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A Systematic Literature Review of Technology-Based Learning Models to Improve Numeracy Literacy in the Indonesian Context

Fitriani Nur[1], Sitti Mania[1,*], Badaruddin Amin[2], & Fatin Nabilah Abdul Wahid[3]

[1]Department of Mathematics Education, UIN Alauddin Makassar, Indonesia

[2]Department of Mathematics, Universitas Hasanuddin, Indonesia

[3]Academy of Contemporary Islamic Studies (ACIS), Universiti Teknologi MARA (UiTM), Malaysia

*Corresponding email: sitti.mania@uin-alauddin.ac.id

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Abstract: A Systematic Literature Review of Technology-Based Learning Models to Improve Numeracy Literacy in the Indonesian Context. Objectives: Technology-based learning is a learning approach that fosters student interaction with various learning resources. This study aims to analyze the characteristics of technology-based learning models that can improve numeracy literacy. **Methods:** This research employed a Systematic Literature Review following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. Data were collected using the Publish or Perish tool from Scopus and Google Scholar databases, limited to articles published between 2016 and 2025. A total of 25 articles were deemed eligible for analysis. **Findings:** The results of this study indicate that various technology-based learning models facilitate the improvement of students' numeracy literacy skills. These models integrate technology to create learning that supports a more concrete understanding of numeracy concepts. In addition, this study also identifies the types of technologies used in technology-based learning models, which consist of four main categories: hardware, general software, mathematical software, and online resources. Notably, the most prominent findings highlight the use of General Software and Online Resources, which are widely applied in various learning models to support students' numeracy literacy development. **Conclusion:** This study concludes that technology-based learning models have the potential to significantly enhance students' numeracy literacy by implementing various forms of technology into the learning process. These models not only provide a more concrete understanding of numeracy concepts but also create interactive and engaging learning environments. The contribution of this research provides a solid basis for educators to adopt more effective and relevant technology-based learning models to improve students' numeracy literacy.

Keywords: learning model, numeracy literacy, technology.

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INTRODUCTION

The 21st century is characterized by rapid technological advancements, globalization, and complex social challenges (Kishore, Appa, Rama, & Bayana, 2024). This development has had a significant impact and affected various aspects of human life (Mahrunnisya, 2023; Majid et al., 2024). In the 21st century, various essential skills are the main demands to prepare the young generation to face increasingly complex global challenges (González Pérez & Ramírez Montoya, 2022; Amin, Hikmah, Wandari, & Kusumayanti, 2023). Skills such as critical thinking, problem-solving, perseverance, high curiosity, and the ability to collaborate are essential in modern life (Diquito, Anter, & Bulonos, 2022; Fajriyah, 2022;

Herlinawati et al., 2024; Kain, Koschmieder, Matischek-Jauk, & Bergner, 2024; Nur, Amin, Fatmah, D, & Nursalam, 2024). Responding to these challenges, the World Economic Forum identified three main domains that must be mastered, namely basic literacy, competence, and character. Basic literacy includes six main aspects: literacy, numeracy literacy, science literacy, digital literacy, financial literacy, and cultural and civic literacy (Ayuningtyas & Sukriyah, 2020; Carpendale et al., 2025; Nudiati, 2020).

Numeracy literacy is a fundamental skill that is crucial in the current era of globalization and digitalization. Numeracy literacy is knowledge and skills that include the ability to use various numbers and mathematical symbols to solve practical problems in various daily life situations, and the ability to analyze information presented in various formats, such as graphs, tables, or diagrams, as well as using the results of these analyses to make predictions and make decisions (Amin, Baharuddin, Nur, Nursalam, & Angriani, 2025; Azubuike, Browne, & Leckie, 2024; Dewayani et al., 2021; Gelbgiser & Gabay-Egozi, 2025; Hornburg, King, Westerberg, Schmitt, & Purpura, 2024; Nursalam, Baharuddin, & Amin, 2025; Resti, Zulkarnain, & Kresnawati, 2020). Numeracy literacy is very important for students because it relates to daily life. In addition to being ready to face life's problems, it is also a form of human civilization's progress in solving problems in daily life, which cannot be separated from the existence of mathematical concepts (Pratiwi, Apriani, & Mahmud, 2024; Rohmah, Sutama, Hidayati, Fauziati, & Rahmawati, 2022). By emphasizing mathematical applications that are relevant to real life, students can develop skills and confidence in thinking numerically, spatially, and data-based, so that they can interpret and critically analyze everyday situations and solve various problems (Susanto, Sihombing, Radjawane, & Wardani, 2021; Syamsuddin, Tayeb, Rasyid, Abrar, & Amin, 2022). UNESCO itself has designated numeracy skills as one of the main indicators of a nation's progress (Han et al., 2017).

Given the importance of numeracy literacy in daily life, an adaptive and relevant learning strategy is needed to keep pace with the times. One such strategy is the implementation of technology-based learning models, which can provide more interactive, flexible, in-depth, and meaningful learning experiences (Aji et al., 2024; Yulianti, 2024). The use of technology in learning enables the presentation of numerical information in an attractive and easy-to-understand visual form, such as simulations, animations, and data-based applications, which can directly have a positive impact on improving learning outcomes, including numeracy literacy skills (Nainggolan, 2024). As concluded by Amidi's research (2024), improvements in numeracy literacy can be achieved through the application of technology in mathematics learning, whether in the form of teaching materials, learning media, learning references, or teaching aids. Technology-based learning models can enhance various aspects of numeracy literacy, such as critical thinking skills, spatial skills, problem-solving skills, and data analysis and interpretation skills (Hartanto, Hamidah, & Kusuma, 2024; Istofany, Negara, & Santosa, 2024; Liang & Wu, 2024; Nurwijaya, 2022; Sarumaha, Putra, & Hermawan, 2024; Zhan, Wu, Liu, & Zhao, 2025). Currently, various policies have been implemented to support the adoption of technology in learning, such as the implementation of Merdeka Belajar (Freedom of Learning) and the digitization of education through online learning platforms (Susanty, 2020; Ningrum & Suryani, 2022).

