Systematic Literature Review: The Implementation of Meaningful Learning in Elementary School Mathematics Education

Abstract

This study aims to examine the implementation of meaningful learning in elementary school mathematics education through a Systematic Literature Review (SLR) approach. Meaningful learning emphasizes the connection between new knowledge and students' prior knowledge, enabling deeper understanding and long-term retention. The study analyzed 25 selected articles obtained from databases such as Google Scholar, ERIC, and ScienceDirect, published between 2010 and 2024. The selection process followed the PRISMA framework, including identification, screening, eligibility, and inclusion stages.

The findings indicate that meaningful learning has a positive impact on students' conceptual understanding, problem-solving skills, and learning motivation. Various instructional strategies, including contextual learning, problem-based learning, and the use of concrete representations, were found to support the successful implementation of meaningful learning. Additionally, approaches such as Realistic Mathematics Education (RME) were identified as effective in promoting meaningful learning experiences.

However, several challenges were identified, including limited teacher understanding, time constraints, and diverse student characteristics. The study also identified research gaps, particularly in the areas of long-term learning outcomes, integration of technology, and the development of students' mental models.

This study concludes that meaningful learning is an effective and relevant approach for improving mathematics education in elementary schools. The results are expected to contribute to the development of teaching practices and future research in the field of mathematics education.

Keywords

Meaningful Learning; Mathematics Education; Elementary School; Systematic Literature Review; Conceptual Understanding; Problem Solving

Introduction

Mathematics learning in elementary school plays a fundamental role in developing students' logical, analytical, and problem-solving abilities. As one of the core subjects, mathematics is not only concerned with numerical computation but also with fostering reasoning skills that are essential for daily life and future learning. However, in many classroom practices, mathematics instruction still tends to emphasize procedural fluency and rote memorization rather than conceptual understanding (Hiebert & Carpenter, 1992; Ruseffendi, 2006). This condition often results in students being able to solve routine problems but struggling when faced with non-routine or contextual tasks that require deeper understanding (OECD, 2019).

The persistence of such issues indicates that learning experiences provided to students are not yet meaningful. According to Skemp (1976), there is a distinction between instrumental understanding (knowing rules) and relational understanding (knowing both what to do and why). Many students remain at the instrumental level due to teaching approaches that do not adequately connect new knowledge with prior knowledge. Similarly, Suherman et al. (2003) highlight that ineffective instructional strategies contribute to students' difficulties in grasping mathematical concepts meaningfully.

To address this challenge, the concept of *meaningful learning* has been widely recognized as an effective approach. Introduced by Ausubel (1968), meaningful learning emphasizes that new information should be actively related to learners' existing cognitive structures. This perspective aligns with constructivist theories, which assert that knowledge is constructed through active engagement and interaction with the environment (Piaget, 1970; Vygotsky, 1978; Jonassen, 1991). In this sense, meaningful learning shifts the focus from teacher-centered instruction to student-centered learning, where learners actively build their own understanding.

Meaningful learning is further supported by cognitive learning theories, which emphasize the importance of understanding over memorization. Mayer (2002) distinguishes between rote learning and meaningful learning, stating that meaningful learning leads to better retention and transfer of knowledge. Additionally, Sweller (1988) highlights the importance of managing cognitive load to ensure that students can process and integrate new information effectively. These theoretical perspectives reinforce the idea that meaningful learning is essential for achieving deep and lasting understanding in mathematics.

In the context of mathematics education, meaningful learning is closely related to the use of appropriate instructional strategies and representations. Bruner (1961) suggests that learning should progress through enactive, iconic, and symbolic stages, enabling students to understand abstract concepts through concrete experiences. Similarly, Polya (1973) emphasizes the importance of problem-solving strategies that encourage students to think critically and systematically. These approaches align with the principles advocated by the National Council of Teachers of Mathematics (NCTM, 2000), which stress the importance of conceptual understanding, problem-solving, and student engagement in mathematics learning.

Furthermore, meaningful learning contributes significantly to the development of students' mental models. According to Johnson-Laird (1983), mental models are internal representations that individuals use to interpret and solve problems. Through meaningful learning experiences, students can construct more accurate and structured mental models, which enhance their ability to understand complex mathematical concepts. Novak (2010) also supports this idea by introducing concept mapping as a tool to facilitate meaningful knowledge construction.

