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Technology-Enhanced Project-Based Learning for Developing Numeracy Skills in Elementary Education: A Systematic Literature Review

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Abstract. Numeracy skills are among the fundamental competencies that need to be developed in elementary school students. With the rapid advancement of digital technology, technology-enhanced Project-Based Learning (PjBL) has emerged as a promising instructional approach to support the development of these skills. This study aims to systematically review existing research on the implementation of technology-enhanced PjBL for developing numeracy skills in elementary education. The study employed a Systematic Literature Review (SLR) methodology following the PRISMA 2020 guidelines. A literature search was conducted in the Scopus database, yielding 623 records. After applying predefined inclusion and exclusion criteria, 23 articles were selected for further analysis. The findings indicate a growing research interest in technology-enhanced PjBL in recent years. The integration of technology within PjBL was found to positively influence students' numeracy skills, conceptual understanding of mathematics, problem-solving abilities, critical thinking, and learning engagement. However, several challenges remain, including limited technological infrastructure, teachers' digital competencies, and the management of project-based activities. In conclusion, technology-enhanced PjBL demonstrates significant potential for supporting the development of numeracy skills among elementary school students and warrants further exploration in both educational practice and future research.

Keywords: project-based learning; educational technology; numeracy skills; elementary education; systematic literature review

INTRODUCTION

Numeracy skills are one of the fundamental competencies that individuals need to face the challenges of life in the 21st century (Hoogland, 2020). Numeracy is not only related to the ability to perform basic mathematical operations, but also includes the ability to use mathematical concepts, procedures, facts and tools to solve problems in various contexts of daily life (Hoogland, 2020). In its development, numeracy has become an important indicator in assessing the quality of education in a country because it is closely related to the ability to think logically, make decisions, solve problems, and the readiness of individuals to face increasingly complex social, economic and technological developments (Hoogland, 2020). Therefore, strengthening numeracy skills is one of the main priorities in various education policies in various countries, in line with global attention to mathematical literacy achievements as reflected in various large-scale assessments (Huang et al., 2024).

The importance of numeracy skills is reflected in various international assessments, such as those conducted by the OECD through the Programme for International Student Assessment (PISA) (Huang et al., 2024). The assessment shows that students' numeracy and mathematical literacy skills remain a challenge in many countries, including developing countries, with the decline in average mathematics achievement recorded as the largest in a single assessment cycle (Huang et al., 2024). The results of international assessments show that most students still experience difficulties in applying mathematical concepts to solve contextual problems that require high-level reasoning and thinking (Huang et al., 2024). This condition shows that learning mathematics is not enough to just focus on mastering procedures and calculations, but needs to be directed at developing numeracy skills that enable students to connect mathematical knowledge with real situations (Hoogland, 2020).

Numeracy skills at the elementary education level have a very important role because they are the foundation for mastering mathematical competencies at the next level of education (Bognar & Horvat, 2025). Basic education is the initial phase of forming mathematical concepts and thinking skills that will influence students' academic development in the future (Bognar & Horvat, 2025). Students who have good numeracy skills tend to be better able to understand more

complex mathematical concepts, have better problem-solving skills, and are able to make decisions based on accurate quantitative information (Bognar & Horvat, 2025). On the other hand, low numeracy skills in basic education can have an impact on mathematics learning difficulties at the next level and have the potential to affect the overall quality of learning.

Although various efforts have been made to improve students' numeracy skills, various studies show that mathematics learning in elementary schools is still often dominated by a teacher-centered approach (Pratiwi et al., 2025). In this approach, students tend to act as passive recipients of information, while the teacher becomes the main source of knowledge (Putra et al., 2026). As a result, students have limited opportunities to explore mathematical concepts independently, relate learning to real-world experiences, and develop critical thinking and problem-solving skills. This often leads to students viewing mathematics as difficult and less enjoyable, resulting in low motivation and engagement in the learning process (Putra et al., 2026).

Along with the development of constructivist theory in education, various student-centered learning approaches began to be developed to create more meaningful learning experiences (Bhardwaj et al., 2025). One approach that has received a lot of attention is Project-Based Learning (PjBL) (Dogara et al., 2020). PjBL is a learning model that places students as active subjects in the learning process through project activities designed to solve real problems or produce a particular product (Yusri et al., 2024). Through project activities, students are encouraged to conduct investigations, gather information, analyze data, collaborate with peers, and communicate the learning outcomes they have obtained. Thus, learning is not only oriented towards the final result, but also on the learning process that involves direct experience and reflection on the activities carried out (Yusri et al., 2024).

