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SYSTEMATIC LITERATURE REVIEW: AN ANALYSIS OF LEARNING MODELS TO IMPROVE STUDENTS' MATHEMATICAL LITERACY

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ABSTRACT

The low level of Indonesian students' mathematical literacy remains a major challenge in education, as reflected in various national and international assessment results such as PISA. One effort that can be made to improve students' mathematical literacy is through the implementation of appropriate learning models. This study aims to analyze learning models that have been proven effective in improving students' mathematical literacy skills. The method used is Systematic Literature Review with six stages: formulating research questions, establishing selection criteria, developing a search strategy, study selection, quality assessment, and synthesis of results. Literature search was conducted using the Publish or Perish application based on Google Scholar with a range of years 2016–2026. From the initial 200 articles, 17 articles met the inclusion criteria and passed the Quality Assessment stage. The results show that the most widely used learning models that are proven effective in improving students' mathematical literacy include: Problem Based Learning, Project Based Learning, Discovery Learning, Realistic Mathematics Education, Learning Cycle 7E, inquiry model with scaffolding, Group Investigation, Collaborative Learning, and Accelerated Learning Cycle. These models are effective because they encourage active student involvement, contextualization of real problems, and development of critical thinking skills.

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1. INTRODUCTION

Education in the Society 5.0 era is required to prepare students to adapt to technological advancements, solve complex problems, and make critical decisions in real-life situations. The integration of digital technology, artificial intelligence, and information systems into daily life has transformed the demands of 21st-century education. Therefore, mathematics learning focuses not only on procedural mastery but also on the development of higher-order thinking skills and students' ability to apply mathematics meaningfully in various contexts (Srikoon et al., 2024). In this context, mathematical literacy has become one of the most important competencies that students need to master in modern education.

Mathematical literacy refers to an individual's ability to formulate, use, and interpret mathematics in various real-life contexts (PISA 2022 Assessment and Analytical Framework, 2023). This competency encompasses mathematical reasoning, problem-solving, communication, and the ability to connect mathematical concepts to authentic situations. Mathematical literacy enables students to critically understand quantitative information and use mathematics to make effective decisions in daily life. Therefore, mathematical literacy is viewed as a key indicator of educational quality and students' readiness to face global challenges in the digital age.

However, the mathematical literacy levels of Indonesian students remain relatively low. According to the 2022 Programme for International Student Assessment (PISA), Indonesia achieved an average mathematics score of 366, which is well below the OECD average of 472 (PISA 2022 Results (Volume I), 2023). Only a small proportion of Indonesian students reach the minimum proficiency level, while very few students reach the high level requiring abstract thinking and complex problem-solving skills (PISA 2022 Results (Volume II), 2023). These findings indicate that many students still struggle to understand and apply mathematical concepts in contextual situations. This situation indicates that mathematics teaching practices in schools still need to be improved, particularly in fostering reasoning skills and contextual understanding.

One of the causes of low mathematical literacy is the prevalence of teacher-centered, procedure-oriented instruction. Many students are accustomed to solving routine problems but struggle when faced with contextual mathematical problems that require interpretation and reasoning. Therefore, an innovative, student-centered instructional model is needed to support a more meaningful mathematics learning experience. Several studies indicate that learning models emphasizing exploration, contextual problems, collaboration, and active participation can significantly improve students' mathematical literacy skills.

Previous studies have reported the effectiveness of various instructional models in improving mathematical literacy. Problem-Based Learning, STEM-based learning, inquiry learning, ethnomathematics-based learning, blended learning, and the BSCS 5E learning model have shown positive effects on students' mathematical literacy and mathematical problem-solving skills (Guslisnawati et al., 2024; Joswick & Hulings, 2024; Srikoon et al., 2024). Furthermore, ethnomathematics-based learning has been proven to enhance students' understanding of contextual mathematics through cultural integration (Pratama & Yelken, 2024). The use of mobile-based digital instructional materials in a blended learning environment also contributes positively to the development of students' mathematical literacy (Yaniawati et al., 2023). Other studies also confirm that STEM-oriented instructional materials and the integration of digital literacy support the development of mathematical literacy in technology-based learning environments (Komarudin et al., 2024).