In addition to theoretical perspectives, meaningful learning is also supported by instructional design principles. Wiggins and McTighe (2005) propose the concept of *Understanding by Design*, which focuses on designing learning experiences that promote deep understanding rather than superficial knowledge. Similarly, Slavin (2006) emphasizes the importance of effective teaching strategies that actively involve students in the learning process. These approaches highlight the need for teachers to create learning environments that are engaging, contextual, and relevant to students' lives.

In the Indonesian context, the implementation of meaningful learning aligns with current educational policies. The *Merdeka Curriculum* promotes student-centered learning and emphasizes deep understanding of concepts. This is further supported by the Regulation of the Minister of Education and Culture No. 22 of 2016, which requires teachers to implement interactive, inspiring, and student-centered learning processes (Kemendikbud, 2016). Additionally, research by Zulkardi (2002) on Realistic Mathematics Education (RME) demonstrates the importance of contextual learning in helping students understand mathematical concepts more meaningfully.

Despite its advantages, the implementation of meaningful learning in elementary mathematics education is not without challenges. Studies have shown that teachers often face difficulties in designing and implementing meaningful instructional activities (Suryadi, 2012; Fauzan, 2010). Factors such as limited teaching resources, time constraints, and diverse student abilities can hinder the effectiveness of this approach. Moreover, data analysis studies in education (Miles et al., 2014) indicate that instructional practices often do not align with theoretical frameworks, leading to gaps between theory and practice.

On the research side, studies on meaningful learning have grown significantly, covering various aspects such as instructional strategies, student engagement, and learning outcomes. However, these studies are often fragmented and use different methodologies, making it difficult to draw comprehensive conclusions. Creswell (2014) emphasizes the importance of systematic approaches in research synthesis to ensure validity and reliability. Similarly, Yin (2018) highlights the need for rigorous research designs to generate credible findings.

Therefore, a *Systematic Literature Review (SLR)* is needed to systematically analyze and synthesize existing research on meaningful learning in elementary mathematics education. According to Kitchenham (2004), SLR provides a structured method for identifying, evaluating, and interpreting relevant research, ensuring that conclusions are based on comprehensive and unbiased evidence. By applying this method, researchers can identify trends, evaluate effectiveness, and uncover research gaps in the field.

Based on the above discussion, this study aims to: (1) identify research trends in the implementation of meaningful learning in elementary mathematics education, (2) analyze its effectiveness in improving students' learning outcomes, and (3) identify research gaps for future studies. The findings of this study are expected to contribute to the development of both theory and practice, particularly in enhancing the quality of mathematics learning to make it more meaningful, effective, and relevant for elementary school students. This study contributes by specifically highlighting the relationship between meaningful learning and students' mental model development, which has received limited attention in previous SLR studies. Despite the growing number of studies on meaningful learning in mathematics education, most existing research focuses primarily on learning outcomes such as conceptual understanding and achievement, with limited attention to the development of students' mental models as a cognitive structure underlying meaningful learning.

Therefore, this study contributes to the literature by systematically examining not only the effectiveness of meaningful learning but also its relationship with students' mental model development in elementary mathematics education. By synthesizing findings from multiple studies, this research provides a more integrative perspective that bridges instructional approaches and cognitive processes, which has not been sufficiently explored in previous systematic reviews.

Method

This study employed a **Systematic Literature Review (SLR)** approach to analyze and synthesize previous research related to the implementation of meaningful learning in elementary school mathematics education. SLR is a structured and rigorous method used to identify, evaluate, and interpret relevant studies on a particular topic in a systematic and transparent manner (Kitchenham, 2004). This approach enables researchers to minimize bias and produce reliable findings by following clearly defined procedures (Creswell, 2014).

Research Design

The design of this study followed the SLR framework proposed by Kitchenham (2004), which consists of three main stages: planning, conducting, and reporting the review. In the planning stage, the research questions and objectives were defined to guide the review process. In the conducting stage, relevant studies were systematically searched, selected, and analyzed. Finally, in the reporting stage, the findings were synthesized and presented in a structured format.

