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How Can We Enhance PISA Ranking Through Effective Learning Methods? Systematic Literature Review From 2019 to 2024

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Abstract: Objective: The research aims to identify effective learning methods to improve Programme for International Student Assessment (PISA) rankings; this study undertakes a comprehensive analysis of relevant literature. PISA results provide a benchmark for assessing students' reading, mathematics, and science literacy abilities—crucial indicators of a nation's educational success. Most countries within the OECD utilize PISA assessment results to shape their educational policies. As nations strive to enhance their educational frameworks, particularly in teaching methodologies, the pursuit of influencing PISA rankings becomes increasingly competitive. Countries with lower PISA rankings often look to adopt best practices in literacy improvement from those with higher rankings. This study aspires to deliver best practices to bolster students' literacy skills, thereby improving PISA standings. **Methods:** The systematic literature review (SLR) is designed by the PRISMA diagram flow, encompassing the critical stages of identification, screening, eligibility, and inclusion. The SLR draws from 14 articles sourced from the Scopus database. **Findings:** The findings reveal that innovative teaching approaches, such as context-based learning and the integration of digital tools, significantly enhance students' performance in reading, mathematics, and science literacy. Notably, reading literacy is improved through the Cooperative Integrated Reading and Composition (CIRC) model, which focuses on collaborative learning. Mathematics literacy benefits from STEM-themed materials that bridge abstract concepts to real-world applications and through oral questioning techniques that foster critical thinking. Science literacy skills are advanced through digital comic materials, simplifying complex concepts, while STEM learning applications enhance students' understanding and engagement. **Conclusion:** In conclusion, this study underscores the vital role of appropriate teaching methods in improving learning outcomes and boosting student engagement in the international PISA assessment. By strategically adopting effective educational strategies from countries with higher PISA rankings, significant advancements can be made, offering hope for the future of education.

Keywords: learning, method, PISA.

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INTRODUCTION

The Program for International Student Assessment (PISA) is an international evaluation that the Organisation for Economic Co-operation and Development (OECD) conducts to measure the abilities of 15-year-old students in reading, mathematics, and science. PISA assesses academic knowledge and evaluates how students

apply that knowledge in real-world situations. The 2022 PISA results show that countries like Singapore, Japan, and Estonia ranked at the top in all categories, while countries like Indonesia and Brazil remained at the lower end (OECD, 2022). These results reveal a significant gap in global educational achievements, highlighting the need for special attention to the teaching methods used.

PISA evaluates three main domains: reading, mathematics, and science. The assessment focuses on students' abilities to understand, use, and evaluate texts in reading. In mathematics, PISA measures students' ability to apply mathematical concepts in everyday situations. In science, it tests how well students understand and apply scientific concepts. PISA also evaluates non-cognitive factors influencing learning outcomes, such as students' motivation and attitudes toward learning (Kusdinar & Kismiantini, 2022). Therefore, PISA provides a comprehensive picture of the quality of education in various countries.

Previous research indicates that several factors influence PISA ranking achievements, including 1) students' socioeconomic conditions, 2) education quality, 3) teacher competence, 4) school infrastructure, 5) parental involvement, 6) student motivation and engagement, and 7) school policy (Alali & Wardat, 2024). Additionally, Alali and Wardat (2024) note that educational quality is partly contingent on the methods of learning employed. These learning methods are fundamental to student competency (Sahyar et al., 2019). As a country with a low PISA ranking, Indonesia is working to integrate the competencies required for the PISA assessments into its curriculum by adopting more adaptive learning approaches (Sahyar et al., 2019). Alali and Wardat (2024) further emphasize that an evaluation of education in Jordan underscores traditional learning methods as a contributing factor to the country's low PISA ranking in 2022. Likewise, China has strategically leveraged PISA results to reform its education policies, aiming to meet and exceed PISA assessment standards. Learning methods are regarded as a critical indicator of educational success. China believes modifying teaching approaches and optimizing teaching behaviors can positively influence PISA scores (Yang & Fan, 2019). These efforts in reforming teaching methods resulted in China ranking 10th in PISA 2015 and 6th in PISA 2022 (OECD, 2015; 2022). The experiences of these three countries highlight the necessity of focusing on teaching methods to achieve success in PISA assessments.

Developed countries are making efforts to improve their PISA rankings. For example, Finland focuses on project-based and collaborative learning approaches, which have proven effective in enhancing students' critical thinking skills (Liu et al., 2023). In addition, countries like Singapore implement well-structured curricula and provide intensive teacher training to ensure students receive high-quality education. These countries use strategies such as integrating technology in classrooms, adopting differentiated approaches to meet students' diverse needs, and encouraging active learning that promotes student participation (Kerimbayev et al., 2023; Dzay & Abdullah, 2024). These efforts demonstrate that effective learning methods significantly influence PISA rankings.

