

## A SYSTEMATIC LITERATURE REVIEW OF 21ST-CENTURY DIGITAL LEARNING TRENDS AND TEACHERS' TECHNOLOGY INTEGRATION

Ahyani Radhiani<sup>1,\*</sup>, Sriayu<sup>1</sup>, Muh. Arqam<sup>2</sup>, Farouk Abouseada<sup>3</sup>, Asmaul Husna RS<sup>4</sup>

<sup>1</sup> Universitas Nani Bili Nusantara, Papua Selatan, Indonesia

<sup>2</sup> Universitas Lambung Mangkurat, Kalimantan Selatan, Indonesia

<sup>3</sup> University of Texas Rio Grande Valley, Texas, United States

<sup>4</sup> Universitas Bima Internasional MFH, Nusa Tenggara Barat, Indonesia

Corresponding author email: [ahyani.unbn@gmail.com](mailto:ahyani.unbn@gmail.com)

### Article Info

Received: Jan 10, 2026

Revised: Jan 30, 2026

Accepted: Feb 16, 2026

OnlineVersion: Feb 19, 2026

### Abstract

The rapid advancement of digital technology has reshaped communication, information access, and knowledge construction. In education, its integration into 21st-century learning is central to enhancing quality and relevance. Educational institutions worldwide are increasingly adopting digital tools to enrich learning experiences, with digital learning defined as the use of technology and devices to support more engaging, explorative, and interactive learning. This study aimed to determine contemporary trends and developments in 21st-century digital learning through a systematic literature review conducted in accordance with the PRISMA guidelines. A total of 56 articles, published between 2020 and mid-2025 and retrieved from the Scopus database based on predetermined inclusion criteria, were analysed. The findings underscore the critical role of digital technologies in enhancing learning practices. Results indicate that scholarly attention to digital learning peaked in 2024, as evidenced by a notable increase in publications. The majority of research contributions originated from Asia, with digital learning most extensively implemented in higher education institutions. From a scientific perspective, STEM fields were identified as the most frequent adopters of digital technologies in their learning practices. Among the various technological tools employed, game-based learning emerged as the most prevalent, demonstrating substantial contributions to learning effectiveness. Furthermore, the integration of digital technologies into educational contexts was found to enhance learning outcomes, problem-solving abilities, motivation, and students' character and literacy development. Collectively, these findings provide a comprehensive overview of current trends in the application of digital technologies in education and offer valuable insights for policymakers in formulating effective technology-based educational strategies.

**Keywords:** 21st-century Learning, Digital Learning, Trends in Ict, Trends in Digital Learning, STEM Education.



© 2026 by the author(s)

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<https://creativecommons.org/licenses/by/4.0/>).

## INTRODUCTION

Education being one of the basic pillars of national development means that the quality of education system in the country directly proportions with the development of the society. Considering the fast growth of knowledge and digital technology, it is possible to state that educational processes that are well adjusted to the technological progress have greater and more positive results than the old ones. Receptiveness to science and technological advances makes it possible to provide educational practitioners with timely, effective, and efficiency learning experiences.

The twenty-first century has presented the world with more challenges and demands in the field of education than ever before due to the accelerated social, economic, and technological changes. The nature of knowledge and skills demanded has been in a way transformed by the historical development of the society, its agrarian to industrial and then the information era. The traditional educational paradigm, which focuses on imparting information is no longer adequate to equip learners with the demands of today life (Tindowen et al., 2017). As a result, the need to develop and execute models of learning that support the requisite competencies, life, and adaptive skills is urgently needed to effectively react to the dynamics of globalization which are unpredictable.

To respond to such demands, twenty-first-century learning is theorized as a comprehensive learning design that goes beyond mastering the content to include the growth of the critical competencies, predominantly critical thinking, creativity, communication and collaboration, which can be referred to as the “4Cs”. Moreover, modern students must also have high levels of digital literacy together with the lifelong learning ability (Chu et al., 2017). These competencies are a substantial foundation that helps one to operate in efficient problem-solving, make informed decisions, and use knowledge in real-life situations, making them productive, adaptive, and innovating members of the society.

The digitalization of education has become one of the main triggers of improving the quality and relevance of learning in the context of this paradigm shift. Digital age has changed the expectations of the learners given that students are now growing in the technology-based environments and expect similar learning experiences. Digital technologies should not be effectively used in terms of using tools; this also relates to the design of flexible and responsive learning environments that will address the changing needs of students (Cheung et al., 2021; El-Sabagh, 2021). Educational practices, according to the principles of student-centered 21 st century learning, should be related to the real walked-life settings so that the learners can obtain knowledge by various sources, how to formulate problems, think analytically and as teams to solve the complex problems.

Technology integration can help improve professionalism of the teachers, engage students and make the whole learning process richer. Teachers are supposed to promote learning based on the four pillars suggested by the UNESCO international commission on education: Learning to Know, Learning to Do, Learning to Be, and Learning to Live Together (Evans & Pawlina, 2022). These pillars demand that teachers should be creative, hard-working and dedicated to lifelong learning. This means that teachers are recruited to assume more active and innovative roles in the learning process.

One actual solution to these educational issues is digital learning. The terms “global” and “digital” indicate two correlated transformative forces of globalization of the economies and Web 2.0 technologies development (Kulaca et al., 2024; Mirra & Garcia, 2021). Students are able to acquire experiences through digital learning which contribute to knowledge and skills that will be relevant in global challenges navigation. Digital technologies do not only act as instructional media but also help with real-time assessment, enable collaborative learning across the regions in addition to measuring competency achievements in an integrated manner (Haleem et al., 2022; Timotheou et al., 2023).

Digital learning is the process of learning based on the idea of using digital technologies and devices in order to make learning more interesting, interactive, and enjoyable. The teachers can consider a great variety of technologies to make the process of active student participation more interactive, and the online learning platforms and services turn out to be the essential elements of serving as a guiding force in assisting the modern learning process (Aldhafeeri & Alotaibi, 2022; Bergdahl et al., 2020). Nonetheless, successful implementation of digital learning presupposes the in-depth insight of the emerging trends. The adoption of digital technologies in the educational sector has seen the impressive growth within recent years, especially within the period of post-COVID-19 (Shenkoya & Kim, 2023; Wang et al., 2024). Schools and academic centers in different nations have increasingly embraced learning technologies like Virtual and Augmented Reality (VR/AR), Artificial Intelligence (AI), Simulation and Robotics applications, and Learning Management Systems (LMS) (Albar et al., 2025; Mehrotra et al.,

2021; Moral-Sánchez et al., 2022; Radhiani & Abouseada, 2025; Rahimi & Teimouri, 2025) to enhance the learning process. It has been shown that the technological pedagogical competences of teachers are closely related to the complexity of learning activities of students (Sailer et al., 2021). Consequently, the proposed study will use a systematic review as a method to investigate and discuss the important tendencies of digital learning in the 21st century with an ultimate goal to offer a comprehensive perception that can become a practical guide to teachers, curriculum developers, and policy makers.

**RESEARCH METHOD**

The current research carries out systematic literature review. The typical literature review will span between three to five years depending on the topic of discussion and the number of scholarly contributions that have been made (Marzi et al., 2025). In line with this, this research paper reviews the studies discussing the trends in digital learning between 2020 and 2025. Integration of past research findings in a holistic way can be used to come up with the synthesis of various literature. In this regard, a Systematic Literature Review (SLR) has been considered the most rigorous and scholarly methodological strategy as it focuses on methodological accuracy, strong argumentation, and an increased degree of objectivity and transparency (Kraus et al., 2020; Sauer & Seuring, 2023). Not only does a systematically and carefully structured SLR enable the researchers to exhaustively gather and combine extant evidence, but it also provides the relevant and credible empirical bases to the policymakers to devise the data-driven decisions (Carrera-Rivera et al., 2022; Mengist et al., 2020). The PRISMA statement framework (Page et al., 2021) is chosen in this work as it offers a systematic and clear method of identifying, filtering, and selecting articles needed to complete a systematic review.

The systematic review is structured in a way such that it outlines the selection criteria of articles, literature search strategy, data extraction process, as well as data analysis procedures (Tedja et al., 2024). The particular steps that were applied during this study are as follows: (1) determination of novelty in research, formulation of research questions and definition of the boundaries of the study, (2) development of inclusion and exclusion criteria, search queries and data base selection, (3) search of literature, screening of data and carrying out of cross-checks to determine feasibility of the identified studies, (4) data selection and analysis of the data in details to answer research questions, (5) compilation of research report in compliance with PRISMA principles.

The search process of the articles assumes the definition of several categories, such as data sources, search keywords, and article criteria (e.g., language, period of publication, and type of articles) (Kerimbayev et al., 2025). Since publications concerning digital learning have increased tremendously, the selection criteria used to select the articles was tailored to include those studies within the boundaries of this study. The inclusion and exclusion criteria used to select data were clearly stated, and they were followed to increase the validity of the results.

Table 1. Inclusion and exclusion criteria for article selection

| Criteria             | Inclusion   | Exclusion  |
|----------------------|---|--|
| Focus of the article | 21st-century learning based on digital technology                   | Articles that did not focus on 21st-century learning based on digital technology |
| Publication date     | January 2020 – June 2025  | Prior to January 2020 – June 2025  |
| Publication type     | Scholarly articles of original research from peer reviewed journals | Book chapters, technical reports, dissertations, or proceedings                  |
| Language             | Articles written in English   | Articles written in languages other than English                                 |

For the article search, the Boolean search string applied was as follows: TITLE-ABS-KEY ( 21st AND century AND digital AND learning ) AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND ( LIMIT-TO ( LANGUAGE , "English" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) . Scopus was selected as the primary data source for the literature search. Scopus is a multidisciplinary database launched by Elsevier in November 2004 (Pranckutė, 2021). Approximately three million new items are added annually, making it one of the largest abstract and citation databases worldwide. Its content covers over 39,100 serial titles, 120,000 conferences, and 206,000 books from more than 5,000 publishers globally (Baas et al., 2020).

The filtering of the data was performed manually through extraction of information as per the set criteria. To conduct the search in Scopus, two researchers applied the search query to the database on 8 July 2025 and selected a Boolean search query as a search result, which returned an initial set of 683 studies (see Figure 1). Screening of titles and abstracts on the relevance to use of digital technology in 21 st century learning led to the identification of 136 studies. The rest of the articles were then screened by reading the titles and abstracts based on the set inclusion and exclusion criteria to make sure that only articles that had empirically relevant information were included. Thirty-seven articles were filtered out of the screening process because of unreadable or missing texts. The end result was 99 articles that were retained to undergo further detailed analysis as per the pre-established criteria. After the full-text review, 43 studies were excluded because they could not satisfy the inclusion criteria, and there remained 56 studies, which were considered eligible to be included in the final analysis.

