JIPM (Jurnal Ilmiah Pendidikan Matematika) 13(2), 2024, 58-66
DOI : 10.25273/jipm.v13i1.21280

JIPM (Jurnal Ilmiah Pendidikan Matematika)

Journal homepage: http://e-journal.unipma.ac.id/index.php/jipm

Teachers' Perceptions of the Implementation of Scaffolding-Metacognitive Strategies in Mathematics Learning

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 ISSN 2337-9049 (print), ISSN 2502-4671 (online)

Abstract:
Scaffolding-metacognitive is a strategy to help students understand mathematical material, but some teachers do not yet understand the extent to which they can use the metacognitive scaffolding strategy in the learning process. This study aims to determine teachers' perceptions of the implementation of scaffolding-metacognitive strategies in mathematics learning in secondary schools. Scaffolding-metacognitive strategies, combining step-by-step teaching with the development of students' awareness and control of their thinking processes, Scaffolding-metacognitive strategies are an effective approach to improving students' understanding of complex mathematical concepts and critical thinking skills. This study used a qualitative descriptive method and the participants consisted of 15 mathematics teachers from several high schools in Makassar City and Gowa Regency. Data were collected through in-depth interviews and direct observation during the learning process. We used the Miles & Huberman analysis framework to analyze the collected data, namely: (1) data reduction; (2) data interpretation and condensation; (3) verification and drawing conclusions. The results of data analysis showed that 60% of teachers did not understand the scaffolding-metacognitive strategy, teachers mentioned several implementation challenges, such as the difficulty of adapting strategies to students' different abilities and limited time to plan and implement learning. In addition, teachers must estimate students' actual and potential knowledge so that teachers can provide scaffolding according to students' needs. Teachers need further support and training to overcome the challenges they face when implementing scaffolding-metacognitive strategies. This research makes an important contribution to the development of more effective educational policies and teacher training programs to improve the quality of mathematics education in secondary schools.
Keywords: Scaffolding, Scaffolding-Metacognition, Mathematics Learning

Introduction

Mathematics is an important subject to be learned by students from elementary school to college. There are several skills taught in mathematics, including the ability to think and reason (Moore et al., 2013; Paoletti & Moore, 2017). There are five reasons why it is necessary to learn mathematics (Arican, 2019; Finesilver, 2022), including: (1) a means of clear and logical thinking, (2) a means of solving everyday life problems, (3) a means of developing patterns of relationships and generalization of experiences, (4) a means of developing creativity, and (5) a means of increasing awareness of cultural developments.

Learning mathematics not only plays an important role in developing students' thinking skills, but also in building students' competencies to be better in the future

(Torbeyns et al., 2020; Verzosa, 2020). Competence is more than just knowledge or skills, it includes the ability to meet complex demands, represent and mobilize psychological resources such as special skills and attitudes (Haryonik & Bhakti, 2018). Therefore, competence is not only about cognitive aspects but also about skills (Ghanizadeh, 2017). In line with the competencies that students must have, mathematics learning is currently required to develop 21st century skills, namely learning that is able to develop students' competencies to be better. Learning developed in the 21st century is learning that is able to develop competencies as a whole, not only equipping students with a number of core subjects according to their interests, but also needing to equip them with non-academic competencies that are more interpersonal and intrapersonal (Haryonik & Bhakti, 2018).

Mathematics learning needs to be supported by appropriate methods and strategies according to students' intellectual development (Jansen & Spitzer, 2009; Planas, 2020). Teachers' emphasis on the mathematics learning process must be balanced between doing and thinking (Agterberg et al., 2022; Cragg & Gilmore, 2014). Models, techniques or strategies used in learning must be oriented towards student-centered, active, and interactive learning to build their own knowledge. Teachers must be able to foster student awareness in carrying out learning activities so that students can understand why the activity is carried out and what its implications are (Freeman et al., 2020; González-Calero et al., 2020; Luria et al., 2017). The mathematics learning process must be able to involve students' active activities by developing cognitive behavior (Syarifuddin & Atweh, 2022). To overcome this challenge, it is important for teachers to apply effective learning strategies that can help students understand the material more deeply. One strategy that can be applied is the scaffolding-metacognitive strategy.

Scaffolding is an approach in which teachers provide support tailored to students' needs to help them achieve deeper understanding and independence in learning (Chang et al., 2016; Kosko, 2020; Masfingatin & Maharani, 2019). This support can be in the form of guidance, instructions, or other aids, which are gradually reduced as students' abilities increase. By using scaffolding strategies, students are encouraged to complete tasks that may be too difficult to do alone, so that they can build new knowledge and skills (Kosko, 2020).