This study focused on answering the following research questions:

1. What are the research trends in the implementation of meaningful learning in elementary mathematics education?
2. How effective is meaningful learning in improving students' learning outcomes?
3. What research gaps can be identified for future studies?

Search Strategy

The literature search was conducted using several academic databases, including **Google Scholar, ERIC, and ScienceDirect**. Keywords used in the search process included: *"meaningful learning," "mathematics education," "elementary school,"* and *"primary education."* These keywords were combined using Boolean operators (AND, OR) to obtain relevant studies.

The search process aimed to identify peer-reviewed journal articles published between **2010 and 2024**, ensuring that the selected studies reflect recent developments in the field. According to OECD (2019), recent educational research is essential to understand current trends and challenges in learning.

Inclusion and Exclusion Criteria

To ensure the quality and relevance of the selected studies, inclusion and exclusion criteria were established. The inclusion criteria were as follows:

1. Articles focusing on meaningful learning in mathematics education
2. Studies conducted at the elementary school level
3. Peer-reviewed journal articles
4. Articles published in English or Indonesian
5. Studies published between 2010 and 2024

The exclusion criteria included:

1. Articles not related to mathematics learning
2. Studies conducted at secondary or higher education levels
3. Non-academic publications (e.g., blogs, opinion articles)
4. Incomplete or inaccessible full-text articles

These criteria are important to ensure that the review includes only high-quality and relevant studies (Yin, 2018).

Data Collection Procedure

The data collection process followed the **PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)** framework, which provides a standardized method for reporting systematic reviews (Kitchenham, 2004). The procedure consisted of four main steps:

1. **Identification**
   Articles were identified through database searches using predefined keywords.
2. **Screening**
   Duplicate articles were removed, and titles and abstracts were screened for relevance.
3. **Eligibility**
   Full-text articles were assessed based on the inclusion and exclusion criteria.
4. **Included**
   Final articles that met all criteria were selected for analysis.

This structured process ensures transparency and replicability in the review (Creswell, 2014). The article selection process followed the PRISMA framework, as illustrated in Figure 1.

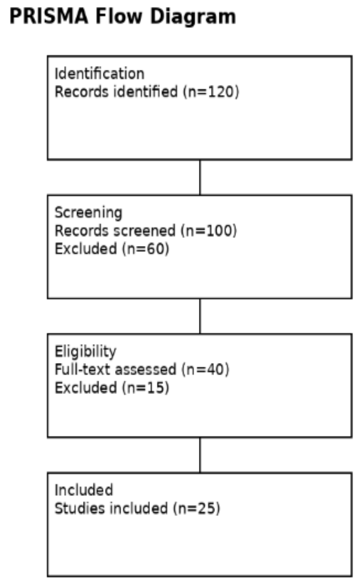

Figure 1. PRISMA Flow Diagram of Article Selection Process

Data Analysis Technique

The selected articles were analyzed using **qualitative content analysis**. This technique involves categorizing and interpreting data to identify patterns, themes, and relationships across studies (Miles et al., 2014). The analysis focused on several aspects, including:

- research objectives
- research methods
- sample characteristics
- key findings
- implications for teaching and learning

The findings were then synthesized to identify common trends and differences among studies. This approach aligns with the principles of qualitative research, which emphasize understanding phenomena in depth (Creswell, 2014).

Validity and Reliability

To ensure the validity and reliability of the findings, several strategies were applied. First, a systematic and transparent procedure was used throughout the review process, following established SLR guidelines (Kitchenham, 2004). Second, multiple sources of literature were included to enhance the comprehensiveness of the data. Third, consistent inclusion and exclusion criteria were applied to minimize selection bias (Yin, 2018).

Additionally, the use of well-established theoretical frameworks, such as meaningful learning theory (Ausubel, 1968) and constructivist learning theory (Vygotsky, 1978; Piaget, 1970), strengthens the credibility of the analysis. By integrating these theoretical perspectives, the study ensures that the findings are grounded in established educational theories.

Results

The systematic literature review identified a total of **120 articles** from initial database searches across Google Scholar, ERIC, and ScienceDirect. After removing duplicates and applying inclusion and exclusion criteria, **25 articles** were deemed relevant and included in the final analysis. The selection process followed the PRISMA framework, ensuring transparency and methodological rigor (Kitchenham, 2004; Creswell, 2014).

