Inter-rater reliability, assessed in 25% of randomly selected cases, also demonstrated high agreement ($\varkappa = .91$), underscoring the robustness of scoring procedures. Taken together, these findings support the reliability of the STS-AT across different raters and occasions.

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Factor Analyses

Construct validity was examined through factor analytic techniques. Exploratory factor analysis (EFA) supported a four-factor solution consistent with the hypothesized domains, explaining 65% of the total variance. All items loaded strongly on their intended factors, with loadings above .59. Confirmatory factor analysis (CFA) further tested the four-factor model and yielded excellent fit indices, $\chi^2/df = 1.92$, RMSEA = .04, CFI = .95, TLI = .93, SRMR = .06. These results provide strong evidence that the STS-AT captures a multidimensional construct aligned with theoretical expectations.

Age Differences

Developmental validity was evaluated by comparing children's scores across age groups. A one-way ANOVA revealed significant differences, $F(3, 278) = 18.81$, $p < .001$, $\eta^2 = .21$. Table 3 presents the group means and standard deviations.

Table 6. Total STS-AT scores by age group

Age (years)	n	Mean	SD
5	71	22.18	4.32
6	98	26.19	4.89
7	67	26.27	5.01
8	46	27.19	4.85

The results indicate a clear developmental trend, with older children outperforming younger ones. Notably, five-year-olds scored significantly lower than the older groups, while the differences between seven- and eight-year-olds were minimal. This pattern is consistent with developmental theories that predict rapid gains in reasoning and problem-solving between ages five and seven, followed by consolidation at later ages.

Gender Differences

Gender comparisons showed that girls (M = 25.07, SD = 4.80) scored slightly higher than boys (M = 24.59, SD = 5.02), although this difference was not statistically significant, $t(278) = –1.01$, $p = .315$, $d = –0.12$. Table 4 presents these findings.

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Table 7. Comparison of STS-AT scores by gender

Gender	n	Mean	SD
Girls	138	25.07	4.80
Boys	144	24.59	5.02

The absence of significant gender differences suggests that the STS-AT is free from bias and performs equivalently across boys and girls. This finding also aligns with contemporary research showing that gender gaps in early scientific reasoning are minimal when children are provided with similar opportunities.

Discussion

The present study introduced and validated the Scientific Thinking Skills Assessment Tool (STS-AT) for children aged 5–8 years, providing multi-source evidence for reliability and construct validity. Internal consistency for the total scale ($\alpha = .87$) and subscales ($\alpha = .78$–$.82$), excellent inter-rater agreement, and high short-term stability collectively support the score reliability of the instrument, consistent with best practices articulated in the *Standards for Educational and Psychological Testing* (AERA/APA/NCME, 2014). The factor-analytic results further substantiate a theoretically coherent, four-factor structure, with EFA indicating substantial explained variance and CFA reflecting excellent global fit ($\chi^2/df = 1.92$, RMSEA = .04, CFI = .95, TLI = .93, SRMR = .06). These indices are well within widely cited benchmarks for acceptable to good fit (e.g., RMSEA $\leq .06$, CFI/TLI $\geq .95$, SRMR $\leq .08$), which strengthens the argument that STS-AT captures interrelated but distinct dimensions of early scientific thinking.

Interpreted against the developmental literature, the observed age-related gains on the STS-AT are theoretically expected and empirically consonant with prior work. Extensive reviews and large-sample studies document that children's abilities in experimentation, evidence evaluation, and causal inference show marked growth through early and middle childhood when instructional opportunities are provided (e.g., Zimmerman, 2007; Koerber et al., 2015). The pattern—particularly the difference between five-year-olds and older peers—parallels results demonstrating increasing competence in coordinating variables and interpreting evidence as schooling progresses and cognitive resources expand. These convergences suggest

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that the STS-AT is sensitive to developmental change, an important aspect of validity for instruments targeting emergent cognition.

At the subdomain level, children's relatively higher performance in analytical interpretation compared with metacognitive awareness resonates with work showing that explicit reflective monitoring lags behind more direct reasoning processes in early childhood. Observational and structured assessments indicate that while young children can engage in simple causal explanations, metacognitive monitoring and regulation are still consolidating during this period, often requiring scaffolds to surface reliably in assessment contexts. The STS-AT's metacognition items appear to detect this still-emerging capacity—consistent with developmental accounts of metacognition and with observational measurement traditions in early childhood.

Gender analyses yielded no statistically significant differences in total scores, a result aligned with multiple strands of recent evidence. Studies using comprehensive inventories of scientific reasoning in kindergarten and early primary school often report negligible or absent gender gaps in core reasoning competencies when opportunities to learn are comparable. A recent validation of the Science-K Inventory likewise reported no gender differences, and broader early-childhood work on foundational quantitative abilities similarly finds parity between girls and boys. Taken together, the lack of differences in our data supports the fairness of the STS-AT scores across genders in this age band and underscores the salience of equitable instructional experiences rather than presumed ability gaps.

Beyond psychometrics, the findings carry implications for curriculum and instruction. The four domains operationalized by the STS-AT—critical inquiry, hypothesis testing, analytical interpretation, and metacognitive awareness—map closely onto national policy frameworks that emphasize scientific practices, evidence use, and the cultivation of reflective learners from the earliest grades. Positioning assessment in service of instruction, educators can use STS-AT profiles to tailor inquiry experiences (e.g., structured prediction–verification tasks) and to explicitly scaffold metacognitive talk, thereby aligning classroom practice with contemporary standards for science learning.

Alongside its robust psychometric foundation, the STS-AT offers teachers concrete opportunities to apply its findings within classroom contexts. Teachers can employ the instrument not only as a diagnostic tool but also as a formative guide to support children's scientific learning. For instance, when a child demonstrates strength in hypothesis testing but relatively weaker metacognitive awareness, teachers may

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intentionally integrate reflective prompts such as "How did you decide that?" or "What might you do differently next time?" into everyday activities. Similarly, observations from the critical inquiry subscale can help teachers recognize children who are naturally curious questioners and design inquiry-based tasks that further cultivate this strength. By embedding the STS-AT into routine classroom interactions, educators can move beyond static assessment to foster individualized scaffolding, thereby aligning daily practices with curricular frameworks that emphasize inquiry and reflective thinking in early STEM education.

Validity Considerations and Future Work

Although the present study provides multi-faceted validity evidence, several avenues can further strengthen the interpretive argument. First, longitudinal designs could establish sensitivity to growth at the individual level and permit the evaluation of predictive validity for later science achievement. Second, convergent and discriminant validity would benefit from multi-method batteries that include established early-years instruments (e.g., domain-specific reasoning tasks) and teacher reports to triangulate scores. Third, given the policy importance of equity, future studies should evaluate measurement invariance explicitly across subgroups (e.g., gender, age bands, linguistic background) using multi-group CFA criteria recommended in the measurement literature (e.g., changes in CFI and RMSEA within recommended thresholds). Such work would extend the current fairness evidence and ensure that observed mean differences—when present—reflect true developmental or instructional effects rather than measurement artifacts.

Limitations

The study's cross-sectional design restricts inferences about individual developmental trajectories; the school-based sampling frame within one national context may also limit generalizability across curricula and languages. While our reliability and factor structure are robust, future research should examine alternative models (e.g., bifactor or hierarchical structures) to test whether a general scientific thinking factor accounts for common variance alongside domain-specific factors, a question raised in large-sample studies of elementary-age learners. Incorporating response-process evidence (e.g., think-alouds) could further illuminate how young children interpret prompts, particularly in metacognitive items.

The STS-AT offers a psychometrically sound and instructionally meaningful assessment of early scientific thinking. By aligning with established developmental findings and contemporary standards while

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demonstrating strong reliability and construct validity, the instrument can support both diagnostic use in classrooms and research on the emergence of scientific reasoning. The absence of gender differences in this age range and the clear age-related progression suggests that high-quality, developmentally appropriate science experiences—especially those that explicitly elicit prediction, evidence coordination, and reflective talk—are likely to benefit all learners. Ongoing work on invariance, growth sensitivity, and cross-cultural applications will further consolidate the STS-AT's contribution to early STEM assessment and practice.

Conclusion

This study developed and validated the Scientific Thinking Skills Assessment Tool (STS-AT), a multidimensional instrument designed to capture critical inquiry, hypothesis testing, analytical interpretation, and metacognitive awareness in children aged 5–8 years. Across a large and diverse Turkish sample, the STS-AT demonstrated strong psychometric properties, including internal consistency, inter-rater agreement, temporal stability, and a theoretically coherent four-factor structure confirmed through exploratory and confirmatory factor analyses. Together, these findings provide robust support for the instrument as a reliable and valid measure of early scientific thinking.

The STS-AT makes several contributions to early childhood science education and assessment. By integrating domains often measured separately, the tool allows for a more comprehensive evaluation of young children's reasoning skills. Its child-centered, play-based tasks and visual supports make it developmentally appropriate and accessible, while its standardized scoring procedures ensure reliable use across research and classroom contexts. For educators, the instrument provides a diagnostic framework that can guide the design of inquiry-based learning activities and targeted instructional interventions.

For policymakers and curriculum developers, it offers empirical evidence of the importance of fostering inquiry, reasoning, and reflection from the earliest years of formal schooling. Despite these strengths, limitations should be acknowledged. The sample was restricted to one national context, and cross-cultural validation will be essential to establish broader generalizability. Criterion validity was not assessed against external standardized measures, which should be addressed in future research. Longitudinal studies are also needed to examine the predictive validity of early scientific thinking for later STEM achievement and to

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evaluate growth trajectories at the individual level. Additionally, advanced psychometric approaches such as multi-group invariance testing and bifactor modeling would further illuminate the structure of scientific thinking across subgroups.

In sum, the STS-AT represents a timely and evidence-based contribution to early childhood research and practice. By capturing the complexity of young children's scientific reasoning, it fills a critical gap in existing assessment tools and offers a foundation for advancing theory, informing pedagogy, and promoting equitable opportunities for scientific learning. Ongoing refinement and cross-cultural application will ensure that the STS-AT continues to support the development of scientifically literate citizens from the earliest stages of education.

Scientific Ethics Declaration

* The author declares that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the author.

* Ethical approval for the study was obtained from the Giresun University Social Sciences, Science, and Engineering Research Ethics Committee (Approval No: E-50288587-050.01.04-74549).

Conflict of Interest

* The author declares that there is no conflict of interest

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Acknowledgements and Notes

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Appendix A.

Item	Critical Inquiry	Hypothesis Testing	Analytical Interpretation	Metacognitive Awareness
ESM1.62	—	—	—	
ESM2.65	—	—	—	
ESM3.71	—	—	—	
H1	—	.59	—	—
H2	—	.63	—	—
H3	—	.67	—	—
AY1	—	—	.74	—
AY2	—	—	.79	—
AY3	—	—	.72	—
MF1	—	—	—	.68
MF2	—	—	—	.71
MF3	—	—	—	.69

Note. All factor loadings are standardized estimates and statistically significant ($p < .001$). Dashes (—) indicate non-specified loadings in the four-factor model. Model fit indices: $\chi^2/df = 1.92$, RMSEA = .04, CFI = .95, TLI = .93, SRMR = .06.

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PROBLAB-SCRATCH GOES TO SCHOOL: DESIGN, TEACHING AND LEARNING OF PROBABILITY WITH INTERACTIVE COMPUTER MODELS

Abstract: Teaching programming and creating interactive computer models has attracted much attention over the years, mostly the attention of curriculum developers and teachers. ProbLab-Scrach is a series of tasks created to teach probability using interactive computer models using Google Colab and Scratch. This application is a means of facilitating discussions regarding probability material for junior high school students and contextualizing the content. This research aims to produce: (1) learning media developed on probability material at the Junior high school level, (2) level feasibility and student responses to learning media developed. This research is research and development (R&D) which uses the ADDIE model. Development procedures include analysis, design, development, implementation, and evaluation stages. In the implementation stage, thirty participants of 8th grade (13-15 years old) Indonesian students learn probability materials with Google Colab and Scratch based on scenarios authored by the researchers. The results show that it is feasible to facilitate learning probability in Junior High School and have a positive impact on learning outcomes, especially theoretical and empirical probability.

Keywords: Interactive computer models, Probability, Google Colab, Scratch

Introduction

Probability is the mathematical study of the degree of uncertainty in real-life events. Probability is a domain in Mathematics that investigates the measurements of an event's uncertainty, such as the concepts of chance, risk, prize, and randomness, which are directly related to the amount of data obtained and must be decided in an uncertain circumstance (Koparan & Rodríguez-Alveal, 2022; Sari et al., 2023). Understanding probability is essential because, according to the OECD (2016), uncertainty is "a phenomenon at the heart of the mathematical analysis of many problem situations." Uncertainty-based decision-making is more prevalent in modern life. Understanding uncertainty and probability can help students make informed judgments in diverse settings (Bryant & Nunes, 2012; Kennedyet et al., 1991; Wijaya et al., 2021).

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Fischbein (2002) proposed that when teaching probability, teachers should not focus solely on procedural skills. Instead, teachers should conduct experiments to provide pupils with experiences that will help them grasp probabilistic circumstances. When the experiment is contextual, it can serve as a useful beginning point for students' learning and assist them enhance their knowledge of mathematical ideas. However, there are times when experiments require a great deal of repetition as is the case in probability. In some research studies, it has been shown that the utilization of technology can aid knowledge construction (Akpinar & Aslan, 2015; Rina, 2021).

With advancements in technology such as media technologies and the advent of the internet, many different tools of learning by programming and learning by designing were developed and studied for example Google Colab and Scratch can be used to teach in the classroom (Akpinar & Aslan, 2015). In this study, the intention is to bring foundational principles of Scratch and Google Colab into mathematics education in order to build an engaging learning environment for students to study an abstract and unpopular mathematics subject, probability. Google Colab or "Collaboratory" is a digital environment available in the cloud, free of charge and hosted by Google (Da Silva, 2020). And Scratch is a visual programming environment used to teach computer science concepts to middle-school students (Meerbaum-Salant et al., 2010). Many software tools for learning probability are either too complex to learn to be helpful, so students have very limited probability to understand the underlying concepts (Abrahamson et al., 2006; Bar-On & Or-Bach, 1988; Konold, 1993; Memnun, 2008; Wilensky & Resnick, 1999). This research aims to produce: (1) learning media developed on probability material at the Junior high school level, (2) level feasibility and student responses to learning media developed.

Method

This research is research and development (R&D). Research and development in education is related to sustainable development and educational innovation such as learning media (Husamah et al., 2022). Learning media that will be produced in research follows the ADDIE development research procedure (Analysis, Design, Development, Implementation, and Evaluation), because the development model is very suitable for the model is very in accordance with the procedure for developing learning products. ADDIE flow is shown in figure 1. The learning products will use SCRATCH and Google Colab. . In the

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implementation stage, thirty participants of 8th grade (13-15 years old) Indonesian students learn probability materials with the product based on scenarios authored by the researchers.