In the context of mathematics learning, Project-Based Learning (PjBL) has significant potential to support the development of students' numeracy skills (Ferrero et al., 2021). Project activities enable students to apply mathematical concepts in authentic and meaningful situations (Nuraini et al., 2025). Through projects related to everyday life, students can understand how mathematical concepts are used to solve real-life problems, such as taking measurements, processing data, making plans, calculating costs, or analyzing quantitative information. These experiences help students develop a deeper conceptual understanding while enhancing critical thinking, creativity, and problem-solving skills, which are essential components of numeracy (Nuraini et al., 2025).

The development of digital technology in recent decades has further expanded the opportunities for implementing Project-Based Learning (PjBL) in education (Fikria et al., 2026). Technology no longer functions solely as a tool for delivering material but also as a means of supporting exploration, collaboration, communication, and creativity in learning (Fadillah & Takiddin, 2022). Various digital tools and platforms, such as learning applications, mathematics software, learning management systems, mobile devices, interactive simulations, and multimedia media, enable students to access information, process data, and present project results more effectively (Dorris et al., 2024). The integration of technology in PjBL also allows for more flexible and contextual learning, tailored to student needs (Hidayat & Firmanti, 2024).

The implementation of technology-assisted PjBL is believed to create a more interactive and student-centered learning environment (Fikria et al., 2026). Technology provides opportunities for students to actively engage in the learning process through various activities that require exploration, collaboration, and problem-solving (Akram et al., 2022). Furthermore, the use of technology can increase student motivation because it provides a more engaging learning experience and aligns with the characteristics of the digital generation. In numeracy learning, technology can be used to visualize abstract mathematical concepts, provide authentic data for analysis, and facilitate project activities that require the application of numeracy skills in various contexts (Bognar & Horvat, 2025).

Several empirical studies have reported that the implementation of technology-assisted PjBL has a positive impact on students' mathematics learning outcomes and numeracy skills (Nuraini et al., 2025). Several studies have shown improvements in problem-solving abilities, understanding of mathematical concepts, critical thinking skills, and student engagement in the learning process (Nuraini et al., 2025). Furthermore, technology integration in learning projects has been shown to support collaboration between students and improve the quality of the resulting products, in line with the collaborative element, which is a core component of PjBL (Dogara et al., 2020).

However, available research still shows variation in terms of implementation context, type of technology used, project design, student characteristics, and measured numeracy indicators (Hasanah et al., 2024). This variation causes research findings to be scattered and does not provide a comprehensive picture of the effectiveness of technology-assisted PjBL in developing numeracy skills in elementary education (Fikria et al., 2026).

Challenges are still found in implementing technology-assisted PjBL (Ibda et al., 2023). These challenges show that the success of implementing technology-assisted PjBL is not only determined by the use of technology alone, but is also influenced by the readiness of human resources, institutional support, and appropriate learning design (Akram et al., 2022). Therefore, a deeper understanding is needed regarding how technology-assisted PjBL is implemented, its impact on numeracy skills, as well as the various challenges faced in learning practices (Fikria et al., 2026).

Although the number of studies on PjBL, educational technology, and numeracy skills continues to increase, studies that specifically synthesize the relationship between these three aspects in the basic education context are still relatively limited (Fikria et al., 2026). Most previous research focused on the effectiveness of PjBL or the use of technology separately, while there have not been many studies that integrate the two in developing numeracy skills (Yusri et al., 2024). These limitations indicate the need to conduct a comprehensive literature synthesis to map research developments, identify implementation characteristics, evaluate reported impacts, and find research gaps that can become the basis for developing future studies.

Based on the identified research gaps, a comprehensive study is needed to synthesize various research findings regarding the implementation of technology-assisted Project-Based Learning (PjBL) in developing numeracy skills in elementary education. Therefore, this study was conducted to map research developments, identify implementation characteristics, evaluate the impact on students' numeracy skills, and examine challenges and future research directions. To achieve these objectives, this study was designed to answer four research questions, namely: (1) what are the research trends regarding the implementation of technology-assisted PjBL to improve numeracy skills in elementary education; (2) what are the characteristics of the implementation of technology-assisted PjBL in numeracy learning in elementary education; (3) what is the impact of the implementation of technology-assisted PjBL on elementary school students' numeracy skills based on existing research findings; and (4) what are the challenges of implementing technology-assisted PjBL in numeracy learning and recommended research directions for the future. The results of this study are expected to provide theoretical contributions in the development of studies on mathematics and numeracy learning, as well as being a reference for educators, researchers, and policy makers in designing more effective learning to support the development of numeracy skills in elementary education.