1. Research Trends in Meaningful Learning

The analysis revealed that research on meaningful learning in elementary mathematics education has increased significantly over the past decade, particularly after 2015. This trend reflects the growing emphasis on student-centered learning and conceptual understanding in global education systems (OECD, 2019). Most studies were conducted in developing countries, including Indonesia, where curriculum reforms have emphasized active learning approaches such as the *Merdeka Curriculum*.

In terms of research design, the majority of studies employed **quasi-experimental and qualitative approaches**. Experimental studies focused on measuring the effectiveness of meaningful learning on students' achievement, while qualitative studies explored students' understanding, engagement, and cognitive processes. This diversity in research design indicates that meaningful learning has been examined from multiple perspectives, including cognitive, pedagogical, and contextual dimensions (Creswell, 2014; Yin, 2018).

No	Author	Year	Method	Sample	Focus	Key Findings
1	Fauzan	2010	Experimental	Elementary students	RME	Improves conceptual understanding
2	Suryadi	2012	Qualitative	Teachers	Teaching strategies	Teacher difficulty in implementation
3	Zulkardi	2002	Design Research	Elementary	RME	Contextual learning is

						effective
4	Slavin	2006	Experimental	Students	Active learning	Improves engagement
5	Mayer	2002	Theoretical	-	Cognitive theory	Meaningful learning improves retention

2. Effectiveness of Meaningful Learning

The findings consistently indicate that meaningful learning has a positive impact on students' mathematical understanding. Several studies reported significant improvements in students' conceptual understanding when meaningful learning strategies were implemented. This supports Ausubel's theory that learning becomes more effective when new knowledge is connected to prior knowledge (Ausubel, 1968).

Moreover, meaningful learning has been shown to enhance students' **problem-solving skills**. Students who engage in meaningful learning activities are better able to analyze problems, select appropriate strategies, and apply mathematical concepts in new situations. This aligns with Polya's (1973) problem-solving framework, which emphasizes understanding the problem and developing appropriate strategies.

Another important finding is the improvement in students' **learning motivation and engagement**. Meaningful learning creates a more interactive and enjoyable learning environment, encouraging students to participate actively in the learning process. According to Slavin (2006), active engagement is a key factor in improving learning outcomes. Similarly, NCTM (2000) highlights that meaningful classroom interactions contribute to deeper understanding and long-term retention.

In addition, meaningful learning supports the development of **mental models**. Students are able to construct internal representations that help them understand abstract mathematical concepts more effectively (Johnson-Laird, 1983). The use of visual representations, real-life contexts, and concept mapping further strengthens students' understanding (Novak, 2010).

3. Instructional Strategies in Meaningful Learning

The review also identified several instructional strategies commonly used to implement meaningful learning in mathematics classrooms. These include:

- contextual learning approaches
- use of concrete and visual media
- problem-based learning
- collaborative learning

These strategies are consistent with constructivist learning theories, which emphasize active knowledge construction (Piaget, 1970; Vygotsky, 1978). Bruner (1961) also supports the use of concrete representations to help students transition from concrete to abstract thinking.

In Indonesia, the implementation of **Realistic Mathematics Education (RME)** has been widely recognized as an effective approach to promote meaningful learning. RME emphasizes the use of real-life contexts to help students understand mathematical concepts (Zulkardi, 2002; Fauzan, 2010). This approach aligns with the principles of meaningful learning and has shown positive results in improving students' understanding.

4. Challenges in Implementation

Despite its benefits, the implementation of meaningful learning is not without challenges. Several studies reported that teachers face difficulties in designing meaningful learning activities due to limited understanding of the approach (Suryadi, 2012). Additionally, time constraints and curriculum demands often limit teachers' ability to implement student-centered learning effectively.

Another challenge is related to **cognitive load**. If learning activities are not properly designed, students may experience cognitive overload, which can hinder understanding (Sweller, 1988). Therefore, teachers need to carefully plan instructional strategies to ensure that learning remains effective and manageable.