Previous studies have shown that technology-based learning has great potential in improving numeracy literacy skills. Research by Anggraeni et al. (2024) highlights the importance of game-based media in helping elementary school students improve their numeracy skills. Furthermore, Karimah et al. (2024) demonstrated that the Nearpod application, as a

STEM-based media, can enhance both numeracy literacy and students' interest in learning. On the other hand, Widaningsih et al. (2023) revealed that the application of Technological Pedagogical and Content Knowledge (TPACK)-based learning has been proven to improve students' numeracy competence. However, these studies tend to emphasize specific tools, applications, or instructional media rather than examining the broader structure of technology-based learning models. As a result, there is still limited understanding of how different components such as instructional strategies, learning processes, and technology integration can be systematically combined into comprehensive models that are adaptable across diverse educational contexts. Therefore, a broader review of technology-based learning models is necessary as a next step to provide educators with holistic frameworks that go beyond individual media support sustainable improvements in students' numeracy literacy.

Therefore, this research aims to fill this gap by identifying how technology-based learning models are applied to improve numeracy literacy. Based on these objectives, the main questions in this study include (1) what technology-based learning models are used to improve numeracy literacy, and what are their main characteristics?, (2) what are the types of technology used to improve numeracy literacy?. By analyzing relevant and comprehensive literature, this research is expected to contribute to the development of education theory and practice in Indonesia, as well as support efforts to improve the quality of numeracy literacy in an ever-changing global context.

METHOD

Research Design

This research was conducted using the Systematic Literature Review (SLR) approach, which refers to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. PRISMA is a guideline used to conduct a systematic literature review, ensuring that the article selection process is carried out in a transparent, consistent, and accountable manner. In the context of this study, the PRISMA protocol was used to filter and select relevant articles that discuss technology-based learning models that focus on numeracy literacy. The stages in this study consist of several steps that are carried out sequentially, including determining inclusion criteria, defining information sources, selecting literature, collecting data, and selecting data items. This activity can be seen in Table 1.

Table 1. Stages of SLR research

Stages	Activities
Determination of Inclusion Criteria (IC)	1) IC1: Articles reviewed are journal articles and conference papers. 2) IC2: Articles published between 2016 and 2025. 3) IC3: The article has gone through *a peer-review* process. 4) IC4: The article discusses the context at all levels of education. 5) IC5: The article is a case study conducted in Indonesia. 6) IC6: Articles are available in *full text*. 7) IC7: Studies related to the development or application of technology-based learning or technology-assisted learning to improve students' numeracy literacy.
Definition of Information Source	Literature searches were conducted on online databases, namely Scopus and Google Scholar.
Literature Selection	1) Using keywords: Numeracy literacy, learning model, digitally based, technology-based.

	2) Search and select the titles, abstracts, and keywords of the articles obtained based on the inclusion criteria. 3) Read the article in whole or in part from the article that had not been eliminated at the previous stage and determine the eligibility of the article for inclusion in the study.
Data Collection	Data collection is carried out by creating a data extraction form consisting of the author's name, year, and article content.
Data Item (DI) Selection	1) DI1: The technology-based or technology-assisted learning model used. 2) DI2: Used learning technologies.

Inclusion and Exclusion Criteria

A strict set of inclusion and exclusion criteria was applied to ensure that only high-quality and relevant publications were considered in this review. A specific focus was given to case studies conducted in Indonesia, as numeracy literacy is a priority program of the Indonesian government through the implementation of the National Assessment (*Asesmen Nasional*). Limiting the scope to Indonesian cases ensures that the findings are directly relevant to the local educational context. Since each country has its own social, cultural, policy, and implementation challenges, concentrating on Indonesia provides more contextualized insights that can better inform national practices and policymaking. In detail, the criteria used in the article selection for this study are presented in Table 2.

Table 2. Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Type of Article	Journal articles and conference papers	Book, book chapter, and thesis
Year of Publication	2016–2025	< 2016
Peer-review	Peer-reviewed	Non-peer-reviewed
Context	All levels of education	None
Setting	Case Study in Indonesia	Case Studies outside Indonesia
Text	A full text	Not a full text
Topic	Technology-based learning model to improve numeracy literacy	In addition to technology-based learning models to improve numeracy literacy

Search Strategy

The source of research data was obtained using the help of *Publish or Perish* (PoP) and came from articles in journals published in the last 10 years (2016-2025) to ensure the relevance and timeliness of the findings for the study. The choice of this 10-year range is based on two main considerations. First, the development of technology and educational models, particularly in technology-based learning, has accelerated significantly over the past decade, making this period critical for capturing the latest innovations. Second, the issue of improving numeracy literacy in Indonesia gained prominence after the government launched the National Assessment (*Asesmen Nasional*) in 2019, which positioned literacy and numeracy as core competencies to be strengthened in the education system. By focusing on this time frame, the study can cover both global advances in technology-based learning and the specific national policy context of literacy and numeracy in Indonesia. However,

it should be acknowledged that this study has a limitation in its search strategy, as only one combination of keywords was applied for each database. This constraint may affect the comprehensiveness of the retrieved literature, and thus, the findings should be interpreted with this consideration in mind. The database of data sources and search strings can be seen in Tables 3 and 4, respectively.