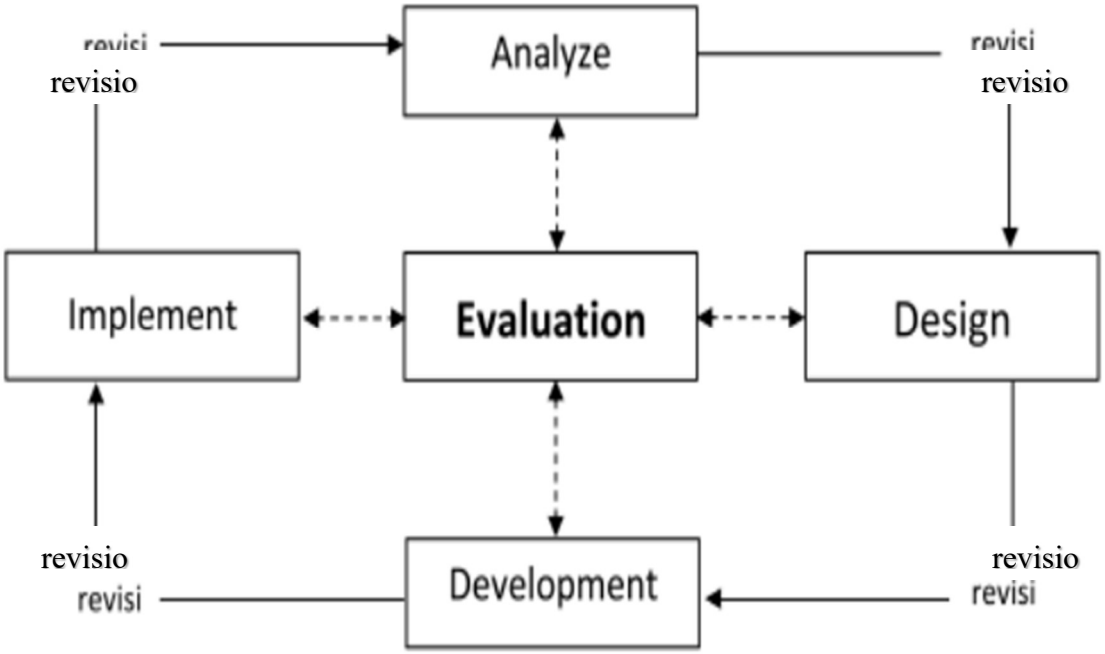

Figure 1. ADDIE model media development process

In general, there are five steps in the ADDIE model, namely Analyze, Design, Develop, Implement, and Evaluate. There are stages or steps that are carried out procedurally, learning design models that are not procedural or cyclical or may start from certain stages, and some are integrated learning design models that start from certain stages, and some are integrative learning design models. The following is a table of the development stages of the ADDIE model of learning design procedurally:

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Table 1. Intructional design: The ADDIE approach

ADDIE approach	Concept	Procedural
Analyze	Identifying the causes of problems in learning and pre-planning which is thinking or deciding about the subject or course to be given.	1. Validation 2. Determine instructional objectives 3. Analyzing the learner 4. Auditing possible sources 5. Changing a management plan project
Design	Verify the desired outcome or achievement (learning goals) and determine the method or strategy to be applied	1. Conduct task inventory 2. Create performance objectives 3. Generate test strategy
Develop	Develop and validate learning resources and development materials and strategies supporting materials and strategies that required	1. Produce content 2. Select and develop media supporting media 3. Conducting Formative Revision 4. Conducting Trial Test
Implement	Preparation learning environment, and implementation	1. Engaging students 2. Involving the teacher

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	learning by involving students	
Evaluate	Assessing quality products and processes learning	1. Determine evaluation criteria 2. Selecting evaluation tools 3. Conducting revision

Results and Discussion

The development research has produced learning device products of Analysis Design Develop Implementation Evaluation (ADDIE) model that have been tested for validity, practicality, and effectiveness, namely lesson plans for mathematics subjects in class VIII junior high school. The development of learning design begins with analyzing students, lesson plans, material selection to the learning design process. The initial stage carried out is called the self-evaluation stage. The researcher then compiled the learning design development using the ADDIE model in the form of lesson plans. Furthermore, the learning design product that has been developed using the ADDIE model is called the first prototype. The name of this specific prototype is ProbLab-Scratch. The next step is validation by experts and one to one, where validation carried out by experts consists of content experts, linguists, and learning media experts using validation assessment sheets that have been prepared by researchers. The conclusion of the validation of the three experts or experts is that the learning design that has been developed using ADDIE model in terms of content, language, and media is in the valid category (Wulandari et al., 2020).

In addition to the validation test against experts or experts, the results of the learning development design were also validated against one to one, namely by involving as many as 3 (three) students with different achievement conditions, namely the first student with good or smart academic achievement, the second student with moderate achievement, and the third student with below average achievement. This trial was conducted with the aim of seeing the practicality and potential effects of the first prototype. The

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implementation of learning with the three students was given material from the learning design of the ADDIE model (Cahyati et al., 2018). Furthermore, at the end of the learning, the three students were asked to complete the prepared test, and obtained an average score of 81.67 from each of the first student's score of 85, the second student 85, and the third student 75.

Based on the test results, it can be concluded that the first prototype has a potential effect on student learning outcomes because it has reached above the minimum completeness criteria for mathematics subjects set in one of the public schools in Indonesia. Besides being asked to do the third test, students were also asked to fill in a questionnaire to see students' responses to the learning design that had been developed. And from the results of the first prototype in one to one, the questionnaire score category is very good.

Based on the results of suggestions and input from validators and students that the first prototype learning design is in the valid and practical category, both in terms of material, language, and media, which is in accordance with the rules for making learning designs by following the learning model, namely the ADDIE model and has a potential effect on student learning outcomes (Agustina & Adesti, 2019). Based on the results of validation by material, language, and media experts as well as input from one to one, namely three students, improvements were made to the learning development design in the form of a lesson plan at this stage called the second prototype which was then tested on small groups, namely students with small groups of each group consisting of 3 (three) students (Hala, 2015) The trial in the small group was the same as the test in one to one by being given learning using it. At the end of the learning in the small group was asked to complete the test that had been prepared, and obtained an average score of 84.67 from each student's score in group one of 88, group two 79, and group three 87.

Based on the test results, it can be concluded that the second prototype ProbLab-Scratch has a potential effect on student learning outcomes because it has reached the minimum completeness criteria for mathematics subjects set in one of the public schools in Indonesia. Besides being asked to do the test, the three groups were also asked to fill out a questionnaire to see students' responses or responses to the learning design that had been developed, while the category of questionnaire scores obtained was very good. Based on the results of validation by experts, one to one, and small groups it can be concluded that the development of the learning design of the ADDIE model has good suitability in terms of material selection, language use, and media. Furthermore, the results of the development of the learning design of ADDIE

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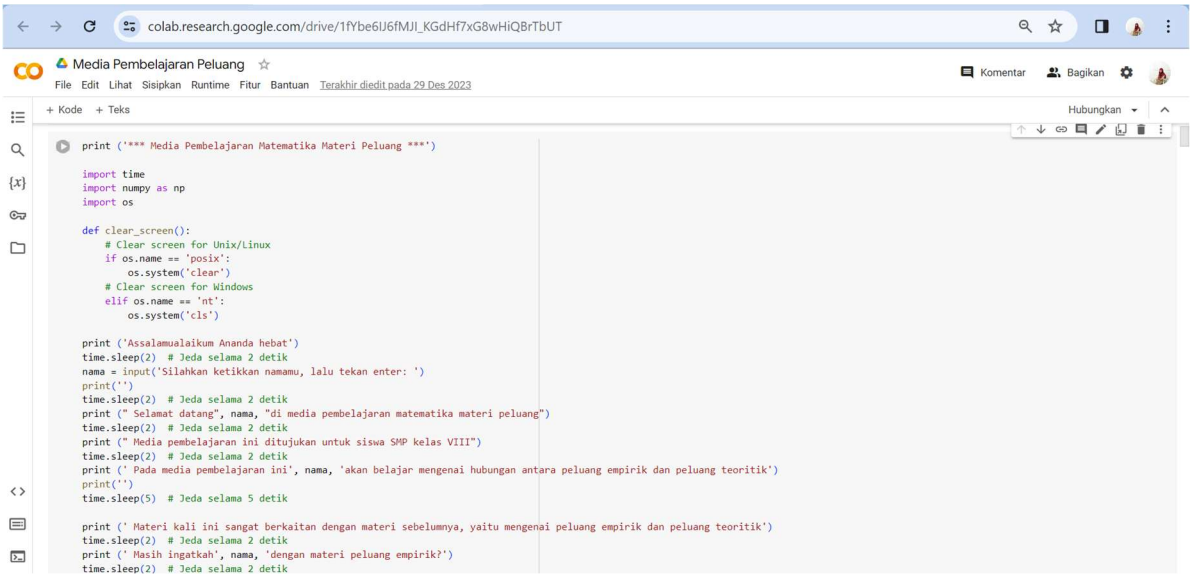
model are given to the actual research subjects, namely students who are the sample in this study, namely VIII grade students totaling 30 people. So, in general it is concluded that the learning design of the ADDIE model developed from the first and second prototypes ProbLab-Scratch is good and in the category of valid and practical prototypes ProbLab-Scratch. After obtaining a second prototype ProbLab-Scratch that is valid, practical, and has a potential impact on learning outcomes, it is then tested in the field on actual research subjects, namely class VIII. Learning using the results of the learning design of the ADDIE model was carried out for two meetings. The first meeting was held on August 03, 2023 and the second meeting was held on August 09, 2023 with probability material consisting of the definition of probability, the chance of an event and the relationship between theoretical and empirical probability. During the learning process, observations were made to see the activities, filling out questionnaires to see student responses, and evaluations were made to see the learning outcomes. The second prototype ProbLab-Scratch we can see in Figure 2.



(a)

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```
Assalamualaikum Ananda hebat
Silahkan ketikkan namamu, lalu tekan enter: Atika

Selamat datang Atika di media pembelajaran matematika materi peluang
Media pembelajaran ini ditujukan untuk siswa SMP kelas VIII
Pada media pembelajaran ini Atika akan belajar mengenai hubungan antara peluang empirik dan peluang teoritik

Materi kali ini sangat berkaitan dengan materi sebelumnya, yaitu mengenai peluang empirik dan peluang teoritik
Masih ingatkah Atika dengan materi peluang empirik?
Jika ya, ketiklah angka "1"
Jika tidak, ketiklah angka "2"
Pilihan (1 atau 2) =
```

```
Ketik angka '1' untuk dadu atau angka '2' untuk koin: 1
Berapa kali ingin melempar dadu? 30
Tabel Frekuensi Hasil Pelemparan Mata Dadu:
Mata Dadu 1: 0 kali
Mata Dadu 2: 2 kali
Mata Dadu 3: 6 kali
Mata Dadu 4: 4 kali
Mata Dadu 5: 11 kali
Mata Dadu 6: 7 kali
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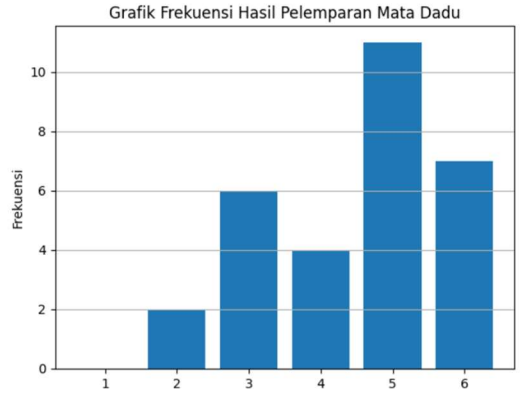

(b)

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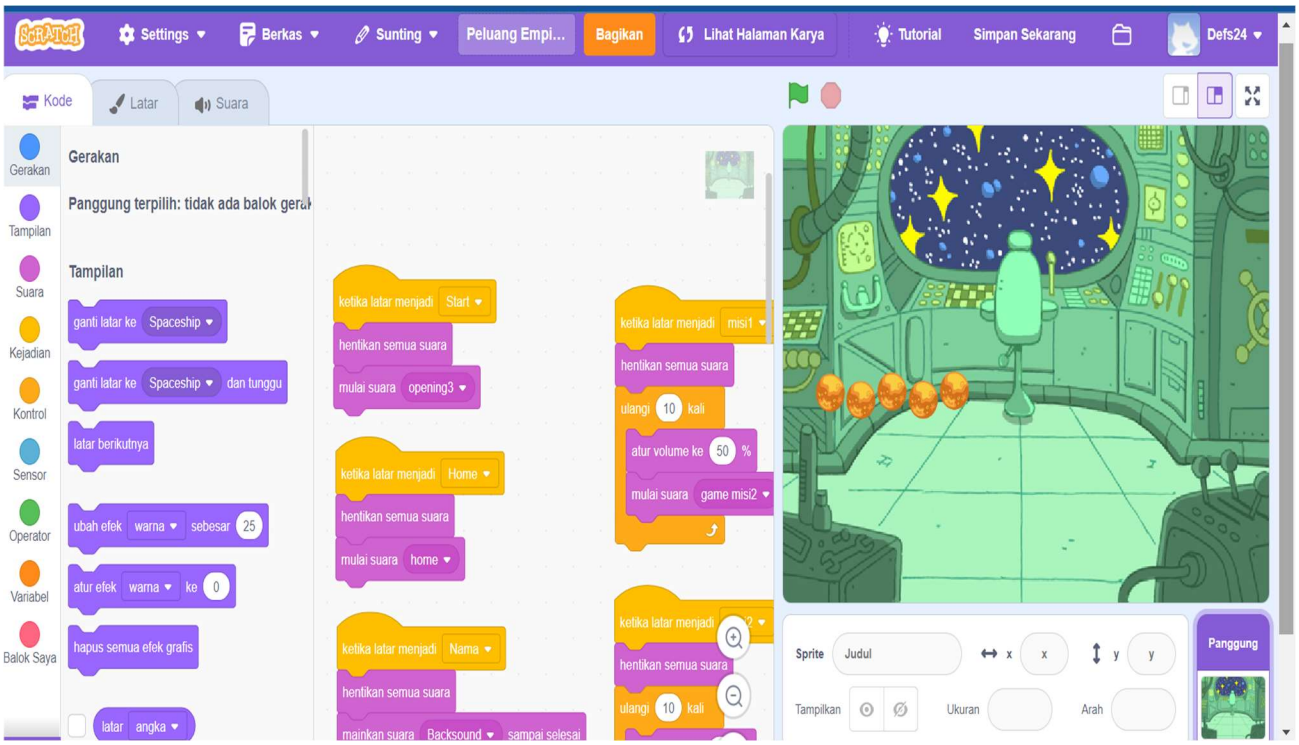

(c)

Figure 2. The second prototype ProbLab-SCRATCH. (a) Google Colab (code view), (b) Google Colab (compile view) (c) SCRATCH (code view)

Analysis of learning outcomes during two meetings of the actual sample, namely students. The students were asked to work on test questions that had been prepared as many as 10 questions with types of multiple-choice questions and essays. From the test results obtained an average score of 83 far above the minimum completeness criteria for mathematics subjects set in class VIII. Based on the acquisition of these scores there are 5 (16.13%) students in the very high category, 18 (58.06%) students in the high category, and 8 (25.81) students in the medium category. There are no students in the low and very low categories. So that researchers can conclude that the results of the effectiveness test of the learning design of the Analysis Design Develop Implementation Evaluation (ADDIE) model developed for the field test which is tested for validity and practicality has an impact on student learning activities and results, meaning that the learning design of the Analysis Design Develop Implementation Evaluation (ADDIE) model developed in the effective category.

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Conclusion

This development research produces ADDIE model learning device products that are tested for validity, practicality, and effectiveness in class VIII mathematics subjects. The results of the validation test by experts in terms of content, language, and media that the learning design of the ADDIE Analysis Design Develop Implementation Evaluation (ADDIE) model developed in the valid category, by students in one to one and small groups in the practical category, and the results of the field test have an impact on student learning activities and results, meaning that the learning design of the Analysis Design Develop Implementation Evaluation (ADDIE) model developed in the effective category.

Recommendations

This application can use only with google collaboration view and student can see the program. The next project hope can be hosted to website so the student only can see the materials not the whole program

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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Acknowledgements or Notes

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METHODOLOGY OF USING INFORMATION TECHNOLOGY SOFTWARE TOOLS IN TEACHING MATHEMATICS

Abstract: The use of modern information technology tools in the process of teaching mathematics and solving mathematical problems leads to an increase in the effectiveness, visuality and level of mastery of the educational process. The use of the created methodological and software tools in the lesson at the right place and time increases the effectiveness and visuality of the lesson, as well as the level of students' perception of information on the subject and their skills of independent work. The importance of computers in the field of education is incomparable. The use of computer tools in lessons: multimedia, virtual laboratories and virtual exhibitions serves as another factor in increasing the effectiveness of the lesson. In the educational process, analyzing the software tools created for teaching mathematics based on information technologies to date, creating and demonstrating methodological and software tools that are convenient for organizing the teaching process of mathematics, providing both theoretical knowledge and practical skills, and demonstrating them in the lesson

Keywords: Information technology, Software tools, Education

Introduction

Information technologies have long occupied an important place among the means of teaching mathematics. The use of multimedia presentations, test shells, electronic textbooks, special programs for drawing function graphs or geometric solids has become an integral part of the mathematics teaching process. The constant development of information technologies offers other options for their use in the educational process discussed in this article. The use of interactive exercises, mobile devices, interactive online whiteboards, mind mapping services, microblogs, applications based on augmented reality allows for the implementation of innovative approaches to the mathematics teaching process. This article provides an analysis of applications that allow the implementation of these opportunities, considers the directions of their application in the educational process, and provides methodological guidelines for their use in order to increase cognitive activity and interest in the mathematics teaching process. Currently, society is at a stage

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where information technologies are becoming an integral part of everyday life and professional activities. At the same time, the education system is not left out, because it depends on how ready our citizens are to transition to the digital economy.

