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The Role of Technology in Academic Performance Students: Scoping Review

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Abstract: *The rapid advancement of educational technology including Virtual Reality (VR), Augmented Reality (AR), the metaverse, Learning Analytics (LA), and Digital Formative Assessment (DFA) has produced mixed findings regarding its impact on students' academic achievement. This study conducted a scoping review of empirical literature published between 2016 and 2025, following the PRISMA-ScR guidelines, to map evidence on the influence of these technologies on academic outcomes, learning participation, and cognitive development. Of the initial 683 records identified, 13 primary empirical studies met the inclusion criteria and were analyzed descriptively. Most studies reported positive outcomes, particularly for immersive technologies; however, the relatively small number of studies, heterogeneity in research designs, and potential publication bias limit the ability to draw broad generalizations. The findings emphasize that the effectiveness of technology depends strongly on pedagogical design, infrastructure readiness, and implementation context, rather than on technology adoption alone. Further large-scale and longitudinal research, along with context-sensitive implementation evaluations, is recommended to better understand the conditions under which educational technology produces meaningful positive impacts.*

Keywords: *Academic Achievement, Educational Technology, Immersive Technology, Learning Analytics, Scoping Review.*

INTRODUCTION

The rapid advancement of technology has brought a fundamental transformation in the modern educational landscape. The integration of various digital tools is no longer an option, but a crucial component in designing an effective teaching and learning process. Various studies have shown that the use of technology, such as computer-based and multimedia learning programs has significant potential to support and improve students' academic achievement. Among the diverse innovations, immersive technologies such as (Al-Nafisah & Al-Domi, 2016; Chenyuei Akwene & Ndjodo Fouda, 2022) Virtual Reality (VR) and Augmented Reality (AR) have emerged as one of the most promising areas. This technology offers an immersive and interactive learning experience, which has the potential to improve understanding in a wide range of subjects, from geography to social studies. In addition, the use of (Alazmi & Alemtairy, 2024; Ozdemir & Ozturk, 2022) learning analytics to provide feedback and the application of web-based formative assessments is also growing rapidly as a method to monitor and improve student learning outcomes in real-time (Akpinar & Çetin, 2023; Cabı & Türkoğlu, 2025) .

Although enthusiasm for this educational technology is high, its application in the field presents mixed findings. On the one hand, immersive technologies such as VR and AR have consistently been reported to improve academic achievement, as is the case with the application of the metaverse and AR to math. On the other hand, the effectiveness of interventions such as (Al-Muqbil, 2024; Cetintav & Yilmaz, 2023) learning analytics has been shown to be more varied and highly dependent on the design of its feedback, where some studies report no significant impact. The rapid development of research and these sometimes inconsistent findings create an urgent need to synthesize the existing evidence. To understand how these technologies affect learning, it is important to review them through a relevant theoretical lens. (Cabı & Türkoğlu, 2025)

Cognitive Load Theory provides a crucial framework, which states that instructional design must minimize

unnecessary cognitive load in order for learning to be maximized. This theory is relevant to studies conducted that found that VR can reduce students' cognitive load. More recently, more specific theories such as Sweller, (2011) Wu et al., (2025) the Cognitive Affective Model of Immersive Learning (CAMIL) have also been developed to explain the unique cognitive and affective mechanisms that play a role when students learn using VR technology. (Makransky & Petersen, 2021)

Suparmini et al., (2024) emphasizes that gamification, while increasing motivation and participation, must always be embedded in a solid pedagogical framework. They warn that without a strong pedagogical foundation, gamification risks fostering superficial learning that is only oriented towards earning points or rewards, rather than on deep content understanding. Therefore, gamification should be seen as a complementary strategy that enhances the affective domain, but it should be supported by DFA designs that provide high-quality other-directed feedback for the cognitive domain.