Educators use various methods to deliver instructional material to students, including direct instruction, project-based learning, and collaborative learning. Learning models guide these methods by outlining learning objectives, activities, and assessments. Learning strategies involve specific techniques that help achieve particular learning goals. Choosing the proper methods, models, and strategies is crucial for creating effective learning environments and supporting student achievement (Almoslamani, 2022).

Araujo et al. (2020) state that PISA questions demand high-level reasoning and critical thinking skills. The PISA difficulty scale consists of six levels: Levels 1 and 2 involve finding and retrieving information; Levels 3 and 4 emphasize integration and interpretation; while Levels 5 and 6 focus on reflection and evaluation. As OECD (2019) noted, these levels reflect different cognitive processes. A benchmark is deemed high-achieving if it reaches Level 4 or above. Furthermore, Araujo et al. (2020) mention a PISA questionnaire administered to students regarding their familiarity with ICT. In light of this information, it is evident that a teaching approach is necessary that encourages students to reason, think critically, and develop strong ICT skills.

The relationship between learning methods and PISA performance is significant. Interactive, student-centered learning methods, such as collaborative and problem-based learning, increase student engagement and improve learning outcomes. In the context of PISA, students who actively participate in learning tend to develop more vital skills in applying knowledge to real-world situations. Research shows that using information and communication technology (ICT) in classrooms improves PISA performance by giving students access to a broader range of learning resources (Wu et al., 2022). Therefore, selecting appropriate learning methods is crucial in preparing students for PISA's challenges.

Innovative, evidence-based learning methods significantly influence PISA rankings. Schools that implement these approaches often outperform those relying on traditional teaching methods. Countries that have enhanced their PISA results typically engage in innovative practices. For example, schools incorporating ICT have improved student learning outcomes globally (Fernández-Gutiérrez et al., 2020). Additionally, strategies that cultivate students' critical and creative thinking skills contribute positively to PISA performance (Gesi et al., 2022). Research by Ristanto and Darmawan (2020) indicates that Cooperative Integrated Reading and Composition (CIRC) has effectively boosted reading literacy. Countries can better prepare their students for the PISA assessments by updating curricula and teaching practices. Mariani et al. (2020) also emphasize that CIRC enhances reading comprehension.

Furthermore, Yýldýrým (2016) underscores the strong connection between STEM education principles and international comparative studies such as PISA/TIMSS. A meta-synthesis reveals that STEM education positively impacts student achievement, attitudes toward STEM fields, problem-solving abilities, and creativity (Yýldýrým, 2016). Recognized globally for its significance to national development and economic competitiveness, STEM education is crucial in improving student performance and attitudes (Yýldýrým, 2016). In response, governments worldwide have developed STEM policies and programs to increase student participation and performance in science and mathematics at both school and college levels (Freeman et al., 2019). Therefore, selecting appropriate teaching methods is essential for effectively preparing students to meet the challenges posed by PISA.

Studies show a positive link between effective learning methods and higher PISA scores. For example, Sempé (2021) found that using project-based approaches in German schools enhanced students' critical thinking skills, leading to better PISA results. Similarly, Hsu et al. (2020) found that problem-based learning models increased student motivation and engagement, which resulted in improved PISA performance. These findings highlight the importance of innovative teaching methods in achieving better results in international assessments.

This systematic literature review aims to identify effective learning methods that can

improve PISA rankings. This research seeks to find patterns and best practices applicable across different educational contexts by analyzing various studies. It will provide recommendations to educators and policymakers striving to enhance education quality and student achievement at the international level.

METHOD

Research Design

The systematic literature review (SLR) method is widely acknowledged as a structured and systematic approach for gathering and analyzing a range of related studies. According to Kitchenham and Charters (2007), SLR aims to identify, assess, and interpret findings from research relevant to the topic under investigation. In this research context, SLR is utilized to gain insights into various teaching methods that could enhance PISA rankings. Through this approach, researchers can better understand the effectiveness of different methods implemented in diverse countries.

The first stage of SLR research involves formulating research questions (RQ) to facilitate the search and extraction of relevant literature. These questions are developed based on five elements, known as PICOC: 1) Population (P): the target group of the research; 2) Intervention (I): the specific aspects of the research or issues of interest to the researcher; 3) Comparison (C): the aspects against which the Intervention (I) will be compared; 4) Outcomes (O): the effects and results of the Intervention (I); and 5) Context (C): the setting and environment of the research (Aliyah & Mulawarman, 2020). The research questions formulated in this study are: a) What are the learning methods used in schools from 2019 to 2024? Moreover, b) Which learning methods can enhance reading, mathematics, and science skills? These focused questions enable the researcher to conduct a more targeted search for relevant and high-quality literature (Petticrew & Roberts, 2006).

Search Strategy

The systematic literature review (SLR) data collection process adheres to the PRISMA flow diagram, encompassing four key stages: identification, screening, eligibility, and inclusion of articles (Cooper et al., 2018). The initial stage, identification, involves accessing electronic databases such as Scopus. A preliminary search using the keywords "Learning Methods" and "PISA" yielded 715 relevant pieces of literature. This extensive dataset highlights the substantial research conducted in this field, underscoring the significance of effective teaching methodologies within the framework of international assessments. In this study, we utilized Scopus databases and employed the keywords "learning method" and "PISA." The keywords used in the SCOPUS search engine are "Learning AND method OR learning AND model" and "PISA". According to Okoli (2015), these keywords were crafted using an online thesaurus, terms from previous research, and those provided by Scopus.

