The Implementation of Scaffolding-Metacognitive Strategies in Flipped Classroom for Mathematics Learning

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Abstract. This study investigated the implementation of scaffolding-metacognitive strategies within a flipped classroom model to enhance mathematics learning. The flipped classroom approach shifted traditional teaching dynamics, enabling students to engage with instructional materials at home and apply knowledge during in-class activities. By integrating scaffolding and metacognitive strategies, the study aimed to support students' cognitive development and self-regulation skills. A mixed-methods design was employed, involving quantitative assessments of student performance and qualitative feedback through interviews and observations. Results indicated a significant improvement in students' mathematical understanding and problem-solving abilities, as well as heightened self-efficacy and motivation. Additionally, students reported greater awareness of their learning processes and strategies for improvement. This research highlighted the potential of scaffolding-metacognitive strategies in creating an effective flipped classroom environment, fostering deeper learning experiences in mathematics education. Recommendations for educators and future research were discussed to further explore this innovative teaching approach.

Keywords: Scaffolding, Scaffolding-Metacognition, Mathematics Learning.

1 Introduction

Mathematics is a vital subject that students should engage with from elementary school through university. It teaches essential skills, including critical thinking and reasoning [1];[2]. here are five key reasons why mathematics education is necessary [3]; [4] 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 [5]; [6]. Competence encompasses not just knowledge and skills but also the ability to meet

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complex requirements and mobilize psychological resources, including specific skills and attitudes [7]. Therefore, competence is not only about cognitive aspects but also about skills [8]. 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 [9].

Mathematics learning needs to be supported by appropriate methods and strategies according to students' intellectual development [10]; [11]. Teachers' emphasis on the mathematics learning process must be balanced between doing and thinking [12]; [13]. 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 [14]; [15]; [16]. The mathematics learning process must be able to involve students' active activities by developing cognitive behavior [17]. 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 [18]; [19]; [20]. 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 [19].

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 [21]; [22]; [23]. 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 [24]; [25]. In the context of mathematics learning, metacognition involves students' ability to plan, monitor, and evaluate their approaches to solving mathematical problems [26]; [22]; [27]. This strategy encourages students to think about how they learn and understand concepts, as well as how they can improve their learning process [28]; [29].

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 [30]; [31].

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 [4]. 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 [32].

Teachers have a very important role in implementing learning strategies in the classroom [33]; [34]; [35]. Teachers' perceptions of scaffolding-metacognitive strategies can influence the way they plan, implement, and evaluate learning [32]. 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.

This study aims to examine teachers' perceptions of the implementation of scaffolding-metacognitive strategies in mathematics learning. 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.

2 Method

This research utilizes a qualitative descriptive method, with participants comprising 10 mathematics teachers from various secondary schools in Makassar and Gowa provinces. Data were collected through in-depth interviews and direct observations during the learning process. The descriptive research was conducted by gathering information based on factual data, which was then organized, processed, and categorized to analyze the data according to the research focus, aiming to provide a comprehensive picture that meets the desired criteria based on the existing issues.

Data collection was carried out using several techniques, including in-depth interviews with mathematics teachers involved in this study. The interview questions were designed to explore teachers' perceptions regarding the implementation of scaffolding-metacognitive strategies, the challenges they encountered, and the impact of these strategies on mathematics learning. Observations were also conducted to examine how teachers implemented scaffolding-metacognitive strategies in their mathematics instruction. The purpose of these observations was to obtain data that would support the interview findings and provide a more concrete understanding of the strategy's implementation.

3 Results 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) How much do you understand the scaffolding-metacognitive strategy in learning? And (b) How important do you think the Implementation of the Scaffolding-Metacognitive Strategy is in Mathematics Learning?

Teachers' abilities related to scaffolding-metacognitive strategies in learning
Based on the results of the responses given by 10 Mathematics teachers, the data obtained in the following figure:

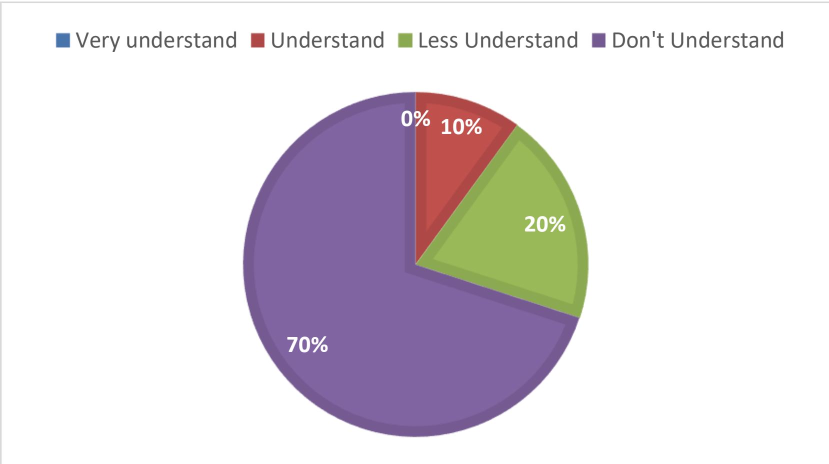

Fig. 1 Teachers' abilities related to scaffolding-metacognitive strategies in learning

Based on Figure 1, it can be seen that as many as 70% or 2 out of 10 teachers stated that they did not understand the scaffolding-metacognitive strategy. 20% or 2 out of 10 teachers stated that they less understood the scaffolding-metacognitive strategy. 10% or 1 out of 10 teachers stated that they understood the scaffolding-metacognitive strategy very well. In general, teachers stated that they did not understand the scaffolding-metacognitive strategy so that its implementation in learning was less than optimal.