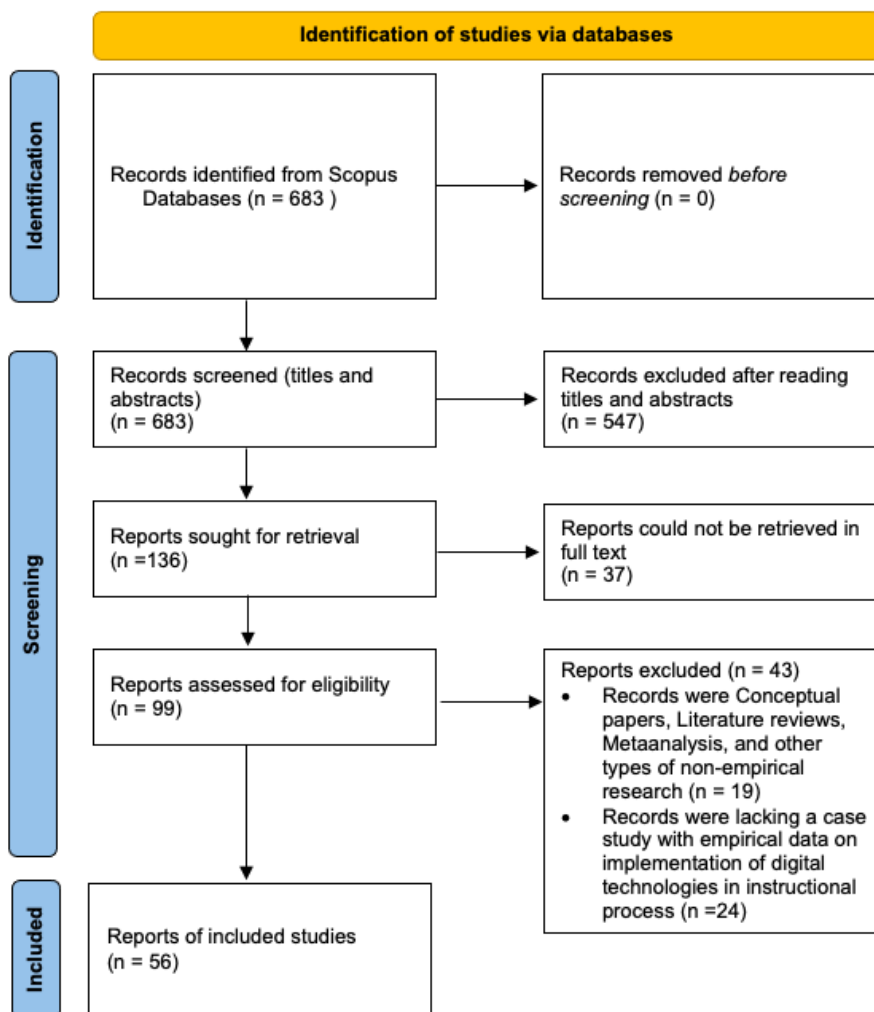


Figure 1. PRISMA Flow Diagram of Article Selection

The 56 remaining studies were subjected to the final data extraction process. In order to have the validity and reliability of the extraction, the research team coded information in a deductive way. The use of data codes was based on the theoretical framework and coding techniques used in previous studies (Alenezi, 2023; Vaicondam et al., 2022; Zou et al., 2025). This step was also taken in order to prepare the particular information of the articles systematically by collecting the information of the Scopus database, the authors affiliation, the time period of publication, the academic field, the geographical location and the research results. The minced data were further tabulated to an existing Excel data collection sheet. In order to make it easy to address the research questions, definite categories were formulated as follows:

R1- article title, authors, year of publication, location, education level, discipline, and type of digital technology implemented; R2- Study findings and a summary of the implementation of digital technology in learning;

**RESULTS AND DISCUSSION**

**Number of Research Studies and Geographical Distribution**

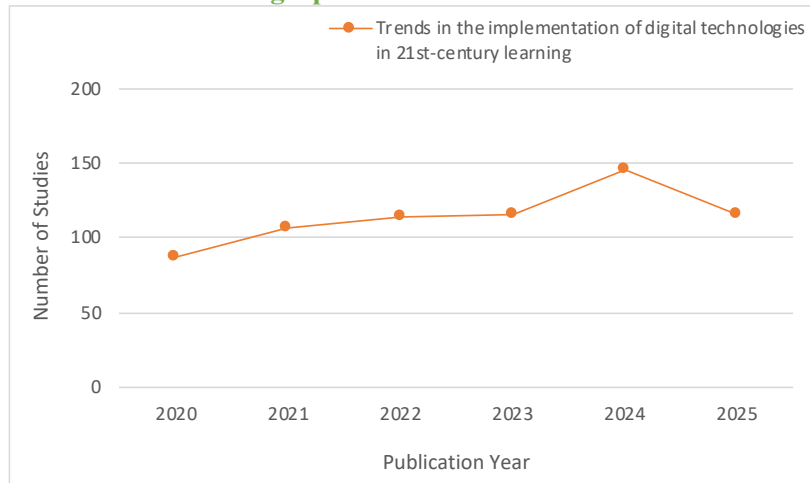


Figure 2. Annual publication trends

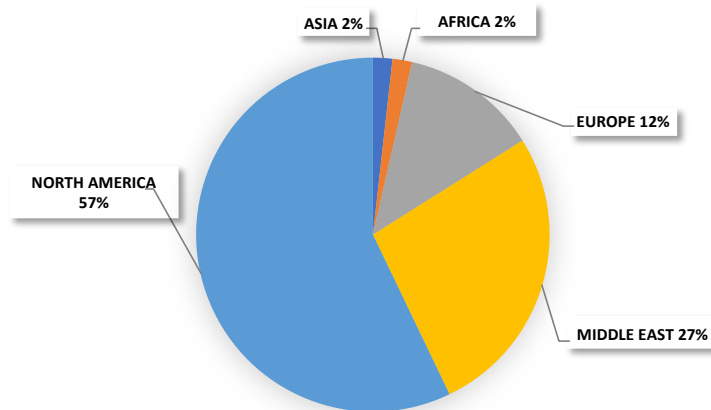


Figure 3. Geographical distribution of selected papers

Figure 2 shows the future development of the studies of the introduction of digital technologies to learning in the 21st century during 2020-2025. The data was captured until 8 June 2025; thus, the number of 2025 does not give the complete number of publications in this year. The general tendency is that the scholarly interest in this area is on the gradual rise of the annual level and is the indication of the enhancement of the understanding of the importance of technology in the development of competencies demanded in the 21 st century learning process.

The highest activity in terms of publication was recorded in 2024, the upsurge due to the further digital revolution in the educational sector during recent years. On the contrary, the number of publications in 2025 is lesser. This should however not be taken to mean that there is a loss of interest in research. Instead, the seeming reduction is explained by incomplete data collection, which was done in the middle of the year. Combined, the results can be seen as the continuing and intensifying scholarly interest in digital technology integration in education, especially the way to meet the demand of more innovative, flexible, and digitally literate solutions to 21st-century learning. There is a high level of diversity of the studies reviewed in terms of the geographical location as shown in Figure 3. As the analysis demonstrates, most studies on the use of digital technologies in the learning process have been done in Asia (57 -percent), then Europe (27 -percent), and then Middle East (12 -percent). By comparison, the contributions of North America and Africa only reached 2 %.

The preeminence of Asia highlights the commitment of the region towards realizing digital transformation in the education sector (Jamalai & Krish, 2021; Hsu & Wu, 2023; Huda et al., 2024; Liamruk et al., 2025). Compared to it, the underrepresentation of other regions illustrates the necessity of having a more global involvement in order to develop a more balanced and inclusive perspective of digital technologies integration in 21st-century learning.

### Disciplinary Focus and Educational Levels

The diagram suggests that implementation of digital technologies in 21st century education is spread across three major disciplinary fields: Science, Technology, Engineering and Mathematics (STEM); Social Sciences and Humanities (SSH) and Health and Medical Sciences. The most popular field is obviously the one that deals with the most numbers of studies (54% of the studies), followed by the SSH (39%), and Health and Medical Sciences (only 7%). Thus, while the use of digital technologies is becoming synonymous with a wide range of academic fields, they remain disproportionately concentrated in the STEM fields. The relatively limited use in the Health and Medical Sciences may be explained by some particular challenges, including stringent regulatory environments, high financial investment, and need for highly developed technical infrastructure (Godsk & Møller, 2025).

Based on the diagram, educational levels in the reviewed studies are grouped into 5 groups: Early Childhood, Elementary School, Middle School, High School and University. As we see in Figure 5, the integration of digital technologies is most visible at the university level (48% of respondents), followed by integration at the K-12 levels, at High School (20% of respondents), Middle School (16% of respondents) and at Elementary School (12% of respondents). Early Childhood education is the lowest at 4% only. This distribution suggests that the use of digital technologies is more common in the secondary and higher education context. The higher the educational level the higher is the complexity of learning materials and therefore the pressure for the need of technological support in the teaching and learning process is increased. The trend also reflects the comparative advantage of the universities in introducing digital technologies and it is due to the stronger infrastructure capacity at the universities and the focus on promoting autonomous learning (Kim et al., 2020; Keane et al., 2023).