METHODS

This study uses the Systematic Literature Review (SLR) method to identify, evaluate, and synthesize research findings related to the application of technology-assisted Project-Based Learning (PjBL) in developing numeracy skills in elementary education. To achieve the research objectives, this study is guided by four research questions that focus on: (1) research trends, (2) implementation characteristics, (3) impacts on numeracy skills, and (4) challenges and future research directions related to the application of technology-assisted Project-Based Learning in elementary education. The review process was carried out systematically by referring to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines which include the stages of identification, screening, eligibility, and inclusion.

The literature search was conducted through the Scopus database, in line with previous systematic studies in the field of educational technology and mathematics learning which also relied on Scopus as a primary source due to its strict indexing standards and broad disciplinary coverage (Hidayat & Firmanti, 2024); (Yusri et al., 2024). The search keywords were structured based on four main research constructs: Project-Based Learning, educational technology, numeracy skills, and elementary education. The search strings used were: ("project-based learning" OR "project based learning" OR PjBL) AND (technology OR digital OR ICT OR "educational technology" OR "digital learning" OR "technology integration" OR "technology-enhanced learning" OR "technology-supported learning" OR "mobile learning" OR "online

learning") AND ("numeracy skills" OR numeracy OR "mathematical literacy" OR "quantitative literacy" OR "number sense") AND ("elementary education" OR "primary education" OR "elementary school" OR "primary school" OR "elementary students" OR "primary students").

The inclusion criteria used included: (1) research articles discussing the implementation of technology-assisted Project-Based Learning; (2) research related to numeracy skills, mathematical literacy, or relevant mathematical competencies; (3) research subjects were at the elementary education level; (4) articles were available in English and could be fully accessed; and (5) articles were published in scientific journals indexed by Scopus. The exclusion criteria included articles that did not focus on numeracy, did not involve technology in the implementation of PjBL, were not conducted in the context of elementary education, or were in the form of proceedings, books, editorials, and review articles. The search process can be seen in Figure 1.

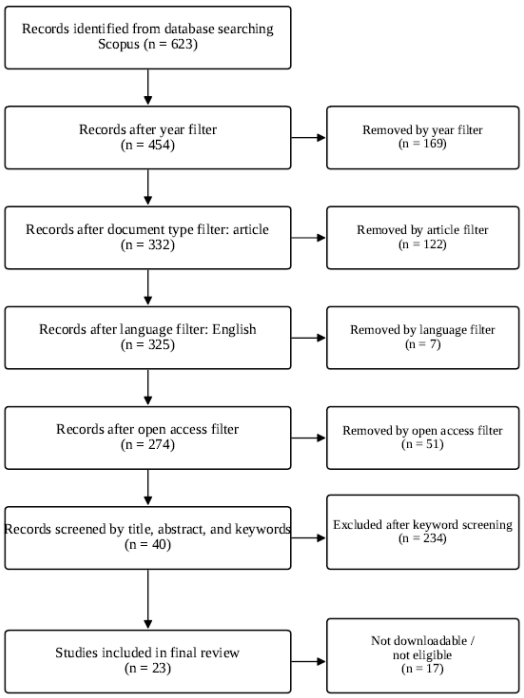

Figure 1. Prisma Diagram

The article selection process began with the identification of 623 articles from the database used. Next, the articles were filtered based on publication year criteria, resulting in 454 articles. After limiting the document type to scientific articles, the number of articles was reduced to 332. The next filtering process was based on language, specifically English-language articles, resulting in 325 articles. Articles were further screened based on open access availability, resulting in 274 articles. The next stage was filtering based on the suitability of keywords, title, abstract, and study focus, resulting in 40 relevant articles for further review. Of these, only 23 articles were fully downloadable and met all inclusion criteria. Therefore, these 23 articles were used as primary sources in this study.

Data from the articles that met the criteria were analyzed descriptively and thematically to answer the research questions. The analysis was conducted by grouping findings based on four main aspects: research trends, characteristics of technology-assisted PjBL implementation, impact on students' numeracy skills, and challenges and recommendations for future research. The results of the analysis are then presented in the form of tables, graphs and narratives to provide a comprehensive overview of research developments in this field.

RESULTS AND DISCUSSION

Research Trends on PjBL

An analysis of 23 articles meeting the inclusion criteria shows that research on technology-assisted Project-Based Learning (PjBL) and numeracy skill development has experienced a significant increase in recent years. Research publications were found between 2021 and 2025, with the number of articles fluctuating but showing an increasing trend. 2025 was the period with the highest number of publications, with 14 articles (60.87%), while 2022 was the year with the lowest number of publications, with 1 article (4.35%). The data can be seen in Figure 2.