Recent developments in VR also include the evaluation of the impact of embodiments on self-efficacy. shows that VR simulations that allow students to interact with virtual environments through realistic avatars can improve their self-efficacy in complex tasks. This embodiment effect, which is one of the key mediators in CAMIL, is particularly relevant in medical or technical skills training, where virtual hands-on experiences directly affect students' confidence in their performance abilities in the real world. Setiawan, (2024)

Finally, the issue of implementation challenges remains the focus. In his research on the metaverse in education, it concluded that although the potential for deep learning is very high, technical and logistical constraints such as high hardware costs, bandwidth requirements, and unavailability of customized educational content are major barriers to large-scale adoption. This reaffirms the finding that practical implementation issues often mediate measurable academic outcomes from immersive technologies. Al-Muqbil, (2024)

Based on these gaps and theoretical foundations, this study was conducted as a scoping review. The purpose of this study is to explore and map the latest empirical evidence (2016-2025) regarding the role of technology, especially immersive technologies (VR, AR, metaverse), learning analytics, and web-based formative assessments in improving students' academic achievement. This review will identify the key findings, methodologies used, and theories underlying these studies to provide insight into how technology can be effectively leveraged.

Based on the description above, the questions in this study are:

1. What are the main benefits of the use of such technology on student learning participation, cognitive development, and academic achievement as reported in the literature?
2. What types of technologies have been identified in the literature to support student achievement?

RESEARCH METHODOLOGY

This study uses the scoping review methodology to explore and map the scientific literature regarding the role of technology in improving students' academic achievement. This methodology was chosen to identify the key concepts, types of technologies studied, and the theories underlying the relationship between the use of technology and learning outcomes. The scoping review process summarizes the findings of 13 relevant empirical studies. From this search strategy, a total of 683 articles were found, with details of 246 articles from Scopus, and 437 articles from the Clarivate Web of Science.

Studies that are reviews (such as literature reviews or other systematic reviews), opinion articles, or that do not directly measure academic achievement, are excluded from this review. Literature searches are carried out systematically through leading academic databases, including Scopus and Web of Science. The search strategy uses a combination of keywords with strings: ("Role of Technology" OR "Technology") AND ("Academic Achievement") AND ("School" OR "Student")). To ensure the relevance and novelty of the data, strict inclusion criteria are applied to search results. The search was limited to Journal Articles and limited to the publication range between 2016 and 2025. This initial screening process aims to identify primary empirical studies that evaluate the impact of technology on students' academic achievement, which is then further screened based on predetermined inclusion and exclusion criteria.

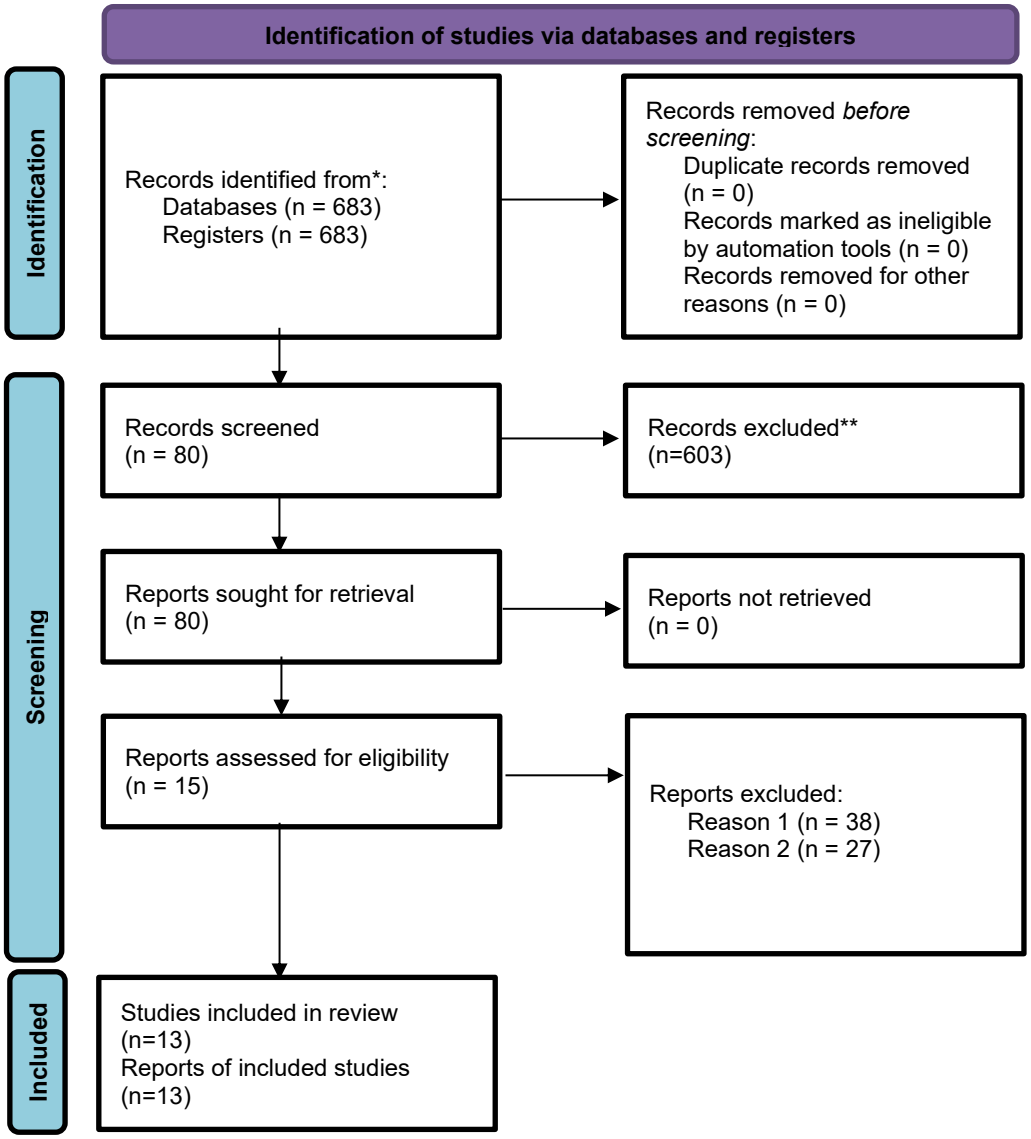
After the selection process, a total of 13 articles were analyzed in depth. The data extraction process is carried out systematically to collect relevant information from each study. The extracted data are summarized in a table (refer to Table 1 in the document) and include: the title of the study, author and year, the research method used, and a summary of the research results. The extracted data is then synthesized descriptively. The analysis is focused on identifying trends and general patterns of the research findings. This synthesis groups the results based on the type of technology used.