Although various studies have examined learning models to improve mathematical literacy, previous findings remain fragmented and generally focus only on specific learning models or specific educational contexts. Most studies emphasize experimental results

without providing a comprehensive synthesis of the characteristics, effectiveness, implementation trends, and contributions of various learning models to the development of mathematical literacy. Consequently, educators and researchers still lack a comprehensive understanding of which learning models are consistently effective and how each model contributes to improving students' mathematical literacy across various learning contexts.

Therefore, a systematic literature review is necessary to synthesize the findings of previous research on learning models used to improve students' mathematical literacy. This study aims to analyze various learning models that have been implemented to improve students' mathematical literacy through a systematic literature review approach. Unlike previous studies that focused only on specific learning models, this study comprehensively identifies research trends, analyzes the characteristics and effectiveness of learning models, and highlights their contributions to mathematics education. The results of this study are expected to provide theoretical contributions to the development of mathematics education research as well as practical recommendations for educators in designing innovative and contextual mathematics instruction to strengthen students' mathematical literacy in the 21st century.

2. METHOD

This study employs a Systematic Literature Review (SLR) method aimed at identifying, reviewing, evaluating, and interpreting relevant research on learning models designed to improve students' mathematical literacy. The SLR method was chosen because it provides a systematic, transparent, and replicable synthesis of the research, thereby enabling researchers to gain a comprehensive understanding of the trends, characteristics, and effectiveness of instructional models in improving mathematical literacy (Zawacki-Richter et al., 2020). The SLR procedure in this study adapts the stages proposed by Zawacki-Richter et al. consisting of six stages: (1) formulating the research question, (2) determining selection criteria, (3) developing a search strategy, (4) selecting studies, (5) assessing study quality, and (6) synthesizing research results.

Stage 1: Formulating the Research Question

The first stage is formulating the Research Question (RQ), which serves as a guideline in the literature review process. The research questions in this study include:

RQ1: What are the trends in research on learning models to improve students' mathematical literacy from 2016 to 2026?

RQ2: What learning models are used to improve students' mathematical literacy skills?

RQ3: How effective are these instructional models in improving students' mathematical literacy skills?

Stage 2: Establishing Selection Criteria

The second stage involves determining the inclusion and exclusion criteria used in the literature selection process. These criteria are intended to ensure that the articles analyzed are relevant to the research focus and meet adequate academic standards. The inclusion and exclusion criteria are presented in table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles relevant to the topic of learning models and students' mathematical literacy skills	Articles not relevant to the research topic
Articles from indexed national or international journals	Articles not from indexed journals
Articles published between 2016 and 2026	Articles published before 2016
Research involving students as research subjects	Research that does not involve students as subjects
Articles available in full text	Articles not available in full

Step 3: Developing the Search Strategy

The third stage is developing a literature search strategy. Articles were collected using the Publish or Perish application by utilizing the Google Scholar databases to identify relevant and reputable articles. Multiple databases were used to broaden the scope of the search and minimize the likelihood of overlooking relevant articles. The search was conducted using the following keywords and Boolean search strings: "literasi matematis" and "model pembelajaran". The literature search was conducted in May 2026, covering articles published between 2016 and 2026. All retrieved articles were then identified and documented using Microsoft Excel to facilitate the selection process and data analysis.

Stage 4: Selecting Studies (Selecting Studies Using the Selection Criteria)

The fourth stage is the literature selection process. Articles obtained from the initial search are then progressively screened by removing duplicates, reviewing titles and abstracts, and verifying whether the article content meets the predetermined inclusion and exclusion criteria. Articles that meet the criteria are then selected for further analysis. In the initial stage, 200 articles were retrieved from the Google Scholar databases. After removing duplicate articles, the titles and abstracts were screened, and a full-text review based on inclusion and exclusion criteria, 37 articles were deemed eligible and used in the analysis. The article selection process was conducted systematically following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to enhance research transparency.