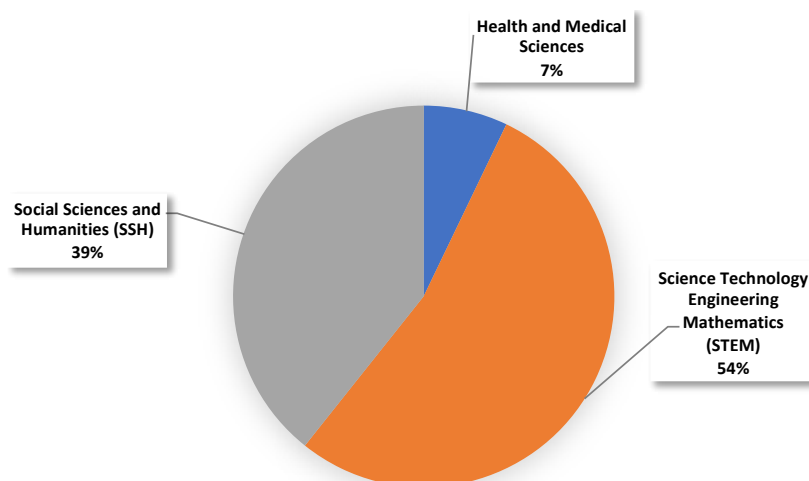


Figure 4. Disciplinary focus

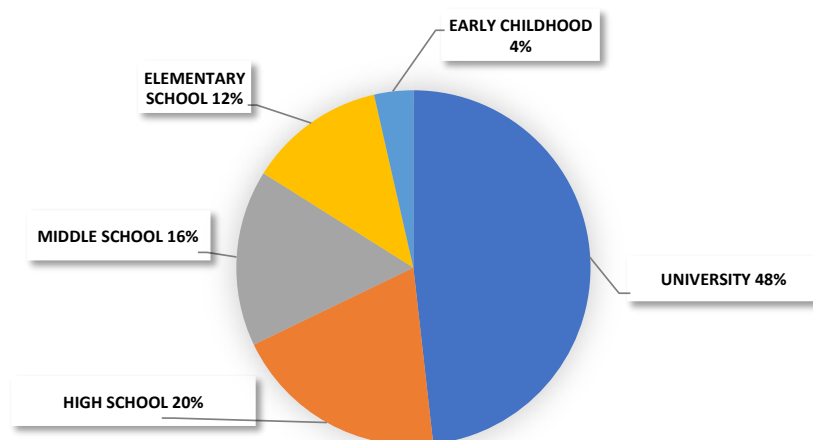


Figure 5. Educational Levels

### Types of Digital Technologies Used

The diagram demonstrates that the integration of digital technologies in 21st-century learning is markedly diverse. As depicted in Figure 6, Gamification and Game Based Learning represent the largest category (27%), followed by Electronic Books (18%), Web Based Learning (13%), Extended Reality (12%), AI Based Learning (9%), Multimedia and Digital Content Based Learning (7%), Mobile Learning and 3D Learning (5% each), and Simulation and Robotics (4%). This distribution suggests that each form of digital technology fulfills distinct pedagogical functions, shaped by contextual needs, available resources, and targeted learning objectives. When effectively implemented, these technologies have the potential to enhance learning quality while fostering alignment with the competencies and demands of the digital era (Karpouzis et al., 2024).

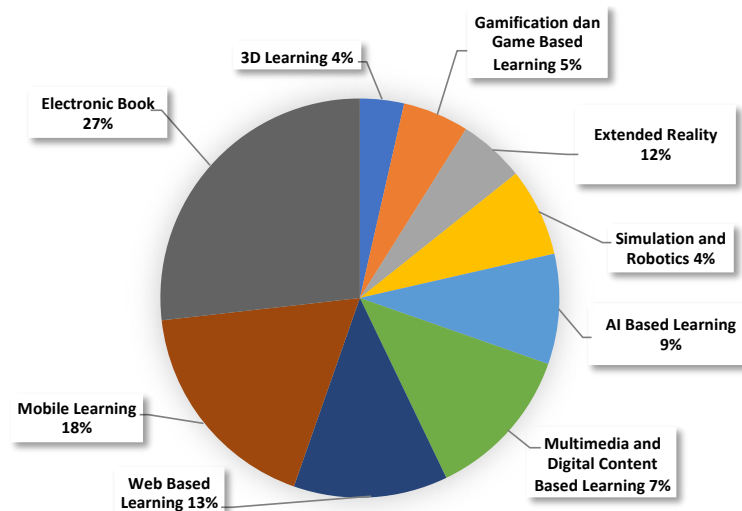


Figure 6. Types of Digital Technologies

### Higher Education

A total of 27 studies were examined concerning the integration of digital technologies into teaching and learning within higher education level.

### Science Technology Engineering Mathematics (STEM)

Within the STEM disciplines, at the higher education level, 14 studies dealt with the integration of digital technologies in the learning process. Three of them in particular researched Gamification and Game-Based Learning. (Andersen & Rustad, 2022) analyzed the use of Minecraft game in math education. This research used a combination of Social Network Analysis (SNA) and Interaction Analysis (IA) to illustrate the patterns of social interaction and collaborative dynamics between students in the course of learning activities with Minecraft. The results showed how students participated in the game activities and engaged in participation and collaboration through activities within the game. (Hagerer, 2025) assessed the use of a serious educational game, PlayMINT, which incorporates a mix of simulation, avatar interaction and digital feedback loops. The results of the study showed that PlayMINT was successful in helping female students in the field of STEMinity develop leadership, creativity, communication, and decision-making skills. Similarly, (Parody et al., 2022) incorporate gamification using the platform Classcraft in a mathematics course. Their study evaluated both academic performance and the learning of 4Cs skills (collaboration, critical thinking, communication and creativity) through game elements such as experience points and rewards, as well as role-playing. The results showed that students participating in gamified learning showed substantial improvements in 4C skills, and were also more motivated and experienced positive experiences with the Classcraft platform.

Three studies were on the usage of the Extended Reality technologies. Inmakerspace courses, (Radu et al., 2023) integrated Augmented Reality (AR), a space where students are actively involved in the co-design of the space. The AR applications were meant to provide support for STEM learning activities that cannot easily be visualized in traditional ways, for example, representing invisible things in experiments, such as electric currents or the movement of objects. The study found that students participating in the AR co-design process showed the improvements in their understanding of technological design principles and critical thinking skills about the technologies they designed and used. (González-Pérez & Marrero-Galván, 2023) used infographics and AR to facilitate analogy based learning

among pre-service science teachers. The AR used in this study was marker tracking based and students were able to interact with three dimensional models, such as oxygen atoms, which enabled them to understand abstract scientific concepts. The study brought out that the analogy plus the digital combination, the infographics and the AR, were viewed very positively and had a key role in boosting the efficiency of science education. (Erçağ & Yasakçı, 2022) created a mobile-based AR application which was integrated into the 7E Learning Model for computer science courses. In the design process AR drove in line with the seven stages of the 7E model (Engage, Explore, Explain, Elaborate, Evaluate, Extend, and Elicit). The results showed that the integration of AR in the framework of 7E led to increasing participation of the students and improved learning skills and positive attitudes towards the course.

Two studies examined the AI-Based Learning. (Bayaga, 2024) investigated the relationship of gamification, Artificial Intelligence and mathematical cognition by using a Game Based Learning approach. The data analysis methods used in the study were multigroup partial least squares structural equation modeling and artificial neural networks by multilayer perceptron. The results showed a significant positive contribution to the engagement of the classroom, the attitude of students toward mathematics, and the overall academic performance. Moreover, the results showed the gender-related differences, thus confirming the robustness and consistency of the proposed model among different groups. (Wei et al., 2025) looked at the effect of Generative Artificial Intelligence (GAI) tools such as ChatGPT, Midjourney, and Runway on Collaborative Problem-Solving skills, Team Creativity Performance, and perceptions of students regarding the role of the GAI in Digital Storytelling (DST) development. The GAI tools were used as collaborative platforms for the creation of DST projects. Specifically, ChatGPT facilitated the collaborative work of creating stories by allowing students to create and revise stories using brainstorming and ongoing feedback. The study showed that incorporating GAI tools into the development of DST significantly increased Collaborative Problem - Solving skills in students. Furthermore, the research showed that, while students had an overall positive view of the use of GAI in the creation of DSTs, they also expressed issues about potential cognitive offloading, over-dependence on the use of GAI technologies, and lack of emotional support within such technologies.

In the area of Multimedia and Digital Content Based Learning, (Elçiçek & Karal, 2020) prepared an online learning model using video-based learning in programming education. The videos were created with Adobe Captivate and then incorporated into the Moodle Learning Management System (LMS). Using the video materials, the learning environment also included an online code editor, giving learners a chance to practice programming at the same time as the instructional videos. The findings of the study believed that there are four critical factors that must be considered in order to establish effective online video-based instruction in programming. First, the instructional content should be arranged in a systematic way, consistent with the prior knowledge of the learners, and regularly refreshed. Second, the visual design should be interesting and easy to understand. Third, interactive features should be built in to encourage learners to be active in posing questions and engaging in discussions, and participate meaningfully. Finally, the design of the learning platform must be practical and easy to use for both teachers and students.

Three studies reviewed the use of Web Based Learning. (Ruiz et al., 2021) used PoliformaT and Microsoft Teams in the teaching of maths during the pandemic. These platforms were integrated into a blended learning framework. Sanchez Ruiz flipped the model of teaching, where the most part of learning content was prepared and studied online by students before they went to face-to-face sessions which were delivered through live classes on Teams. PoliformaT was employed for dissemination of materials and learning management and Microsoft Teams was used for communication and virtual interaction within the blended learning framework, thus sustaining learning adaptations amid the pandemic. The study showed that the use of digital resources and educational platform significantly changed the learning pattern of the students and contributed to improving their digital habits and skills. (Lapisa et al., 2025) analysed effectiveness of a Rifdarmon-based e-learning model on improved learning outcomes and development of 4C skills (creativity, critical thinking, collaboration and communication) in the Automotive Electrical Engineering courses. The Rifdarmon model organized learning activities with the specific aim of developing these competencies, such as problem-based projects which required the students to work together on the Internet and deliver their products on digital formats. The results of the study showed that the combination of e-learning and the Rifdarmon model had a positive impact on the academic performance and the stimulation of the development of complex competencies of the students. (Zotova et al., 2021) looked at the integration of Massive Open Online Courses (MOOCs) via the Khan Academy online platform into engineering education, in this case in the area of fire safety and safety of

the technosphere. Students participated in hands-on tasks and team learning with the use of simulation software such as PyroSim, Pathfinder and FireRisk. The integration of digital pedagogical tools with the students had a positive effect on the acquisition of fundamental engineering competencies, especially in the development of professional knowledge and skills for fire safety projects in simulated risk situations.