In the secondary special education system of our country, a lot of scientific and research works dedicated to the improvement of information technology teaching have been conducted and are being conducted. In addition to studies on the integration of educational content, a certain place has been allocated to this issue in studies not related to pedagogical integration. During the following years, a number of monographs, scientific articles, educational programs related to this issue were published. A lot of attention is paid to this issue, especially abroad. It also shows that the integration of educational content is one of the most interesting, socio-pedagogical and practical issues.

As part of the digitalization of educational institutions, it is necessary to integrate modern technologies into the process of teaching individual subjects, including those based on virtual and augmented reality, which will allow training highly qualified personnel with appropriate competencies. In addition, the use of modern developments in the field of information technology allows activating the process of teaching individual subjects in the continuous education system, comprehensively building educational levels from school to university and beyond (Mukasheva, 2009).

The field of mathematics provides great opportunities for the use of information technologies in the educational process. They can be used at different stages of the educational process (learning new material, consolidating and systematizing previously learned material, controlling knowledge and learned methods of activity, generalizing and repeating material) and at different stages of lessons (updating knowledge, presenting new material, etc.), and, of course, in extracurricular activities that are an integral part of the educational process. Analysis of the work experience of mathematics teachers allows us to identify the main tools of information technology traditionally used in the process of teaching mathematics. These include:

- multimedia presentations, which are often used to study theoretical material.
- electronic textbooks with embedded video clips, test questions and questions for self-control.

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- drawing programs used in the process of teaching algebra (excel, advan-cedgrapher, math cad, etc.);
- virtual constructors used in teaching geometry ("Live Geometry", WinGeom, "Stereoconstructor", etc.).

The current rapid development of information technologies, which can be successfully used in the educational process, significantly updates this list. Modern information technology tools allow not only to obtain ready-made information from various sources, but also to independently collect and analyze data in order to draw conclusions and obtain results that correspond to the tasks facing teachers. Interviews with mathematics teachers show that most of them are ready to introduce modern information technologies into the educational process, but the following difficulties hinder this process:

- lack of necessary material and technical support: in schools - the necessary equipment is not always available (mainly mathematics classrooms are equipped) or the equipment used in the educational process does not allow realizing the existing capabilities of information technologies;
- lack of necessary training of teachers (especially middle and senior) in the field of using modern information technologies;
- methodologically insufficient development of innovative approaches to the use of information technologies, independent preparation and development of educational materials requires a lot of time, and the teacher often does not have enough time.

In this regard, the problem arises of the need to study the modern capabilities of information technologies and develop methodological guidelines for their application in the process of teaching mathematics at school, and then in secondary specialized and higher educational institutions. Solving this problem allows us to talk about the introduction of innovative technologies into the educational process, by which we mean the use of new methods of interaction between teachers and students, which ensures the effective achievement of this result (Udalov, 2005).

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Materials and Methods

Thus, by innovative approaches to the use of information technologies in teaching mathematics, we understand the use of computer programs, special applications and Internet resources that ensure interactivity, remoteness and mobility of all participants in the educational process. At the same time, it is worth noting that the use of modern information technologies allows students to form not only certain knowledge and scientific skills, but also the necessary ICT competencies that they can use in continuing their studies in secondary specialized and higher educational institutions (Adolf, 1998). We will consider one of the innovative directions of introducing information technologies into the teaching process of mathematics - interactive exercises created using online services.

Interactive teaching methods are a form of interaction aimed at the wider communication of students not only with the teacher, but also with each other, as well as the dominance of students' activities in the learning process. Today, pedagogical research offers a wide variety of forms of interactive exercises and tasks: Creative and debatable tasks, work in small groups, educational games, the POPS formula, project methods, brainstorming, six hats, interviews, case studies, training and SMART interactive technologies.

The use of information technologies in the implementation of interactive methods involves the creation of special interactive exercises that can be used at different stages of the lesson or in extracurricular activities. You can create such exercises using special computer programs (for example, Hot Potatoes, etc.) or using online services on the Internet (Learning Apps, Kahoot, Quizizz, Flippity, etc.). Let's consider in more detail the specific features of these services and their potential in teaching mathematics.

The creators of many interactive exercises are Web 2.0 services, and their functionality and interface are periodically updated. These include services with ready-made templates with the ability to insert text, formulas, images and videos to present new information or test already acquired knowledge and skills; services for creating crosswords, rebuses and puzzles; services for creating didactic games, etc. With the help of a large number of online services, we can create a whole set of interactive tasks of the following nature: studying an interactive lecture and answering the questions posed; answering test questions, quizzes (with one or more correct answers); creating a timetable, etc. One of the most popular at the moment is the Learning Apps service (http://learningapps.org). It not only has a rich library of ready-made exercises in

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various subjects but also allows you to create your own tasks using ready-made templates. With the help of this interactive exercise constructor, it is possible to organize the study of new material using a video lecture template with built-in questions.

Figure 1. Example of a video lecture prepared in LearningApps.org

This format of presenting the material allows you to immediately monitor how well students have learned it and adjust subsequent work to consolidate it. At the same time, it should be noted that the tasks presented to students during the video lecture can also have a different format: simple test tasks, non-standard elements in the form of puzzles, etc.

The possibilities of this online service for organizing stages of updating and controlling students' knowledge during the lesson, as well as in extracurricular activities, are even more interesting. This is due to the fact that it contains a wide variety of templates that allow you to create tasks with a choice of answers in a non-standard (game) form. Thus, the use of online services for creating interactive exercises in the learning process allows you to: individualize the learning process in accordance with the personal

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characteristics and needs of students; organize educational material taking into account various methods of educational activity; enhance visual perception and facilitate the assimilation of educational material; activate the cognitive activity of students.

A person, his all-round harmonious development and well-being, creating conditions and effective mechanisms for realizing individual interests, changing outdated patterns of thinking and social behavior are the main goal and driving force of the reforms being carried out in the republic. The formation of an excellent system of personnel training based on the rich intellectual heritage of the people and universal values, as well as the achievements of modern culture, economy, science, technology and engineering, is an important condition for the development of the country.

New information and communication technologies are one of the most relevant topics today, due to the need to use various methods for studying, researching and gaining experience in each field. Therefore, it is advisable to use new information and communication technologies from kindergarten to master a perfect profession. Modern specialists, regardless of their field of activity, must have extensive knowledge of mathematics, sufficient skills in modern computing, information and communication systems, technical means and their use, as well as knowledge of the basics of new information technology and technology, its future development. Due to the daily development of modern computing and information technology and the increasing informatization of society, a number of subjects on mathematics, computerization of production and management processes have been included in the middle and higher levels of the continuing education system.

We know that the Chinese philosopher Confucius, who said 3,500 years ago, "I remember what I hear, I remember what I see, and I understand what I do," still holds true today. When using technology in teaching mathematics, students have the opportunity to think independently based on what they hear, see, and see. There are certain conditions for organizing lessons using modern technologies in teaching mathematics. First, there must be information resources. These include:

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- a personal computer.
- a projector.
- multimedia tools.
- a scanner (for transferring complex diagrams and drawings, images from negative film to a computer);
- a digital camera.
- a video camera (for video conferences and other
- purposes);
- printer, copier (for copying and duplicating handouts and for other purposes) and other resources.

Secondly, special software. In the education system, these are special programs that are needed to create multimedia electronic educational literature, lectures, virtual laboratory work, various animation programs and other works. There are many of these programs, for example: Macromedia Flash MX is used to create animation videos. To create multimedia presentations, we all use the familiar Power Point, Canva, and Prezi programs. Mathematics teachers can use various software such as MS-Word, MS-Excel, MS-PowerPoint, GeoGebra Classic 5 and other web tools to create effective ICT for teaching. For example:

- MS-Word can be used to develop questionnaires, texts, images and other electronic documents.
- MS-Excel can be used where column presentations are required, such as drawing the differences between living and non-living organs.
- High-quality images can be created in Photoshop.
- GeoGebra Classic 5 can be used to teach various concepts.

Definition 1. The locus of points in a plane whose sum of distances to two fixed points is constant is called an ellipse. Let us be given two fixed points. These two fixed points are called foci. Let us be given two points $F1$ and $F2$ in a plane. Let us draw a straight line through points $F1$ and $F2$ and give a direction to the straight line and call it the abscissa axis. Let us draw the ordinate axis through the middle of points

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$F1$ and $F2$. Using the given, we will show the students that we can draw an arbitrary ellipse on a plane using the GeoGebra Classic 5 program.

This image can easily accommodate photos developed in Photoshop or animations created with Flash. In order to increase the interest of students in teaching mathematics, it is necessary to display them using various programs. Animations, films and presentations created using the programs presented above can be effectively used by teachers in teaching mathematics. The use of electronic textbooks and study guides in teaching mathematics further increases the effectiveness of the lesson.

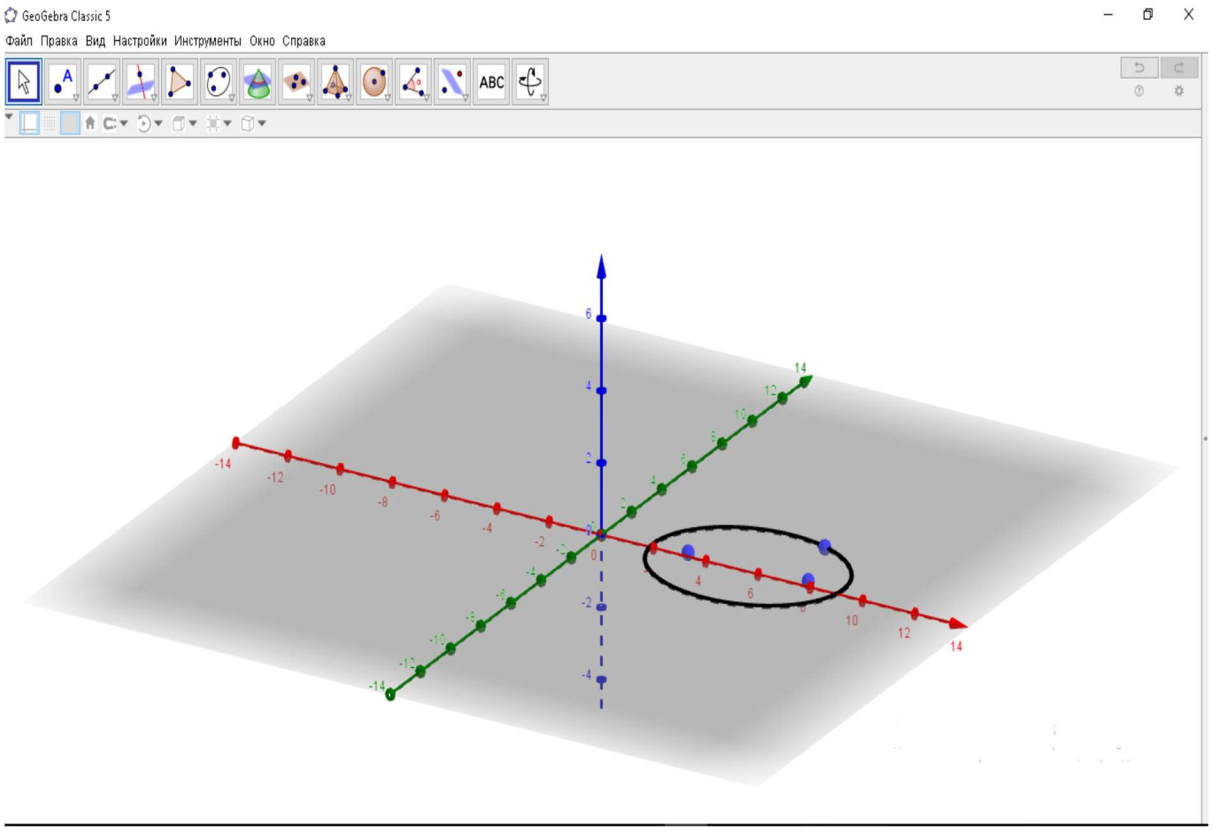

Figure 2. GeoGebra application

When the necessary equipment for demonstration classes in mathematics is lacking, using virtual and visual representations helps students develop general subject-related competencies and form their own independent thinking. It should be noted that the use of various advanced pedagogical technologies and the

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works of our great scientists in lessons increases efficiency. This will help students improve their knowledge and conduct scientific research in the future.

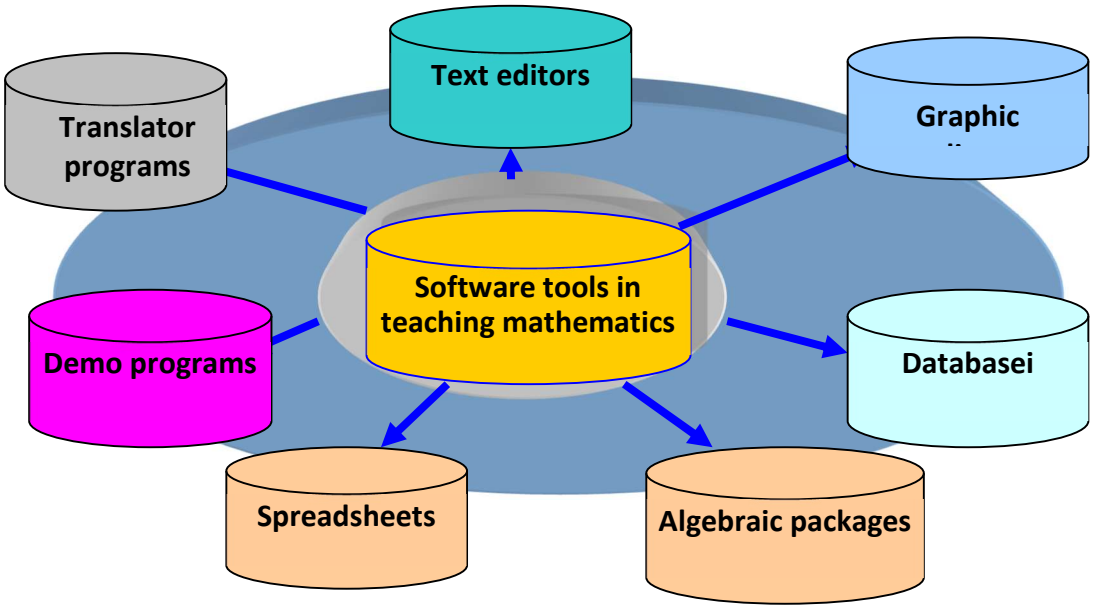

Figure 3. Application package

Over the past decade, the use of computers in teaching mathematics has been carried out in several main directions. These include computer-assisted assessment of knowledge, the development and development of various types of educational programs, the development of mathematical games for cognition, and others. The use of information technologies in teaching mathematics in secondary schools also has a good effect on the problem-solving process and the creation of function graphs. The use of computer technologies in creating function graphs makes it easier for students to imagine the process of creating graphs. Software tools have been developed to help create function graphs. It is enough to download these programs to a computer and enter the function. It is not necessary to have a high level of computer literacy to work in the program. An example of such a program is GeoGebra

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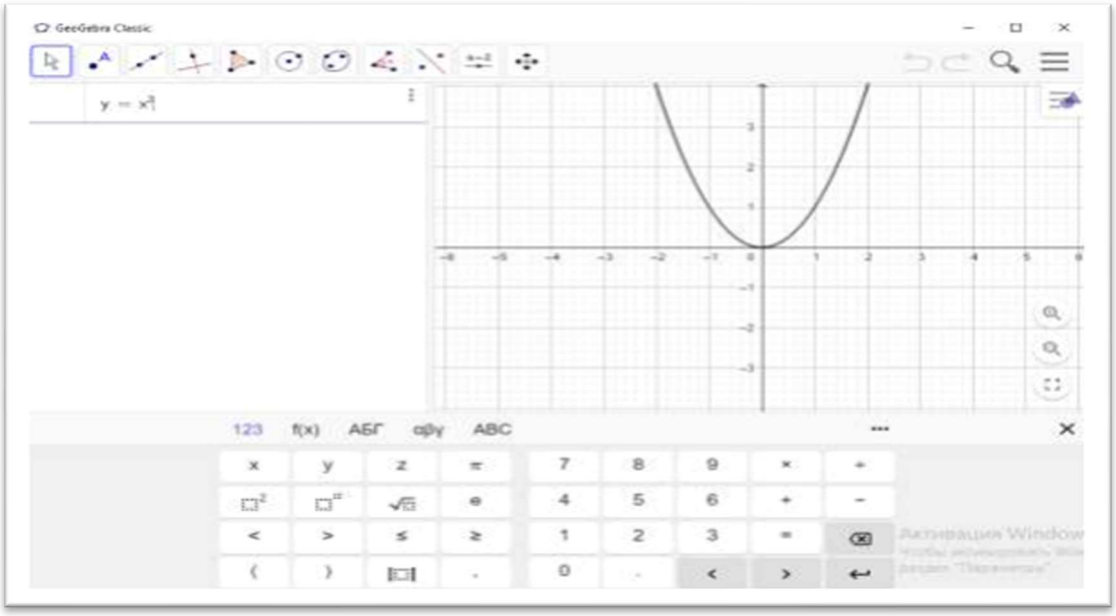

Figure 4. GeoGebra program interface

In the above picture, a graph of a quadratic function is created in the GeoGebra program. The function is entered in the line at the top of the program, and a graph is immediately created in the center. In the upper part of the program window, there is an auxiliary keyboard for entering degrees, roots, and other symbols. The program also allows you to create graphs in three-dimensional space. Such software tools can be used to teach the topic of functions in secondary schools. While much attention is paid to teaching mathematics in secondary schools in our country, teachers are required to cover the topics of science using modern innovative technologies.