Step 5: Assessing the Quality of the Studies

The fifth stage is the assessment of study quality using Quality Assessment (QA). A quality assessment was conducted to ensure that the articles analyzed met adequate methodological standards and were relevant to the research objectives. The quality assessment criteria are presented in table 2.

Table 2. Quality Assessment (QA)

Evaluation Criteria	Yes	No
The article is relevant to learning models and mathematical literacy	1	0
The article is published in an indexed journal	1	0
The research method is clearly explained	1	0
The article reports findings related to the improvement of mathematical literacy	1	0

Each article was scored based on these criteria. Articles that received a score of less than 3 were excluded from the analysis because they were deemed not to meet the quality standards required for this study.

Step 6: Synthesizing the Results (Synthesizing the Results based on the Research Question)

The final stage is the synthesis of the research findings. The articles that passed the selection process were analyzed based on the type of learning model used, the educational level, the research method, and the research findings regarding the improvement of students' mathematical literacy skills. The synthesis was conducted to identify research patterns and the effectiveness of learning models in improving students' mathematical literacy skills in order to answer RQ1, RQ2, and RQ3. The synthesis process was conducted in a descriptive and comparative manner to provide a comprehensive overview of trends and the effectiveness of instructional models in improving students' mathematical literacy.

3. RESULTS AND DISCUSSION

3.1 Result

Following the screening of titles, abstracts, and full-text articles, as well as a quality assessment of the studies, 17 articles were identified as meeting the criteria and were included in the analysis. These articles consist of quasi-experimental studies and classroom action research that examine the implementation of various instructional models aimed at improving students' mathematical literacy at the SD, SMP, SMA, and SMK. A summary of the research findings from the selected literature is presented in table 3.

Table 3. Research Findings from the Selected Literature

Literature Code	Author, Year	Instructional Model	Grade Level	Research Method	Key Findings
L01	(Khotimah et al., 2018)	7E Learning Cycle	SMP	Quasi eksperimen	Improving mathematical literacy through group exploration
L02	(Noor et al., 2024)	Contextual PBL	SMK	Quasi eksperimen	Improving understanding of contextual problems
L03	(Kusumawati et al., 2024)	GeoGebra-assisted PBL	SMA	Quasi eksperimen	Helping to visualize abstract concepts
L04	(Nolaputra et al., 2018)	RME	SMP	Quasi eksperimen	Connecting mathematical concepts to real life
L05	(Manurung et al., 2022)	Project-Based Learning	SMP	Quasi eksperimen	Enhancing engagement and independent learning
L06	(Rohana et al., 2021)	Discovery Learning	SMA	Quasi eksperimen	Supporting independent

		berbasis e-learning			discovery of concepts
L07	(Seta et al., 2021)	Project-Based Learning	SMP	Quasi eksperimen	Improving reasoning and mathematical literacy
L08	(Maysarah et al., 2023)	Innovative Learning Model	SMA	Quasi eksperimen	Improving the ability to formulate mathematical facts
L09	(Pernandes & Asmara, 2020)	Discovery Learning	SMP	Quasi eksperimen	Helping students discover contextual concepts
L10	(Fironika et al., 2019)	Discovery Learning	SD	Quasi eksperimen	Improving the identification of mathematical concepts in reading materials
L11	(Buyung & Dwijanto, 2017)	Inquiry dengan scaffolding	SMP	Quasi eksperimen	Helping students overcome learning barriers
L12	(Setyowati & Nurcahyo, 2023)	Self-efficacy approach	SMA	Quasi eksperimen	Improving the communication of mathematical ideas
L13	(Wicaksana et al., 2017)	Schoology-assisted PjBL	SMA	Quasi eksperimen	Fostering curiosity and engagement in learning
L14	(Tasyanti & Wardono, 2018)	Group Investigation	SMA	Quasi eksperimen	Enhancing critical thinking skills
L15	(Komang Ari Damayanti et al., 2017)	Collaborative Learning	SMP	PTK	Improving the ability to exchange ideas in problem-solving
L16	(Ainun Fajriah et al., 2021)	Accelerated Learning Cycle	SMA	Quasi eksperimen	Enhancing mathematical representation skills
L17	(Huda et al., 2023)	Literacy-oriented learning	SMP	Quasi eksperimen	Helping students apply mathematics in real-world contexts

(RQ1) What are the research trends regarding instructional models for improving students' mathematical literacy from 2016 to 2026?