Other studies focused on the use of the Mobile Learning and the Electronic Books. For example, (Indrawati et al., 2025) blended cooperative learning strategies that were grounded in Treffinger's creativity model, and a blended learning model enabled through the social media site Facebook in physics courses. The structure of the learning was structured by Treffinger's stages of creativity development - fluency, flexibility, originality, and elaboration. These stages were implemented in blended learning activities using a mixture of face-to-face interaction and online discussions & reflections using Facebook. Students had the opportunity to interact with each other, exchange ideas, and build knowledge together outside of class hours through asynchronous discussion features on the platform. The study concluded that Facebook as a medium in the blended learning addressed technical challenges, encouraged participation of the students and created an inclusive and collaborative learning environment. Similarly, (Riyanto et al., 2020) created an interactive Flipbook-based digital learning media using the assistance of Aurora 3D Animation Maker and incorporated into the Anchored Instruction learning model for a genetics course. The development process consisted of three stages; namely, the development of instructional animation videos using the Aurora 3D Animation Maker, the compilation of the Flipbook in line with the syntax of the Anchored Instruction model using the Kvisoft Flipbook Maker Pro, and the production of the Flipbook in various formats such as the Html, EXE and SWF. The results of the study showed that implementing the Flipbook, which was created by using the application Aurora 3D Animation Maker and the Anchored Instruction approach, had a significant impact on the increased engagement of students and the improvement of their critical thinking skills.

### Social Sciences and Humanities (SSH)

In the field of Social Sciences and Humanities (SSH) and especially with the concept of higher education, there are nine studies that discovered the integration of technology in the learning process. These include two studies into the use of Gamification and Game-Based Learning. (Hsu & Wu, 2023) investigated the success of the combination of Project-Based Learning (PBL) and Business Simulation Games (BSGs) using a flipped classroom model in an e-Commerce course. A licensed simulation game, the Cross-Border E-Commerce Marketing and Operations Simulation (CEMO Simulation), was used which was specifically developed to create a virtual operational environment for Cross-Border E-Commerce (CBEC). The online CEMO BSG included market environments, e-commerce platform data analytics and other specific operational activities. The results of the study showed that incorporating the use of business simulation games in the flipped classroom approach proved to be a good way to enhance the learning of students while at the same time improving their critical thinking and creativity and problem-solving skills. Similarly, (Ghani et al., 2022) discussed the application of mobile based digital games to Arabic Language instruction. The game was designed specifically as a vocabulary acquisition tool, where a simple mechanism of gameplay is used (drag-and-drop). Features such as sound elements, including recorded pronunciations, supported students to enhance Arabic listening and speaking skills that ultimately resulted in significant improvements in learning outcomes and vocabulary development.

Two additional studies were conducted on the use of multimedia and digital content-based learning. (Girón-García, 2024) possible multimodal characteristics of youtube videos as an emerging digital genre in English language courses, with a specific interest in the case of legal English instruction. Animated videos on the following theme Sources of International Law with a duration of 1 minute 06 seconds to 1 minute 54 seconds were used for improving listening, writing and vocabulary acquisition skills of students. The investigation proved that the combination of embodied modes (gestures, facial expressions) with filmic modes (moving images, voice-over narration), accompanied with subtitles, resulted in an effective multimodal ensemble that promoted the teaching and understanding of international law in Legal English classrooms. Similarly, (Huang, 2021) studied the use of smartphone-based collaborative video projects in English language courses. The results showed three main contributions of the integration of collaborative vlog projects, among others: the stimulation of the speaking skills of students, the development of 21st century skills, especially in the field of digital media production, the improvement of the engagement and the group skills of the students.

Two other studies investigated the use of web-based learning. (Jamalai & Krish, 2021) looked at the use of online discussion forums (ODFs) that are embedded with a university learning management

system to support English language learning. The study revealed the potential of the ODFs as platforms that promoted language development through discussion and knowledge sharing in group assignments, thus promoting active participation of the learners and gave passive learners more chance to express their opinion in a confident way. In another study, (Jamali et al., 2025) examined the use of digital discussion forums (DDFs) in English classes. Forum rules requiring the exclusive use of English proved to reduce tendencies towards code-switching and to enhance communicative competence of the students.

In the context of the integration of artificial intelligence (AI), mobile learning and electronic books, there are several studies that give important insights. Regarding AI-based learning, (Khlaisang & Sukavatee, 2023) evaluated the use of MALLIE, which is a chatbot-based mobile assisted language learning application. MALLIE included features of a chatbot and iReview that were intended to help English language skills development (listening, speaking, reading and writing skills) and encourage the development of 21st-century skills, such as communication and collaboration. In terms of mobile learning, (Pratiwi et al., 2020) discussed the use of mobile assisted language learning (MALL) in the case of English as a foreign language learning. Mobile devices (smartphones, tablets, laptops and computers), which provided voice recorder functions, supported places for offline and online speaking practice, and vocabulary, spelling and pronunciation checking. Social media platforms (including YouTube, Facebook, Instagram, WhatsApp) were also used as additional resources for informal language learning from peer and community interactions. The study concluded that MALL encouraged flexible learning because it allowed learners access anywhere and anytime. Moreover, MALL offered a variety of educational resources and helped instruction in formulating learning materials that were more effective and interesting. Finally, about the electronic books, (Susanti et al., 2025) explored the use of electronic modules (e-modules) to improve critical-thinking skills for English language teaching. The study used the Conversational Framework of Laurillard as the basis for the instructional design of the e- module which incorporated information and communication technology (ICT) into the learning process. Students accessed and downloaded the e-modules from a learning management system. The findings showed that the e-module showed a great potential in enhancing critical thinking skills of the students.

### Health And Medical Sciences

In the field of health and medical sciences, especially in higher education, there were four studies that incorporate technology into the learning process. Two of these studies involved the use of 3D learning. (Ralte et al., 2023) investigated the use of 3D technology with the study of human anatomy, showing that, in contrast to traditional cadaveric dissection, which has some limitations in terms of observing small anatomical structures or some anatomical structures that are less accessible from the cadaver (such as the ear, limbic system or fibrous skeleton of the heart), virtual 3D dissection allows students to rotate and dissect anatomical models interactively. This capability enables learners to visualise structures of the anatomy in three-dimensional orientations and gain a better understanding of the spatial relationship between structures of the body that are otherwise hard to access through traditional cadaver-based dissection. Similarly, (Tiznado-Matzner et al., 2020) studied the application of 3D learning in the study of anatomy. Their results proved that the use of 3D models is very effective in anatomy education especially considering the limitations of the laboratory capacity, which is often higher than the number of cadavers, available body donations are limited, in this case to restrict the opportunity for students to go in depth of anatomy exploration.

In terms of gamification and game-based learning, in the study by (Sáiz-Manzanares et al., 2021), a digital game-based learning model was created in which the aim was to increase the motivation of the student and their academic performance by integrating the H5P plugin within the learning management system (LMS). The gamified activities included crossword puzzles, word search, memory games, word sequencing and true/false questions. The results showed that gamification of health sciences curriculum has a significant impact on how well students learn and engage in the course, especially in the context of clinical practice. More specifically, the use of game-based approaches enhanced LMS interaction and led to measurable improvements in the academic performance of nursing students. With regard to the issue of AI-based learning, (Agaoglu et al., 2025) focused on the effects of artificial intelligence on the creative thinking ability of nursing students. Their study showed that the AI technology in education has a lot of potential to help with the development of digital competencies in students, as well as help them develop creative thinking. However, the findings stressed out that in order to maximize the benefits of AI, academic support mechanisms - including instructor guidance, structured pathways for learning and appropriate assessment systems - are key.

**K12**

Twenty-seven studies have been reviewed concerning the integration of digital technology into learning processes at the K–12 level.

**Science Technology Engineering Mathematics (STEM)**

Within the field of STEM, especially at primary school level, there were three studies which focused on how Game-Based Learning (GBL) and gamification can be used in learning. (Laakso et al., 2021) had introduced maker culture into schools with collaborative game design projects using Scratch, GDevelop and Unity in science and technology courses. The results of the research in the study reported that developing digital skill, both technical and artistic, was improved by students in collaborative game design projects and also developed their ability to collaborate by distributing roles in their groups. As a result, problem-solving skills of the students and creative expression were further developed. Similarly, (Ramli et al., 2022) used digital GBL with Learning Analytics (LA) for mathematics teaching. The results showed that compared with the traditional teaching approach, GBL also showed a significant improvement in student's achievement in mathematics. LA was used to gather digital data from GBL applications, allowing teachers to track the progress of students in real-time, as well as to predict learning results. This allowed early interventions for those students who were at risk of lagging behind or who were having difficulties with learning mathematics. In another study, (Deng et al., 2020) investigated the Making Thinking Visible instructional approach in conjunction with a digital game, Wuzzit Trouble, in order to evaluate student engagement and interest in learning mathematics, specifically in relation to prime numbers, addition, subtraction, multiplication, division, fractions and polynomials. Their findings suggested that the digital game-based learning did a good job in enhancing student engagement. However, some students reported issues in using such learning activities to help achieve the acquisition of important mathematical knowledge, which may impact on academic achievement. Furthermore, negative physical and mental health effects, such as eye strain, were also found as potential negative aspects of long-term game-based learning.

In the field of STEM learning education at the junior high school level, four research studies were found which infuse digital learning. Two of these were using Extended Reality technologies. (Maulana et al., 2025) designed a science learning medium using the concept of Virtual Reality and Augmented Reality. Their results showed the application of VAR significantly improved student engagement, learning interest and Higher Order Thinking Skills (HOTS). Similarly, (Moral-Sánchez et al., 2022) devised a gamified learning approach of STEM subject to enhance learning with the usage of AR, VR, and manipulatives, social networking, mobile learning, cooperative learning, and flipped learning would enable methodology transformation. The study has been done in two cycles. In the first cycle, the learning process used the Edmodo platform to submit the assignment and receive the badge, but this stage was not fully gamified as it did not have gamification features. Final assessment was done through Gymkhana using basic technologies like smart phones and virtual maps etc. In the second cycle, gamification was implemented with the help of the Classcraft platform. At the same time, evaluation was conducted via Breakout EDU which incorporated elements of smartphones, augmented reality, virtual reality and video game elements like quizzes and QR codes. The results showed that the learning motivation of students, academic achievement, participation, and group cohesion of mathematics is significantly increased in the second cycle. This was attributed due to the iterative development of the second stage which was characterized by higher level of complexity in learning features, more sophisticated gamification elements and a wider variety of evaluation methods and activities that encourage active interaction by learners.