In the current era of rapid introduction of new technical means, including computers and other information technologies, into the teaching of mathematics, one of the pressing issues is the use of mathematical achievements to ensure interdisciplinary coherence. The introduction of computer technology in educational institutions opens a wide range of opportunities for optimizing the teaching process. Although spreadsheets are mainly designed to solve economic problems, the tools included in them also help solve problems related to other areas, for example, performing calculations using formulas, building graphs and diagrams. Using a spreadsheet, you can solve problems based on a given algorithm, create various forms based on the values in the table, and print them. Using the autofill feature in Excel, you can make it

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easier to enter numerical values and text elements. This feature is especially helpful when tabulating function values. Calculating function values with a certain step is found in many departments of mathematics. Using these features, students at the faculty of mathematics can create graphs of functions and thus clearly see the properties of some more complex functions on the screen. The function wizard in Excel helps to enter a function and its arguments in a semi-automatic manner. Using the function wizard ensures that the function is written and all its arguments are entered in the syntactically correct order. This, in turn, greatly helps students learn the properties of functions easily and quickly.

Using the auto-fill feature in Excel, you can make it easier to enter numerical values and text elements. This feature is especially useful when tabulating function values. Calculating function values with a certain step is found in many branches of mathematics. Using these features, students in the faculty of mathematics can create graphs of functions and thus clearly see the properties of some more complex functions on the screen. The Function Wizard in Excel helps to enter a function and its arguments in a semi-automatic manner. Using the Function Wizard ensures that the function is written and all its arguments are entered into the syntactically correct order. This, in turn, greatly helps students learn the properties of functions without difficulty and quickly. Displaying data in the form of diagrams helps to quickly understand the work being done and solve it quickly. In particular, diagrams are very useful for visually depicting very large numbers and determining the relationship between them.

Scenario of a lecture based on multimedia developments. The group gives a briefing on the topic and purpose of the lesson, as well as brief information on the technologies used during the lesson. To introduce new subject concepts, questions and quick-to-solve tasks prepared in the form of electronic visual aids are displayed on the screen to repeat, organize, and focus on the set goal the mathematical concepts and statements that have been learned. The teacher evaluates the students' answers and draws attention to the active participation of all students in this question-and-answer session.

When moving to a new topic, in order to determine how familiar students are with sets and operations performed on them from school mathematics, and to supplement and deepen their knowledge based on the requirements of higher education, new concepts are introduced by asking students targeted questions and filling in their answers (cluster formation can be assigned), sorting. Students are given information about Euler-Venn diagrams using electronic visual aids and several examples are solved together. During the lesson,

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operations performed on sets and Euler-Venn diagrams are demonstrated using electronic visual aids prepared using the PowerPoint program using multimedia capabilities.

In order to organize and consolidate the knowledge gained by students during the lesson, each student is given individually structured tasks through the screen. Students complete the tasks for 10 minutes and give them to their partner next to them for checking. When the teacher collects the notebooks, he checks the tasks and evaluates each student. At the end of the lesson, students are given questions and homework assignments on the screen to prepare for the next lesson topic.

Results

Based on the results of the above research, we determined the purpose of the pilot study, such as developing electronic educational resources for teaching mathematics to students and using them to increase educational efficiency. In order to use electronic educational resources in the process of teaching mathematics, we used a set of complementary methods to organize pilot study. The pilot study was conducted among students of school No. 43 in the Kashtegirmon neighborhood of the Qo'shrobot district of the Samarkand region during the 2022-2023 and 2024-2025 academic years.

As a result of the research, 128 out of 258 students were involved in the experimental group and 130 in the control group. The experimental group will be taught in a conversational manner based on the e-learning resources we offer, while the control group will be taught in a traditional manner. During the experimental study, students' interest in developing and using e-learning resources in teaching mathematics was analyzed. Initially, we determined the level of knowledge of the students. For this, we conducted a test consisting of 20 questions on the basic concepts of mathematics in both selected groups. The average percentage of students who answered correctly is: 299/20*20=299/400, which gives their percentage of 71.19%.

This data shows that the groups have a similar level of knowledge, and a pedagogical experiment was conducted in both groups. Group 1 was selected as the experimental group, and they were taught using electronic learning resources prepared on a computer. Group 2 was selected as the control group, and they were taught in the traditional way as usual. After both groups had fully covered the topics of the section,

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two test surveys related to the topics of this section were administered to both groups. The first test consisted of 30 tests and the second test consisted of 15 questions. The results of the test conducted in the control group (group 2) were as follows:

We have determined teachers' interest in mathematics lessons through these e-learning resources. During the pilot study, we witnessed that teachers have mastered the topics covered in developing electronic learning resources for teaching mathematics and organizing lessons using them. The results of our pilot study were good. Through this, we learned about their interest in developing innovative methods for teaching mathematics and organizing lessons using them, as well as their independent thinking skills.

Table 1. Experimental and control group information

Groups	Number of students	Grades 2	3	4	5
Experimental group	n=128	n_1=1	n_2=49	n_3=49	n_4=29
Control group	m=130	m_1=5	m_2=79	m_3=35	m_4=11

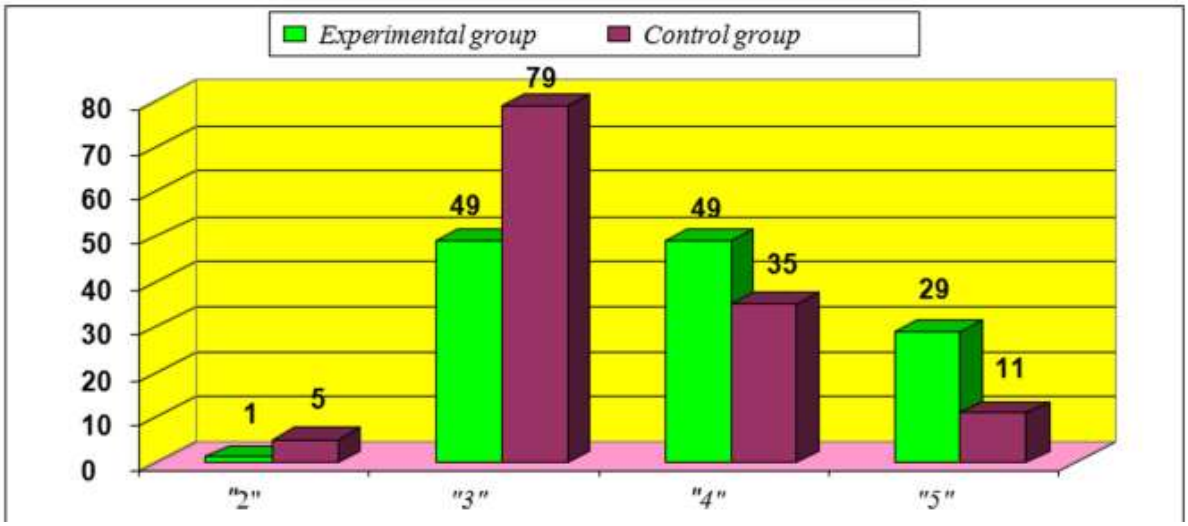

Figure 5. Its diagram looks like this

Practice shows that teaching students using electronic educational resources is twice as effective and time-saving. When learning using electronic educational resources, up to 30% of time can be saved, and the acquired knowledge is retained in memory for a long time. If students perceive the materials presented

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visually, the retention of information in memory increases by 25-30%. In addition, if educational materials are presented in the form of audio, video and graphics, the retention of materials in memory increases by 75%. We were once again convinced of this in the process of studying mathematics using electronic educational resources.

- Teaching students on the basis of electronic educational resources has the following advantages:
- the possibility of deeper and more complete mastery of the materials provided.
- the desire to get acquainted with new areas of education increases.
- the opportunity to save time as a result of reducing the time spent on education.
- the knowledge gained is retained in a person's memory for a long time and can be applied in practice if necessary.

Conclusion

It is dedicated to the basics and importance of teaching mathematics using software tools and it is dedicated to the basics and importance of teaching mathematics using software tools and technologies, and it highlights the main capabilities, features and effectiveness of modern information and pedagogical technologies used in teaching mathematics. In general, as a result of using the above-mentioned basic tools of information technologies in the educational process, our main goal is to achieve the following:

- develop students' all-round mental thinking and imagination skills, prepare them for independent thinking and work in a modern information society, that is, to make independent decisions in the implementation of any complex processes, to teach them to express their thoughts and opinions, to form diligent and inquisitive activity.
- create and involve new information and pedagogical technologies in all education systems to accelerate learning processes and increase their efficiency;

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- increase the perfection, productivity, quality and efficiency of education by introducing all the capabilities of information and telecommunications technologies and software tools into it;
- organize independent work of students using information and telecommunications technologies and thereby expand and activate their independent thinking and imagination;
- deepen interdisciplinary ties using information and telecommunications technologies, while introducing modern technologies into all areas;
- creation, implementation and improvement of modern educational systems based on network technologies, including distance learning systems.

In general, the use of modern technologies and electronic educational resources in organizing mathematics lessons has the following advantages:

- The use of software tools in studying mathematics ensures the fundamentals of mathematical and technical education and the improvement of students' skills in applying theoretical knowledge to practice;
- When directly interacting with software tools in the educational process, students see and understand that computer technology tools are a means of solving professional problems and will have the opportunity to use them in their practical activities in the future;
- They learn methods for solving complex examples using software tools, their mathematical knowledge increases, and they also assign time-consuming calculations to software tools;
- Their knowledge and the scope of logical thinking in mathematics expand and they feel that complex calculations can be performed quickly and without errors in software tools
- The teacher connects mathematics and mathematical disciplines during the lesson and forms the initial skills of automation problems; students develop a need for knowledge;
- activates students' cognitive activity;
- increases students' interest in studying science;
- introduces the world to modern methods of scientific knowledge related to the use of information technologies and software;

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- increases the level of student individuality in education;
- develops students' creative abilities;
- ensures the diversity of the content of materials;
- expands the range of educational materials used in education;
- enhances demonstration in education.

In increasing the effectiveness of the educational process using electronic educational resources, the role and importance of teachers with excellent knowledge, skills and experience in computer technologies will be great. In other words, for the perfect use of electronic educational resources in the educational process, the main attention should be paid, first of all, to creating the necessary conditions for the teacher and the student and the effective use of computer technologies in educational processes. At the same time, in order to organize the educational process on the basis of modern information and computer technologies, it is necessary to provide modern software tools along with electronic educational resources. We believe that this will be carried out jointly with the participation of qualified specialists, subject teachers and pedagogical psychologists.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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Conflict of Interest

* The authors declare that they have no conflicts of interest

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BIBLIOMETRIC PERSPECTIVES ON E-BOOK EVALUATION

Abstract: The remarkable advancement in the computing technology brings a new paradigm shift in the book perspective, transitioning from the physical book to the virtual book. It involves multiple sectors such as in the educational, health, engineering, economics, arts and many more. Rapid evolvement in the economic sector creates innovative platform that allows the authors to delve into E-book business that can reach to a wider audience without geographical limitations. Nowadays, anyone able to produce an E-book, however, to ensure that the E-book meets the usability and requirements of the audience is also important and cannot be neglected. Therefore, E-book evaluation is critical in this perspective. This study aims to explore the publication trends in E-book evaluation from 1984 until 2025. Several key aspects were investigated in this study that related to the (1) publication trends and growth, (2) the key authors and collaboration patterns, (3) institutional and country influence and (4) keyword analysis. The data were derived from the Scopus database by using the keywords (e-book OR ebook OR "electronic book" OR "digital book") AND evaluation. There are 595 obtained results in which after screening, the number of publications included for the study is 452. Data analysis and visualization were made using the biblioMagika and VOSviewer. The most productive years in E-book evaluation publications is in 2019 with 33 publications. The most prolific author is Ogata, Hiroaki from Kyoto University with total of 19 publications. Meanwhile for the influential institution for E-book evaluation is Kyoto University, Japan with 11 total publications with 90 total citations. The most productive country is United States with 85 publications in E-book evaluation. The E-book evaluation can be done either quantitatively or qualitatively. Notably, the advancement of artificial intelligence offers new dimensions for assisting in the evaluation process.

Keywords: E-book, E-book evaluation, Bibliometric analysis, VOSviewer

Introduction

The proliferation of digital technologies has significantly transformed the landscape of reading and information consumption, with e-books emerging as a prevalent medium in both academic and recreational contexts. E-books offer advantages such as instant access, portability, and interactive features, making them

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appealing to a broad spectrum of users. However, the effectiveness of e-books is contingent upon their usability, which encompasses factors like interface design, navigation, and user satisfaction. Usability evaluation is thus essential to ensure that e-books meet the needs and expectations of their users, facilitating efficient and enjoyable reading experiences.

The acceptance and usage of the E-books in the higher academic setting is increasing since the emergence of COVID-19 pandemic (Jallas et al., 2023). The COVID-19 pandemic markedly accelerated the acceptance and usage of e-books in higher education, with studies reporting a 99% acceptance rate among students, highlighting e-books' effectiveness in supporting learning and seamless integration with online education platforms (Wardaya, 2022). This trend was also evident at Kyushu University, where e-book access surged significantly in 2020 compared to 2019 (Kodama et al., 2021). Together, these findings highlight the critical role of e-books in ensuring academic continuity and adaptability during periods of disruption.

The reviewed literature highlights several significant challenges in e-book and e-textbook design, particularly in transitioning from traditional print formats to interactive, digital experiences. Chen et al. (2016) underscore the limitations imposed by linear, paper-based design models, advocating for more nonlinear and interactive structures that leverage digital media's potential. Similarly, Huang et al. (2012) identifies challenges in adapting to information-based learning environments, emphasizing the need for comprehensive instructional design frameworks that integrate user experience, multimedia, and content evaluation. Dick and Goncalves (2019) further point out the complexities of e-book design, stressing the importance of a systemic approach that considers content, technology, and stakeholder dynamics. Finally, Sioki (2021) critiques the prevailing tendency to prioritize usability over typographic and visual innovation, noting that while major e-reader platforms hinder design evolution, independent creators are beginning to explore more expressive digital text formats. Together, these studies call for a more holistic, innovative approach to e-book design that transcends traditional paradigms and meets the evolving needs of digital readers.