Based on the synthesis results, research on learning models designed to improve mathematical literacy has increased during the 2021–2024 period. This indicates growing attention among researchers to the importance of developing mathematical literacy in 21st-century education. Based on the analysis of the 17 selected articles, research trends regarding learning models to improve students' mathematical literacy reveal an interesting pattern, as shown in Figure 1. In terms of educational levels, the majority of research was conducted at the Junior High School (SMP) level with 9 articles, followed by Senior High School (SMA) with 5 articles, Elementary School (SD) with 1 article, and Vocational High School (SMK) with 1 article. This indicates that improving the mathematical literacy of junior high school students is the primary focus of researchers, as it aligns with the importance of a strong foundation in mathematical literacy at that level.

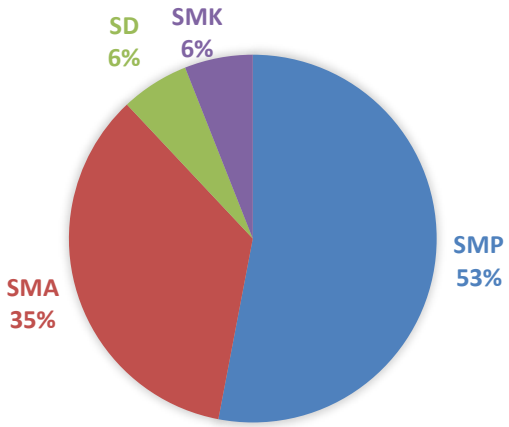

Figure 1. Percentage of Research Trends

Research focusing on the junior high school level indicates that mathematical literacy is considered important to develop starting in early secondary education as the foundation for students' mathematical thinking skills. In addition, several recent studies have begun to integrate digital technology into mathematics instruction, such as the use of GeoGebra and the Schoology platform to support the visualization of concepts and interactive learning.

(RQ2) What Learning Models Are Used to Improve Students' Mathematical Literacy Skills?

Research findings indicate that there are various instructional models used to improve students' mathematical literacy. Problem-Based Learning (PBL) is the most widely used model, with various adaptations such as contextual PBL and GeoGebra-assisted PBL. In addition, other widely used models include Project-Based Learning (PjBL), Discovery Learning, Realistic Mathematics Education (RME), inquiry-based learning with scaffolding, Group Investigation, Collaborative Learning, and the Accelerated Learning Cycle. These models can be grouped into several categories:

1. Problem-based learning model.

   Problem-Based Learning (PBL) is the most widely used model, with three variations: conventional PBL, PBL with a contextual approach and GeoGebra-assisted PBL. This model uses real-world problems as the starting point for learning, encouraging students to analyze, formulate, and solve mathematical problems independently.

2. Project-based learning model.

   Project-based Learning (PjBL) was used in two studies as well as one study that integrated it with the Schoology platform. This model provides students with authentic learning experiences through meaningful project work.

3. Discovery model.

   Discovery Learning comes in two forms: conventional Discovery Learning. This model encourages students to discover mathematical concepts independently through structured exploration.

4. A reality- and context-based model.

   Realistic Mathematics Education (RME) was used in one study. RME uses real-life contexts as a starting point for learning to help students understand abstract concepts in a meaningful way.

5. Collaborative and cooperative models.

   There are several models that emphasize collaboration, including Group Investigation, the 7E Learning Cycle, the inquiry model with scaffolding, and the Accelerated Learning Cycle.

In general, these models share similar characteristics, namely an emphasis on student-centered learning, the use of contextual problems, collaboration, conceptual exploration, and active student engagement in the learning process. Several studies have also shown that the integration of digital technology can support the implementation of these learning models, particularly by helping to visualize abstract concepts and enhancing student motivation.