Although the search process identified 683 articles (Scopus + Web of Science), only 13 primary empirical studies met the inclusion criteria. This number is relatively small for scoping reviews that address diverse technologies and educational contexts; Therefore, this review aims to be *evidence mapping*, not to definitively test causal hypotheses. The heterogeneity of the study design (experimental, quasi-experimental, survey), variations in sample sizes, and differences in subject domains limit direct comparability between studies. In addition, limitations on two databases and English/selected publications can lead to *selection bias*. Searches to additional databases (ERIC, Google Scholar, regional journals), inclusion of non-English literature, or grey literature are recommended for further study.

This study adopts PRISMA-ScR guidelines to ensure transparency and quality of reporting with stages that include identification of articles from the database, initial screening, application of inclusion and exclusion criteria, (Tricco et al.,

2018) *full-text* review, and descriptive data synthesis. The final results were analyzed narratively and descriptively to map the role of technology in increasing academic participation and achievement, the types and uses of technology used for inclusive education, and its challenges and implications in technology implementation. The results are shown in the form of PRISMA-ScR in Figure 1 and a narrative description as shown in Figure 1

Figure 1. Prisma-ScR



RESULTS AND DISCUSSION

Results

This section presents the main findings of *the scoping review* according to the methodology that has been described. The results include a study selection process and a summary of the included articles. The study selection process, which follows the PRISMA-ScR guidelines, began with the identification of 683 articles from the *Scopus* database and *the Web of Science*. After the screening process, in which 603 articles were excluded, a total of 80 articles were *screened (records screened*). Of these, 15 reports *were assessed for eligibility*. In the end, a total of 13 primary empirical studies that met all inclusion and exclusion criteria were analyzed in depth in this review. The results of data extraction from the 13 articles reviewed are presented in table 1 below. This table summarizes the title, author and year, methodology used, as well as key findings from each study to map the empirical evidence on the role of technology in student academic achievement.