Scaffolding is a support strategy for children's convergent developmental areas. It is based on controlled support offered by adults who are able to modify the cognitive difficulties that children face when they are unable to solve problems at their current developmental level. It is important that such support is temporary. As children's skills progress with support, the scaffolding fades and children are eventually able to perform independently (Ayalon & Wilkie, 2020; Musgrave & Carlson, 2017; Rezat et al., 2021). We identified five different scaffolding strategies that teachers can use to help students gain conceptual understanding: this classification is used in this study as: offering explanations; inviting student participation; verifying and clarifying student understanding; modeling desired behavior and inviting students to provide clues.

Metacognition, on the other hand, refers to the awareness and regulation of one's own thinking processes (Carlson & Bloom, 2005; Guo, 2020; Yimer & Ellerton, 2010). In the context of mathematics learning, metacognition involves students' ability to plan, monitor, and evaluate their approaches to solving mathematical problems (Carlson & Thompson, 2017; Musgrave & Carlson, 2017; Thompson et al., 2014). This strategy encourages students to think about how they learn and understand concepts, as well as how they can improve their learning process (Misu et al., 2019; Pate & Miller, 2011).

In general, metacognition is a person's knowledge and control over the entire cognitive process they have. Metacognition also concerns beliefs and knowledge about a person's cognitive process towards their conscious efforts to play a role in the process of behavior and thinking so as to improve learning abilities both from the process and their memory (Riskika Alfia Ningrum et al., 2023; Sucipto, 2017).

The combination of scaffolding and metacognition in mathematics learning is expected to create a more supportive learning environment, where students do not only receive information passively but also actively participate in the learning process (Ayala-Altamirano & Molina, 2021). Thus, the scaffolding-metacognition strategy does not only focus on learning outcomes, but also on the learning process itself, which can help students develop critical and reflective thinking skills (An & Cao, 2014).

Teachers have a very important role in implementing learning strategies in the classroom (Hilton et al., 2016; Meyer et al., 2023; Singer & Voica, 2013). Teachers' perceptions of scaffolding-metacognitive strategies can influence the way they plan, implement, and evaluate learning (An & Cao, 2014). Positive perceptions of this strategy can encourage teachers to be more motivated and creative in implementing approaches that support active student engagement. Conversely, negative perceptions can hinder the implementation of the strategy, for example if teachers feel that this strategy is too complicated or takes too much time to prepare.

Novelty of the Research introduces a unique perspective by focusing on teachers' views, which is less commonly explored in studies on scaffolding and metacognitive strategies. Most research in this area tends to concentrate on student outcomes or the theoretical development of the strategies themselves. However, understanding how teachers perceive and implement these strategies in the classroom can provide insight into practical challenges, pedagogical adjustments, and the real-world effectiveness of scaffolding-metacognitive approaches. This research could reveal new findings related to teacher readiness, professional development needs, and the impact of teachers' attitudes on student engagement and success in mathematics learning.

This study aims to determine teachers' perceptions of the implementation of scaffolding-metacognitive strategies in mathematics learning in secondary schools. The focus of the study includes teachers' understanding of the concept of scaffolding-metacognitive and the support needed to implement it more effectively. By understanding teachers' perceptions, this study is expected to provide an overview of how scaffolding-metacognitive strategies are accepted and implemented in the classroom, as well as their impact on mathematics learning.

Method

This study uses a qualitative descriptive method and the participants consisted of 15 mathematics teachers from several high schools in Makassar City and Gowa Regency. Data were collected through in-depth interviews and direct observation during the learning process. Descriptive research is conducted through the collection of information or data based on facts, then the compilation, processing and sorting of data are carried out to be analyzed according to the focus of the research to provide a picture that is in accordance with the desired needs based on the existing problems.