The aim of this research is to conduct a bibliometric study on e-book evaluation to identify publication trends, key contributors, influential institutions and countries, and the authors' keywords that reflect the focus of the field. Conducting a bibliometric analysis is essential as it offers a systematic and quantitative overview of research developments, assisting scholars and practitioners to understand the structure and evolution of a domain, as well as to identify gaps and future research directions (Donthu et al., 2021; Kumar,

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2025). Bibliometric methods also enhance the visibility of influential works and collaborations, thereby supporting strategic decisions in academic research (Kumar, 2025).

This study aims to answer the following research questions pertaining to the E-book evaluation.

1. What are the publication trends in the field of E-book evaluation?
2. What are the most highly cited documents?
3. Who are the most productive and influential authors?
4. What are the patterns of co-authorship?
5. Which institutions contribute most significantly to the research?
6. What are the most active countries?
7. What are the most frequently occurring keywords in literature?

Method

This study conducted a bibliometric analysis focused on the evaluation of e-books. The methodology followed several key steps as illustrated in Figure 1. The chosen topic for investigation was "E-book Evaluation," reflecting the interest in understanding how electronic books are assessed in academic research. The bibliometric data was sourced from the Scopus database. The search was made through the article titles, abstract and keywords to ensure relevance and specificity. The time frame for the study spanned from 1991 to 2025, covering more than three decades of scholarly work. Publications in all languages in the Scopus database were considered, and all source types were included. The document types were limited to articles, conference papers, and book chapters. The search string used was (e-book OR ebook OR "electronic book" OR "digital book") AND evaluation. This query was designed to capture a wide range of terminologies associated with electronic books, combined with a focus on their evaluation. The search was executed, and data was extracted on March 20, 2025.

An initial 595 records were identified and screened. Screening involved checking duplicate entries and assessing relevance to the topic based on titles and abstracts. This was done manually by the author. A total of 143 records were removed due to duplication and irrelevance to the theme of e-book evaluation. After

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screening, 452 records were retained and included for subsequent bibliometric analysis. These records form the basis for examining publication trends, influential sources, authorship patterns, and thematic developments in the field of e-book evaluation.

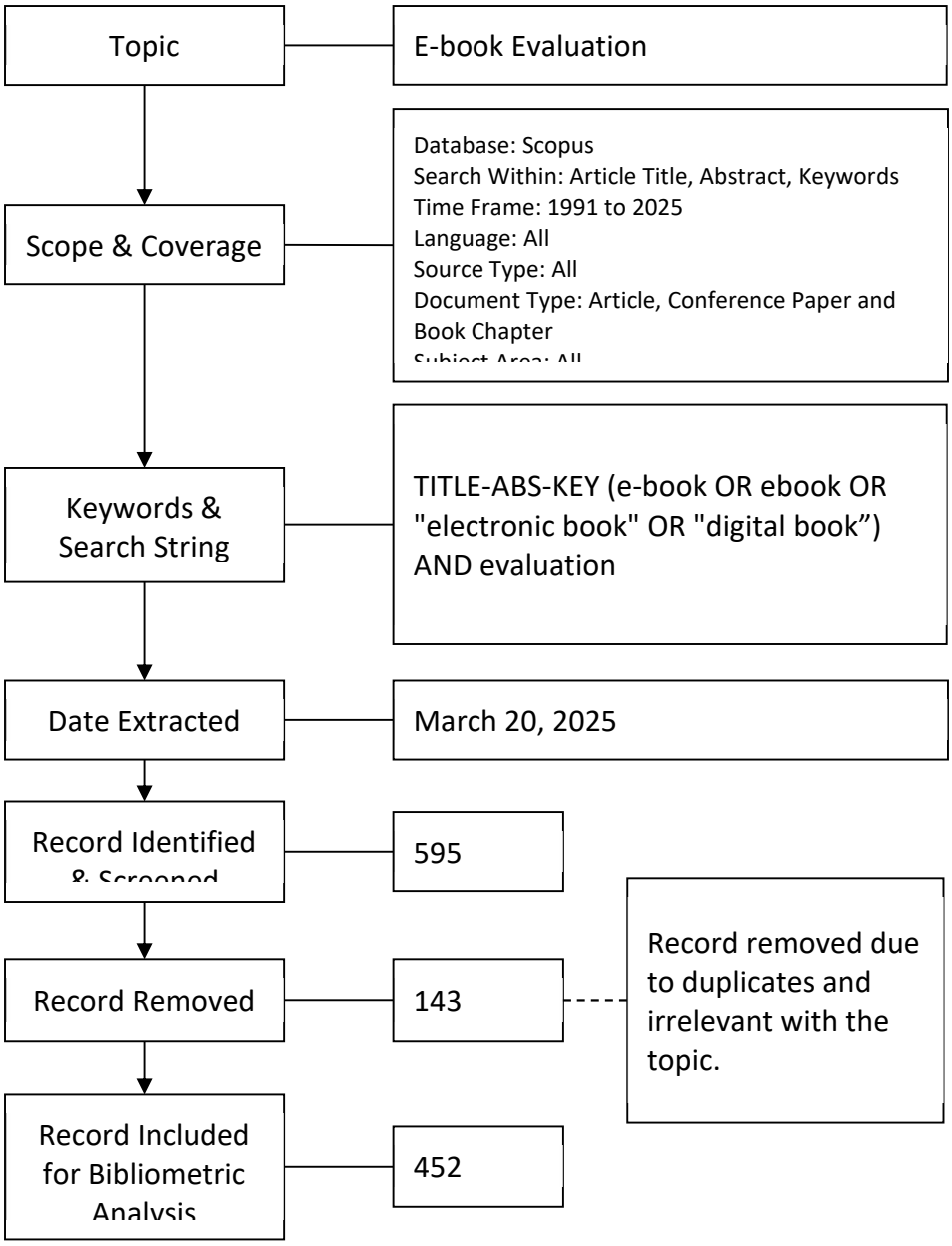

Figure 1. Flowchart of bibliometric search strategy and record screening Source: Lim et al. (2024)

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Before conducting the bibliometric analysis, a thorough data cleaning and harmonization process was performed. This step involved standardizing and correcting variations in the authors' full names, affiliations, and keywords to ensure consistency across the dataset. Any missing data detected during this phase was carefully resolved to maintain the integrity of the analysis.

Tools such as biblioMagika (Ahmi, 2004) and OpenRefine (Ahmi, 2023) were employed to assist in the cleaning and harmonization processes, helping to merge duplicate entries and correct inconsistencies. After the dataset was refined, bibliometric analysis was conducted using biblioMagika and VOSviewer (Van Eck & Waltman, 2014) to generate comprehensive insights into publication trends, collaboration and keywords networks.

Results and Discussion

This section presents the findings of the bibliometric analysis on e-book evaluation research. The discussion begins by examining the publication trends and growth over the selected time frame, highlighting the evolution and increasing scholarly interest in the field. It then explores the contributions of key authors and collaboration patterns, identifying influential researchers and mapping their networks of cooperation. Following this, the analysis addresses the institutional and country influence, showcasing leading organizations and nations driving research in this area. Finally, a keyword and thematic analysis is provided to uncover the major research themes, emerging topics, and shifts in focus within the literature.

Publication Trends and Growth

Document Type

Table 1 presents the distribution of document types related to e-book evaluation research. Out of a total of 452 publications, articles constitute the largest proportion, accounting for 50.66% (229 publications). Conference proceedings closely follow, representing 47.35% (214 publications), indicating that scholarly communication on this topic is actively shared through conference platforms, possibly due to the rapidly evolving nature of digital technologies. Book chapters make up a small fraction, comprising only 1.99% (9

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publications), suggesting that while the topic is significant, it is less frequently explored in longer, edited volumes. Overall, the results highlight that journal articles and conference proceedings are the primary mediums for disseminating research on e-book evaluation.

Document Type	Total Publication	Percentage (N=452)
Article	229	50.66
Conference proceeding	214	47.35
Book chapter	9	1.99

Table 1. Document type

Publication and Citation Trends

Table 2 and Figure 2 illustrate the publication trends and growth of e-book evaluation research within the global academic community. The publication trend on e-book evaluation research from 1991 to 2025 reveals a gradual but significant growth over the years. The early period (1991–2000) showed very low publication activity, with only 1 to 2 publications per year and modest citation impact. This period represents the emerging phase of research on e-book evaluation.

A notable increase began in 2002, where the number of publications rose to 5, followed by consistent outputs between 5 to 8 publications annually until 2009. This indicates a slow maturation phase, where interest in the topic steadily grew but remained modest. A major milestone occurred in 2010, with publications jumping to 20 articles, marking the beginning of a more accelerated growth phase.

From 2010 to 2019, publication numbers continued to rise, peaking at 33 publications in 2019, suggesting that the academic community's interest in e-book evaluation had significantly expanded during this decade. This period also shows a corresponding increase in total citations, particularly notable in 2011 (606 citations) and 2017 (1065 citations), indicating that publications during these years were highly influential. After 2019, a slight fluctuation is observed. Although publication numbers remained relatively high (21–31 publications per year between 2020 and 2024), the total citations in more recent years (2020–2024) were lower, likely due to the shorter time window for newer articles to accumulate citations. In 2025, only 4 publications were recorded, which is expected as the data extraction date was March 20, 2025, and the year was still ongoing.

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The notable rise in publications from 2010 onward reflects the increasing integration of digital technologies in education, libraries, and publishing. The proliferation of e-readers like the Amazon Kindle which was launched in 2007 (Ascoli et al., 2008) and tablets such as the iPad that was introduced in 2010 (Merchant, 2015) significantly boosted both consumer and academic interest in e-books. These technological shifts encouraged research not only into e-book adoption but also into how e-books were evaluated for usability, accessibility, and learning outcomes.

Table 2. Total publication and total citation per year

Year	Total Publication	Total Citation
1991	1	49
1995	2	1
1996	2	13
1997	1	4
1998	2	3
1999	2	18
2000	1	19
2001	2	36
2002	5	108
2003	5	144
2004	7	58
2005	8	125
2006	5	38
2007	5	47
2008	13	126
2009	5	59
2010	20	192
2011	19	606
2012	23	522
2013	26	225
2014	26	147
2015	23	172
2016	27	271
2017	29	1065
2018	28	151
2019	33	387
2020	21	95
2021	29	144
2022	24	123
2023	23	44
2024	31	30
2025	4	0

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Year	Total Publication	Total Citation
Grand Total	452	5022

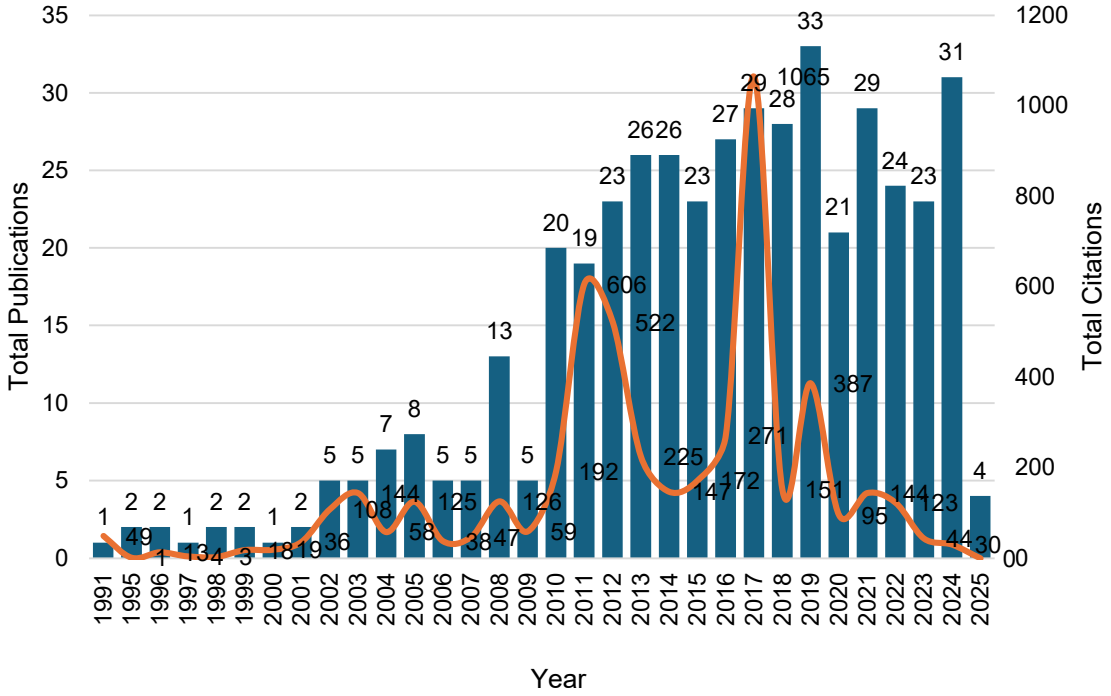

Figure 2. Total publication and citation per year

The significant spike in citations in 2011 and 2017 suggests the publication of highly influential works or systematic reviews consolidating previous findings. Studies during this time began focusing more highly interdisciplinary, blending technology, education, usability, accessibility, and content quality that contributed to significant advancements in the field of e-book evaluation and usage (G.-D. Chen et al., 2016; Colombo, 2011; Hussain et al., 2017; Wong et al., 2011). Additionally, increased institutional investments in digital collections during this period may have stimulated related e-books usage, evaluations and research (Klatt & Meeks, 2020; Maceviciute et al., 2014).

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Productive Source Title

The analysis of the most productive source titles related to e-book evaluation research highlights several key publication venues as shown in Table 3. Lecture Notes in Computer Science, including its subseries in Artificial Intelligence and Bioinformatics, is the leading source with 35 publications (TP), contributed by 125 authors (NCA), 23 of which were cited (NCP), and accumulating a total of 122 citations (TC).

Table 3. Most productive source title

Source Title	TP	NCA	NCP	TC
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	35	125	23	122
Journal of Physics: Conference Series	16	51	12	48
AIP Conference Proceedings	12	46	6	58
ACM International Conference Proceeding Series	11	31	6	23
Electronic Library	7	16	7	157
Library Hi Tech	6	14	6	207
Proceedings of the International Display Workshops	6	28	0	0
Communications in Computer and Information Science	5	13	3	3
ASEE Annual Conference and Exposition, Conference Proceedings	5	12	3	13
International Conference on Information and Knowledge Management, Proceedings	5	7	4	25
Educational Technology and Society	4	12	4	131
International Journal of Information and Education Technology	4	15	4	8
Advances in Intelligent Systems and Computing	4	13	3	60
Medical Reference Services Quarterly	3	6	2	12
Publishing Research Quarterly	3	3	3	16
Education and Information Technologies	3	9	3	16
Computers and Education	3	12	2	94
International Journal of Interactive Mobile Technologies	3	12	2	22
CEUR Workshop Proceedings	3	14	2	14
Procedia Computer Science	2	3	1	8

Note: TP=total number of publications; NCA=number of contributing authors; NCP=number of cited publications; TC=total citations

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Following this, the Journal of Physics: Conference Series ranks second with 16 publications, 51 contributing authors, 12 cited papers, and 48 total citations. The AIP Conference Proceedings and the ACM International Conference Proceeding Series also show significant activity, with 12 and 11 publications respectively, though their total citation counts are moderate at 58 and 23 citations. Among journal publications, the Electronic Library and Library Hi Tech stand out with 7 and 6 publications respectively. Notably, Library Hi Tech exhibits a strong impact relative to its number of publications, gathering 207 total citations, indicating a high influence of individual articles published in this journal. The findings suggest that while conference proceedings dominate in terms of the number of publications, journal articles tend to have a higher citation impact, emphasizing the importance of both dissemination channels in the evolution of e-book evaluation.

Highly Cited Publication

The analysis of the most highly cited publications reveals several key studies that have significantly influenced the field of e-book evaluation research. The top ten of the highly cited publications can be referred to at Table 4. The highest-cited publication is by Wilson et al. (2002), which emphasizes the importance of user-centered design and user experience in the development of electronic textbooks. Their study led to the formulation of the Electronic Textbook Design Guidelines, offering practical recommendations for developers and content creators to enhance the design and usability of educational digital publications.