Upon completing the identification stage, the next step is screening. During this phase, automation tools filter the obtained articles, removing duplicates and screening based on publication year, article type, subject, journal, language, and open access. This process yields 650 articles, which are then chosen for further review. Applying the predetermined inclusion and exclusion criteria narrows the number of articles to 65. This meticulous process ensures that only pertinent and high-quality articles undergo further analysis.

Out of the initial 65 articles, 17 were excluded for not meeting the eligibility criteria, determined through a manual screening process. Of the remaining 48 articles, 33 were further removed for not aligning with the specified

population criteria (age 15 years) and the objective of enhancing literacy skills in PISA assessments. This rigorous screening process underscores the researchers' dedication to including only the most pertinent and valuable studies in the analysis. Ultimately, 14 articles remain, paving the way for a comprehensive examination of teaching methods proven effective in enhancing PISA rankings. The PRISMA flow diagram can be seen in figure 1.

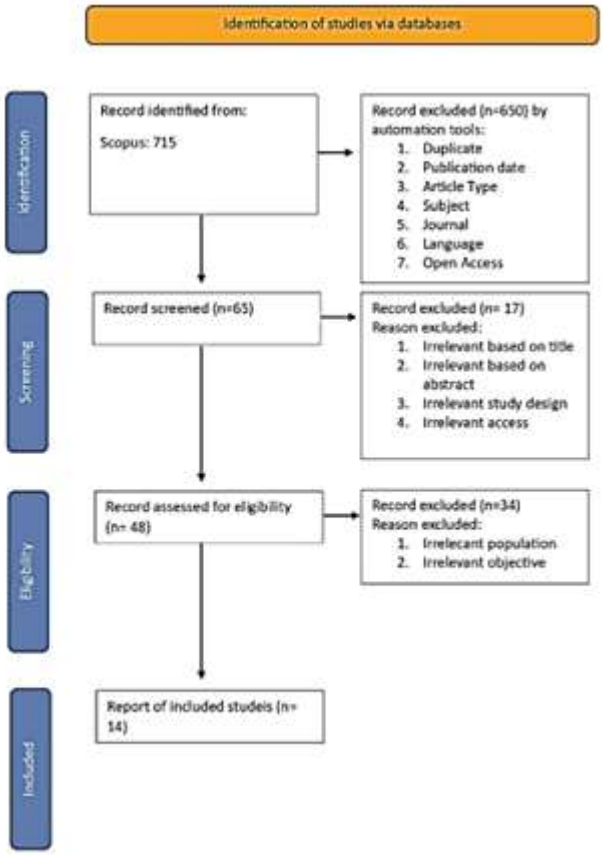

Figure 1. PRISMA flow diagram

Inclusion and Exclusion Criteria

The screening procedure involves clearly defining inclusion and exclusion criteria. Inclusion criteria consist of articles that discuss teaching methods in schools and studies related to PISA outcomes. In contrast, articles focusing solely on theoretical concepts without practical application are included in the analysis (Gough et al., 2019). These criteria ensure that only studies that significantly enhance our understanding of the relationship between teaching methods and PISA outcomes are included. Furthermore, this approach is designed to verify that the teaching methods tested effectively impact students' reading, mathematics, and science literacy skills, resulting in a more focused analysis with high validity. Detailed inclusion and exclusion criteria can be found in Table 1.

Data analysis

The critical components of quality assessment involve assessing the suitability of the research design for the study topic and conducting a comprehensive review of the primary

Tabel 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication Years	2019-2024	Before 2019
Population	Focused on 15 years	Studies not on 15 years
Document types	Research articles	Not research articles such as books, book chapters, proceedings, term papers, etc.
Language	English	Other than English
Access	Open Access	Close Access
Objective	Enhance reading literacy, math literacy, and science literacy	Not enhance reading literacy, math literacy, and science literacy

characteristics of the design. According to Munn et al. (2020), quality evaluation is a method used to gauge the relevance and validity of research findings by assessing the strengths and weaknesses of research publications. Thus, this study evaluates the quality of the articles by examining several questions: 1) Are the formulated research questions relevant? 2) Does the research design address the research questions? 3) Does the article discuss the learning methods? 4) Does the article present research results on learning methods to enhance reading, mathematical, or science literacy?

The quality of the 14 articles included in this study was assessed through a peer review conducted by two experts. These articles were evaluated using Quality Assessment (QA) criteria based on the guidelines established by Kitchenham and Brereton. The criteria encompassed clarity in study objectives, research significance, methodological rigor, definition of concepts, and clarity of results. The QA evaluation utilized a scoring system where YES (Y) was assigned a score of 1, PARTIAL (P) received 0.5, and NO (N) was given a score of 0. Researchers ensured that the selected articles met a minimum quality threshold of 3.0. According to Kitchenham and Brereton (2013), the number of articles typically included in a Systematic Literature Review (SLR) is often less than 50 and frequently fewer than 10. Consequently, the 14 articles chosen for this SLR met all established criteria, achieving scores above 3.