Table 1. *Scoping Review Article Results*

No.	Research Title	Author and Year	Research Methods	Research Results

1	The Investigation of Mobile Virtual Reality Application Instructional Content in Geography Education: Academic Achievement, Presence, and Student Interaction	Durmus Ozdemir & Faruk Ozturk (2022)	The population sample consisted of 40 high school students (grade 9) from junior high school in the Orhaneli district of Bursa, Turkey, during the 2019-2020 academic year. The students were randomly divided into two groups: the experimental group (n = 20) using mobile VR software and the control group (n = 20) receiving traditional instruction. No students have any prior experience with VR technology	The study concluded that VR-based learning environments significantly improve students' academic achievement compared to traditional methods.
2	The effects of immersive virtual reality field trips upon student academic achievement, cognitive load, and multimodal presence in a social studies educational context	Huda S. Alazmi, Ghader M. Alemtairy (2024)	The study used a quasi-experimental approach, utilizing pre- and post-test evaluations to measure academic achievement among seventh-graders. The study focused on 48 seventh-graders.	The study concluded that immersive virtual reality (IVR) applications can significantly improve academic achievement in high school social studies compared to traditional teaching methods. It was found that students who used IVR experienced lower cognitive load, indicating a more efficient learning process.
3	The Effect of Individualized Instruction System on the Academic Achievement Scores of Students	Ferhat Bahçeci, and Mehmet Gürol (2016)	The study used experimental design, specifically a pre-post-test control group model, to assess the impact of the Individual Instruction web environment on academic achievement	The results showed that the "LessonTutor" Smart Instruction System was more effective than traditional teaching methods, as evidenced by a significant increase in posttest scores
4	Synergistic effects of AR and reflective pedagogy: growth and challenges in practical learning among students of varying academic achievement	Min Jou, Yu-Chun Chiang, Yanwei Dang, Jingying Wang & Chun-Chiang Huang (2025)	This study uses a mixed-methods design to investigate the integration of augmented reality (AR) with reflective pedagogy, with a focus on improving practical learning among students with different levels of academic achievement	The integration of reflective teaching strategies with AR technology significantly improves technical education by addressing the diverse needs of students and promoting long-term skills development

5	Multimedia-Influence-Achievement Model (Miam): Proposed New Model As Predictive Determinant Of Academic Achievement	Godwill Chenyuei Akwene, Marcel Ndjodo Fouda (2022)	The study used questionnaire surveys to collect data from students in four secondary schools in Yaoundé, which have well-developed multimedia infrastructure and explicit policies for multimedia use	This study concludes that the Multimedia-Influence-Achievement Model (MIAM) functions as a predictive determinant of academic achievement through multimedia relevance in the classroom.
6	Impact of Metaverse Technology on Academic Achievement and Motivation in Middle School Science	Norah Saleh Mohamed Al-Muqbil (2024)	The study used a quasi-experimental design, which involved an experimental group taught using Metaverse techniques and a control group using traditional methods	The study concluded that Metaverse technology significantly improved the academic performance and motivation of high school students in science subjects, as evidenced by an increase in post-test scores in the experimental group compared to the control group
7	Computer-Based Training in Math and Working Memory Improves Cognitive Skills and Academic Achievement in Primary School Children: Behavioral Results	Noelia Sánchez-Pérez, Alejandro Castillo, José A. López-López, Violeta Pina, Jorge L. Puga, Guillermo Campoy, Carmen González-Salinas, Luis J. Fuentes (2018)	The study uses a computer-based training program that includes components focused on working memory and math tasks, which aim to improve children's cognitive skills and academic achievement. The final sample consisted of 104 children aged 7 to 12 years (M = 9.17, SD = 1.20), with 56 boys included in the study.	The training group showed significant improvements in cognitive skills, such as non-verbal IQ and inhibition, compared to the control group
8	The Effect of Augmented Reality Technology on Middle School Students' Mathematic Academic Achievement, Self-Regulated Learning Skills, and Motivation	Gulay Cetintav, Ramazan Yilmaz (2023)	The study used a quasi-experimental design with a pretest-posttest control group. The study involved 40 eighth-graders, divided into experimental groups (EGs) using augmented reality (AR) applications and control groups (CG) who received traditional education	The study concluded that the use of augmented reality (AR) materials significantly improved academic achievement, independent learning skills (SRLS), and motivation among eighth-graders in geometry education