(RQ3) How Effective Are Learning Models in Improving Students' Mathematical Literacy Skills?

All 17 articles analyzed reported that the instructional models implemented proved effective in improving students' mathematical literacy skills. This effectiveness can be explained as follows. First, the contextualization of real-world problems. Models such as PBL, RME, and PjBL proved effective because they used problems relevant to students' daily lives. When students are presented with contextual problems, they are more motivated to understand and apply mathematical concepts (Noor et al., 2024). This aligns with the PISA definition of mathematical literacy, which emphasizes the ability to apply mathematics in real-world contexts (PISA 2022 Assessment and Analytical Framework, 2023). Second, active student engagement. Models such as Discovery Learning, the 7E Learning Cycle, and Group Investigation are effective because they encourage students' active engagement in the

learning process. Students do not merely passively receive information but actively construct their own knowledge. This active engagement has been shown to enhance conceptual understanding and mathematical literacy skills.

Third, technology integration. Several studies indicate that the integration of digital technology into learning models provides significant added value. GeoGebra helps students visualize abstract concepts and Schoology stimulates students' curiosity. Fourth, scaffolding and step-by-step guidance. The inquiry model with scaffolding strategies and the Accelerated Learning Cycle have proven effective because they provide structured guidance that helps students overcome learning barriers step by step. This approach ensures that every student receives the necessary support to develop their mathematical literacy skills.

All of the articles analyzed reported that the instructional models implemented had a positive impact on improving students' mathematical literacy. This improvement was demonstrated through students' ability to understand contextual problems, engage in mathematical reasoning, communicate mathematical ideas, and apply mathematical concepts in everyday life.

Problem-based learning models such as PBL and RME have proven highly effective because they use real-world problems as the context for learning. Meanwhile, project-based and collaborative models such as PjBL, Group Investigation, and Collaborative Learning are effective in increasing students' active engagement during the learning process. In addition, the use of digital technologies such as GeoGebra and Schoology supports the visualization of mathematical concepts and fosters more dynamic learning interactions.

Overall, the findings of the synthesis indicate that instructional models that emphasize contextualization, active engagement, collaboration, conceptual exploration, and the integration of technology tend to be more effective in improving students' mathematical literacy than conventional instruction. The findings of this study indicate that there is no single universal learning model that is most effective. The effectiveness of a learning model depends heavily on the context, student characteristics, learning material, and the teacher's ability to implement it. However, models that emphasize contextualization, active engagement, and collaboration consistently yield positive results in improving students' mathematical literacy.

3.2 Discussion

The results of a systematic literature review indicate that various instructional models applied in mathematics education contribute positively to improving students' mathematical literacy. Although the models used vary, there is a consistent pattern: effective instructional models generally share characteristics such as the use of contextual problems, active student engagement, collaboration, conceptual exploration, and providing students with opportunities to construct mathematical understanding independently. These findings indicate that the development of mathematical literacy is influenced not only by the content taught but also by how the learning process is designed and implemented.

One of the key findings of this study is the prevalence of Problem-Based Learning (PBL) across the studies analyzed. PBL is the most widely used model because its characteristics align with the concept of mathematical literacy developed by the (PISA 2022 Assessment and Analytical Framework, 2023), namely the ability to formulate, use, and interpret mathematics in various real-life contexts. By presenting authentic problems closely related to students' lives, PBL encourages students to identify relevant information, select problem-solving strategies, and interpret the results obtained. This process directly involves the core components of mathematical literacy: reasoning, problem solving, and mathematical communication. These findings align with the research by (Srikoon et al.,

2024), which demonstrates that learning that positions students as active problem solvers significantly enhances mathematical literacy and problem-solving skills.

In addition to PBL, this study also found that context-based approaches such as Realistic Mathematics Education (RME) make a positive contribution to the development of mathematical literacy. RME utilizes real-life situations as a starting point for learning so that students can gradually build mathematical concepts from concrete experiences toward more abstract understanding. This finding supports Freudenthal's view that mathematics is a human activity that should be learned through the process of mathematizing real-life situations. In the context of mathematical literacy, the use of authentic contexts helps students understand the relevance of mathematics in daily life and enhances their ability to apply mathematical concepts to solve various problems.