Additionally, the author employs thematic analysis techniques. Xu and Zammit (2020) assert that thematic analysis is an accessible and adaptable method for analyzing qualitative data. Furthermore, Flemming et al. (2019) explain that thematic analysis is recognized as the most effective method for synthesizing data in an integrative (mixed) research design. The thematic analysis in this article is divided into two parts: the first part describes the essence of the article, and the second part outlines the description of learning methods from 2019 to 2024, as well as how these methods can enhance reading literacy, mathematical literacy, or science literacy during the same period.

■ RESULT AND DISCUSSION

The study found 15 articles that satisfied the inclusion and exclusion criteria. These articles are listed in Table 2. The research findings were then divided into two sections. The first section discusses the publication year, research methods, and research results, while the second section is organized around the research questions (RQ). In the first section, the articles are grouped according to publication year, research methods, and research results.

Tabel 2. Article review result

No.	Title and Author	Year	Method	Result
1	Artificial Neural Network and Adaptive Neuro Fuzzy Inference System Hybridized Models in the Sustainable Integration of Language and Mathematics Skills: The Case of Singapore and Hong Kong Author: Kalaycı Alas, D., & Tezer, M.	2024	Mixed method	The findings suggest that the integration of language skills into mathematics teaching programs does not significantly impact PISA scores in these countries. This contradicts previous studies that found a stronger relationship between language and mathematics skills.
2	Interpretable-machine-learning evidence for importance and optimum of learning time Author: Nadaf, A., & Seb, A.	2021	Quantitative	The analysis found that learning time is the most important factor influencing cognitive achievement, but with a nonlinear relationship. Specifically: Learning time between 18 and 22 hours per week is optimal and positively contributes to student achievement. Learning time beyond 35 hours per week is associated with a less positive or even negative effect on the predicted outcomes. A nonlinear pattern emerges, where more learning time does not necessarily lead to better cognitive results, indicating diminishing returns on learning time.
3	The Development of STEM-nuanced Mathematics Teaching Materials to Enhance Students' Mathematical Literacy Ability Through Information and Communication Technology-Assisted Preprospec Learning Model Author: Dewi, N. R., & Maulida, N. F.	2023	Research and Development (R&D)	After using the STEM-nuanced teaching materials, students' mathematical literacy improved, as evidenced by the Wilcoxon test results (significant difference between pretest and posttest) and a normalized gain (N-gain) score of 0.485, indicating a moderate improvement in mathematical literacy

4	The use of oral questioning to improve students' reasoning skills in primary school mathematics learning Author: Mahmud, M. S., & Mohd D rus, N. F.	2023	Qualitative	The study revealed that using a variety of oral questioning techniques helps stimulate students' reasoning skills and encourages them to think critically and logically during mathematics lessons. Provocative mathematical questions to challenge students' thinking. Puzzle-shaped questions to encourage active thinking and problem-solving. Breaking down hard problems into easier parts to simplify complex concepts. Contextual questions based on real-life situations. Questions to explain mistakes, allowing students to reflect on their errors. Questions asking for clarification to deepen understanding and promote logical reasoning.
5	Mediating effects of motivation and socioeconomic status on reading achievement: a secondary analysis of PISA 2018 Author: Michael, D., & Kyriakides, L.	2023	Structural Equation Modelling (SEM)	The findings show that the direct effect of SES on reading achievement is reduced significantly after accounting for the mediating factors, proving that academic motivation plays a crucial role in this relationship
6	Digital comic teaching materials: It's role to enhance student's literacy on organism characteristic topic Author: Fitria, Y., Malik, A., Mutia ramses, H., Halili, S. H., & Amelia, R.	2023	Quasi-Experimental Design	The digital comic materials were highly effective in improving students' scientific literacy, particularly in understanding the characteristics of living organisms
7	Evaluating the Results of PISA Assessment: Are There Gaps Between the Teaching of Mathematical Literacy at Schools and in PISA Assessment?	2023	Mixed method	The study highlighted a gap between school-based mathematics instruction and the mathematical literacy skills assessed by PISA. The focus in schools on