Furthermore, variations in students' abilities and backgrounds can affect the success of meaningful learning. Teachers must adapt their instruction to accommodate diverse learners, which requires strong pedagogical skills and experience (Ruseffendi, 2006).

Discussion

The findings of this study confirm that meaningful learning is a highly effective approach in elementary mathematics education. By connecting new knowledge with prior knowledge, students are able to develop deeper conceptual understanding and improve their problem-solving abilities. This supports the theoretical framework proposed by Ausubel (1968) and is reinforced by constructivist theories (Piaget, 1970; Vygotsky, 1978).

The positive impact of meaningful learning on students' engagement and motivation also highlights the importance of student-centered instruction. As emphasized by Wiggins and McTighe (2005), meaningful learning requires careful instructional design that prioritizes understanding over memorization. This approach is particularly relevant in the context of modern education, which emphasizes higher-order thinking skills.

However, the challenges identified in this study suggest that the successful implementation of meaningful learning requires adequate teacher training and support. Teachers need to develop the skills and knowledge necessary to design and implement effective learning activities. Additionally, educational policies should provide sufficient flexibility to allow teachers to adopt innovative teaching approaches (Kemendikbud, 2016).

Research Gap

Based on the analysis, several research gaps were identified:

1. Most studies focus on short-term learning outcomes, with limited research on long-term retention.
2. There is a lack of studies exploring meaningful learning in diverse student populations.
3. Limited research integrates meaningful learning with digital technology.
4. Few studies examine the development of students' mental models in depth.

These gaps indicate opportunities for future research to further explore and develop meaningful learning approaches in mathematics education.

Conclusion

This study aimed to systematically review the implementation of meaningful learning in elementary school mathematics education. Based on the analysis of 25 selected articles, it can be concluded that meaningful learning plays a significant role in improving students' conceptual understanding, problem-solving skills, and learning motivation. By connecting new knowledge with students' prior knowledge, meaningful learning enables deeper and more lasting understanding, as emphasized by Ausubel (1968) and supported by constructivist theories (Piaget, 1970; Vygotsky, 1978).

The findings also indicate that various instructional strategies, such as contextual learning, problem-based learning, and the use of concrete media, contribute to the effectiveness of meaningful learning. These strategies help students bridge the gap between abstract mathematical concepts and real-life experiences, making learning more relevant and engaging. In particular, approaches such as Realistic Mathematics Education (RME) have shown strong alignment with the principles of meaningful learning and have demonstrated positive outcomes in classroom implementation (Zulkardi, 2002; Fauzan, 2010).

However, this study also identified several challenges in the implementation of meaningful learning. These include teachers' limited understanding of the approach, time constraints, and the need to address diverse student characteristics. Additionally, the risk of cognitive overload must be carefully managed to ensure that students can effectively process new information (Sweller, 1988). Therefore, it is essential for teachers to receive adequate training and support in designing meaningful learning experiences.

Furthermore, this review revealed several research gaps that need to be addressed in future studies. These include the lack of research on long-term learning outcomes, limited integration of digital technology in meaningful learning, and insufficient exploration of students' mental model development. Addressing these gaps will contribute to a more comprehensive understanding of meaningful learning and its potential in improving mathematics education.

Although the majority of studies reported positive effects of meaningful learning on students' conceptual understanding, several inconsistencies were identified. Some studies indicated that the effectiveness of meaningful learning highly depends on teachers' pedagogical competence and the design of instructional activities. In cases where teachers lacked sufficient understanding of meaningful learning principles, the implementation tended to remain superficial and did not significantly improve students' higher-order thinking skills.

Furthermore, variations in student characteristics, such as prior knowledge and cognitive readiness, were found to influence the effectiveness of meaningful learning. This suggests that meaningful learning is not universally effective, but requires adaptive instructional design tailored to diverse learners.

These findings highlight that meaningful learning should not be viewed merely as a teaching approach, but as a complex pedagogical process that involves the interaction between instructional design, teacher competence, and students' cognitive structures.

In conclusion, meaningful learning is a promising approach that can enhance the quality of mathematics education at the elementary level. It is recommended that educators, researchers, and policymakers collaborate to promote its implementation through curriculum development, teacher training, and further research.

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