Based on Table 3, the search in the Scopus database resulted in no eligible articles being selected. Two main factors may explain this outcome. First, the specific focus of this review on numeracy literacy in the Indonesian context is rarely highlighted in Scopus-indexed publications, which more commonly adopt broader or cross-country perspectives. Second, many studies on numeracy literacy in Indonesia particularly those related to the implementation of the National Assessment (*Asesmen Nasional*) are published in national or regional journals that are not indexed in Scopus. This limited representation of local studies international databases likely contributed to the absence of eligible articles retrieved.

Table 3. Data source

No	Data Source	Number of Articles	Number of Selected Articles
1	Scopus	117	0
2	Google Scholar	1480	25
	Total	**1597**	**25**

Table 4. Search strings by database

No	Database	String
1	Scopus	Numeracy literacy, learning model, digitally based
2	Google Scholar	Numeracy literacy, learning model, technology-based

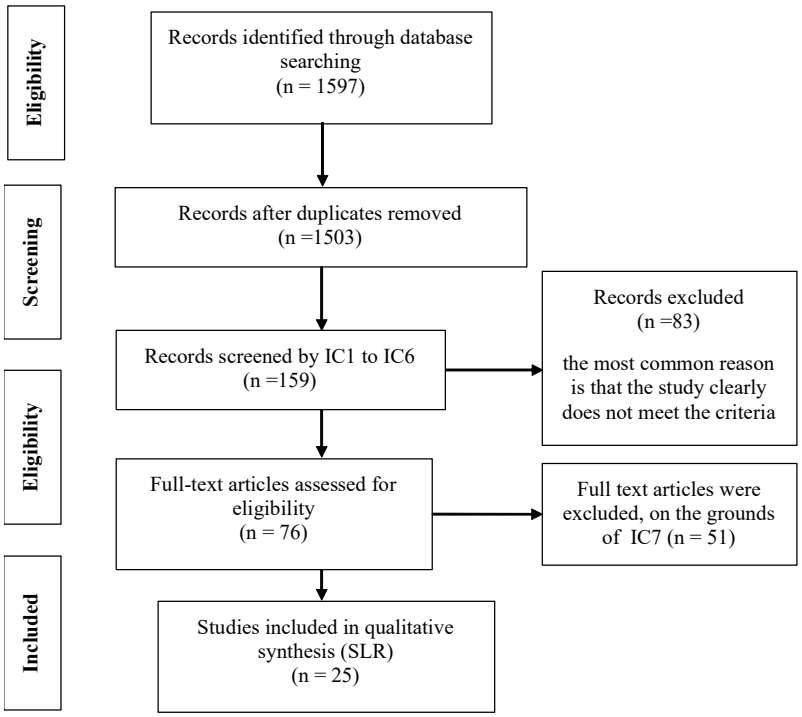

Figure 1. Data collection flow based on prism flow diagram format

Data Analysis

The data analysis process was conducted through systematic extraction of information from the selected articles. Each study was reviewed, and its key characteristics were recorded in a spreadsheet to ensure consistency and comparability. The data collected included author(s), year of publication, article title, URL/DOI, learning model or method applied, its implementation in numeracy learning, and the research methodology used. The use of spreadsheets allowed the data to be organized and categorized effectively, making it easier to identify trends, similarities, and differences among the studies. Through this process, patterns of technology-based learning models and their influence on numeracy literacy were synthesized into a comprehensive understanding.

The PRISMA flow diagram in Figure 1 illustrates the step-by-step process of article identification, screening, eligibility assessment, and inclusion in the final review.

RESULT AND DISCUSSION

This section presents the results of a systematic literature study analyzing the application of technology-based learning models in improving numeracy literacy. A total of 25 articles (see Table 6) were selected to answer research questions related to the effectiveness of technology-based learning models in improving numeracy literacy, as well as the types of technology and technology integration used in implementing these models.

Characteristics of Technology-Based Learning Models to Improve Numeracy Literacy

Technology-based learning models have been widely used to improve students' numeracy literacy, with various approaches tailored to current technological developments and educational needs. Each learning model integrates technology to create a more engaging and effective learning experience for students. The results of the study on technology-based learning models applied to improve numeracy literacy can be seen in Table 5.

Problem-Based Learning

Problem-Based Learning (PBL) is recognized as an instructional model that positions

Table 5. Characteristics of learning model implementation

Authors/Year	Learning Models	Subjects/ Levels	Resources (Learning Technology)
Rizqi & Ardani (2025)	Children Learning in Science (CLIS)	Mathematics/ Elementary School	*GeoGebra*
Mukti & Yustitia (2025)	Problem-Based Learning (PBL)	Mathematics/ Elementary School	*Kahoot*
Nursya'bani, Mursidik, & Laksana (2024)	Joyful Learning	Mathematics/ Elementary School	*Articulate Storyline*
Iffah et al. (2024)	Team Games Tournament (TGT)	Mathematics/ Elementary School	*Wordwall*
Shahira, Sumaji, & Uly (2024)	Creative Problem Solving	Mathematics/ Junior High School	*Permath Apps*
Sari et al. (2024)	Problem-Based Learning (PBL) - Flipped Classroom	Mathematics/ Senior High School	*Google Sites*
Safitri, Nirawati, & Utama (2024)	Project-Based Learning (PjBL)	Mathematics/ Elementary School	Animated Video
Tarigan & Siregar (2024)	Problem-Based Learning (PBL)	Mathematics/ Junior High School	Electronic Learner Worksheet