9	The Impact of a Learning Analytics Based Feedback System on Students' Academic Achievement and Self-Regulated Learning in a Flipped Classroom	Emine Cabı, Hacer Türkoğlu (2025)	The study used a quasi-experimental design, involving an experimental group and a control group without random assignment, to assess the impact of a learning analysis-based feedback system (LA) on academic achievement and independent learning (SRL) in a flipped learning (FL) environment. The study involved 71 student teachers in the experimental group and 56 in the control group, both enrolled in information technology courses, ensuring a controlled educational setting	The study found that the learning analysis-based feedback system (LA) did not significantly affect students' self-paced learning (SRL) and academic achievement in the flipped learning (FL) classroom
10	The Effects of Computerized Instructional Program on Saudi High School Students' Academic Achievement in English	Khalid I. Al-Nafisah, Ibrahim M. Al-Domi (2016)	The study used a pre-test post-test control group (PPGD) design as its methodology. The sample size of the population consists of 100 students.	The study found that the use of Computer-Assisted English Language Learning (CALL) had a positive effect on the academic achievement of the experimental group students.
11	The effects of digital animation technology on the academic achievement and spatial perception of middle school students	İbrahim Ethem Gürbüz (2025)	This study used a quasi-experimental design with a pretest/posttest control group to assess the effects of digital animation technology on students' academic achievement and spatial perception. The population sample consists of a total of 82 students studying in the 6th grade of secondary schools in Türkiye	The study concludes that digital animation technology significantly improves students' academic achievement and spatial perception in the "Journey to History" unit of the social studies course
12	Investigation of the Effect of Online (Web-Based) Formative Assessment Applications on Students' Academic Achievement	Şeref AKPINAR, Bayram ÇETİN (2023)	The study used a quasi-experimental design, using pre-test and post-test achievement tests along with follow-up tests to assess students' success in math. Data was collected from 302 students in 4 schools using multi-tiered random cluster sampling, ensuring a representative sample	The study concluded that online (web-based) formative assessment apps significantly improve students' academic success in math, especially in quadratic equations
13	Information Technology Capability (ITC) Framework to Improve Learning Experience and Academic Achievement of Mathematics in Malaysia	Lew Sook Ling, Sivapoorani Krishnasamy (2023)	The study used an experimental approach conducted with the control group and experiments to assess the effectiveness of the developed Multimedia Probability and Statistics (MMPASS) system	The study found that the use of the Multimedia Probability and Statistics (MMPASS) system significantly improved student learning performance, with the experimental group achieving an average score of 9.65/10.00 compared to the control group of 8.03/10.00

Discussion

The most consistent finding from *this scoping review* is the extraordinary effectiveness of immersive technologies, especially *Virtual Reality (VR), Augmented Reality (AR),* and *the Metaverse* in improving student learning outcomes. These results are in line with recent meta-analyses showing that VR significantly increases student engagement in cognitive, behavioral, and affective dimensions. Immersive technology creates an immersive and interactive learning experience, allowing students to explore abstract concepts through realistic simulations. Research by confirms that VR-based learning results in significant improvements in learning outcomes compared to conventional video methods, especially for students with mixed learning styles. (Lin et al., 2024) (Ayu Lestari et al., 2025)

A comprehensive meta-analysis of 68 AR studies showed significant effect measures on three categories of learning outcomes: response ($g = 0.49$), knowledge and skills ($g = 0.65$), and performance ($g = 0.74$). These findings reinforce the results of the review that AR not only improves academic achievement but also students' affective responses such as motivation and positive attitudes towards learning. Recent research in Indonesian vocational education shows that AR-based learning media resulted in an increase in post-test scores of 7.31 points ($p < 0.001$) compared to traditional methods. (Chang et al., 2022) (Fahira et al., 2025)

Metaverse technology is also showing promising results. A quasi-experimental study by found that metaverse app-enabled science education significantly improved the academic achievement of high school students compared to traditional textbook-based instruction. Systematic literature review by identifying that metaverse technology enhances student engagement, practical skill development, and individualized learning experiences through virtual collaborative environments, gamification elements, and VR and AR integration (Al-Muqbil, 2024) (Sripan & Jeerapattanatorn, 2025)

The success of immersive technology can be explained through two main theoretical frameworks identified in this study. First, the findings strongly support *the Cognitive Load Theory* (CLT) proposed by Sweller. Studies by explicitly found that immersive VR successfully lowered students' cognitive load compared to traditional methods. (Alazmi & Alemtairy, 2024) *A recent systematic review* by confirms that AI-based adaptive learning systems and (Gkintoni et al., 2025) *machine learning* significantly improve learning efficacy by automatically managing cognitive load, providing personalized instruction, and dynamically adjusting learning paths based on real-time neurophysiological data.