Two studies used Electronic Books (e - modules). (Pantiwati et al., 2025) designed an android based e- module, based on project-based learning which forms the basis of literacy and character formation in science education. The prototype has been developed with the help of Android Studio and JavaScript. Findings showed that use of this e- module showed significant improvement in enhancing the conceptual understanding as well as problem solving skills of the students. In the context of character development and scientific literacy, the e- module did positively contribute with project-based peer learning activities. Likewise, (Pramasdyahsari et al., 2023) came up with a digital book designed based on STEM Project based Learning (STEM-PjBL) for mathematics teaching. The Flip PDF Pro software was used to design the digital Flipbook, while the Adobe Animate was used to create animations and interactive elements embedded in the digital book. Their outcomes showed that the digital book introduced multiple activities and exercises in line with Engineering Design Process (EDP) which stimulated and developed student's mathematical critical thinking skills.

Within the scope of STEM education at the senior high school level, nine studies were found in which digital learning is integrated. Two of the studies were concerned with gamification and game-based learning. (Rizki et al., 2024) created a digital learning medium called Adventuring Physics which combines an adventure-type digital game with marker-based Augmented Reality (AR) as a single Android mobile application. This medium was realised in the form of the Cooperative Academic Puzzle (CAP) model which includes collaborative learning activities, problem-solving in game contexts, and visualisation of abstract physics concepts such as magnetic fields, magnetic forces, and current direction through AR. The implementation was based on a structured lesson plan with initial motivation, information delivery, group organization, guidance, evaluation, and recognition. Findings showed that the integration of this digital medium in the CAP model greatly improved critical thinking ability as well as the learning motivation of students in physics education. Similarly, (Mårell-Olsson, 2021) incorporated gamification in biology teaching by using the Octalysis Framework which incorporated the use of points and clues to promote motivation and collaboration between students. The gamified activity has been designed as a treasure hunt, composed of a number of sub - activities. Students played in teams to gather points and clues needed to solve a final challenge. Findings suggested that gamification can be a good way to motivate and engage students in learning. Nevertheless, the study stressed that the use of technology tools and pedagogical strategies must be carefully balanced by the teacher to ensure meaningful and effective learning outcomes for a smart learning ecosystem.

In the context of Extended Reality, (Astalini et al., 2024) have designed a Physics e-modules based on the Assemblr Edu platform, which combines the use of Augmented Reality (AR) technology in the context of the topic of renewable energy and at the level of senior high school students. The development process included several stages: (1) designing learning content in line with the curriculum, (2) preparing the learning materials in an interactive way using Assemblr Edu functionalities with AR integration, (3) compiling the module in accessible digital format, and (4) conducting the trials to students for their evaluation and later revision according to their feedback. The module was carried out using expository and discussion-based learning strategies in order to increase student engagement. Findings showed that the implementation of e-Assemblr Edu-based e-module has improved significantly students argumentative skills, perseverance and curiosity in learning physics, while also making the learning experience more engaging.

With regard to simulation and robotics technologies, (Mehrotra et al., 2021) created CreroBot, a robotics learning tool, based on a maker-based pedagogy and made of cardboard and simple electronic components. Its goal was to expose students to the maker mentality and underlying principles of robotic programming in online learning environments. The device was intentionally designed to be easy to assemble and accessible to both students and teachers and to maintain a constructionist orientation (through hands on experiential learning). CreroBot's structure was based on a simple structure that had two cardboard pieces connected with a slit system and some built-in components like micro-servo motor, wheels, microcontroller, which could be connected with many programming interfaces. In the context of distance learning, CreroBot was assisted by tutorial videos and programming guides to help overcome distance learning barriers associated with access to physical tools. Findings indicated that, even though they have some challenges, such as the supervision needed for the cutting tools and the relatively long assembly time, CreroBot succeeded in introducing students to the principles of making and programming and may prove a complementary solution to online robotics education, especially for students with limited access to school facilities. In addition, (Hidayatullah et al., 2024) proposed the Digital Learning Simulator for Smartphone (DSL) for motorcycle fuel injection system. The design of the simulator was guided by the following design principles: It is an interactive learning medium designed to integrate project-based approaches and real world work scenarios to enhance student conceptual understanding before core instruction. Through the DSL, students were not only able to read instructional content but they were able to observe visual simulations and engage in problem-solving activities with regard to vehicle systems. Features like automated assessment, individualized learning - achievement reports and adaptive learning recommendations made the simulator an effective instructional tool within vocational education settings.

In the field of web-based learning, (Albar et al., 2025) created a flipped classroom model supported by Google Sites, to integrate design of Discovery Flipped Classroom (DFC) approach to improve mathematical solving skills and learner autonomy. Google Sites was used to create interactive learning content, such as videos, quizzes and simulations, that students could view independently outside of class. Findings showed that the integration of Google Sites with the DFC model was able to enhance the problem-solving ability of students in mathematics as well as their learning independence

significantly. With respect to mobile learning, (Sukatiman et al., 2024) studied the effect of the Articulate Storyline based learning application accessed via smartphone on the creative thinking and learning motivation of students. The application served as an interactive platform for the education of graphic design by integrating a variety of media including text, video and case studies. It also allowed the students to work together to complete tasks and produce creative ideas together. Findings revealed that this medium not only facilitated understanding of complex concepts, it also effectively enhanced the creativity and critical thinking skills of the students.

Other research has been conducted with electronic books. For example, (Huda et al., 2024) conducted a project with a digital module designed based on project-based learning to improve the quality of instruction in printing graphic design subject. The module was created with Unity software to control the layout and animation, Adobe Illustrator for the interface and asset creation and Visual Studio Code for the application programming. The development process was done using the Multimedia Development Life Cycle (MDLC), which is comprised of the concept, design, material gathering, assembly, testing, and distribution stages. The digital module was evaluated by alpha testing to ensure feasibility and to support an interactive learning that provides students with the ability to effectively and independently develop graphic-design skills. Findings demonstrated that the module was very practical for both teachers as well as students and successfully contributed to the acquisition of 21st century skills in the context of printing graphic design education. Similarly, (Batur & Çakıroğlu, 2023) incorporated a digital storytelling (DST) approach in statistics education in order to improve aggregate reasoning of students. The DST creation process had started with a pre-production stage, which included writing scripts for narratives that represented statistical concepts linked to the Covid-19 pandemic with the input of statisticians and healthcare professionals. In the production stage, the digital stories were produced by using Animaker. This application permits the combination of visuals, audio and narration in interactive stories of about two to five minutes in length. The post-production stage included the review and editing of the digital stories before their distribution to students during three weeks of instruction in school. Findings showed that the integration of DST technology has significantly improved aggregate reasoning skills of students in relation to data analysis and interpretation skills and has decreased anxiety about statistical content by displaying abstract concepts in the form of interactive multimedia narratives.

### Social Sciences and Humanities (SSH)

Within the field of social-scientific humanities, especially at the elementary school level, there have been 4 studies that have used digital technologies. In terms of gamification and game-based learning, (Saban et al., 2024) created digital escape room games to enhance spelling skills in English language learning. The escape room was organized in three phases: (1) teaching phase, with teacher-recorded instructional videos explaining learning material (phoneme-grapheme correspondences) and Google Slides showing the same content; (2) practice phase, which gave access to different digital games designed to reinforce the new acquired material and immediate feedback, as well as Google Slides, which allowed learners to read the same stories on their own; and (3) testing phase, in which learners accessed games that generated the codes necessary to "escape" the room. Findings indicated that the use of digital escape rooms had a significant effect on the improvement of the students spelling ability as the activities offered them repeated opportunities to practice and make connections between phonic and graphemes that resulted in the automatization process of word spelling in their memory.

With regard to the use of the Extended Reality, (Liamruk et al., 2025) designed an AR-based serious game called KideClass to support learning relating to cultural literacy and scientific literacy including cultural history, ecology, traditional agriculture and environmental science. KideClass used AR technology to combine the digital world with the real world. The game was created in Unity engine and ARCore, two platforms which make it easy to develop dynamic and responsive AR applications. KideClass included six mini-games, with AR combined with specific learning content, including orchid farming, lotus preservation, and community challenges. With the support of the backend platform provided by Firebase, the platform was able to provide real-time feedback and evaluation to learners. Findings indicated that through the integration of AR technology and serious gaming approaches, KideClass as an innovative and engaging medium for cultural learning was able to reinforce educational interaction between younger generations and parents.

Two other research studies investigated the use of Electronic Books. (Istiq'faroh et al., 2020) used digital comics as a learning medium in the language learning process of Indonesian language. The digital comics have been created using the Kvisoft Flipbook Maker, and have been integrated with various

types of interactive content, such as visuals, text narration, and musical effects to augment the learning process. The study found that as an innovative learning medium, digital comics successfully stimulated the active participation of students, while at the same time, stimulating the development of creativity in the composition of stories and the ability to compose interesting and meaningful stories. Similarly, (Korosidou & Griva, 2024) used Digital Storytelling (DST) to help develop writing skills in second language (L2) education, namely, the teaching of the Greek language as a second language to students from an immigrant background. The DSTs were made with Storyboard, StoryLogic and Plotagons. These web-based applications allowed students to create digital narratives by integrating different multimedia resources including images, audio, text and music in interactive and creative formats. The results showed that the integration of DST into L2 instruction proved to be effective in boosting the motivation of students to learn, their writing skills and multiliteracy skills.

In the domain of Social Sciences and Humanities (SSH), especially in junior high school, there are currently five studies that have incorporated digital technologies in classroom practices. Concerning the application of 3D Learning, (Nair & Md Yunus, 2022) explored the application of the digital storytelling application Toontastic 3D in English language education. The application, which is highly user-friendliness for learners from ages 6-12 years, features that can be selected and personalized according to the imaginative ideas of the students. Learners could choose characters and settings relevant to their intended stories, recorded their own voices to tell them thus practicing speaking, pronunciation, intonation and verbal expression. Furthermore, students were able to bring their characters to life and control them according to the storylines they had created. The results of the study showed that the use of Toontastic 3D has a significant impact on the improvement of the students' speaking skills. In addition, the process of integrating digital storytelling boosted student interest, motivation and confidence in English language speaking.

In the area of Gamification and Game Based Learning, (Kabak & Korucu, 2021) developed a block based programming game by using Scratch in English language classes and students were affected directly in the design process. Learners made and developed the content of their own digital games. This approach allowed the students opportunities to learn while creative production and in turn, a deeper understanding of the material. The study concluded that student-developed digital games had a positive impact on both academic achievement as well as learning attitudes.