Haryanto, Samsudi, & Arbarini (2024)	Project-Based Learning Model Based on Ethno-STEAM	Mathematics/ Junior High School	Text Animation, Audio, Video, and Images
Mustika, Maulana, & Syahid (2024)	Problem Solving	Mathematics/ Elementary School	Computer
Hutauruk & Ardiansyah (2024)	CBL-STEM Context	Not Explained	*Wordwall*
Husna, Isnarto, & Suyitno (2024)	Problem-Based Learning (PBL)	Mathematics/ Junior High School	*Liveworksheet*
Purnomo (2024)	Problem-Based Learning (PBL)	Mathematics/ Senior High School	*GeoGebra*
Salsabila, Lubis, & Narpila (2024)	Flipped Classroom	Mathematics/ Junior High School	Learning Video
Irawati, Sapti, & Yuzianah (2024)	Aptitude Treatment Interaction (ATI)	Mathematics/ Junior High School	*Wordwall*
Suardipa, Handayani, & Budayani (2023)	Accelerated Learning Cycle (ALC)	Mathematics/ Elementary School	*Quizizz*
Yusnidah, Siagian, & Maulana (2023)	Problem-Based Collaborative	Physics/ High School	*Livewire*
Khamdani, Rasiman, & Sulianto (2023)	Flipped Classroom	Mathematics/ Elementary School	Learning Video
Wulandari & Widiansyah (2023)	Games-Based Learning	Literacy and Numeracy/ Elementary School	*PowerPoint*
Andini, Fuady, & Nursit (2023)	Problem-Based Learning (PBL)	Mathematics/ Junior High School	*YouTube*
Lestari et al. (2022)	Blended Learning	Mathematics/ Junior High School	*YouTube*
Ambarwati & Kurniasih (2021)	Problem-Based Learning (PBL)	Mathematics/ Junior High School	*YouTube*
Widiastuti & Kurniasih (2021)	Problem-Based Learning (PBL)	Mathematics/ Junior High School	*Cabri 3D V2*
Dantes & Handayani (2021)	Blended Learning	Mathematics/ Elementary School	Online Resources
Nirmalasari, Jumadi, & Ekayanti (2021)	STEAM	Mathematics/ Elementary School	Learning Video

problem-solving at the core of the learning process (Yew & Goh, 2016). Rather than beginning with direct explanations, students are first presented with authentic problems that are closely related to the subject matter under study. The purpose of discussing these issues in the beginning is to stimulate students' existing knowledge and lay the groundwork for additional research (Dolmans, Loyens, Marcq, & Gijbels, 2016). Students are encouraged to participate actively in this process, which fosters critical thinking, enhances problem-solving skills, and facilitates the acquisition of key ideas and information from the challenges (Sabar, Latuconsina, Angriani, Suharti, & Amin, 2023).

Conversely, numeracy literacy describes a collection of abilities and knowledge that includes the use of numbers and mathematical symbols to solve real-world problems in everyday situations. It also includes the ability to decipher and evaluate data presented in various formats, such as tables, graphs, and diagrams, and to use the results of these analyses to make predictions and decisions

(Resti et al., 2020; Dewayani et al., 2021; Amin et al., 2025). Several studies, including those by Mukti & Yustitia (2025), Purnomo (2024), Husna et al. (2024), Ambarwati & Kurniasih (2021), and Andini et al. (2023), Widiastuti & Kurniasih (2021), Tarigan & Siregar (2024), highlight that the development of numeracy literacy can be strengthened through problem-solving practices, information analysis, and the application of mathematical concepts within the framework of the Problem-Based Learning model.

Furthermore, these studies describe how PBL is implemented through systematic stages: explaining learning objectives, presenting problems, helping students identify tasks, and guiding them in investigating and solving problems. Students generally work in groups, develop learning products, and evaluate the process. These activities not only enhance student engagement but also serve as a means to assess the effectiveness of PBL in improving numeracy literacy. The analysis indicates that the *Guiding Group Investigation* phase has the most significant influence on students' numeracy achievement. Moreover, learning becomes more meaningful when students are confronted with real-life situations that require the application of knowledge. This aligns with the PISA assessment framework, which emphasizes students' ability to use knowledge to reason and solve contextual problems. Thus, PBL holds great potential in fostering numeracy literacy that is relevant to the demands of 21st-century life.

Blended Learning

Silverman & Hoyos (2016) explain the concept of blended learning, which consists of e-learning, texts, theory, practice-oriented, and mentoring. Blended learning is also defined as combining technology-based learning with face-to-face learning (Kerres & Witt, 2003; M. Lai, Lam, & Lim, 2016). Blended learning combines the power of face-to-face and online learning environments (Istiningsih & Hasbullah, 2015; Scott, 2014; Wardani, Toenlioe, & Wedi, 2018). In simple terms, Blended Learning is a learning model that combines various strategies, including face-to-face learning, computer-based learning, and online technology-based learning (such as internet and mobile learning). Subject matter is delivered through media that include various elements, such as graphics, text, animation, simulation, audio, and video (Dantes & Handayani, 2021). This model allows students to access the material first online and then discuss or apply that knowledge in face-to-face sessions.

Research by Dantes & Handayani (2021), Lestari et al. (2022), Khamdani et al. (2023), and Salsabila et al. (2024) emphasizes students' activities to gain experience in hypothesis testing, prediction, object manipulation, questioning, seeking answers, and imagination in learning. Video assistance can deepen your understanding of the material, discover new knowledge, and enable students to learn anywhere and anytime. The results of the research by Supriadi et al. (2025) revealed that technology-based blended learning activities promote numeracy literacy.

Problem-Based Learning (PBL)-Flipped Classroom

A study on the application of the combination of the Problem-Based Learning (PBL) and Flipped Classroom models has been conducted by Sari et al. (2024), integrating these two models using the Teaching at the Right Level (TaRL) approach assisted by Google Sites. PBL provides students with a more applicable context by connecting mathematical ideas to real-world scenarios. In contrast, the Flipped Classroom allows students to study the content independently before class, enabling them to be better prepared and maximize their learning time. The Flipped Classroom model reinterprets the conventional learning framework by giving students access to brief films or other multimedia materials before

class. In this way, the initial exposure to new material takes place outside the classroom, allowing the face-to-face sessions to be used primarily for reinforcement through practice, problem-solving, and interactive activities (Tawfik & Lilly, 2015).