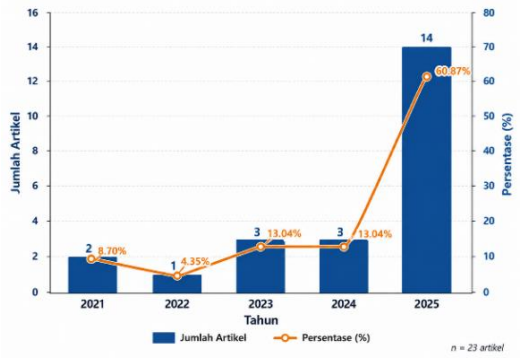

Figure 2. Research Distribution

These findings indicate that the integration of PjBL, digital technology, and numeracy is increasingly attracting attention from researchers in line with the increasing demands of 21st-century learning and the digital transformation of education. Overall, research trends indicate that

technology integration in PjBL is seen as a potential strategy to support the development of students' numeracy skills. The increasing number of publications over the past five years also demonstrates the growing academic attention to the importance of mathematics learning that focuses not only on conceptual mastery but also on students' ability to apply mathematical knowledge to solve real-world problems through the support of digital technology.

Characteristics of PjBL Implementation

An analysis of the reviewed articles shows that the implementation of technology-assisted Project-Based Learning (PjBL) in numeracy learning in elementary education has diverse characteristics, both in terms of the technology used, the learning approach, and the competencies developed. Most studies integrate digital technology as a means to support project activities, exploration of mathematical concepts, collaboration, and presentation of learning outcomes. The technologies used include digital learning applications, mobile learning, or Augmented Reality (AR).

In addition to the use of technology, another prominent characteristic is the implementation of project-based learning oriented towards contextual problem-solving. Students not only learn mathematical concepts theoretically but also apply them in real-life projects that require measurement, data processing, planning, problem-solving, and decision-making. In several studies, the PjBL approach was also combined with STEAM to strengthen the connection between numeracy and real-world problems.

The review also shows that most studies used a student-centered learning design. Students play an active role in gathering information, utilizing digital technology, working collaboratively in groups, and presenting project results. Meanwhile, the teacher acts as a facilitator, guiding the investigation and reflection process. These characteristics can be seen in table 1.

Table 1. Characteristics of PjBL Implementation

Aspect	Characteristics Found
Technology Used	GeoGebra, learning applications, mobile learning, LMS, AR, and AI
Learning Approach	Student-centered learning, collaborative learning, and project-based learning
Main Student Activities	Investigation, data collection, problem solving, product creation, and project presentation
Competencies Developed	Numeracy, mathematical literacy, problem solving, critical thinking, and creativity
Project Forms	Contextual projects
Teacher's Role	Facilitator and guide

Based on these findings, it can be concluded that the main characteristic of technology-assisted PjBL implementation lies in the integration of digital technology with authentic, student-centered project activities. Technology is used not only as a medium for delivering material but also as a tool to support the exploration of mathematical concepts, collaboration, communication, and problem-solving. Thus, numeracy learning becomes more contextual, interactive, and relevant to the needs of 21st-century skills.

The Impact of Technology-Assisted PjBL on Elementary School Students' Numeracy Skills

Based on the analysis of the reviewed articles, the implementation of technology-assisted Project-Based Learning (PjBL) generally has a positive impact on elementary school students' numeracy skills. Most studies report that integrating learning projects with digital technology can improve students' understanding of mathematical concepts, problem-solving skills, mathematical literacy, and critical thinking skills. Student-centered, real-world problem-solving learning enables students to connect mathematical concepts to contextual situations, making learning more meaningful and understandable.

Research findings indicate that the use of technology in PjBL helps students visualize abstract mathematical concepts through various digital media, such as learning apps, interactive simulations, Augmented Reality (AR), GeoGebra, and other digital learning platforms. This technology provides students with opportunities to explore mathematical concepts in greater depth, conduct virtual experiments, and receive direct feedback during the learning process. This contributes to improved numeracy skills, demonstrated through improved learning outcomes, the ability to solve contextual problems, and the ability to apply mathematical concepts in everyday life.

In addition to improving numeracy skills, several studies also report positive impacts on

supporting skills related to numeracy. Students demonstrated improved critical thinking, creativity, communication, and collaboration skills during project completion. Project activities that require students to collect data, conduct measurements, analyze information, and develop solutions to problems foster the development of higher-order thinking skills. Thus, technology-assisted PjBL contributes not only to mastery of mathematical concepts but also to the development of 21st-century competencies that support numeracy skills.