The study by demonstrated that VR applications designed following the principles of CLT with immersive content that offers realistic experiences in the natural habitats of animal species facilitate elementary school students to engage in more immersive and authentic learning journeys. This study confirms that a well-designed environment can minimize extrinsic (unnecessary) cognitive load and allow students to focus their cognitive resources on learning materials, resulting in better understanding and higher academic achievement. (Sulisworo et al., n.d.)

Second, the findings regarding increased motivation and presence are in line with the *Cognitive Affective Model of Immersive Learning* (CAMIL) developed by . The CAMIL model identifies six affective and cognitive factors that lead to VR-based learning outcomes: interest, motivation, (Makransky & Petersen, 2021) *self-efficacy,* embodiment, cognitive load, and *self-regulation*. This theory states that VR not only affects cognition but also affection (emotions). A literature review of 24 K-6 studies showed that improved learning in IVR appeared to be moderately associated with situational interest and (Dubach et al., 2025) *self-efficacy*, while intrinsic motivation and self-regulation showed a more complex relationship.

However, the findings of this review are not uniform, leading to important interpretations. A study by Türkoğlu found that learning analytics-based feedback systems (LA) did not have a significant impact on academic performance or self-regulated learning. These findings are crucial because they highlight that the availability of technology alone does not guarantee positive outcomes. (Cabı & Türkoğlu, 2025)

A recent meta-analysis by showing that learning analytics-based interventions can significantly improve student learning outcomes with moderate overall effect sizes ($g = 0.359$, 95% CI = 0.230–0.487). However, this effectiveness is strongly influenced by various moderator factors including education level, learning environment, type of intervention, and diagnostic assessment tools. Research by shows that sending proactive warning emails to at-risk students based on learning analytics positively affects their attitudes, behaviors, and cognitive processes, but its effectiveness depends on the specific design of the intervention. (Liu et al., 2025) (Larrabee Sønderlund et al., 2019)

A systematic review of 28 studies with 4,597 K-12 students found that the effects of Intelligent Tutoring Systems (ITS) on learning and performance were generally positive, but diminished when compared to non-intelligent tutoring systems. This research confirms that the pedagogical design that underlies the application of technology is a determining factor. Immersive technology may be successful because it is inherently aligned with the principles of CLT and CAMIL, while the effectiveness of LA and ITS depends entirely on how the system is designed to provide actionable feedback by students. Létourneau et al., (2025)

In addition to academic achievement, the study identified secondary benefits that are important for cognitive development and participation. Computer-based training has been shown to improve cognitive skills such as non-verbal IQ and *inhibition* (Rossignoli-Palomeque et al., 2018) Digital animation technology significantly improves the spatial perception of high school students in social studies learning. A quasi-experimental study with 82 students showed that there was no significant difference in pretest academic achievement across all groups, but there were significant differences in posttest in favor of the experimental group using digital animation technology. (Gürbüz, 2025)

Immersive technologies such as the Metaverse and AR are reported to significantly increase student motivation. The study found that Metaverse technology significantly improved the academic performance and motivation of high school students in science subjects, as evidenced by an increase in post-test scores in the experimental group compared to the control group. The use of AR was also found to contribute to the improvement of self-regulated learning skills. reports that the use of AR materials significantly improves academic achievement, independent learning skills, and motivation among eighth-graders in geometry education. (Al-Muqbil, 2024) (Cetintav & Yilmaz, 2023)

A systematic literature review of 25 international and national articles (2019-2025) shows that AR-based learning media can consistently improve student learning outcomes in science learning, with significant potential in supporting science learning and presenting the fundamental concepts behind complex abstract concepts to students. A meta-analysis of 8 articles (2019-2024) using a paired sample test confirmed that AR technology significantly improves students' critical thinking skills in science learning. (Ratnasari et al., 2025) (Kusumaningrum et al., 2025)

Intang Sappaile et al., (2025) In a study with 210 undergraduate students it was found that gamification features significantly increased students' intrinsic motivation and encouraged higher levels of participation, with qualitative findings revealing that meaningful design and feedback mechanisms contribute to a more positive learning experience. However, it warns that while gamification strategies have a positive influence on student motivation, in the long run they can decrease, emphasizing the importance of sustainable gamification design. (Mustafa et al., 2024; Ratinho & Martins, 2023)

A systematic literature review of 25 articles (2020-2025) found that rewarding elements such as points (88%), badges (80%), and leaderboards (72%) were most commonly applied in learning environments, while reflective features such as storytelling (20%), student autonomy (24%), and role-playing activities (16%) were highly effective in increasing emotional engagement, self-directed learning, and practical skills. Thematic analysis shows that external rewards often only encourage temporary motivation, while reflective components support a more durable and meaningful learning process. (Innocent, n.d.)