The use of technology such as Google Sites is efficient because it is easy to create and manage by ordinary users (Jubaidah & Zulkarnain, 2020). The integration of Problem-Based Learning with the Flipped Classroom model, facilitated by digital tools such as Google Sites, creates opportunities for students to engage in a more dynamic and interactive learning atmosphere. In addition to encouraging group conversations, this environment helps students become more adept at approaching and resolving issues. With a more organized and focused approach to learning, students can better understand mathematical ideas, which contributes significantly to the development of their numeracy literacy (Sari et al., 2024).

Project-Based Learning (PjBL)

Project-Based Learning (PjBL) is a learning model that emphasizes student involvement in projects that are oriented towards real problem-solving. In PjBL, students work collaboratively to design and complete a project that is relevant to their lives. When students collaborate, they exchange strategies, test each other's thinking, and collectively navigate the problem-solving process (Rehman, Huang, Mahmood, AlGerafi, & Javed, 2024). Project-based Learning is a student-focused learning model that involves investigation, decision-making based on data analysis, collaboration, and a product-oriented approach, as well as document preparation (Handrianto & Rahman, 2018).

According to research by Safitri et al. (2024) and Haryanto et al. (2024), numeracy literacy skills can be facilitated through Project-Based Learning activities. Through this model, learning is carried out with contextual problems in the student environment so that students can more easily understand the existing problems and can apply them in daily life. This is in line with the main focus of numeracy literacy, which is the ability to solve problems that occur in daily life (Haryanto et al., 2024).

Science, Technology, Engineering, Art, and Mathematics (STEAM)

The STEAM-based learning model (Science, Technology, Engineering, Art, and Mathematics) integrates five disciplines to offer a holistic and immersive learning experience relevant to the demands of the 21st century (Lestari et al., 2023). STEAM prioritizes the development of critical thinking, creativity, and problem-solving abilities that are directly related to real-world situations rather than just academic knowledge (Sari et al., 2023). It has been demonstrated that this method is effective in helping children improve their numeracy literacy, particularly in contexts where science, technology, engineering, art, and mathematics are used simultaneously. For instance, Nirmalasari et al. (2021) demonstrated that the STEAM model can significantly strengthen students' numeracy competencies.

The integration of STEAM-based learning with other educational techniques has also been the subject of recent studies. Examples include Project-Based Learning grounded in Ethno-STEAM (Haryanto et al., 2024) and Challenge-Based Learning (CBL) within a STEM framework supported by Wordwall (Hutauruk & Ardiansyah, 2024). Technology is essential to the successful execution of these integrations. For instance, Wordwall is used to promote interaction, offer interesting quiz formats, and make it easier to track students' progress in their comprehension of the subject matter. This technological support indirectly contributes to the enhancement of numeracy literacy, as highlighted in Devi's (2024) study, which specifically promoted numeracy skills through the use of Wordwall media.

Children Learning in Science (CLIS)

Constructivist philosophy is the foundation of the Children Learning in Science (CLIS) model, which emphasizes the use of observation in the learning process. Giving pupils the chance to voice their preliminary opinions about a subject before delving deeper into it is one of its main goals. Through experience, firsthand observation, or comparison with material found in textbooks, these early concepts are subsequently reviewed and improved (Hujrotunnahdiyah & Ratnasari, 2023; Darsanianti et al., 2024). Because it incorporates constructivist features that promote meaningful learning and deeper comprehension, CLIS is frequently seen as a good option in scientific education (Sari et al., 2020). By doing this, the model enhances students' problem-solving abilities, particularly in numeracy, while also helping them overcome obstacles that arise during sessions.

CLIS's flexibility about digital learning resources is another benefit that contributes to its increased efficacy. As an example of the synergy between constructivist approaches and technology in the classroom, research by Rizqi & Ardani (2025) revealed that using GeoGebra to execute CLIS significantly increased students' numeracy literacy. In practice, students view the design of a building and respond to the easier question that asks them to connect the shape to a real-world object. They then collaborate in groups and have a discussion. Additionally, utilizing the GeoGebra tool, which facilitates the exact, accurate, and efficient representation of materials, students investigate the idea of digitally creating space. By using mathematical tools to solve issues in real-world scenarios, this practice indirectly enhances numeracy literacy abilities (Iswara, Ahmadi, & Ary, 2022).

Joyful Learning

Joyful Learning is defined as a learning process or learning experience with joy (Bhakti, Ghiffari, & Salsabila, 2018). Joyful learning can help develop thinking skills, build subject matter concepts, and the ability to formulate conclusions in students, and expose students to pleasant situations so that students like the material given because the learning process is designed to be more dynamic, emphasizing visual and fun things (Ardiyanti, Qurbaniah, & Muldayanti, 2021). Thus, students not only learn in theory, but also engage in activities that can spark their enthusiasm and focus. This model allows students to learn in a fun way, which can indirectly improve their numeracy skills.

Research by Nursya'bani et al. (2024) indicates that the Joyful Learning model is successful in enhancing students' numeracy abilities when implemented with the help of an articulate storyline. Through interactive components that enhance the educational process, this model adds a new level to learning and enables active engagement from students. By offering dynamic and captivating educational resources, the incorporation of technology, such as Articulate Storyline, may further improve the educational process (Kurniawati & Erwinda, 2023). This method makes learning experiences more effective and memorable, which helps students understand and grasp mathematical topics more clearly.