We used an instrument that has been validated. The instrument is a needs analysis questionnaire related to teacher perceptions of scaffolding-metacognitive strategies in mathematics learning. A total of 16 questions were developed to explore teacher understanding in schools. Furthermore, we collected the perception data through a Google form and asked the teachers to take 10-20 minutes to work on the questions. The form of the questionnaire instrument is shown in the following table 1:

Table 1 Questionnaire Questions

No	Questionnaire Questions
1	What curriculum is currently being implemented at your school?
2	What materials have you taught on the topic of geometry?
3	How often do you use technology in teaching geometry?
4	What types of technology do you use in teaching?
5	Do you understand the concept of flipped classroom?
6	If yes, have you ever implemented a flipped classroom in previous learning?
7	How effective do you think flipped classroom is in geometry learning?
8	How well do you understand the metacognitive scaffolding strategy in learning?
9	How often do you apply the Scafolding-Metacognitive strategy in learning?
10	How important do you think the implementation of the Scafolding-Metacognitive strategy is in geometry learning?
11	How do you assess the spatial abilities of the students you are currently teaching?
12	What are the difficulties that students usually face in understanding geometry concepts?
13	What do you do to help students who have difficulty understanding geometry material?
14	Describe what obstacles you experience when teaching geometry material?
15	Describe your needs that can support improving learning outcomes in geometry material?
16	Do you have any other suggestions or comments regarding the development of a geometry learning model with the Scaffolding-Metacognitive strategy in the flipped classroom to improve students' spatial abilities?

Data collection was carried out through several techniques, namely: In-depth interviews with mathematics teachers who were the subjects of the study. Interview questions were designed to explore teachers' perceptions of the implementation of scaffolding-metacognitive strategies, the challenges faced, and the impact of implementing this strategy on mathematics learning. Observations were also conducted to see how teachers implement scaffolding-metacognitive strategies in mathematics learning in the classroom. This observation aims to obtain data that supports the results of the interview, as well as provide a more concrete picture of the implementation of the strategy.

The methods used to determine the credibility of the data and analysis techniques are triangulation. Methodological triangulation was used using interviews and observations. This helps cross-verify findings and ensure consistency between what teachers say and how they act in practice. Following interviews and observations, preliminary findings are shared with participants to ascertain whether the interpretations accurately reflect their experiences and perceptions. This feedback helps refine the analysis. Analysis and findings are reviewed by colleagues or experts in the fields of education and qualitative research to provide critical feedback. This ensures the interpretation is unbiased and reflects the reality of the data. Spending sufficient time in the field (observing lessons and interacting with participants) allows researchers to gain a deeper understanding of the context and ensures that the data collected is comprehensive. Thorough documentation of the data collection and analysis process is maintained to ensure transparency. This includes keeping records of interview transcripts, observation notes, and the coding process.

Resuts and Discussion

Research data on Teachers' Perceptions of the Implementation of Scaffolding-Metacognitive Strategies in Mathematics Learning, which includes the results of teacher interviews and answers to the questions asked, namely; (a) Understanding the Scaffolding-Metacognitive Strategy in Learning (b) Importance of Implementing the Scaffolding-Metacognitive Strategy in Mathematics Learning.

Teachers' abilities related to scaffolding-metacognitive strategies in learning

Based on the results of the responses given by 15 Mathematics teachers, the data obtained in the following diagram 1:

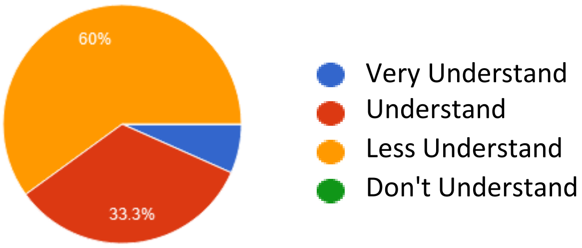

Diagram 1. Teachers' Abilities Related to Scaffolding-Metacognitive Strategies in Learning

Based on diagram 1, it can be seen that as many as 60% or 9 out of 15 teachers stated that they did not understand the scaffolding-matacognitive strategy. 33.3% or 5 out of 15 teachers stated that they understood the scaffolding-matacognitive strategy. 6.7% or 1 out of 15 teachers stated that they understood the scaffolding-matacognitive strategy very well. In general, teachers stated that they did not understand the scaffolding-matacognitive strategy so that its implementation in learning was less than optimal.

Limited Exposure to Training, several teachers mentioned that they had never received formal training on how to implement scaffolding-metacognitive strategies in their classrooms. One teacher remarked, "*I've heard of scaffolding in general, but no one has ever explained how to use it in a metacognitive context, especially for teaching mathematics.*" This reflects the teachers' limited professional development opportunities on the topic.