	Author: Kusmaryono, I., & Kusuma ningsih, W.			memorizing formulas and procedures was not aligned with PISA's emphasis on reasoning and problem-solving
8	Developing STEM autonomous learning city map application to improve critical thinking skills of primary school teacher education students Author: Hermita, N., Alim, J. A., P utra, Z., & Wijoyo, H.	2023	Research and Development (R&D)	The results indicated a significant improvement in students' critical thinking skills after using the STEM Autonomous Learning City Map Application
9	Biology reading literacy: Measurement and empowerment through circ learning model Author: Ristanto, R. H., & Darmaw an, E.	2020	Quasi-Experimental Design	The results showed a significant influence of the Cooperative Integrated Reading and Composition (CIRC) learning model on students' reading literacy
10	Portrait of Education in Indonesia: Learning from PISA Results 2015 to Present Author: Ismawati, E., Hersulastuti, & Amertawengrum, I. P.	2023	Qualitative	The study found that teachers tend to rely on lower-order thinking skills (LOTS), focusing on memorization rather than critical thinking, which affects students' ability to excel in PISA
11	Information Technology Capability (ITC) Framework to Improve Learning Experience and Academic Achievement of Mathematics in Malaysia Author: Lew, S. L., & Krishnasamy , S.	2023	ADDIE model	Student interest and confidence in learning mathematics increased significantly through the use of multimedia elements like animations, audio, and interactive content
12	Is the use of ICT in education leading to higher student outcomes? Analysis from the Spanish Autonomous Communities Author: Fernández-Gutiérrez, M., Gimenez, G. , & Calero, J.	2020	Hierarchical Linear Model (HLM)	The study found that the impact of ICT on educational outcomes varied by subject and depended on how ICT was used in the classroom. ICT use for interactive learning and resource access was more effective in science than in mathematics or reading

13	Mathematical Modeling Learning Design with PISA Framework on Grade X Function Author: Saputri, N. W., Zulkardi, & Darmawijoyo.	2022	Validation Studies	The study found that using familiar contexts, like online taxibikes, made it easier for students to grasp the concept of functions and apply mathematical reasoning to real-life situations.
14	How Learning Time Allocation Make Sense on Secondary School Students' Academic Performance: A Chinese Evidence Based on PISA 2018 Author: Liu, A., Wei, Y., Xiu, Q., Y ao, H., & Liu, J.	2023	Reggresion	Mathematics: The optimal learning time is 200-240 minutes per week. Science: The optimal learning time is 440-520 minutes per week. Reading: The optimal learning time is approximately 200 minutes per week.

Research Location

The research studies outlined in the document center on various prominent locations such as Singapore, Hong Kong, Malaysia, Spain, China, and Indonesia. These studies cover a wide range of topics, from curriculum development to student performance, and some delve into global trends, specifically those related to PISA assessments. Specifically, multiple studies focus on Singapore and Hong Kong (n=2), one on Malaysia, one on Spain, one on China, and one on Indonesia, while the remaining studies have a more global scope.

Publication Year

In terms of publication years, the studies range from 2020 to 2024, with a total of studies published in 2020 (n=2), 2021 (n=1), and 2023 (n=9). There is also 1 study expected to be published in 2024 (n=1), reflecting the growing interest in contemporary educational issues over recent years.

Research Methods

Regarding research methods, the studies employ a variety of approaches. 2 studies use mixed methods, combining both qualitative and quantitative data (n=2). Additionally, four studies utilize qualitative approaches (n=4), while two rely on quantitative methods (n=2), employing tools such as regression models and statistical tests. Quasi-experimental designs are used in 2 studies (n=2) to evaluate the impact of educational interventions. Two studies based on the Research and Development (R&D) method (n=2) aimed at creating new educational materials. Lastly, more complex models like Hierarchical Linear Models (HLM) and Structural Equation Modeling (SEM) are employed in 1 study each (n=1).

RQ 1: What are the learning methods used in schools from 2019 to 2024?

From 2019 to 2024, schools in different countries utilized a range of learning methods,

Tabel 3. Learning methods used in schools from 2019 to 2024

No	Learning Methods
1	Artificial Neural Network and Adaptive Neuro Fuzzy Inference System: This method is to integrate language and mathematics skills into the teaching program (Kalaycı Alas dan Tezer, 2024)
2	STEM-nuanced Teaching Materials: use of STEM-themed learning materials (Dewi dan Maulida, 2023)
3	Oral Questioning Techniques: The use of various oral questioning techniques helps improve logical and critical thinking skills (Mahmud dan Mohd Drus, 2023)
4	Cooperative Integrated Reading and Composition (CIRC) Learning Model (Ristanto dan Darmawan, 2020)
5	Digital Comic Materials (Fitria et al., 2023)
6	STEM Autonomous Learning City Map Application (Hermita et al., 2023)
7	Multimedia Learning Elements (Lew dan Krishnasamy, 2023)
8	Context-based Learning with Technological Applications (Saputri et al., 2022)

each tailored to specific learning objectives and outcomes. These methods were implemented for students aged 15 years and are detailed in Table 3.

RQ 2: Which learning methods can enhance reading, mathematics, and science skills?

This section identifies several learning methods that can be used to improve literacy skills in reading, mathematics, and science. The results of the identification can be seen in Table 4.