Team Games Tournament (TGT)

The Teams-activities-Tournaments (TGT) model is a teaching strategy that prioritizes student cooperation in small groups. After completing learning assignments together, students participate in competitive activities intended to gauge their level of subject understanding (Bayu, 2023). This strategy fosters students' social and communication skills while creating an interesting and participatory learning environment by mixing collaboration and competition (Sya'adah, Sutrisno, & Happy, 2023). Furthermore, by making learning more engaging and dynamic, TGT has been demonstrated to improve cognitive function and numeracy abilities. This model's

competitive component frequently acts as an extra source of inspiration, motivating students to work hard to meet learning goals (Ayunda & Febriandi, 2023).

One of the recent innovations in applying the TGT model involves the integration of Wordwall as a supporting medium, as demonstrated in the study conducted by Iffah et al. (2024). According to their findings, Wordwall is a useful tool for improving numeracy literacy in TGT classes. By demonstrating that working with numeracy does not have to be perceived as challenging or daunting, the incorporation of game-based aspects enhances the learning experience and helps change students' perspectives.

Problem Solving

The goal of the problem-solving learning paradigm is to help students become more adept at solving issues by using their critical thinking skills and previously learned ideas. According to this technique, students are given complex problems to solve and are urged to do so methodically (Liska, Ruhyanto, & Yanti, 2021). In addition to enhancing subject-matter proficiency, the model fosters critical, logical, and rational thinking abilities that are applicable in real-world situations, such as numeracy (Sukarni, 2021).

With the development of technology, computer-based learning resources can help to further increase this model's efficacy. Students' numeracy performance is much enhanced when a computer-assisted problem-solving strategy is used, according to research by Mustika et al. (2024). Students can enhance their problem-solving skills and deepen their conceptual understanding by utilizing interactive feedback, visual representations, and simulations provided by digital platforms and software. Through organized, technologically enhanced activities, students may effectively and engagingly improve their numeracy skills.

Creative Problem Solving

The goal of the Creative Problem Solving (CPS) model of education is to encourage students to think critically and creatively while solving challenges. Students are encouraged to devise creative and practical solutions that can be applied in real-world contexts, rather than merely solving routine mathematics problems. Learning becomes more dynamic and captivating when CPS is included in the classroom. It also fosters students' creativity and gives them better problem-solving skills (Wulandari, 2023).

An example of how the CPS model can be implemented to support numeracy literacy is through the use of application-based learning media, such as PerMath Apps (Shahira et al., 2024). Developed with *Articulate Storyline 3*, this digital tool is specifically designed to assist students who often rely on rote memorization of formulas without fully understanding the mathematical concepts underlying them. In PerMath Apps, some features can stimulate and improve students' numeracy skills. One of them is an example of a problem whose solution is created in groups, allowing students to fill it in based on the ideas and understandings they have gained, thereby improving their numeracy skills.

Aptitude Treatment Interaction (ATI)

The Aptitude Treatment Interaction (ATI) model can be substantively and theoretically interpreted as a concept that incorporates several effective learning strategies (treatment) tailored to certain individuals according to their respective abilities (Endaninta & Pesik, 2023; Arifin et al., 2023). This model takes into account the differences in students' abilities and their educational experiences, allowing for the implementation of more targeted learning strategies.

Utilizing interactive platforms like Wordwall represents a recent advancement in applying the ATI model. This resource offers a range of engaging and challenging exercises that can be

adapted to suit students' diverse skill levels. The classroom environment becomes more lively and captivating when such media are used, which in turn boosts students' enthusiasm to study. According to data from Irawati et al. (2024), using the ATI model in a practical way with Wordwall helps improve students' numeracy literacy. Students can develop a more thorough understanding of numeracy topics by combining interactive digital media with learning models tailored to their individual capacities.

Accelerated Learning Cycle (ALC)

Through several useful tactics that complement students' chosen learning environments, the Accelerated Learning Cycle (ALC) is an educational model created to encourage rapid learning (Fayudha, Wanabuliandari, & Bintoro, 2021). Beyond fostering a meaningful learning environment, the ALC also stimulates positive emotions that contribute to the development of constructive perceptions, thereby enabling students to optimize their potential (Fajriah, Nursalam, Suharti, & Nur, 2021). The model encourages students to actively engage with ideas, tackle real-world issues, and apply their knowledge in practical situations. Students improve their critical thinking and problem-solving skills with these exercises, which are essential elements of numeracy literacy.

The effectiveness of the ALC can be further strengthened through the use of technology-based learning media, such as Quizizz. Findings from Suardipa et al. (2023) indicate that the integration of Quizizz with the ALC model positively influences students' numeracy literacy. As a game-oriented learning platform, Quizizz engages learners with interactive and competitive quizzes, making the process both enjoyable and impactful. With its diverse features, the platform proves to be highly effective in supporting the development of mathematical numeracy skills (Utari et al., 2021).

Problem-Based Collaborative

Problem-Based Collaborative Learning combines the principles of collaborative learning with the problem-based learning model. In this model, problems serve as the central source of learning while student cooperation becomes the main focus (Ningrum, 2016). Through collaboration, learners are encouraged to strengthen their communication, reflection, and problem-solving abilities. As they work together on a given task, students clarify their own understanding, critique the ideas of peers, formulate conjectures, select appropriate strategies, and ultimately reach solutions (Kanca, Ginaya, & Astuti, 2021).

The effectiveness of this model can be further enhanced through the integration of digital media, such as Livewire, a simulation platform designed to facilitate the exploration of engineering and science concepts. Evidence from Yusnidah et al. (2023) demonstrates that incorporating Livewire into problem-based collaborative learning positively impacts students' numeracy literacy. The platform enables learners to directly engage with simulations, visualize abstract phenomena, and collaborate on solving contextual problems. Such practices align with the essence of numeracy literacy, which emphasizes the use of multiple mathematical representations, tools, and strategies address problems across different contexts (Singh, Chand, Kumar, & Ali, 2023).