In the context of Multimedia and Digital Content - Based Learning, (Razak & Din, 2020) incorporated edutainment videos (educational and entertainment content) in learning English during the pandemic of Covid-19. Such video contents as animations and educational films showed that there is potential to promote students' motivation and inspiration to learn, especially in language learning, through the introduction of cultural aspects, language usage, and pronunciation from various contexts. Additionally, videos were used as visual support for better understanding of material, memorable visual representations, or to spark student's imagination with visual representations of places they had never seen before. Findings showed that the use of videos improved concentration of students, made comprehension easier, sparked the imagination and provided impressive visual impressions in order to enrich the depth of the learning experience. Finally, on the Web-Based Learning part, (Csachová, 2020) applied the geospatial technologies using the WebGIS platform in geography education. WebGIS was used to analyze political maps of the world along with demographic world information. Its use was adapted to different levels of complexity in learning activities: basic level tasks consisted of exploring geographic content via Web sites; intermediate level tasks consisted of visualizing demographic data such as population pyramids; and advanced level tasks consisted of programming for spatial analysis such as finding centroid points as possible locations for capital cities. Findings showed that students achieved a deeper understanding of population dynamics across the globe, started to use new terminology in the field of demography, and showed greater interest in studying related materials further.

Another study that looked at the use of Electronic Books was done by (Santosa et al., 2022), who created a handbook of gamification in English language teaching and learning. The handbook has multiple chapters to help the readers better understand gamification. It comprised an introduction to the basic concepts of gamification, best practice examples of its use, and a number of supporting tools. Amongst these were digital platforms that allowed for the integration of gamification into instruction and the SOLO taxonomy which allowed for students' progression of understanding to be measured through this approach. The handbook development process included designing the content and adding supporting media such as images, instructional materials and QR codes for access to video and audio links. The mentioned study reported that the gamification handbook had met some of the essential criteria, namely

the comprehensible presentation of information related to the concept of 21st century learning as well as gamification; the focus on developing interpersonal, interpretive, and presentational skills; the provision of interactive activities that can be adapted to classroom situations; and the contribution to strengthening the 21st century skills, digital literacy, and technology integration into pedagogy.

Within the Social Science and Humanities (SSH) area, more exactly, the senior high school level, two empirical investigations focused on the integration of digital technology. In the field of AI- Based Learning, (Rahimi & Teimouri, 2025) addressed the use of AI chatbots in the English language learning. The design of the syllabus incorporated features of ChatGPT - features such as anthropomorphism, interactivity, digital authenticity, and personalization. Results indicated that the interactive properties of ChatGPT had a significant impact on improving the students' communicative skills, digital creativity, and problem-solving skills. Conversely, the anthropomorphic attributes such as human-like voices and avatars had a negative impact on digital collaboration as the students were likely to engage more with the AI system than their peers.

Regarding the use of electronic books, an example was created by (Djono et al., 2023) who developed a digital culinary learning module for learning history. The idea behind this module was to incorporate the culture of cuisine as a means of retaining national heritage and instilling a sense of nationalism in younger generations. It was structured on subthemes that consist of local types of cuisine, recipes, ingredients, methods as well as additional information that explains philosophical values embedded in traditional cuisines. Although students already had familiarity with a variety of traditional foods of Surakarta, through the investigation, it was found that there was limited understanding about philosophical significances behind those types of foods. As a result, the digital module proved to be effective in improving understanding of students the cultural and philosophical values associated with local cuisine.

### **Preschool**

A total of two studies investigated the integration of digital technology into learning processes at the preschool level.

### **Science Technology Engineering Mathematics (STEM)**

(Behnamnia et al., 2025) examined the use of digital game-based learning in the science education through a digital game "Thinking Kid." The study reported significant positive effects on preschool children (ages 3 - 6) in terms of creativity, learning motivation and competency development. Additionally, psychomotor assessments given before and after participation in the STEM game-based learning environment showed different developmental trajectories for fine motor skills across the learning process.

### **Social Sciences and Humanities (SSH)**

Within the field of social and emotional development, (Xiong et al., 2022) created a training paradigm to develop the creative thinking ability of preschool children through an educational digital game "Thinking Paradise". The results showed that digital educational games helped to establish creative thinking among preschool children with differing effect sizes for the different age cohorts and they were well received by both learners and parents.

Overall, this study shows that 21st-century digital learning trends are moving towards more complex, collaborative, and data-driven integration. In this context, teachers play a role that is more design-oriented than simply being technology users. Technology integration depends not only on the availability of devices, but also on teachers' digital pedagogical competencies, institutional support, and the educational policy ecosystem. Thus, digital transformation in education is systemic and multifaceted. Theoretically, this study reinforces the conceptual framework of technology integration by emphasizing the importance of interaction between pedagogical, technological, and contextual dimensions. These findings indicate the need for a holistic approach to understanding technology integration, beyond linear adoption models. Practically, the results of this study provide important insights for the development of teacher training programs that should focus on digital learning design, data literacy, and innovative technology-based pedagogical strategies. For policymakers, it is essential to provide equitable infrastructure and policies that support continuous professional development. At the institutional level, an organizational culture that supports pedagogical experimentation using technology is needed.

## CONCLUSION

This review covered a total of 56 research studies developed in a wide range of educational levels, countries, and domains over a period of 2020 until mid 2025 that focuses on 21st-century digital learning trends. The results show that the use of digital technologies in education is still growing and occupying more central positions in the academy as can be seen in the yearly growing number of research papers about digital learning. Publication activity peaked in 2024. The results of the review can be summarized as follows: First, most of the 21st century digital learning studies have been conducted at the university level. Second, the contributions of research came mainly from the Asian region. Third, a field that emerged with the most frequent use of digital learning was STEM (Science, Technology, Engineering, and Mathematics). Fourth, the most widely used forms of digital technologies in education were game-based approaches - specifically gamification and game-based learning. Fifth, the integration of digital technologies in learning showed potential to increase instructional effectiveness, problem-solving skills, student motivation, character development, and literacy.

Although this article provides a comprehensive overview of 21st-century digital learning trends and the integration of digital technology into teachers' teaching practices, it has several limitations and offers implications for further research. First, the literature search was limited to the Scopus database and only included English-language articles published between January 2020 and June 2025. This means that important studies in other languages or from other databases may have been missed, potentially affecting the completeness of the review as a whole. Future research should expand the scope of data sources by including additional databases to achieve a more comprehensive and globally representative synthesis. Second, the rapidly evolving landscape of educational technology poses additional challenges. New advances, including data-driven adaptive systems, immersive learning, and generative artificial intelligence, are constantly changing the landscape of digital learning. Therefore, some of the insights gained in this review may quickly become obsolete as new technologies and teaching techniques are introduced. It is therefore recommended that future research employ longitudinal designs and forward-looking research approaches. The purpose of this study is to assess the sustainability of technology integration practices by teachers and evaluate the pedagogical, ethical, and professional impacts of new technologies in transforming learning in the 21st century. This study not only explores the growth of digital learning literature in the 21st century, but also offers valuable insights and practical ways to improve how teachers integrate technology in today's ever-changing educational landscape.

## ACKNOWLEDGMENTS

The authors declare that no contributions beyond the listed authors were involved in the preparation of this research.

## AUTHOR CONTRIBUTIONS

The first author contributed to the study conceptualization, methodology, data analysis and writing; the second and fourth authors was responsible for writing, review and editing; the third and fifth authors contributed equally to literature screening and data extraction.

## CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

## REFERENCES

- Agaoglu, F. O., Bas, M., Tarsuslu, S., Ekinici, L. O., & Agaoglu, N. B. (2025). The mediating digital literacy and the moderating role of academic support in the relationship between artificial intelligence usage and creative thinking in nursing students. *BMC Nursing*, 24(1). <https://doi.org/10.1186/s12912-025-03128-3>.
- Albar, M., Masitoh, S., Kristanto, A., & Rajiman, W. (2025). Effect of Google Sites-assisted Flipped Classroom Discovery Learning Model and Cognitive Style on Mathematics Problem-Solving

- Skills and Student Learning Independence. *Ianna Journal of Interdisciplinary Studies*, 7(2), 236–249. <https://doi.org/10.5281/zenodo.15462037>.
- Aldhafeeri, F. M., & Alotaibi, A. A. (2022). Effectiveness of digital education shifting model on high school students' engagement. *Education and Information Technologies*, 27(5), 6869–6891. <https://doi.org/10.1007/s10639-021-10879-4>.
- Alenezi, M. (2023). Digital learning and digital institution in higher education. *Education Sciences*, 13(1), 88. <https://doi.org/10.3390/educsci13010088>.
- Andersen, R., & Rustad, M. (2022). Using Minecraft as an educational tool for supporting collaboration as a 21st century skill. *Computers and Education Open*, 3. <https://doi.org/10.1016/j.caeo.2022.100094>.
- Astalini, A., Darmaji, D., Kurniawan, D. A., & Octavia, S. W. (2024). Assembler edu e-modules: improving argumentation skills, perseverance, and curiosity in physics learning. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, 8(2), 550–562. <https://doi.org/10.22437/jiituj.v8i2.37238>.
- Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, 1(1), 377–386. [https://doi.org/10.1162/qss\\_a\\_00019](https://doi.org/10.1162/qss_a_00019).
- Batur, A., & Çakıroğlu, Ü. (2023). Implementing digital storytelling in statistics classrooms: Influences on aggregate reasoning. *Computers and Education*, 200. <https://doi.org/10.1016/j.compedu.2023.104810>.
- Bayaga, A. (2024). Enhancing M Enhancing mathematics problem-solving skills in AI-driven environment: Integrated SEM-neural network approach. *Computers in Human Behavior Reports*, 16. <https://doi.org/10.1016/j.chbr.2024.100491>.
- Behnamnia, N., Kamsin, A., Ismail, M. A. B., & Hayati, S. A. (2025). Relationship between creative thinking and outcomes in a digital STEM-based learning environment: A mixed methods case study. *Thinking Skills and Creativity*, 57. <https://doi.org/10.1016/j.tsc.2025.101816>.
- Bergdahl, N., Nouri, J., & Fors, U. (2020). Disengagement, engagement and digital skills in technology-enhanced learning. *Education and Information Technologies*, 25(2), 957–983. <https://doi.org/10.1007/s10639-019-09998-w>.
- Carrera-Rivera, A., Larrinaga, F., & Lasa, G. (2022). Context-awareness for the design of Smart-product service systems: Literature review. *Computers in Industry*, 142, 103730. <https://doi.org/10.1016/j.compind.2022.103730>.
- Cheung, S. K., Kwok, L. F., Phusavat, K., & Yang, H. H. (2021). Shaping the future learning environments with smart elements: challenges and opportunities. *International Journal of Educational Technology in Higher Education*, 18(1), 16. <https://doi.org/10.1186/s41239-021-00254-1>.
- Chu, S., Reynolds, R., Tavares, N., Notari, M., & Lee, C. (2017). 21st Century Skills Development Through Inquiry-Based Learning. In *21st Century Skills Development Through Inquiry-Based Learning: From Theory to Practice*. <https://doi.org/10.1007/978-981-10-2481-8>.
- Csachová, S. (2020). Using WebGIS platforms and inquiry based activities to teach about world political map and world population. *Review of International Geographical Education Online*, 10(2), 72–91. <https://doi.org/10.33403/rigeo.678026>.
- Deng, L., Wu, S., Chen, Y., & Peng, Z. (2020). Digital game-based learning in a Shanghai primary-school mathematics class: A case study. *Journal of Computer Assisted Learning*, 36(5), 709–717. <https://doi.org/10.1111/jcal.12438>.
- Djono, D., Sutiya, S., Sukmawati, F., & Salimi, M. (2023). Development of Digital Teaching Materials about Surakarta Culinary in History Learning. *International Journal of Intelligent Systems and Applications in Engineering*, 11(9s), 572–580. <https://ijisae.org/index.php/IJISAE/article/view/3197>.
- Elçiçek, M., & Karal, H. (2020). A framework proposal for the design of video-assisted online learning environments for programming teaching. *Elementary Education Online*, 19(3), 1820–1837. <https://doi.org/10.17051/ilkonline.2020.735175>.
- El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education*, 18(1). <https://doi.org/10.1186/s41239-021-00289-4>.
- Erçağ, E., & Yasakçı, A. (2022). The Perception Scale for the 7E Model-Based Augmented Reality Enriched Computer Course (7EMAGBAÖ): Validity and Reliability Study. *Sustainability*