Improving reading skills is one of the main focuses in education, as good reading ability is essential for students' overall academic success. The Cooperative Integrated Reading and Composition (CIRC) model has been proven effective in enhancing students' reading literacy, particularly in biology subjects (Ristanto & Darmawan, 2020). This model emphasizes collaborative learning, where students read and discuss in groups. This approach helps students process complex information, such as plant structures, which can often be challenging to

Tabel 4. Learning methods enhance reading, mathematics, and science literacy skills

No	Learning methods	Literacy Skills
1	Cooperative Integrated Reading and Composition (CIRC) L earning Model (Ristanto dan Darmawan, 2020)	Reading Literacy
2	STEM-nuanced Teaching Materials: use of STEM-themed learning materials (Dewi dan Maulida, 2023)	Mathematics Literacy
3	Oral Questioning Techniques: The use of various oral questioning techniques helps improve logical and critical thinking skills (Mahmud dan Mohd Drus, 2023)	Mathematics Literacy
4	Multimedia Learning Elements (Lew dan Krishnasamy, 2023)	Mathematics Literacy
5	Context-based Learning with Technological Applications (Saputri et al., 2022)	Mathematics Literacy
6	Digital Comic Materials (Fitria et al., 2023)	Science Literacy
7	STEM Autonomous Learning City Map Application (Hermi ta et al., 2023)	Science Literacy

understand when taught conventionally. This research shows that teaching involving social interaction can enhance students' comprehension of the material.

Data from the Programme for International Student Assessment (PISA) also indicates a strong correlation between reading skills and students' success in other areas. According to the OECD (2022), students with good reading skills tend to perform better in other subjects, including mathematics and science. Therefore, efforts to improve reading skills will not only impact literacy but also overall academic achievement. In this context, it is empowering for educators to know that applying holistic and integrated strategies in reading instruction is not just beneficial, but necessary for student success.

Case studies from several schools implementing the CIRC model have shown encouraging results. In one junior high school in Jakarta, applying CIRC over one semester increased students' average reading scores by 15%. This demonstrates that this method is theoretical and can be successfully implemented in daily educational practice. Finally, it is crucial to recognize that improving reading skills is a complex and multifaceted process. In addition to instructional and motivational factors, support from parents and the community is also of utmost importance. Research by Ristanto and Darmawan (2020) shows that parental involvement in the reading learning process is not just beneficial, but crucial. It can significantly enhance students' motivation and achievement, making parents an integral part of their child's educational journey. Therefore, collaboration among schools, parents, and the community is essential to create an environment that supports effective reading learning.

The Cooperative Integrated Reading and Composition (CIRC) model presents several implementation challenges. Educators must create appropriate materials, manage time effectively, and foster a conducive classroom environment (Sakkir & Haturrahma, 2023). The strategy demands systematic application and can be time-consuming to execute optimally (Sakkir & Haturrahma, 2023; Bramlett, 1994). Nonetheless, CIRC has demonstrated positive outcomes, such as enhanced reading comprehension, particularly for lower-ability students (Bramlett, 1994), and improved writing skills (Haturrahma et al., 2023). It also fosters students' critical thinking, motivation, and self-confidence (Sakkir & Haturrahma, 2023; Fhathah & Nuraeni, 2020). CIRC can be implemented through heterogeneous or homogeneous grouping, catering to diverse student ability levels (Fhathah & Nuraeni, 2020). Despite the challenges, teachers tend to hold favorable attitudes toward CIRC (Bramlett, 1994). This strategy aids in developing students' creativity, independence, collaboration, and communication skills while enhancing vocabulary mastery and the expression of ideas (Haturrahma et al., 2023).

Mathematics education often focuses on memorizing formulas, but several studies indicate the need for a shift toward problem-solving skills and reasoning. Dewi and Maulida (2023) demonstrate that STEM-oriented teaching materials significantly enhance students' mathematical literacy. This research shows that integrating STEM contexts into learning can increase student engagement by connecting abstract mathematical concepts with real-world applications. This aligns with educational approaches that emphasize the relevance of teaching materials to students' daily lives.

The implementation of STEM education in schools encounters several challenges. Teachers' readiness and content knowledge are a significant barrier, with many educators needing more confidence and adequate training (Jekri & Han, 2020; Ramli et al., 2017). Additional obstacles include insufficient funding, standardized testing

requirements, and the necessity for integrated curricula (Williams, 2015). The engineering aspect of STEM poses particular difficulties, as it demands specialized educator certification and comprehensive curriculum development (Williams, 2015). Policy implementation may also be impeded by competing agendas and interests among stakeholders, along with funding limitations and tight timelines (Johnson, 2012). Various instructional approaches have been adopted in response to these challenges, such as model-based, project-based, and problem-based learning (Ramli et al., 2017). Setyowati et al. (2024) confirmed that through the project based learning service method, it has an impact on learning motivation so that interest in learning grows. Addressing these obstacles is essential for effective STEM education, as it significantly influences students' pursuit of STEM careers in higher education (Williams, 2015).