Project-based learning models, such as Project-Based Learning (PjBL), have also proven highly effective in improving mathematical literacy. Students' engagement in completing projects allows them to integrate various mathematical concepts into a single meaningful activity. In addition to enhancing conceptual understanding, project-based activities also foster critical thinking, collaboration, communication, and decision-making skills. These findings indicate that mathematical literacy is not only related to the ability to solve math problems, but also to the ability to use mathematics to understand and solve complex problems.

This study also found that discovery-oriented learning models, such as Discovery Learning and Inquiry Learning, contribute to improved mathematical literacy through the process of independent knowledge construction. These findings support constructivist theory, which states that knowledge is actively constructed by students through interaction with the learning environment. When students are given the opportunity to explore, make conjectures, and discover concepts independently, they not only gain a deeper understanding of mathematical concepts but also develop reasoning skills, which are a key component of mathematical literacy.

Another interesting finding is the increasing integration of digital technology into mathematics learning models. The use of GeoGebra and Schoology demonstrates that technology serves not only as a learning medium but also as a tool to strengthen the development of mathematical literacy. GeoGebra helps students visualize abstract mathematical concepts, while Schoology supports interaction and collaboration in learning. These findings indicate that advancements in educational technology have opened new opportunities to enhance the quality of mathematics learning, making it more interactive, flexible, and student-centered. These results also align with the demands of education in the Society 5.0 era, which emphasizes the integration of digital technology into the learning process.

Based on educational levels, research on mathematical literacy is conducted more frequently at the junior high school level than at other levels. This finding suggests that the junior high school phase is viewed as a critical period in the development of mathematical literacy. At this level, students begin to transition from a concrete understanding of mathematics to more abstract thinking. Therefore, various instructional models that can connect mathematical concepts to real-world contexts are crucial to helping students build a strong foundation in mathematical literacy before advancing to higher levels of education.

Overall, the synthesis results indicate that there is no single instructional model that can be considered the most effective for all learning situations. The effectiveness of an instructional model is greatly influenced by learner characteristics, instructional content, the learning environment, and the teacher's competence in implementing the model. However, this study found that learning models that are consistently effective share five key characteristics: they are oriented toward contextual problems, actively engage students,

encourage collaboration, provide opportunities for concept exploration, and utilize technology to support learning. These five characteristics can serve as a reference for teachers and curriculum developers in designing mathematics instruction focused on strengthening mathematical literacy.

This study makes an important contribution to the development of mathematics education by presenting a comprehensive synthesis of various instructional models that have been used to improve students' mathematical literacy. The results indicate that developing mathematical literacy requires a learning approach that focuses not only on mastering mathematical procedures but also on students' ability to connect mathematics to real-world situations, reason logically, communicate mathematically, and utilize technology to support problem-solving processes.

4. CONCLUSION

The results of a systematic literature review of 17 articles indicate that research on learning models to improve mathematical literacy has increased in recent years and is dominated by studies at the junior high school level. The various learning models used include Problem-Based Learning (PBL), Project-Based Learning (PjBL), Discovery Learning, Realistic Mathematics Education (RME), the 7E Learning Cycle, Inquiry Learning, Group Investigation, Collaborative Learning, and the Accelerated Learning Cycle. Among these models, PBL is the most widely applied in the analyzed studies.

Research findings indicate that the effectiveness of instructional models in improving mathematical literacy is determined not only by the type of model used but also by the characteristics of the learning process. Effective models generally feature the use of contextual problems, active student engagement, collaboration, concept exploration, and digital technology support. Therefore, the development of mathematical literacy requires student-centered learning that connects mathematical concepts to real-world situations.

The findings of this study can serve as a reference for teachers in selecting and developing instructional models that support the improvement of mathematical literacy. Future research is recommended to expand the scope of the database and conduct a more in-depth comparative analysis of the effectiveness of various instructional models across different educational levels and contexts.

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