- (Switzerland), 14(19). <https://doi.org/10.3390/su141912037>.
- Evans, D. J., & Pawlina, W. (2022). The future of anatomy education: learning from Covid-19 disruption. *Anatomical Sciences Education*, 15(4), 643–649. <https://doi.org/10.1002/ase.2203>.
- Ghani, M. T. A., Hamzah, M., Daud, W. A. A. W., & Romli, T. R. M. (2022). The Impact of Mobile Digital Game in Learning Arabic Language at Tertiary Level. *Contemporary Educational Technology*, 14(1). <https://doi.org/10.30935/cedtech/11480>.
- Girón-García, C. (2024). YOUTUBE videos to develop multimodal literacy. *Elia: Studies in Applied English Linguistics/Estudios de Lingüística Inglesa Aplicada*, 24. <https://doi.org/10.12795/elia.2024.i24.7>.
- Godsk, M., & Møller, K. L. (2025). Engaging students in higher education with educational technology. *Education and Information Technologies*, 30(3), 2941–2976. <https://doi.org/10.1007/s10639-024-12901-x>.
- González-Pérez, P., & Marrero-Galván, J. J. (2023). Development of a formative sequence for prospective science teachers: the challenge of improving teaching with analogies through the integration of infographics and augmented reality. *Journal of Technology and Science Education*, 13(1), 159–177. <https://doi.org/10.3926/jotse.1919>.
- Hagerer, I. (2025). PlayMINT—an effective digital learning game for leadership competencies of female STEM students. *Computers and Education Open*, 8. <https://doi.org/10.1016/j.caeo.2025.100256>.
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. <https://doi.org/10.1016/j.susoc.2022.05.004>.
- Hidayatullah, R. S., Supardji, S., & Susila, I. W. (2024). Development of Digital Learning Simulators to Increase Vocational Students' Prior Knowledge. *TEM Journal*, 13(3), 1981–1988. <https://doi.org/10.18421/TEM133-26>.
- Hsu, C. Y., & Wu, T. T. (2023). Application of business simulation games in flipped classrooms to facilitate student engagement and higher-order thinking skills for sustainable learning practices. *Sustainability*, 15(24), 16867. <https://doi.org/10.3390/su152416867>.
- Huang, H. W. (2021). Effects of smartphone-based collaborative vlog projects on EFL learners' speaking performance and learning engagement. *Australasian Journal of Educational Technology*, 37(6), 18–40. <https://doi.org/doi:10.14742/ajet.6623>.
- Huda, A., Febrianti, W., Firdaus, Hendriyani, Y., Fajri, B. R., & Sukmawati, M. (2024). Designing Digital Modules in Project-Based Learning-Based Printing Graphic Design Subjects at SMK N 1 Koto Baru Dharmasraya. *International Journal of Interactive Mobile Technologies*, 18(18), 94–111. <https://doi.org/10.3991/ijim.v18i18.50551>.
- Indrawati, E. S., Festiyed, F., & Ratnawulan, R. (2025). Blending creativity and connectivity: A Treffinger-based cooperative learning model using Facebook. *International Journal of Innovative Research and Scientific Studies*, 8(4), 428–436. <https://doi.org/10.53894/ijirss.v8i4.7869>.
- Istiq'faroh, N., Suhardi, & Mustadi, A. (2020). Improving elementary school students' creativity and writing skills through digital comics. *Elementary Education Online*, 19(2), 426–435. <https://doi.org/10.17051/ilkonline.2020.689661>.
- Jamalai, M., & Krish, P. (2021). FOSTERING 21st century skills using an online discussion forum in an english for specific purpose course. *Malaysian Journal of Learning and Instruction*, 18(1), 219–240. <https://doi.org/10.32890/MJLI2021.18.1.9>.
- Jamali, M. J., Azmuddin, R. A., & Chand, V. (2025). Online communication and collaboration via digital discussion forums: impacts on 21st century skills and english language learning. *Issues in Language Studies*, 14(1), 19–36. <https://doi.org/10.33736/ils.7442.2025>.
- Kabak, K., & Korucu, A. T. (2021). The effect of students' developing their own digital games on their academic achievement and attitudes towards for english lessons. *Participatory Educational Research*, 8(2), 74–93. <https://doi.org/10.17275/per.21.30.8.2>.
- Karpouzis, K., Pantazatos, D., Taouki, J., & Meli, K. (2024, May). Tailoring education with GenAI: A new horizon in lesson planning. In *2024 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1-10). IEEE. <https://doi.org/10.48550/arXiv.2403.12071>.
- Keane, T., Linden, T., Hernandez-Martinez, P., Molnar, A., & Blicblau, A. (2023). Digital technologies: students' expectations and experiences during their transition from high school to university. *Education and Information Technologies*, 28(1), 857–877. <https://doi.org/10.1007/s10639-022-11184-4>.
-

- Kerimbayev, N., Adamova, K., Shadiev, R., & Altinay, Z. (2025). Intelligent educational technologies in individual learning: a systematic literature review. In *Smart Learning Environments* (Vol. 12, Issue 1). Springer. <https://doi.org/10.1186/s40561-024-00360-3>.
- Khlaisang, J., & Sukavatee, P. (2023). Mobile-Assisted Language Learning to Support English Language Communication among Higher Education Learners in Thailand. *The Electronic Journal of E-Learning*, 21(3), 234–247. <https://doi.org/10.34190/ejel.21.3.2974>.
- Kim, H. J., Yi, P., & Hong, J. I. (2020). Students' academic use of mobile technology and higher-order thinking skills: The role of active engagement. *Education Sciences*, 10(3), 47. <https://doi.org/10.3390/educsci10030047>.
- Korosidou, E., & Griva, E. (2024). Fostering Students' L2 Writing Skills and Intercultural Awareness through Digital Storytelling in Elementary Education. *International Electronic Journal of Elementary Education*, 16(5), 585-597. <https://doi.org/10.26822/iejee.2024.355>.
- Kraus, S., Breier, M., & Dasi-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal*, 16(3), 1023–1042. <https://doi.org/10.1007/s11365-020-00635-4>.
- Kulaca, I., Yazıcı, H., & Selanik Ay, T. (2024). The Effect of Web 2.0 Supported Social Studies on the Digital Literacy Skills of Secondary School Students. *Journal of Theoretical Educational Sciences*, 17(3), 539–562. <https://doi.org/10.30831/akukeg.1376954>.
- Laakso, N. L., Korhonen, T. S., & Hakkarainen, K. P. J. (2021). Developing students' digital competences through collaborative game design. *Computers and Education*, 174. <https://doi.org/10.1016/j.compedu.2021.104308>.
- Lapisa, R., Syaifullah, L., Maksum, H., Irfan, D., Rifdarmon, & Nanda, I. (2025). Digital Technology Innovation in TVET: Rifdarmon-Based E-Learning Model Enhancing Learning Outcomes and 4C Skills. *Salud, Ciencia y Tecnología*, 5. <https://doi.org/10.56294/saludcyt20251491>.
- Liamruk, P., Onwong, N., Amornrat, K., Arayapipatkul, A., & Sipiyaruk, K. (2025). Development and evaluation of an augmented reality serious game to enhance 21st century skills in cultural tourism. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-95615-5>.
- Mårell-Olsson, E. (2021). Using gamification as an online teaching strategy to develop students' 21st century skills. *IxD&A*, 47. <https://doi.org/10.55612/s-5002-047-004>.
- Marzi, G., Balzano, M., Caputo, A., & Pellegrini, M. M. (2025). Guidelines for Bibliometric-Systematic Literature Reviews: 10 steps to combine analysis, synthesis and theory development. *International Journal of Management Reviews*, 27(1), 81–103. <https://doi.org/10.1111/ijmr.12381>.
- Maulana, I., Siswandari, Gunarhadi, & Efendi, A. (2025). Virtual – Augmented Reality (VAR) for Science Learning: Development and Impact on Students' HOTS Skills. *Electronic Journal of E-Learning*, 23(1), 129–142. <https://doi.org/10.34190/ejel.23.1.3733>.
- Mehrotra, A., Giang, C., El-Hamamsy, L., Guinchar, A., Dame, A., Zahnd, G., & Mondada, F. (2021). Accessible Maker-Based Approaches to Educational Robotics in Online Learning. *IEEE Access*, 9, 96877–96889. <https://doi.org/10.1109/ACCESS.2021.3094158>.
- Mengist, W., Soromessa, T., & Legese, G. (2020). Ecosystem services research in mountainous regions: A systematic literature review on current knowledge and research gaps. In *Science of the Total Environment* (Vol. 702). Elsevier B.V. <https://doi.org/10.1016/j.scitotenv.2019.134581>.
- Mirra, N., & Garcia, A. (2021). In Search of the Meaning and Purpose of 21st-Century Literacy Learning: A Critical Review of Research and Practice. *Reading Research Quarterly*, 56(3), 463–496. <https://doi.org/10.1002/rrq.313>.
- Moral-Sánchez, S. N., Sánchez-Compañá, M. a. T., & Romero, I. (2022). Geometry with a STEM and Gamification Approach: A Didactic Experience in Secondary Education. *Mathematics*, 10(18). <https://doi.org/10.3390/math10183252>.
- Nair, V., & Md Yunus, M. (2022). Using Digital Storytelling to Improve Pupils' Speaking Skills in the Age of COVID 19. *Sustainability (Switzerland)*, 14(15). <https://doi.org/10.3390/su14159215>.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. In *BMJ* (Vol. 372). BMJ Publishing Group. <https://doi.org/10.1136/bmj.n71>.
- Pantiwati, Y., Aminudin, Waluyo, L., Permana, F. H., Sari, T. N. I., & Nurrohman, E. (2025). E-Module