Furthermore, Mahmud and Mohd Drus (2023) highlight how diverse oral questioning techniques, can stimulate logical reasoning, allowing students to deepen their understanding of mathematical concepts. This research indicates that good questions can trigger in-depth discussions and improve students' critical thinking skills. This finding is consistent with the work of Kusmaryono and Kusumaningsih (2023), which emphasizes the need for teachers to adopt teaching practices aligned with PISA's focus on problem-solving rather than just procedural knowledge.

Implementing effective questioning techniques in schools presents several challenges. Teachers often struggle to incorporate higher-order thinking questions, resulting in a predominance of lower-order questions during classroom interactions (Zainudin et al., 2019). Key obstacles include students' cognitive readiness, unproductive learning environments, and vocabulary limitations (Zainudin et al., 2019). In game-based learning approaches, teachers encounter difficulties designing practice games, analyzing student learning, and making necessary adjustments (Harvey & Light, 2015). Additionally, the effective use of productive questioning remains a significant concern (Harvey & Light, 2015). Nepali math teachers face issues related to power dynamics within the classroom, which can hinder student participation in mathematical discussions (Dahal, 2022). To address these challenges, teachers can employ various questioning techniques and adapt their methods to foster greater student engagement (Harvey & Light, 2015; Dahal, 2022). Establishing a positive questioning culture requires tackling these obstacles and implementing practical strategies (Belmekki, 2021).

The importance of context-based learning is also emphasized in the research by Saputri et al. (2022), where students using familiar real-world scenarios are better able to understand mathematical functions. This approach bridges the gap between abstract mathematical concepts and their practical applications, making learning more meaningful. Additionally, the use of specific multimedia learning elements, has been found to enhance student engagement and confidence in learning mathematics (Lew & Krishnasamy, 2023).

Context-based learning in schools encounters several implementation challenges. Limited resources for practical experiments and a lack of opportunities to develop contextual media hinder practical application (Situmorang et al., 2019). Teachers face difficulties with technology accessibility, unpredictable student learning outcomes, and the pressures of content-driven curricula (Ulrich, 2012). To address these obstacles, significant curricular reform is essential (Smiley, 2020). Moreover, the need for more educators familiar with local cultural contexts presents a challenge for implementing culture-based contextual learning (Harisatunisa & Sauqi, 2023). Additional complications arise from time

constraints, high-stakes testing, and inadequate teacher collaboration (Ulrich, 2012). Nevertheless, context-based learning has demonstrated the potential to enhance scientific literacy, enabling students to gather information, evaluate source credibility, and make informed decisions (Smiley, 2020). Practical implementation strategies include using physical and cultural artifacts as educational resources and incorporating field trips and observational experiences (Harisatunisa & Sauqi, 2023).

Interestingly, Nadaf and Seb (2021) explored the impact of study time on students' achievements in mathematics, finding that optimal study time lies between 18 and 22 hours per week. These findings highlight the importance of balancing study time to maximize cognitive benefits, suggesting that excessive study hours may hinder rather than enhance performance. This reinforces the need for schools and educators to focus on learning efficiency rather than merely increasing study hours. Thus, a combination of innovative teaching approaches, the use of technology, and attention to the learning context can create a learning environment that supports the holistic development of students' mathematical skills.

Science education increasingly leverages digital tools and innovative strategies to enhance student learning outcomes. The use of digital comic materials, as explored by Fitria et al. (2023), has proven effective in improving students' literacy on scientific topics, particularly the characteristics of living organisms. This approach suits younger learners, making abstract scientific concepts more accessible and engaging through visuals and storytelling. The resounding success of this method demonstrates that integrating creative multimedia into science education can significantly enhance students' understanding and retention, instilling confidence in educators about the effectiveness of digital tools.

Digital comics have emerged as an innovative approach to enhancing school science education and literacy. Research indicates that these materials can significantly improve students' scientific literacy scores and boost engagement (Fitria et al., 2023). The visually captivating and colorful format of digital comics presents scientific concepts within relatable everyday contexts, making complex ideas easier for students to understand (Fitria et al., 2023; Habiddin et al., 2022). Prabawa (2023; 2024) added that ease of learning will foster students' psychological well-being and increase academic hardiness. Psychological well-being also has an impact on a student's productivity and reduces academic burnout (Indreswari et al., 2022; Pratiwi & Setiyowati, 2024). Integrating augmented reality technology and mobile app-based platforms further enriches the interactive learning experience (Habiddin et al., 2022). Furthermore, inquiry-based science comics have shown promise in fostering character development and cognitive achievement among primary school students (Yulianti et al., 2016). These digital resources are precious in online learning environments, especially during challenging times like the COVID-19 pandemic (Habiddin et al., 2022). In addition, reading can also improve problem-solving skills so that the ability to solve a problem is increased (Suryahadikusumah et al., 2024). Overall, digital comics hold great potential as effective supplementary teaching materials for enhancing science education and literacy in schools.

In a study by Fernández-Gutiérrez et al. (2020), information and communication technology (ICT) in science education was more effective than in mathematics or reading. This may be because science often involves experiments, visual representations, and interactions with technology, making ICT a natural tool for enhancing learning outcomes in this subject. Hermita et al. (2023) also discovered that the

Self-Directed STEM City Map Application significantly improved students' critical thinking skills, which are essential competencies in scientific research. This highlights the potential of digital tools not only to engage students but also to foster more profound cognitive skills that are crucial for success in science.