Although the potential of educational technology is promising, its implementation faces significant challenges. A literature review by found that the digital divide has a significant impact on efforts to promote technology integration in rural schools, with challenges ranging from suboptimal outcomes due to poorly designed strategies to the cost of expensive ICT tools and resistance from various stakeholders. The study identified key challenges in the implementation of IT infrastructure in remote areas of Indonesia: limited internet connectivity, insufficient digital devices, low digital literacy among educators, and suboptimal government policies. (Mustafa et al., 2024) (Harahap et al., 2025)

(Sripan & Jeerapattanatorn, 2025) In a comprehensive review they identified persistent systemic barriers including inadequate infrastructure, limited teacher training, and a lack of strategic policy support that hindered wider adoption of AR and VR technologies. The review emphasizes the urgent need for comprehensive policies, infrastructure investment, and sustainable teacher development to harness the full potential of AR and VR in education.

Ohyama et al., (2025) In the review on the implementation of *digital dentistry*, it identifies the multifaceted challenges faced by educational institutions: educational, financial, technological, psychological, ethical, and regulatory constraints. Without strong leadership to champion initiatives, even the most sophisticated tools may remain underutilized. The ability to mobilize faculty engagement, secure funding, and align institutional priorities

with evolving educational standards relies heavily on this top-down commitment.

In keeping with reflective practice in research, it is important to acknowledge the limitations *of this scoping review*. First, the *scoping review* methodology aims to map the literature, not to assess the methodological quality of studies in depth or synthesize data statistically as in systematic review or meta-analysis. Therefore, the conclusion about "how effective" this technology is must be interpreted with caution. The global findings of the analyzed study cannot necessarily be transferred directly to Indonesia. Real obstacles in many regions of Indonesia include the gap in internet access between regions, limited devices in public schools, variations in teachers' digital literacy, and curriculum focus that still dominates national assessments.

Second, the literature search was limited to two main databases *(Scopus and Web of Science)* and the 2016-2025 time span. It is possible that relevant studies published in other databases, in languages other than English, or outside of that time span are not identified. Third, like other reviews, this study may be susceptible to publication bias. Studies that reported positive results (such as 12 of the 13 studies found) were more likely to be published than studies that reported negative or zero results.

Future research should move from the question of "whether" technology works to the investigation of "why" and "under what conditions" specific technological interventions succeed or fail. Longitudinal studies with a larger and more diverse sample are needed to understand the long-term effects of educational technology. Interdisciplinary research that explores long-term learning outcomes, user experience, and equitable access is indispensable to guide the effective integration of immersive technologies into future-ready education systems.

CONCLUSION

The results of *this scoping review* show a tendency that educational technology, especially immersive technology, has the potential to support students' academic achievement as well as affective and cognitive aspects. However, the available evidence comes from a relatively small and heterogeneous number of studies; Therefore, these findings should be interpreted as an indication of a pattern, not a definitive generalization. The main determinant of success is *how technology* is integrated through strong pedagogical design, teacher readiness, and adequate infrastructure rather than just the adoption of the technology. To strengthen the evidence base, longitudinal studies with larger samples, evaluation of implementation in local contexts (including Indonesia), and inclusion of grey literature and regional databases are needed. Although various studies have shown positive results, the findings need to be interpreted with caution due to a number of implementation and context limitations. Technologies such as VR, AR, and the metaverse demand adequate device costs, maintenance, and network infrastructure, which is a real obstacle for schools with limited resources. In addition, many studies focus on student learning outcomes without assessing teacher readiness, even though without adequate pedagogical training support, technology tends to be used only for visualization, not as a tool for learning transformation. The reported increase in motivation also has the potential to be influenced by *the novelty effect*, which can be decreased if not accompanied by a continuous learning design. Cognitively, the benefits of immersive technology are not automatic; Designs that are not aligned with the principles *of Cognitive Load Theory* risk adding irrelevant cognitive load. In addition, the dominance of small-scale studies and the tendency to publish bias limit the generalization of findings. Therefore, before widespread implementation, policymakers and practitioners need to consider the total cost of ownership, the readiness of human resources, and the importance of controlled trials at a limited scale.

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