Games-Based Learning (GBL)

Game-Based Learning (GBL) is a learning model in which students take an active role through game elements designed to achieve educational objectives (Rahayu et al., 2024). Components such as challenges, scoring, levels, and rewards are incorporated to create a learning atmosphere that is both engaging and interactive. This model provides meaningful learning experiences while also stimulating student development through enjoyable activities (Winatha & Setiawan, 2020).

A positive and fun environment increases students' interest and motivation, which subsequently encourages curiosity and deeper exploration of the subject matter.

The implementation of GBL can be further strengthened by integrating technology, such as PowerPoint (PPT), to design interactive learning materials. Research conducted by Wulandari & Widiansyah (2023) indicates that the use of the PPT-assisted GBL model effectively improves students' numeracy literacy. In practice, PPT-based interactive games help students engage in solving numerical problems in a playful manner, making the learning process more dynamic and enhancing their understanding of mathematical concepts.

Types of Technology

Based on the reviewed studies, the findings concerning the types of technology employed to enhance numeracy literacy skills were analyzed by focusing on the specific learning technologies applied. From this analysis, four main classifications of technology use in supporting numeracy literacy development were identified. These classifications are illustrated in Figure 2.

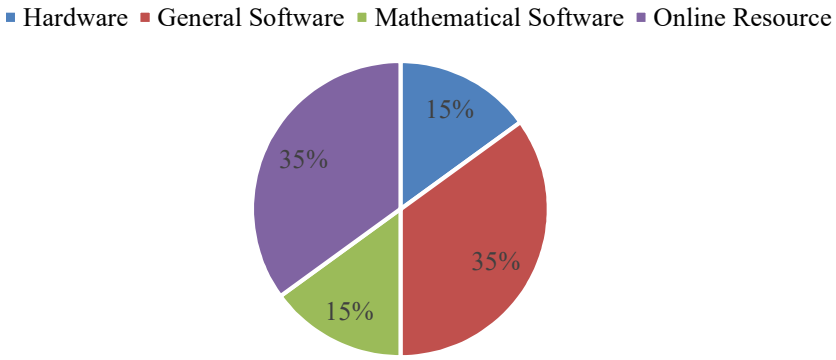

Figure 2. Types of technology used to improve numeracy and literacy

The first category, hardware, serves as a fundamental component in supporting the development of numeracy literacy through technology-assisted learning. Devices such as smartphones, laptops, and desktop computers (Mustika et al., 2024) provide students with direct access to digital resources, enabling them to engage with learning applications and communicate effectively with teachers and peers. Their portability also allows for flexible learning experiences, both in traditional classrooms and in online or blended settings. Beyond their role as mere tools, hardware functions pedagogically by providing access to multimodal learning resources, enabling collaborative and synchronous learning, and facilitating immediate feedback when combined with appropriate software. In this way, hardware helps remove access barriers and allows students to engage repeatedly with learning tasks, thereby supporting the development of procedural fluency and applied numeracy skills.

The second category, general software, is among the most widely applied technologies in educational practice. A range of commonly used applications has been integrated into numeracy-focused learning, including *PowerPoint* (Wulandari & Widiansyah, 2023), learning videos (Nirmalasari et al., 2021; Khamdani et al., 2023; Haryanto et al., 2024; Safitri et al., 2024), Articulate Storyline (Nursya'bani et al., 2024), electronic learner worksheet (Tarigan & Siregar, 2024), text animation, audio, and images (Haryanto et al., 2024). Among these, learning videos stand out as one of the most dominant tools, as they can simplify abstract mathematical

concepts and allow students to revisit material repeatedly, thus fostering deeper comprehension. Pedagogically, general software functions as a medium for explanation, modeling, and scaffolding. Through multimedia features such as text, images, animations, and audio, these tools can reduce cognitive load, strengthen conceptual clarity, and provide opportunities for guided practice. By enabling students to revisit content and regulate their own pace of learning, general software supports both conceptual understanding and self-directed learning in numeracy.

The third category involves specialized mathematical software, which plays a significant role in enhancing students' conceptual understanding. Applications such as *GeoGebra* (Purnomo, 2024; Rizqi & Ardani, 2025), *Permath Apps* (Shahira et al., 2024), and *Cabri 3D V2* (Widiastuti & Kurniasih, 2021) are utilized in educational settings. Among these, *GeoGebra* is particularly notable (Hidayat & Firmanti, 2024), as it allows visualization and manipulation of concepts in geometry, algebra, and calculus. *GeoGebra* allows students to explore and manipulate mathematical objects directly through an interactive interface. The interactive nature of this software makes it an effective tool for creating active, problem-solving-oriented learning. This will indirectly impact students' numeracy literacy skills. According to Junaidi & Wulandari (2024), GeoGebra is a valuable tool for improving students' numeracy skills. The pedagogical strength of this category lies in its ability to offer dynamic visualization and interactive experimentation. By allowing learners to explore mathematical objects through multiple representations—symbolic, graphical, and numerical—these tools promote inquiry, problem solving, and reasoning. This process helps students transition from concrete experiences to abstract thinking, ultimately fostering deeper conceptual understanding and representational fluency, which are crucial for numeracy literacy.

Finally, online resources represent one of the most accessible and widely adopted technologies. Platforms such as *Kahoot* (Mukti & Yustitia, 2025), *Wordwall* (Irawati et al., 2024; Iffah et al., 2024; Hutauruk & Ardiansyah, 2024), *Google Sites* (Sari et al., 2024), *Liveworksheet* (Husna et al., 2024), *Quizizz* (Suardipa et al., 2023), *Livewire* (Yusnidah et al., 2023), and *YouTube* (Ambarwati & Kurniasih, 2021; Lestari et al., 2022; Andini et al., 2023), have been widely utilized to foster interactive and engaging learning experiences. These platforms not only enhance classroom dynamics but also provide flexible opportunities for students to strengthen their numeracy literacy through accessible, context-rich activities. From a pedagogical perspective, online resources play an important role in supporting formative assessment, retrieval practice, and peer interaction through gamified quizzes and collaborative tasks. They also foster motivation and engagement through interactive learning experiences and asynchronous content review. Such features make online resources particularly valuable for reinforcing numeracy fluency and providing authentic, contextualized opportunities for application.