- Based on LI-PRO-GP Learning Model to Improve Students' Conceptual Understanding and Problem-Solving Abilities in Science Learning. *International Journal of Information and Education Technology*, 15(3), 549–564. <https://doi.org/10.18178/ijiet.2025.15.3.2265>.
- Parody, L., Santos, J., Trujillo-Cayado, L. A., & Ceballos, M. (2022). Gamification in Engineering Education: The Use of Classcraft Platform to Improve Motivation and Academic Performance. *Applied Sciences (Switzerland)*, 12(22). <https://doi.org/10.3390/app122211832>.
- Pramasdyahsari, A. S., Setyawati, R. D., Aini, S. N., Nusuki, U., Arum, J. P., Astutik, L. D., Widodo, W., Zuliah, N., & Salmah, U. (2023). Fostering students' mathematical critical thinking skills on number patterns through digital book STEM PjBL. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(7). <https://doi.org/10.29333/ejmste/13342>.
- Pranckutė, R. (2021). Web of Science (WoS) and Scopus: the titans of bibliographic information in today's academic world. In Publications (Vol. 9, Issue 1). *Multidisciplinary Digital Publishing Institute (MDPI)*. <https://doi.org/10.3390/publications9010012>.
- Pratiwi, N. P. A., Nariyati, N. P. L., & Sudirman, S. (2020). EFL pre-service teachers' perception toward the use of mobile assisted language learning in teaching English. *International Journal of Language Education*, 4(1), 38–47. <https://doi.org/10.26858/ijole.v4i2.10052>.
- Radhiani, A., & Abouseada, F. (2025). Immersive Technology: A Bibliometric Analysis of Extended Reality Research Trends in STEM Education. *Journal of Educational Technology and Learning Creativity*, 3(2), 528–543. <https://doi.org/10.37251/jetlc.v3i2.2509>.
- Radu, I., Yuan, J., Huang, X., & Schneider, B. (2023). Charting opportunities and guidelines for augmented reality in makerspaces through prototyping and co-design research. *Computers and Education: X Reality*, 2. <https://doi.org/10.1016/j.cexr.2023.100008>.
- Rahimi, A. R., & Teimouri, R. (2025). Advancing language education with ChatGPT: A path to cultivate 21st-century digital skills. *Research Methods in Applied Linguistics*, 4(2). <https://doi.org/10.1016/j.rmal.2025.100218>.
- Ralte, S., Bhattacharyya, A., Momin, A. D., & Sundaram, S. P. (2023). Perceived Effectiveness of Cadaveric and Three dimensional Virtual Dissection in Learning Anatomy among First Year MBBS Students: A Cross sectional Study from Northeastern India. *National Journal of Clinical Anatomy*, 12(3), 157–164. [https://doi.org/10.4103/NJCA.NJCA\\_79\\_23](https://doi.org/10.4103/NJCA.NJCA_79_23).
- Ramli, I. S. M., Maat, S. M., & Khalid, F. (2022). Digital Game-based Learning and Learning Analytics in Mathematics. *Pegem Egitim ve Ogretim Dergisi*, 13(1), 168–176. <https://doi.org/10.47750/pegegog.13.01.19>.
- Razak, N. S. A. A., & Din, R. (2020). Video usage among secondary school students during the covid-19 pandemic. *Universal Journal of Educational Research*, 8(11 A), 43–48. <https://doi.org/10.13189/ujer.2020.082106>.
- Riyanto, Amin, M., Suwono, H., & Lestari, U. (2020). The new face of digital books in genetic learning: A preliminary development study for students' critical thinking. *International Journal of Emerging Technologies in Learning*, 15(10), 175–190. <https://doi.org/10.3991/ijet.v15i10.14321>.
- Rizki, I. A., Suprpto, N., Saphira, H. V., Alfarizy, Y., Ramadani, R., Saputri, A. D., & Suryani, D. (2024). Cooperative model, digital game, and augmented reality-based learning to enhance students' critical thinking skills and learning motivation. *Journal of Pedagogical Research*, 8(1), 339–355. <https://doi.org/10.33902/JPR.202423825>.
- Ruiz, L. M. S., Moll-López, S., Morano-Fernández, J. A., & Llobregat-Gómez, N. (2021). B-learning and technology: Enablers for university education resilience. An experience case under COVID-19 in Spain. *Sustainability (Switzerland)*, 13(6). <https://doi.org/10.3390/su13063532>.
- Saban, M., Grünke, M., & Kahn-Horwitz, J. (2024). Enhancing spelling competence for English as a foreign language young learners through digital escape rooms. *Frontiers in Education*, 9. <https://doi.org/10.3389/feduc.2024.1434336>.
- Sailer, M., Murböck, J., & Fischer, F. (2021). Digital learning in schools: What does it take beyond digital technology?. *Teaching and Teacher Education*, 103. <https://doi.org/10.1016/j.tate.2021.103346>.
- Sáiz-Manzanares, M. C., Martín, C. F., Alonso-Martínez, L., & Almeida, L. S. (2021). Usefulness of digital game-based learning in nursing and occupational therapy degrees: A comparative study at the university of burgos. *International Journal of Environmental Research and Public Health*, 18(22). <https://doi.org/10.3390/ijerph182211757>.
- Santosa, M. H., Harismayanti, I., & Jaya Putra, I. N. A. (2022). Technology in Action: Developing Gamification Handbook in English Teaching and Learning for the 21st Century Learners. *TESL-*

- EJ*, 26(1). <https://doi.org/10.55593/EJ.26101A2>.
- Sauer, P. C., & Seuring, S. (2023). How to conduct systematic literature reviews in management research: a guide in 6 steps and 14 decisions. In *Review of Managerial Science* (Vol. 17, Issue 5, pp. 1899–1933). Springer Science and Business Media Deutschland GmbH. <https://doi.org/10.1007/s11846-023-00668-3>.
- Shenkoya, T., & Kim, E. (2023). Sustainability in Higher Education: Digital Transformation of the Fourth Industrial Revolution and Its Impact on Open Knowledge. *Sustainability (Switzerland)*, 15(3). <https://doi.org/10.3390/su15032473>.
- Sukatiman, Saputro, I. N., & Budiarto, M. K. (2024). Digital classroom innovations: leveraging smartphone-based application to stimulate students creative thinking skills. *Journal on Efficiency and Responsibility in Education and Science*, 17(4), 349–360. <https://doi.org/10.7160/eriesj.2024.170407>.
- Susanti, A., Rachmajanti, S., Suryati, N., & Astuti, U. (2025). Digital teaching tools: An ELT methods e-module to foster critical thinking skills for English student teachers in Indonesia. *International Journal of Innovative Research and Scientific Studies*, 8(3), 2292–2305. <https://doi.org/10.53894/ijirss.v8i3.6985>.
- Tedja, B., Al Musadieq, M., Kusumawati, A., & Yulianto, E. (2024). Systematic literature review using PRISMA: exploring the influence of service quality and perceived value on satisfaction and intention to continue relationship. *Future Business Journal*, 10(1). <https://doi.org/10.1186/s43093-024-00326-4>.
- Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies*, 28(6), 6695–6726. <https://doi.org/10.1007/s10639-022-11431-8>.
- Tindowen, D. J. C., Bassig, J. M., & Cagurangan, J. A. (2017). Twenty-First-Century Skills of Alternative Learning System Learners. *SAGE Open*, 7(3), 1–8. <https://doi.org/10.1177/2158244017726116>.
- Tiznado-Matzner, G., Bucarey-Arriagada, S., & Lizama Pérez, R. (2020). Three-dimensional Virtual Models of 3D-Scanned Real Cadaveric Samples Used as a Complementary Educational Resource for the Study of Human Anatomy: Undergraduate Student's Perception of this New Technology. In *Int. J. Morphol*, 38(6). <https://doi.org/10.4067/S0717-95022020000601686>.
- Vaicondam, Y., Sikandar, H., Irum, S., Khan, N., & Qureshi, M. I. (2022). Research Landscape of Digital Learning Over the Past 20 Years: A Bibliometric and Visualisation Analysis. *International Journal of Online and Biomedical Engineering*, 18(8), 4–22. <https://doi.org/10.3991/ijoe.v18i08.31963>.
- Wang, C., Chen, X., Yu, T., Liu, Y., & Jing, Y. (2024). Education reform and change driven by digital technology: a bibliometric study from a global perspective. In *Humanities and Social Sciences Communications* (Vol. 11, Issue 1). Springer Nature. <https://doi.org/10.1057/s41599-024-02717-Y>.
- Wei, X., Wang, L., Koszalka, T. A., Lee, L. K., & Liu, R. (2025). Enhancing pre-service teachers' reflective thinking skills through generative AI-assisted digital storytelling creation: A three-dimensional framework analysis. *Computers and Education*, 235. <https://doi.org/10.1016/j.compedu.2025.105356>.
- Xiong, Z., Liu, Q., & Huang, X. (2022). The influence of digital educational games on preschool Children's creative thinking. *Computers and Education*, 189. <https://doi.org/10.1016/j.compedu.2022.104578>.
- Zotova, M., Likhouzova, T., Shegai, L., & Korobeynikova, E. (2021). The use of moocs in online engineering education. *International Journal of Engineering Pedagogy*, 11(3), 157–173. <https://doi.org/10.3991/IJEP.V11I3.20411>.
- Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: trends, challenges, and innovations in technology integration. In *Frontiers in Education* (Vol. 10). Frontiers Media SA. <https://doi.org/10.3389/feduc.2025.1562391>.