Table 4. Top 10 highly cited publication

No.	Authors	Title	Source Title	Total Citation
1	Wilson et al. (2002)	A user-centred approach to e-book design	Electronic Library	46
2	Richardson and Mahmood (2012)	eBook readers: User satisfaction and usability issues	Library Hi Tech	45
3	Gibson and Gibb (2011)	An evaluation of second-generation ebook readers	Electronic Library	41
4	Korat and Falk (2019)	Ten years after: Revisiting the question of e-book quality as early language and literacy support	Journal of Early Childhood Literacy	40

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No.	Authors	Title	Source Title	Total Citation
5	Roskos et al. (2017)	An analysis of e-book learning platforms: Affordances, architecture, functionality and analytics	International Journal of Child-Computer Interaction	35
6	Zhang-Kennedy et al. (2017)	Cyberheroes: The design and evaluation of an interactive ebook to educate children about online privacy	International Journal of Child-Computer Interaction	35
7	Bozkurt and Bozkaya (2015)	Evaluation Criteria for Interactive E-Books for Open and Distance Learning	International Review of Research in Open and Distributed Learning	33
8	Hsin-Chieh et al. (2007)	Ergonomic evaluation of three popular Chinese e-book displays for prolonged reading	International Journal of Industrial Ergonomics	31
9	Chang et al. (2015)	A hybrid fuzzy model for selecting and evaluating the e-book business model: A case study on Taiwan e-book firms	Applied Soft Computing Journal	29
10	Crestani et al. (2006)	Appearance and functionality of electronic books: Lessons from the Visual Book and Hyper-TextBook project	International Journal on Digital Libraries	26

Several highly cited studies have shaped the understanding of e-book development and evaluation. They investigate user satisfaction and usability issues in e-book readers, emphasizing factors such as screen readability, navigation, battery life, and ergonomic design improvements. Research on early childhood education highlights the role of high-quality multimedia in supporting literacy development. Evaluations of e-book learning platforms focus on their educational affordances, system architecture, and analytics capabilities. Other studies explore the use of interactive e-books for teaching cybersecurity to children, propose comprehensive evaluation criteria for interactive e-books in open and distance learning, assess ergonomic factors affecting prolonged e-book reading, analyze business model selection for the e-book industry using fuzzy modeling approaches, and examine the balance between appearance and functionality in electronic book interfaces.

Key Authors and Collaboration Patterns

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Most Productive Authors

The analysis of publication data for 10 researchers as illustrated in Table 5 reveals significant variation in both productivity and impact. Hiroaki Ogata from Kyoto University stands out as the most prolific and influential contributor, with 19 total publications, 16 of which are cited, and a total of 185 citations which demonstrate both high output and academic influence. Monica Landoni from the University of Lugano also shows a remarkable impact, with all 10 of her publications cited and accumulating 143 citations, indicating consistently high-quality work. Noriko Uosaki and Kousuke Mouri both produced 11 publications with 10 cited, each receiving 76 citations, reflecting solid scholarly performance. In contrast, Masaru Miyao and Takehito Kojima also have 11 publications but only one cited publication and a modest citation count of 11, suggesting limited reach or niche research areas. Several other researchers (Ishii, Iwata, Lege, and Koizuka) have fewer publications, ranging from 6 to 8, with little to no citations, possibly indicating early-career stages or recent entry into publishing. Overall, while a few researchers contribute heavily to scholarly output and impact, others show potential but may require more time or broader dissemination strategies to increase their visibility and citation rates.

Table 5. Top 10 most productive authors

No.	Full Name	Current Affiliation	Country	TP	NCP	TC
1	Ogata, Hiroaki	Kyoto University	Japan	19	16	185
2	Uosaki, Noriko	Osaka University	Japan	11	10	76
3	Miyao, Masaru	Nagoya University	Japan	11	1	11
4	Kojima, Takehito	Chubu Gakuin University	Japan	11	1	11
5	Mouri, Kousuke	Tokyo University of Agriculture and Technology	Japan	11	10	76
6	Landoni, Monica	University of Lugano	Switzerland	10	10	143
7	Ishii, Yuki	Nagoya University	Japan	8	0	0
8	Iwata, Kohei	Nagoya University	Japan	6	0	0
9	Lege, Ranson Paul	Nagoya University	Japan	6	0	0
10	Koizuka, Tatsuya	Nagoya University	Japan	6	1	11

Note: TP=total number of publications; NCP=number of cited publications; TC=total citations

The co-authorship network visualization and data reveal two distinct clusters of collaboration among the authors, with Masaru Miyao serving as a central connecting figure as illustrated in Figure 3. The green cluster, which includes Masaru Miyao, Takehito Kojima, Tatsuya Koizuka, and Shunta Sano, demonstrates a tightly

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connected group with strong and frequent collaborations. Notably, the strongest co-authorship link exists between Miyao and Koizuka, who co-authored 11 publications together. These authors appear to work closely, possibly within the same research team or academic university. In contrast, the red cluster features authors such as Shigusa Matsunaga, Ranson Paul Lege, Yuki Ishii, Kohei Iwata, and Nobuhiro Ishio. This group exhibits broader but generally weaker connections, indicating more dispersed or early-stage collaborations, possibly among junior researchers or those working on interdisciplinary projects.

Masaru Miyao plays a crucial bridging role in the network, connecting both clusters and collaborating with nearly all the other authors. His position suggests that he may be a senior researcher or project leader, facilitating collaboration across different groups. The co-authorship strengths, reflected in the number of joint publications, vary widely from single collaborations to highly productive partnerships, such as those between Miyao and Koizuka, as well as with Kojima and others. Overall, the network demonstrates a balanced structure that includes both established, productive teams and emerging scholars, with strong potential for expanded interdisciplinary collaboration.

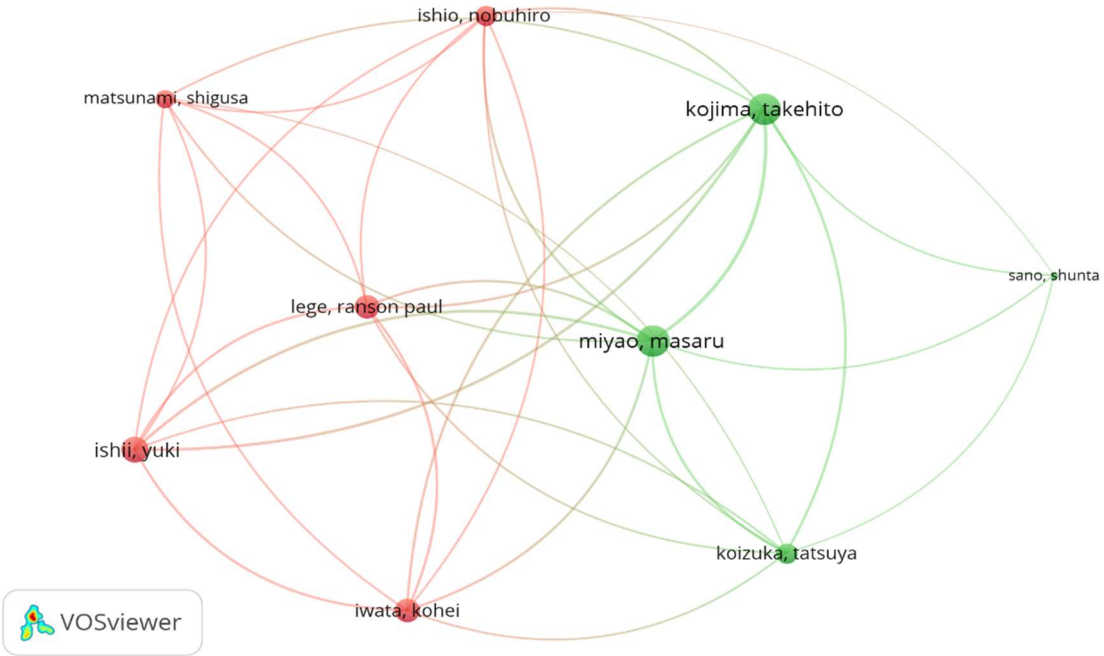

Figure 3. Network visualization of co-authorship by authors

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Institutional and Country Influence

Most Productive Institutions and Countries

Table 6 shows the analysis of institutional research performance highlights notable trends in publication output, citation impact, and collaborative reach across ten institutions. Among these, the University of Strathclyde (UK) stands out prominently, with 10 total publications and all 10 cited, resulting in the highest total citations (TC = 241) which means a clear indicator of high-impact research. Similarly, National Cheng Kung University (Taiwan), with 7 publications and 6 cited, achieves an impressive 276 total citations, the highest among all, suggesting exceptional research influence despite fewer publications.

In terms of volume, Kyoto University, Osaka University, and Nagoya University (all Japan) lead with 11 publications each. However, their impact varies significantly: Kyoto has 8 cited publications and 90 citations, Osaka has 10 cited and 76 citations, while Nagoya lags in terms of impact, with only 1 cited publication out of 11 and just 11 total citations, despite having the highest number of contributing authors (58). This suggests that Nagoya's research may be less visible or impactful, or possibly skewed toward co-authored or collaborative works with less individual recognition.

Table 6. Top 10 most productive institutions

No.	Institution Name	Country	TP	NCA	NCP	TC
1	Kyoto University	Japan	11	18	8	90
2	Osaka University	Japan	11	12	10	76
3	Nagoya University	Japan	11	58	1	11
4	University of Strathclyde	United Kingdom	10	18	10	241
5	Kyushu University	Japan	10	32	10	99
6	Universitas Negeri Jakarta	Indonesia	7	18	5	32
7	National Cheng Kung University	Taiwan	7	19	6	276
8	University College London	United Kingdom	6	9	6	49
9	National Taiwan University of Science and Technology	Taiwan	6	14	4	128
10	University of Salamanca	Spain	6	18	3	12

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Note: TP=total number of publications; NCA=number of contribution authors; NCP=number of cited publications; TC=total citations

Kyushu University (Japan) also shows strong performance with 10 publications, all cited, and 99 citations, indicating consistently recognized research. Other institutions such as University College London (UK) and National Taiwan University of Science and Technology (Taiwan) demonstrate a good balance between publication count and citation impact, with the latter achieving 128 citations from just 4 cited papers, suggesting high selectivity or breakthrough works. In contrast, University of Salamanca (Spain) and Universitas Negeri Jakarta (Indonesia) show lower citation impact despite moderate author contributions and publication counts. Salamanca, for instance, records 18 authors and 3 cited papers but only 12 citations overall, pointing to possible issues in dissemination or relevance of research topics. The total publication (TP) data across different countries and continents reveals clear patterns of global research productivity as listed in Table 7 and portrayed in Figure 4. The United States leads significantly with 85 publications, accounting for 16.80% of the total output. This dominance reflects the country's well-established research infrastructure and international presence in academic publishing.

Table 7. Top 10 most productive countries

No.	Country	Continent	TP	%
1	United States	North America	85	16.80%
2	Indonesia	Asia	53	10.47%
3	Japan	Asia	47	9.29%
4	United Kingdom	Europe	42	8.30%
5	Taiwan	Asia	40	7.91%
6	China	Asia	25	4.94%
7	India	Asia	21	4.15%
8	Brazil	South America	17	3.36%
9	Malaysia	Asia	17	3.36%
10	Spain	Europe	16	3.16%

Note: TP=total number of publications

Among Asian countries, Indonesia ranks impressively second overall with 53 publications (10.47%), surpassing traditional research powerhouses like Japan (47 publications, 9.29%) and China (25 publications, 4.94%). This indicates a growing research contribution from Southeast Asia, particularly from Indonesia, which is increasingly active in international scholarly work. Other notable contributors from Asia include

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Taiwan with 40 publications (7.91%), India (21, 4.15%), and Malaysia (17, 3.36%). Collectively, Asia represents a substantial portion of the global publication share, highlighting the region's expanding role in academic research. From Europe, the United Kingdom stands out with 42 publications (8.30%), followed by Spain with 16 (3.16%). These figures suggest consistent contributions from European institutions, albeit lower than their Asian counterparts in this dataset. Brazil, representing South America, contributes 17 publications (3.36%), showing a modest but visible role in global research.

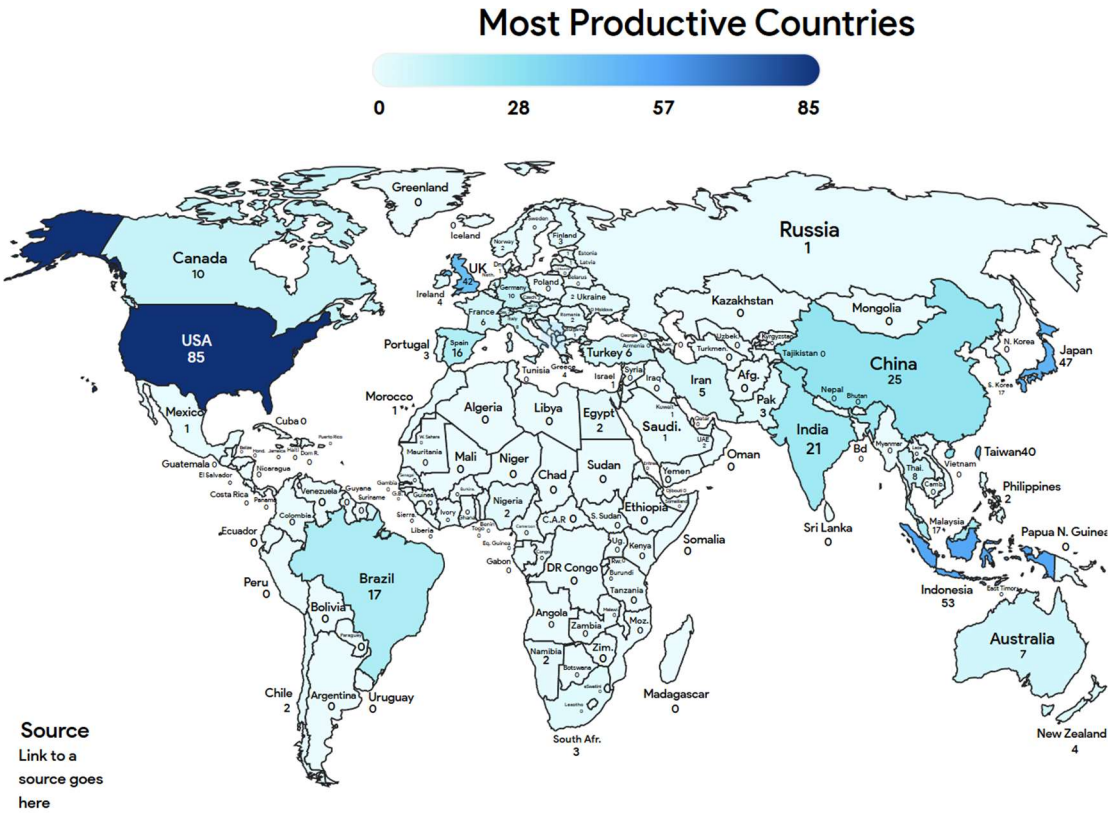

Figure 4. World map chart according to most productive countries

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Keyword Analysis

The visualization in Figure 5 presents a comprehensive author keyword co-occurrence network related to the concept of e-books, based on bibliometric data. At the core of the map, the keyword "e-book" dominates, signifying it as the central and most influential topic across the analyzed literature. Surrounding it are multiple interconnected clusters that reflect various thematic directions in e-book research. The green cluster, which is the most extensive, encompasses terms such as "e-learning," "mobile learning," "learning analytics," "reading comprehension," and "seamless learning." This indicates a strong focus on the role of e-books in educational technology and digital learning environments, emphasizing the integration of e-books into mobile and online learning contexts, as well as their connection to emerging educational frameworks like analytics and neural networks.

The orange cluster includes keywords like "evaluation," "usability," "design," and "user study," pointing to research interests in user experience and interface evaluation of e-books. This suggests a focus on how users interact with e-books, including interface quality, ease of navigation, and overall user satisfaction. Another notable cluster, purple, groups terms such as "e-paper," "readability," and "visibility." This cluster is concerned with the technical and visual aspects of digital reading, including how text is displayed on various digital formats and devices, especially e-paper technologies.