A closer analysis of the identified learning models shows that, despite their diverse formats, they share several overlapping characteristics that can be synthesized into broader themes. First, several models such as Problem-Based Learning (PBL), Creative Problem Solving (CPS), Problem Solving, Problem-Based Collaborative Learning, and Project-Based Learning (PjBL) emphasize problem orientation and contextual learning. These approaches enable students to connect mathematical concepts with real-life situations, engage in inquiry, and develop critical thinking skills, especially when supported by technologies such as *Google Sites, PerMath Apps,* or *Livewire*. Second, collaborative and interactive approaches, including Team Games Tournament (TGT), Game-Based Learning (GBL), and Joyful Learning, highlight the role of peer interaction, gamification, and motivation in learning. Supported by tools like Wordwall, Articulate Storyline, and PowerPoint, these

models create dynamic learning experiences that reduce mathematics anxiety and cultivate positive attitudes toward numeracy. Third, hybrid and technology-mediated models, such as Blended Learning, Flipped Classroom, and the Accelerated Learning Cycle (ALC), combine face-to-face instruction with online environments, allowing students to engage flexibly with learning materials before, during, or after class. This integration of platforms such as Quizizz, digital videos, and e-learning resources increases accessibility, personalization, and depth of understanding. Finally, integrated and multidisciplinary approaches, represented by STEAM, CLIS, and ATI, broaden numeracy learning by linking it with science, technology, engineering, art, or individual aptitudes. The use of applications such as GeoGebra and Wordwall facilitates visualization, simulation, and exploration, making abstract concepts more concrete and accessible.

Viewed in this way, the various models are not isolated strategies but rather interconnected approaches that share common principles of authentic problem orientation, collaboration, hybrid structures, and integrative use of technology. Together, these thematic patterns provide a more comprehensive picture of how technology-enhanced learning environments can foster students' problem-solving capacity, creativity, and positive engagement with numeracy literacy in diverse educational contexts.

■ CONCLUSION

Based on a systematic review of 25 studies conducted using the Systematic Literature Review (SLR) method with the PRISMA framework, it can be concluded that the integration of technology-based learning models has made a substantial contribution to enhancing students' numeracy literacy. The learning models identified include Children Learning in Science (CLIS), Problem-Based Learning (PBL), Joyful Learning, Team Games Tournament (TGT), Creative Problem Solving (CPS), Problem Solving, Flipped Classroom, Project-Based Learning (PjBL), Problem-Based Collaborative Learning, CBL-STEM Context, Game-Based Learning (GBL), Aptitude Treatment Interaction (ATI), Accelerated Learning Cycle (ALC), Blended Learning, Knisley Integrated STEAM, and STEAM. A wide range of technologies has been employed to support these models, including *GeoGebra, Kahoot, Articulate Storyline, Wordwall, PerMath Apps, Google Sites*, animated videos, electronic worksheets, text and audio media, images, computers, *Livework sheets, Livewire, Quizizz, PowerPoint, YouTube, Cabri 3D V2,* and other video-based learning resources. The synthesis of these findings highlights that combining appropriate learning models with supporting technologies not only creates more interactive, engaging, and student-centered learning environments but also strengthens students' ability to apply numeracy skills in relevant and contextual ways. Overall, the review underscores that technology-enhanced learning models play a pivotal role in addressing the challenges of 21st-century education by fostering more profound understanding, improving problem-solving capacity, and promoting active student participation.

The finding that Problem-Based Learning (PBL) emerged as the most frequently identified model suggests that this approach is particularly well suited to the goals of numeracy education. PBL situates learners in authentic contexts that demand analysis, problem solving, and the application of mathematical concepts, thereby reinforcing the importance of student-centered, problem-oriented pedagogies. From this, we learn that PBL remains a dominant and practical choice because it not only develops critical thinking and collaboration but also integrates seamlessly with interactive technologies. At the same time, it is noteworthy that certain potentially impactful models, such as Discovery Learning, were largely absent from the findings. This absence highlights

existing research gaps and provides directions for future exploration, particularly in expanding the use of innovative, technology-enhanced approaches to strengthen numeracy literacy across diverse educational contexts.

This study's primary contribution is a more thorough comprehension of how technology might improve students' numeracy literacy. Specifically, it systematically identifies effective technology-based learning strategies and organizes the range of technologies into meaningful categories that reveal their roles in supporting numeracy development. By offering a comprehensive synthesis of relevant and contextual approaches and tools, the study guides educators in creating more interactive and engaging learning experiences, while also laying the groundwork for future research aimed at developing stronger technology-based learning models across diverse educational contexts.

Instructors are encouraged to actively incorporate technology-based learning methods into numeracy education based on the findings. The selection of these technologies should be aligned with students' learning needs and the available school infrastructure to maximize their effectiveness. Furthermore, continuous teacher training is essential to equip educators with the skills to design interactive and contextually relevant learning materials, ensuring that technology integration truly enhances students' numeracy learning outcomes. Future research should investigate the long-term effects of integrating specific technology categories on students' numeracy skills development, including mathematical software, digital learning videos, and online platforms. Studies could also explore how these technologies function in diverse educational contexts, including inclusive classrooms with students of varying abilities, schools in 3T (frontier, outermost, and disadvantaged) regions with limited digital infrastructure, and classrooms implementing the Independent Curriculum, where flexibility and contextual learning are emphasized.

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