Overall, the study results indicate that technology-assisted PjBL is an effective approach to supporting the development of numeracy skills in elementary school students. This success is supported by the contextual, collaborative, and student-centered learning characteristics, as well as the use of technology to enrich the learning experience. Therefore, the integration of PjBL and technology can be a relevant alternative learning strategy to improve numeracy skills while preparing students for the demands of learning and life in the digital era.

Implementation Challenges and Further Research Directions

Based on a synthesis of 23 articles, the application of technology-assisted Project-Based Learning to improve numeracy skills in elementary education shows strong potential, but still faces several implementation challenges. The first challenge relates to teacher readiness in designing technology-integrated, numeracy-oriented project-based learning. Several articles indicate that the use of technologies such as mobile learning, augmented reality, GeoGebra, dynamic mathematics software, and the STEAM approach requires adequate pedagogical and digital skills. Without such readiness, technology serves only as a supplementary medium, not as a tool that encourages students' numeracy exploration, problem-solving, and mathematical reasoning.

The second challenge lies in limited infrastructure and access to technology in elementary schools. Technology-assisted learning requires devices, internet connections, appropriate applications, and stable technical support. In the elementary education context, limited facilities can hinder equitable implementation. This is crucial because the effectiveness of technology-assisted Project-Based Learning relies heavily on active student engagement during the investigation process, project design, data processing, and presentation of results.

The third challenge relates to the integration of Project-Based Learning into numeracy learning. Most articles in the dataset discuss Project-Based Learning (PjBL) in relation to mathematical literacy, problem-solving, creative thinking, scientific creativity, or 21st-century skills. However, studies specifically linking technology-assisted PjBL to improving numeracy skills in elementary education are still limited. This indicates that numeracy has not yet fully become a central focus of project-based learning design. Numeracy requires not only the ability to calculate, but also the ability to understand quantitative information, interpret data, select strategies, and apply mathematical concepts in real-world contexts.

The fourth challenge is time constraints and the complexity of project implementation. Project-Based Learning requires systematic stages, from problem identification, project planning, exploration, data collection, product development, reflection, and evaluation. In elementary education, these stages need to be tailored to the age, cognitive abilities, and independence of students. If the project is too complex, students may struggle to understand the objectives of numeracy. Conversely, if the project is too simple, the learning may not be robust enough to improve numerical thinking and problem-solving skills.

The fifth challenge relates to measuring learning outcomes. Some articles use tests, questionnaires, observations, interviews, or quasi-experimental designs. However, instruments specifically measuring project-based numeracy skills are still underdeveloped. Numeracy assessment in the context of Project-Based Learning (PjBL) needs to encompass both process and product. Aspects that need to be measured include the ability to understand problems, use mathematical concepts, read data, make decisions based on numerical information, explain strategies, and reflect on project outcomes.

Based on these challenges, future research should focus on developing technology-assisted Project-Based Learning models specifically designed to improve numeracy in elementary education. These models should incorporate simple, contextual syntax, and be tailored to the characteristics of elementary school students. Projects should be based on real-world problems experienced by students, such as measurement, simple data management, comparison, number patterns, money, time, area, volume, or simple graph interpretation.

Future research should also develop technology that is easily accessible to elementary schools. Simple mobile applications, offline interactive media, lightweight device-based augmented reality, and digital platforms that teachers can use without complex technical training are relevant options. The technology used should function as a thinking tool, not just a presentation tool. This way, students can use technology to actively experiment with strategies, visualize concepts, process data, and solve numeracy problems.

Furthermore, future research needs to employ more robust research designs. Most studies in the dataset still use quasi-experimental designs, descriptive studies, mixed methods, or bibliometric studies. Future research could employ longitudinal designs to examine the long-term impact of technology-assisted Project-Based Learning on numeracy skills. Research also needs to involve a wider sample, different grade levels, and diverse school contexts so that the results are more robust and can be carefully generalized.

CONCLUSION

This study demonstrates that technology-assisted Project-Based Learning (PjBL) has significant potential to improve elementary school students' numeracy skills. A review of 23 articles indicates that technology integration in PjBL can improve students' understanding of mathematical concepts, mathematical literacy, problem-solving skills, and engagement in learning. However, its implementation still faces challenges in the form of limited teacher digital competency, technological infrastructure, and learning project management. Therefore, the development of more effective implementation models and strategies is needed so that technology-assisted PjBL can optimally support the development of numeracy skills in elementary education.

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