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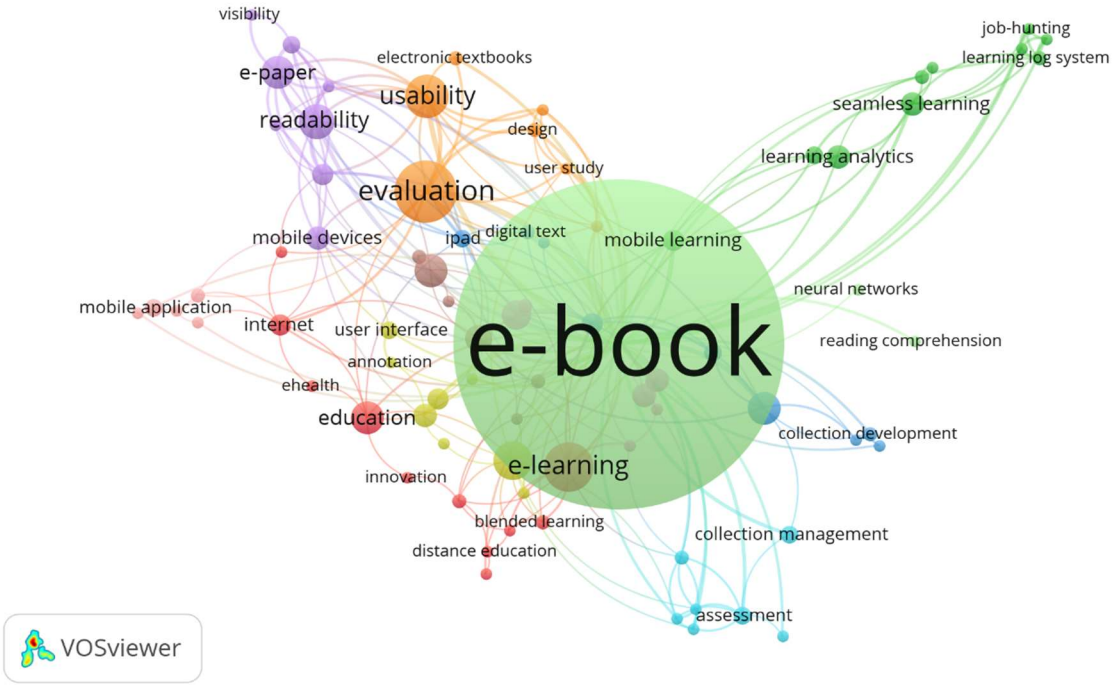

Figure 5. Networks visualization of co-occurences by author keywords

The red cluster contains keywords like "education," "internet," "mobile application," and "innovation," indicating a broader perspective on the integration of digital tools in education, with e-books being part of a wider ecosystem that includes mobile and online learning applications. Additional smaller clusters (light blue, yellow, and brown) emphasize topics like "collection management," "assessment," "digital text," and "ipad," revealing areas of focus on library science, digital resource management, and device-specific research.

Conclusion

This study was conducted to examine the landscape of e-book evaluation research using bibliometric analysis. By analyzing data from the Scopus database between 1991 and 2025, the research aimed to identify publication trends, key contributors, influential institutions and countries, and keywords patterns in the

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literature. The primary objective was to provide a comprehensive overview of how e-book evaluation has evolved over time and to uncover gaps and directions for future research in this growing area.

The findings indicate that interest in e-book evaluation has grown significantly since 2010, with a peak in publications observed in 2019. Prominent contributors include Ogata Hiroaki and institutions such as Kyoto University, while the United States emerged as the most productive country. The keyword analysis showed strong research emphasis on educational contexts, usability, mobile learning, and digital interface design. Highly cited works focused on usability, interactive features, and pedagogical affordances, emphasizing the critical role of user experience in e-book development.

This bibliometric review contributes to the field by systematically mapping its intellectual structure and research dynamics. It highlights influential sources and collaboration networks that shape the discourse on e-book usability and evaluation. Additionally, the study provides valuable insights for researchers, librarians, and developers by identifying prominent authors, impactful studies, and dominant keywords, which can inform strategic decisions in research, library acquisitions, and digital content design.

Despite its comprehensive scope, the study is limited by its reliance on a single database (Scopus) and exclusion of non-indexed literature, which may omit some relevant contributions. Future research can expand by incorporating multiple databases and conducting content or citation analyses to deepen the qualitative understanding. Furthermore, emerging technologies such as AI-driven content personalization and immersive e-reading experiences present new avenues for exploration in usability and evaluation studies.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS Journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest.

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Acknowledgements and Notes

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INTEGRATING TECHNOLOGY TO IMPROVE RESEARCH COMPETENCIES THROUGH SPSS PRACTICAL TRAINING

Abstract: The aim of this study was to investigate the effectiveness of SPSS practical training to improve the research competencies of the students and academic staff of "Fan S. Noli" University. The population consists of 42 participants in the training sessions that were conducted during the development of the "Technology and data analysis in scientific research: Applications in SPSS, R and EViews" project, implemented in "Fan. S. Noli" University. The instrument used was a pretest and posttest questionnaire that was distributed among staff and students taking part in the training. The questionnaire's aim was to grasp the perceptions of participants related to data entry, descriptive statistics, testing hypothesis, regression analysis, correlation analysis, and categorical data analysis. Subsequently, the data gathered was compared using the Wilcoxon Signed Rank Test. The results indicated a statistically significant difference in all the fields mentioned above, thus confirming that participants performed better after the training than before.

Keywords: SPSS, Training, Research competencies, Technology

Introduction

Several researchers in recent years have shown a strong commitment to using a variety of software applications in their research activities such as writing research papers, theses, and performing analytical tasks of any kind. Understanding this, scientists worldwide employ IBM SPSS (Statistical Package for the Social Sciences) as one of the most popular statistical analysis programs. SPSS is of the most widely used tools for statistical analysis in the social sciences, education, health, agriculture, business fields etc.

While theoretical knowledge is essential in research, it is through practical training with tools like SPSS that students and researchers truly develop the competencies required to conduct meaningful and reliable research. SPSS has undergone a number of modifications since its founding around fifty years ago according to the demands of social science scholars due to the necessity for precision and accurate data representation in quantitative data analysis.

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In a scientific research, data analysis is the most essential part of the research that makes the result of the study more effective. It involves collecting, presenting, transforming, cleaning and modeling data in order to discover information that is important in supporting the researcher's results. Therefore, to say that data analysis is important for a scientific research is an understatement, when in fact no research can survive without data analysis. Nowadays, where information is everything, mastering statistical computer tools for data processing has become a necessity for researchers, their students or experienced researchers. In their studies, Rahman and Muktadir (2021), Masuadi et al. (2021), Curtis and Nunez (2022) conclude that SPSS (Statistical Packages for Social Sciences) is the most widely used statistical program in various fields for scientific research based on surveys, and its usage rate has been increasing (Okagbue et al., 2021).

According Jatnika, (2015) there is a significant increase in the cognitive aspects of learning Statistics after using SPSS as measured by Survey of Attitudes toward Statistics (SATS). Regarding Šebjan and Tominc (2014) there is a positive relationship between perceived usefulness of statistics and perceived usefulness of SPSS, perceived ease of use of SPSS, and attitude towards using the SPSS. Results, at Karanu and Omollo (2023) and Kimani et al. (2017) researches among graduated and post graduate students revealed that the level of knowledge significantly increased after the practical training of SPSS. Correspondingly, the research of Kimani and Simba (2017) titled: Effect of Practical SPSS Training on Students' Research Competence; A Survey of Jomo Kenyatta University of Agriculture and Technology Mombasa Campus Postgraduate Students revealed that most of the participant had low knowledge in data entry, descriptive statistics, regression and correlation analysis, parametric and non-parametric analysis, and also the increase of the level of knowledge after the training session. Recommending the frequent organization of such trainings. At Mathews and Musonda (2016) findings revealed that SPSS may be an effective tool for teaching hypothesis testing to students at Colleges and Universities asserting that the use of SPSS had a positive impact on students' performance in hypothesis testing. Moreover, students' attitude towards learning statistics through technology was improved and no gender disparities were founded.

This study was conducted within the framework of an institutional research project whose main goal was to improve the ability to perform solid and trustworthy statistical analysis as an indispensable research skill in an era where data drives important decisions among academic, professional and policy-making spheres. Our focus was academic researchers, university staff and students especially master students of "Fan S. Noli" University that require acquiring additional training in software, such as SPSS, that helps in their

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studies and their diploma thesis research. Since today's research requires not just a solid theoretical grasp but also involves the capacity to use statistical tools in practice, developing research skills in statistical analysis is crucial for professionals, researchers, educators and students who want to use evidence-based inquiry to make significant contributions to their disciplines.

Throughout the course of this project we observed that there is a paucity of research related to improving research competencies through SPSS practical training in the Albanian context. The present research seeks to fill this identified gap providing empirical insight on the role of SPSS practical training in enhancing research skills. To achieve this objective a three-day training session was organized at "Fan S. Noli University". The program was designed for academic staff and students and offered an integrated approach that combined small portions of statistical theory with practical applications in scientific research. At the end, a pre- and post-training assessments was used to measuring participants' self-reported knowledge levels across six key domains: data entry, descriptive statistics, hypothesis testing, correlation analysis, regression analysis, and categorical data analysis. The results of our training were promising and demonstrated the improvement of skills of the participants in using SPSS to perform presentation and statistical analysis of the data according to their study field.

Method

Data Collection Instrument and Participants

The participants of interest were students and staff from "F. S. Noli" University of Korca, Albania, which took part in a three-day SPSS practical training session. After the end of the training session all participants were given a questionnaire to fill out. The questionnaire was formulated based on the training program and on previous research studies. It had a total of seventeen closed questions, organized into three sections. The first section included four questions on the students' demographic and academic characteristics such as age, gender, job status, and level of education. In the second section participants were asked if they use SPSS program and about their perceptions related their ability to perform entering the data, descriptive statistics, hypothesis test, correlation analysis, regression analysis, and categorical data analysis before the training.

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Additionally, in the third session participants were asked about their perceptions after the training sessions. The last two sections both use a 5- point Likert- Scale.

In total there were 42 participants (21% were male and 79% were female). The majority (45.2%) were between 20-30 years old, 26.2% between 31-40 years old 23.8% were between 41-50 years old, and 4.8% were over 50 years old. Regarding their level of education, most participants (31%) were Master of Science students, 14% were Professional Master students, 9% were Bachelor students, 7% Associate Professors, 29% were Ph.D. holders, and 10% were Ph.D. students. 54.8% of participants declared that they had rarely used SPSS for statistical analysis, 14.3% used it often, while 31% had never used SPSS before.

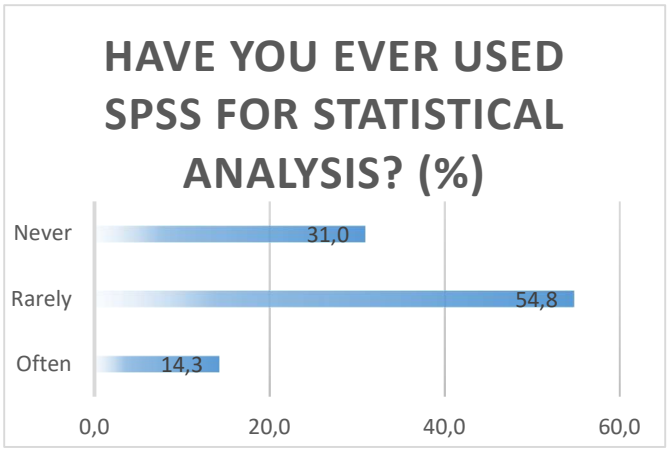

Figure 1. Distribution of respondents' experience with SPSS for statistical analysis

Statistical Analysis

Data analysis was conducted using the software IBM SPSS v. 20. Frequencies and percentages were used to describe changes in perceived knowledge before and after the training. In each domain, a marked improvement was observed, with substantial increases in the proportion of participants reporting very high knowledge levels and corresponding decreases in those reporting very low knowledge. To statistically assess these changes, the Wilcoxon Signed Rank Test was employed, as the data were paired and ordinal.

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Results

In this section we present the results related to the sixth domains: data entry, descriptive statistics, testing hypothesis, regression analysis, correlation analysis, and categorical data analysis.

Data Entry on SPSS

Before the training sessions only 40.5 % of the participants revealed very high knowledge in data entry while 38.1% of them revealed very low knowledge. After the training sessions a notable improvement was seen in entering the data knowledge with 61.9% of participants declare very high knowledge and only 4.8% of them very low knowledge. The percentage of participants declaring very high knowledge increased dramatically from 40.5% to 61.9%. Meanwhile the percentage of participants declaring very low knowledge decreased from 38.1% to 4.8% indicating substantial improvement (Figure 2).

This shift of participants from very low knowledge to very high knowledge levels provide evidence of the effectiveness of the training sessions. Most notably, the increase in the performers from 40.5% to 61.9% shows a positive effect. A Wilcoxon Signed Rank Test was used to test whether the median of scores significantly changed (Table 1).

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Figure 2. Comparison of participants' self-assessed ability to enter data before and after training

Table 1. Wilcoxon Signed Rank test for data entry before and after training

		N	Mean Rank	Sum of Ranks	Z	Asymp.Sig (2-tailed)
Entering the data After. – Entering the data Before.	Negative Ranks	1[a]	4.50	4.50	-4.102	.000
	Positive Ranks	22[b]	12.34	271.50		
	Ties	19[c]				
	Total	42				

a. Entering the data After. < Entering the data Before.
b. Entering the data After. > Entering the data Before.
c. Entering the data After. = Entering the data Before.

Participants' test results were compared before and after the training sessions. On average, participants performed better (Median = 5) after the training than before (Median = 3). A Wilcoxon Sign-Rank Test indicated that this improvement was statistically significant, Z=-4.102, p=.000<0.05.

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Descriptive Statistics with SPSS

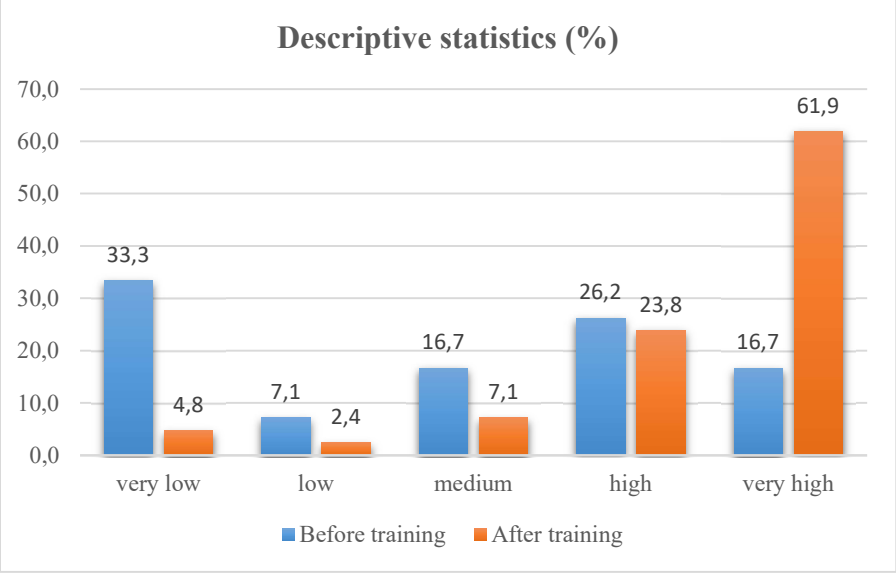

Figure 3. Comparison of participants' self-assessed ability to conduct descriptive statistics before and after training

Before the training sessions only 16.7 % of participants revealed very high knowledge and 26.2% high knowledge in descriptive statistics while 33.3% of them revealed very low knowledge. After the training sessions a significant improvement was seen in descriptive statistics knowledge with 61.9% of participants declaring very high knowledge and only 4.8% of them very low knowledge. The percentage of participants declaring very high knowledge increased significantly from 16.7% to 61.9%. Meanwhile the percentage of participants declaring very low knowledge decreased from 33.3% to 4.8% indicating substantial improvement. This shift of participants from very low knowledge to very high knowledge levels provide evidence of the effectiveness of the training sessions. Most notably, the increase in the performers from 16.7% to 61.9% shows a strong positive effect. A Wilcoxon Signed Rank Test was used to test whether the median of scores significantly changed.