The significance of technology integration in science education is supported by numerous studies indicating that students exposed to digital devices demonstrate enhanced comprehension of scientific concepts. Research conducted by Fitria et al. (2023) revealed that students utilizing digital comic materials experienced a remarkable increase of up to 20% in science test scores compared to traditional learning methods. Furthermore, Zakaria and Salwa (2024) highlighted the critical role of ICT integration in teaching, emphasizing its potential to enhance understanding and skills and positively influence the application of educational outcomes in students' lives. These findings illustrate that innovative teaching methods can profoundly impact student learning results.

However, challenges remain in the implementation of technology in science education. Some teachers may feel less skilled in using digital tools, which can hinder effective implementation. Therefore, training and support for teachers are essential to ensure they can effectively leverage technology in their teaching. Moreover, educators are encouraged to be part of the ongoing development in science education, as further research is needed to explore ways in which this training can be integrated into professional development programs for teachers.

The integration of ICT in science education faces significant challenges in developing countries. Common obstacles include inadequate infrastructure, limited internet connectivity, and insufficient ICT resources (Kibirige, 2023; Ugwuanyi & Nwagbo, 2012; Ngodu et al., 2024). Teachers frequently need more ICT skills, confidence, and training opportunities (Kibirige, 2023; Ugwuanyi & Nwagbo, 2012; Ngodu et al., 2024). Additionally, administrative support and time constraints impede effective ICT integration (Kibirige, 2023; Ugwuanyi & Nwagbo, 2012). The gap between mathematical and scientific approaches also complicates the communication of STEM concepts through e-learning platforms (Gunga, 2010). To tackle these challenges, researchers advocate for a multi-faceted approach that includes increased investment in infrastructure, comprehensive teacher training programs, the development of suitable ICT curriculum materials, and the involvement of educational technology experts (Kibirige, 2023; Ngodu et al., 2024). Furthermore, making ICT compulsory at all levels of education and enhancing access to digital content are proposed as viable solutions (Ngodu et al., 2024).

Limitations and Further Research

The systematic literature review (SLR) is limited to studies published between 2019 and 2024, which may exclude relevant research conducted before this timeframe that could provide valuable insights into effective learning methods. The thematic analysis may also introduce subjectivity, as the interpretation of themes and findings can vary between researchers. This subjectivity may influence the conclusions drawn about the effectiveness of the teaching methods analyzed. Future research should expand the literature review timeframe to include studies before 2019 and employ multiple researchers in the thematic analysis process to minimize subjectivity and enhance the reliability of the findings.

■ CONCLUSION

The studies reviewed provide valuable insights into the effectiveness of various educational strategies to improve student

performance in reading, mathematics, and science. Key findings highlight the importance of integrating context-based learning, STEM approaches, and interactive digital tools to enhance student engagement and cognitive development. Specifically, strategies such as the CIRC learning model significantly improve literacy outcomes in reading. Using STEM-nuanced materials, oral questioning techniques, and multimedia tools fosters a more profound understanding and critical thinking in mathematics. Science education benefits greatly from digital tools like comic materials and ICT, which make abstract concepts more accessible and stimulate critical thinking. The research also shows that balanced learning time plays a crucial role in academic success, with an optimal range of study hours that boost cognitive achievement while preventing burnout.

Educational systems should prioritize the adoption of context-based and problem-solving approaches, particularly in mathematics and science, to help students apply abstract concepts to real-world scenarios. Context-based learning enhances students' comprehension by making lessons more relatable and practical. This strategy should be more widely integrated across curricula, ensuring that students develop a strong connection between theoretical knowledge and practical applications. The leveraging of digital and multimedia tools is another key recommendation. Tools such as STEM applications, interactive multimedia, and digital comics have been proven effective in boosting student engagement and improving learning outcomes, especially in science.

Schools should therefore invest in digital learning platforms that provide both cognitive and emotional engagement, enriching the overall learning experience for students. Additionally, it is essential that teachers work to foster critical thinking and higher-order skills in their students, moving away from rote memorization towards more analytical tasks. Techniques such as oral questioning, collaborative learning models like CIRC, and activities that encourage students to evaluate and synthesize information will cultivate stronger problem-solving abilities.

Education policymakers and teachers should also focus on optimizing learning time, balancing study hours to enhance efficiency rather than simply increasing time spent studying. Addressing socioeconomic and motivational factors is another critical aspect of improving reading outcomes. Policymakers play a crucial role in ensuring that schools provide additional resources and targeted interventions to ensure that students from lower socioeconomic backgrounds have equal opportunities. Finally, ongoing teacher professional development is vital for implementing these strategies, equipping educators with the necessary skills to utilize digital tools and promote higher-order thinking, while adapting to the diverse needs of their students in the rapidly evolving digital learning environment.

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