The Importance of Applying Scaffolding-Metacognitive Strategies in Mathematics Learning

Based on the results of the responses given by 15 Mathematics teachers, the data obtained in the following diagram 2:

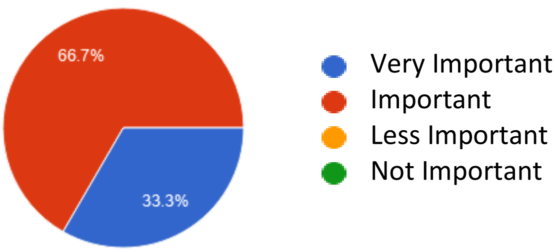

Diagram 2. The Importance of Applying Scaffolding-Metacognitive Strategies in Mathematics Learning

Based on diagram 2, it shows that 66.7% or 10 out of 15 teachers stated that the scaffolding-matacognitive strategy is important to apply in mathematics learning and 33.3% or 5 out of 15 teachers stated that the scaffolding-matacognitive strategy is important to apply in mathematics learning. Encouraging Independent Learning, some teachers also noted that this strategy helps students become more independent in their learning. One teacher shared, "*This strategy allows students to think for themselves and develop their problem-solving skills. They become more aware of their own thinking process.*" Thus, scaffolding-metacognitive strategies not only assist in understanding the material but also enhance students' critical thinking skills and independence.

The scaffolding-metacognitive strategy combines two complementary approaches to learning: scaffolding as gradual support to help students achieve understanding and independence, and metacognition as the ability to be aware of, control, and reflect on one's own thinking process. In the context of mathematics learning, this strategy does not stand alone but is integrated as a whole that provides a framework for teachers to support students' cognitive and metacognitive development. This aims to help students not only understand mathematics material but also become more independent and reflective learners. This is in line with the opinion of (Cevikbas & Kaiser, 2020; Holton & Clarke, 2006; Kosko, 2020; Manik et al., 2023) which states that the Role of Scaffolding-Metacognitive is a stimulus to develop students' abilities in the thinking process.

Metacognitive-scaffolding emphasizes the integration of incremental support with the development of students' awareness and self-management of their learning process. The teacher acts as a facilitator who provides assistance when needed, while guiding students to actively think about how they learn and solve problems. The teacher must be able to identify points where students need help, both in understanding mathematical concepts and in organizing their learning strategies. Support is provided incrementally and is tailored to the student's abilities, starting from more explicit support such as direct examples, to more implicit support such as guiding questions. The teacher encourages students to think about the strategies they use, monitors progress, and evaluates the results of the approaches they apply.

Scaffolding-metacognitive helps students build understanding of mathematical concepts by integrating external assistance and internal reflection. This makes students learn not only "how" to solve problems but also "why" certain strategies work or fail. Mathematical problem-solving skills require an approach that is not only procedural but also reflective. With scaffolding-metacognitive, students are taught to continue to apply reflection to their process, which strengthens their ability to solve more complex problems in the future. This approach helps students become independent learners by reducing dependence on teachers and improving their skills in managing their own learning. Through reflection, students learn to recognize their strengths and weaknesses and organize strategies that suit their needs. In line with Sukestiarno's opinion which states that the Effect further shows that the Scaffolding provided shows metacognitive activities; planning the problem-solving process, monitoring the progress of thinking, evaluating the effectiveness of solutions, to interpreting the truth of the solution along with other possible alternatives (Guo, 2020; Utami et al., 2020).

Some challenges in implementing this strategy as a whole include: Teachers must be able to adjust the level of scaffolding and combine it with metacognitive development, which can be difficult in a classroom with diverse student abilities. This process requires time for deep reflection and discussion, which can be difficult to do in a limited class time.

Conclussion

Based on the discussion on Teachers' Perceptions of the Implementation of Scaffolding-Metacognitive Strategies in Mathematics Learning, we findings two main ide of the research. *First,* teachers have a generally positive perception of the implementation of scaffolding-metacognitive strategies in mathematics learning. They recognize the benefits of this strategy in improving students' conceptual understanding, developing metacognitive skills, and facilitating more independent learning. Despite their positive perceptions, teachers face various challenges in implementing scaffolding-metacognitive strategies, including time constraints, diversity of student abilities, and lack of resources and school support. These challenges often hinder the consistency and effectiveness of implementation. *Second,* the implementation of scaffolding-metacognitive strategies is greatly influenced by teachers' understanding of the concept of scaffolding-metacognitive, as well as the support they receive in the form of training and resources. Teachers who have a deep understanding and adequate support tend to implement this strategy more effectively. To improve the effectiveness of this implementation strategy, improvements are needed in more practical and sustainable teacher training, the development of supportive open materials, and stronger school support. This support will help address existing challenges and maximize the potential of metacognitive scaffolding strategies in mathematics learning. Please write in a concise, clear, and compact manner based on the results of the research.

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