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Table 2. Wilcoxon Signed Rank test for descriptive statistics before and after training

		N	Mean Rank	Sum of Ranks	Z	Asymp.Sig (2-tailed)
Descriptive Statistics After. – Descriptive Statistics Before.	Negative Ranks	0[a]	.00	.00	-4.918	.000
	Positive Ranks	31[b]	16.00	496.00		
	Ties	11[c]				
	Total	42				

a. Descriptive Statistics After. < Descriptive Statistics Before.
b. Descriptive Statistics After. > Descriptive Statistics Before.
c. Descriptive Statistics After. = Descriptive Statistics Before.

Participants' test results were compared before and after the training sessions. On average, participants performed better (Median = 5) after the training than before (Median = 3). A Wilcoxon Sign-Rank Test indicated that this improvement was statistically significant, Z=-4.918, p=.000<0.05.

Testing Hypothesis with SPSS

Before the training sessions of Hypothesis Testing, 9.5 % of the participants revealed very high knowledge and 21.4% high knowledge while 38.1% of them revealed very low knowledge. After the training sessions a significant improvement was seen in testing hypothesis knowledge with 42.9% of participants declaring very high knowledge and only 4.8% of them very low knowledge. The percentage of participants declaring very high knowledge increased significantly from 9.5% to 42.9%. Meanwhile the percentage of participants declaring very low knowledge decreased from 38.1% to 4.8% indicating substantial improvement.

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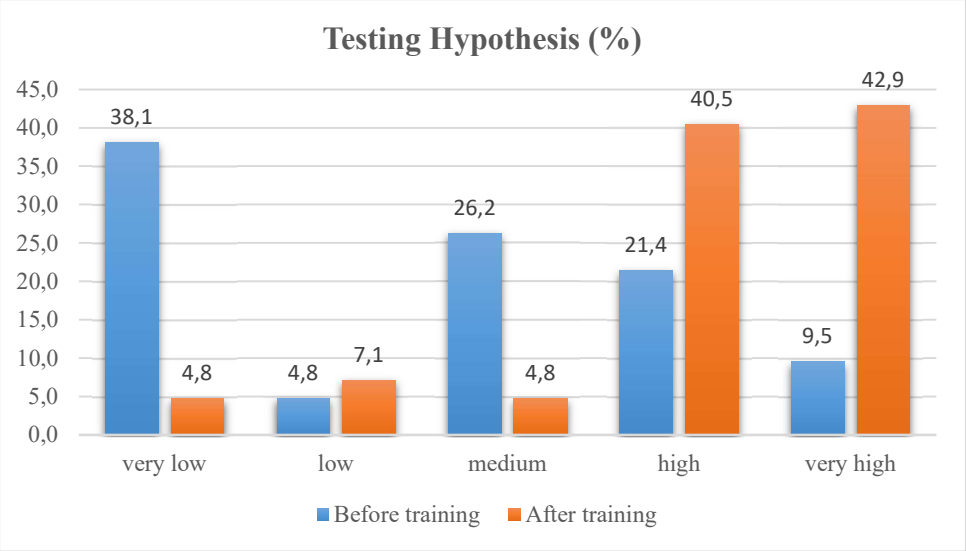

Figure 4. Comparison of participants' self-assessed ability to test hypothesis before and after training

This shift of participants from very low knowledge to very high knowledge levels provides evidence of the effectiveness of the training sessions. Most notably, the increase in the performers from 9.5% to 42.9% shows a strong positive effect. A Wilcoxon Signed Rank Test was used to test whether the median of scores significantly changed.

Table 3. Wilcoxon Signed Rank test for testing hypothesis before and after training

		N	Mean Rank	Sum of Ranks	Z	Asymp.Sig (2-tailed)
Hypothesis testing After. – Hypothesis testing Before.	Negative Ranks	0[a]	.00	.00	-5.250	.000
	Positive Ranks	35[b]	18.00	630.00		
	Ties	7[c]				
	Total	42				

a. Hypothesis testing After. < Hypothesis testing Before.
b. Hypothesis testing After. > Hypothesis testing Before.
c. Hypothesis testing After. = Hypothesis testing Before.

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Participants' test results were compared before and after the training sessions. On average, participants performed better (Median = 4) after the training than before (Median = 3). A Wilcoxon Sign-Rank Test indicated that this improvement, was statistically significant, Z=-5.205, p=.000<0.05.

Correlation Analysis with SPSS

Regarding the Correlation Analysis knowledge before the training sessions, 7.1% of participants revealed very high knowledge and 26.2% high knowledge while 38.1% of them revealed very low knowledge. After the training sessions a significant improvement was seen in correlation analysis knowledge with 42.9% of participants declaring very high knowledge and only 7.1% of them very low knowledge. The percentage of participants declaring very high knowledge increased significantly from 7.1% to 42.9%. Meanwhile the percentage of participants declaring very low knowledge decreased from 38.1% to 7.1% indicating substantial improvement.

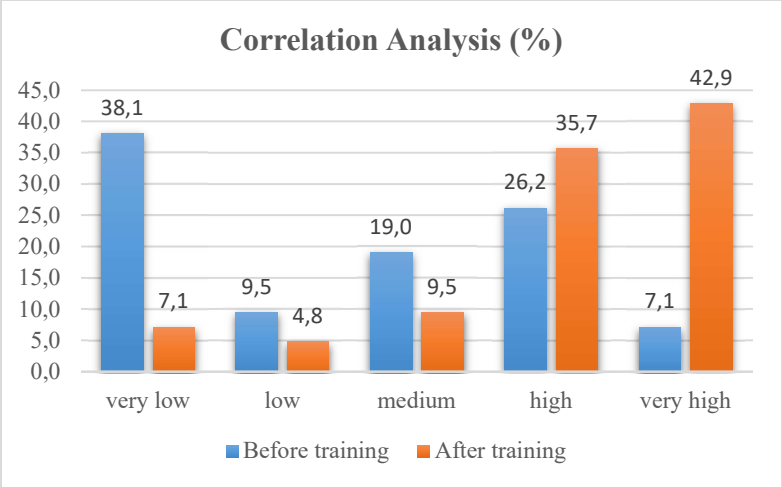

Figure 5. Comparison of participants' self-assessed ability to conduct correlation analysis before and after training

This shift of participants from very low knowledge to very high knowledge levels provides evidence of the effectiveness of the training sessions. Most notably, the increase in the performers from 7.1% to 42.9% shows a strong positive effect. A Wilcoxon Signed Rank Test was used to test whether the median of scores significantly changed.

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Table 4. Wilcoxon Signed Rank test correlation analysis before and after training

		N	Mean Rank	Sum of Ranks	Z	Asymp.Sig (2-tailed)
Correlation Analysis After. – Correlation Analysis Before.	Negative Ranks	0[a]	.00	.00	-5.178	.000
	Positive Ranks	34[b]	17.50	595.00		
	Ties	8[c]				
	Total	42				

a. Correlation Analysis After. < Correlation Analysis Before.
b. Correlation Analysis After. > Correlation Analysis Before.
c. Correlation Analysis After. = Correlation Analysis Before.

Participants' test results were compared before and after the training sessions. On average, participants performed better (Median = 4) after the training than before (Median = 3). A Wilcoxon Sign-Rank Test indicated that this improvement, was statistically significant, Z=-5.178, p=.000<0.05.

Regression Analysis with SPSS

In the Regression Analysis domain before the training sessions, 4.8% of participants revealed very high knowledge and 28.6% high knowledge while 42.9% of them revealed very low knowledge. After the training sessions a significant improvement was seen in correlation analysis knowledge with 42.9% of participants declaring very high knowledge and only 4.8% of them very low knowledge. The percentage of participants declaring very high knowledge increased significantly from 4.8% to 42.9%. Meanwhile the percentage of participants declaring very low knowledge decreased from 42.9% to 4.8% indicating substantial improvement.

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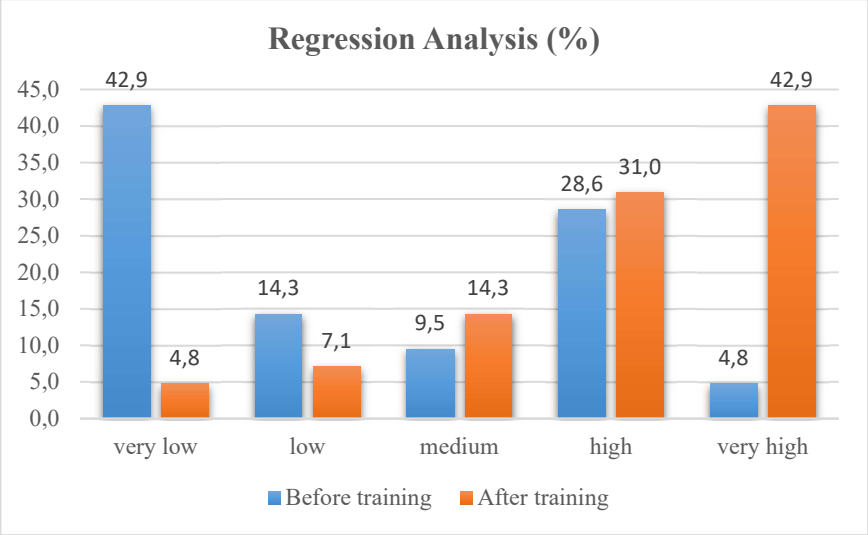

Figure 6. Comparison of participants' self-assessed ability to conduct regression analysis before and after training

This shift of participants from very low knowledge on regression analysis to very high knowledge levels provides evidence of the effectiveness of the training sessions. Most notably, the increase in the performers from 4.8% to 42.9% shows a strong positive effect. A Wilcoxon Signed Rank Test was used to test whether the median of scores significantly changed.

Table 5. Wilcoxon Signed Rank test for regression analysis before and after training

		N	Mean Rank	Sum of Ranks	Z	Asymp.Sig (2-tailed)
Regression Analysis After. – Regression Analysis Before.	Negative Ranks	0[a]	.00	.00	-5.394	.000
	Positive Ranks	37[b]	19.00	703.00		
	Ties	5[c]				
	Total	42				

a. Regression Analysis After. < Regression Analysis Before.
b. Regression Analysis After. > Regression Analysis Before.
c. Regression Analysis After. = Regression Analysis Before.

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Participants' test results were compared before and after the training sessions. On average, participants performed better (Median = 4) after the training than before (Median = 2). A Wilcoxon Sign-Rank Test indicated that this improvement was statistically significant, Z=-5.394, p=.000<0.05.

Categorical Data Analysis with SPSS

In the Categorical data analysis domain before the training sessions, 7.1% of participants revealed very high knowledge and 26.2% high knowledge while 38.1% of them revealed very low knowledge. After the training sessions a significant improvement was seen in categorical data analysis knowledge with 40.5% of participants declaring very high knowledge and only 7.1% of them very low knowledge. The percentage of participants declaring very high knowledge increased significantly from 7.1% to 40.5%. Meanwhile the percentage of participants declaring very low knowledge decreased from 38.1% to 7.1% indicating substantial improvement.

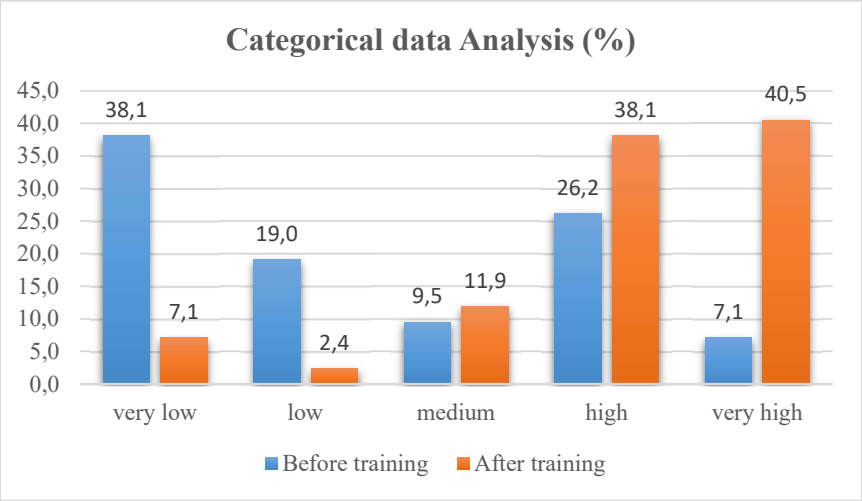

Figure 7. Comparison of participants' self-assessed ability to analyse categorical data before and after training

This shift of participants, from very low knowledge of categorical data analysis to very high knowledge levels, provides evidence of the effectiveness of the training sessions. Most notably, the increase in the

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performers from 7.1% to 40.5% shows a strong positive effect. A Wilcoxon Signed Rank Test was used to test whether the median of scores significantly changed.

Table 6. Wilcoxon Signed Rank test for categorical data analysis before and after training

		N	Mean Rank	Sum of Ranks	Z	Asymp.Sig (2-tailed)
Categorical data analysis After. – Categorical data analysis Before.	Negative Ranks	0[a]	.00	.00	-5.239	.000
	Positive Ranks	35[b]	18.00	630.00		
	Ties	7[c]				
	Total	42				

a. Categorical data analysis After. < Categorical data analysis Before.
b. Categorical data analysis After. > Categorical data analysis Before.
c. Categorical data analysis After. = Categorical data analysis Before.

Participants' test results were compared before and after the training sessions. On average, participants performed better (Median = 4) after the training than before (Median = 2). A Wilcoxon Sign-Rank Test indicated that this improvement was statistically significant, Z=-5.239, p=.000<0.05.

Conclusions

The statistical analysis of before training data revealed that 40.5% of the participants show high knowledge in data entry in SPSS, while 38.1% of them declare very low knowledge. In descriptive statistics before the training only 16.7% reveal very high knowledge, while 33.3% show very low knowledge. In the domain of hypothesis testing 9.5% declare very high knowledge while very low 38.1% of them. Almost the same results are revealed in correlation analysis and categorical data analysis where 7.1% of participants declare very high knowledge and 38.1% of them very low knowledge. While respect to regression analysis only 4.8% of participants declare very high knowledge and 42.9% of them reveal very low knowledge.

Findings from analysis of after training data were so promising, in data entry and descriptive statistics only 4.8% of participants declare very low knowledge while 61.9% of them declare very high knowledge. Most notably, the increase in the performers in data entry from 40.5% to 61.9% shows a positive effect and the increase in the performers from 16.7% to 61.9% in descriptive statistics shows a strong positive effect.

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In the domain of testing hypothesis and regression analysis only 4.8% of participants declare very low knowledge while 42.9% of them declare very high knowledge. Compared to before training, there is an increase in the very high level of knowledge from 9.5% to 42.9% in testing hypothesis and from 4.8% to 42.9% in regression analysis which shows in both cases a strong positive effect. After training only 7.1% of participants in the domain of categorical data analysis declare very low knowledge and 40.5% of them declare very high knowledge. Compared to before training the increase in the very high level of knowledge from 7.1% to 40.5% shows a strong positive effect.

This shift of participants from very low knowledge to very high knowledge levels provides evidence of the effectiveness of the training sessions. The application of the Wilcoxon Sign-Rank Test further confirmed that the above changes are statistically significant for all domains ($p<0.05$). The outcome reveals a noteworthy distinction between the participants' proficiency in using SPSS to process quantitative data prior to and following the SPSS training practice. On average, participants performed better after the training than before.

Recommendations

These findings demonstrate the success of the training in building statistical competencies and suggest that similar training formats could be beneficial in other educational or professional development settings. Overall, the program proved effective in addressing knowledge gaps and equipping participants with practical skills in SPSS-based data analysis. Based on these findings, it is recommended that future training be organized for a broader audience, including students, researchers and professionals from different fields. This would help ensure the sustained development of statistical skills. Furthermore, future training could benefit from the inclusion of domain-specific or advanced modules—such as time series analysis or multivariate analysis—in order to address different levels of expertise and meet specific research or professional needs. Making these efforts would not only reinforce the impact of the initial training but also promote long-term competency in statistical analysis using SPSS.

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Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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