The Importance of Applying Scaffolding-Metacognitive Strategies in Mathematics Learning

Based on the results of the responses given by 10 Mathematics teachers, the data obtained in the following figure:

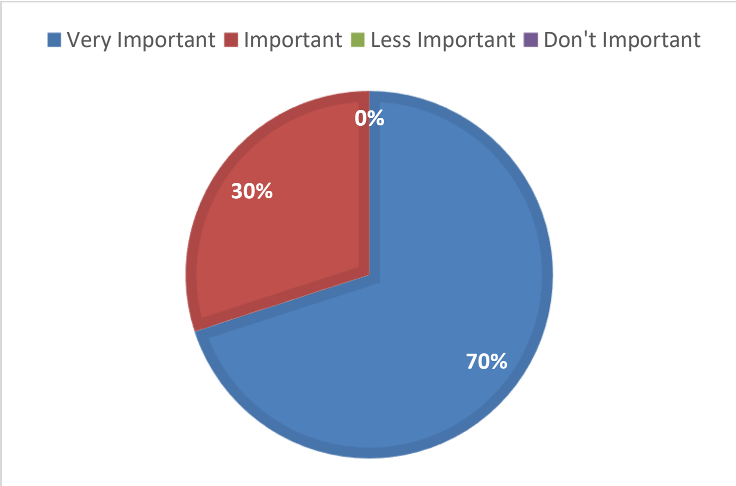

Fig. 2. The Importance of Applying Scaffolding-Metacognitive Strategies in Mathematics Learning

Based on Figure 2, it shows that 66.7% or 7 out of 10 teachers stated that the scaffolding-metacognitive strategy is important to apply in mathematics learning and 33.3% or 3 out of 10 teachers stated that the scaffolding-metacognitive strategy is important to apply in mathematics learning.

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 [36]; [37]; [19]; [38] 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 [25]; [39].

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.

One notable limitation of this study is the relatively small participant pool, which comprised only 10 mathematics teachers. While this sample size facilitated a comprehensive qualitative examination of the teachers' perceptions and experiences, it also poses challenges regarding the generalizability and broader applicability of the findings.

Descriptive research inherently seeks to provide in-depth insights into specific phenomena. However, when conducted with a limited number of respondents, it may inadvertently reduce the variability and diversity of perspectives captured. In this study, the findings may not fully encapsulate the experiences of mathematics teachers in different regions or educational contexts, as the participants were selected from a specific geographical area. Teachers from other environments, characterized by varying resource availability and cultural influences, may possess distinct perceptions and approaches to scaffolding metacognitive strategies.

Moreover, the small sample size affects the reliability of the conclusions drawn. While the qualitative data obtained from interviews and observations offered valuable insights, a larger participant pool would facilitate a more thorough analysis and enhance the triangulation of findings. For instance, a more extensive group of participants may uncover patterns or outliers that are less likely to appear within smaller samples. Consequently, the limited number of respondents in this study represents a methodological limitation that should be addressed in future research.

The limited capacity of descriptive research to demonstrate causality or produce statistically significant results frequently draws criticism. This study is largely exploratory even though it provides rich qualitative data that expands our knowledge of scaffolding-metacognitive strategies. A larger sample size in future research could improve the validity of the findings and allow for more thorough quantitative analysis to support the qualitative findings.

Additionally, the participant selection process may have introduced biases. Because of their interest in professional development or familiarity with innovative teaching methods, the teachers involved may have had a positive attitude toward scaffolding-metacognitive strategies. This potential bias could skew the study's findings, making them less representative of the general teaching population. Including participants with a diverse range of experiences and perspectives would help to mitigate such biases and provide a more balanced understanding of the strategies' efficacy.

Another limitation is the lack of subgroup analyses. A larger and more diverse sample would have allowed for a better understanding of how demographic factors like teaching experience, age, and educational background influence perceptions and implementation of scaffolding-metacognitive strategies.

Despite these limitations, the study adds significant qualitative depth to the field of mathematics education. It offers a nuanced perspective on the challenges and opportunities associated with scaffolding-metacognitive strategies by highlighting teachers' voices and lived experiences. These findings provide a foundation for future research and classroom applications. Moving forward, future studies should prioritize addressing these limitations. Using a mixed-methods approach with a larger and more diverse sample size would allow researchers to combine the richness of qualitative data with the statistical rigor of quantitative techniques. Such studies could not only validate but also expand on the current findings, revealing broader trends and implications. While the small sample size is a significant limitation, it highlights the need for additional research into scaffolding-metacognitive strategies. Future research must broaden its scope in order to fully realize these strategies' potential to improve mathematics learning and foster deeper student engagement.

4 Conclussion

The integration of scaffolding-metacognitive strategies in a flipped classroom model has demonstrated significant potential for enhancing mathematics learning. The findings from this study reveal that when students are provided with structured support and encouraged to engage in metacognitive reflection, their understanding of mathematical concepts improves substantially. The flipped classroom format facilitates active learning and collaboration, allowing students to apply their knowledge in a supportive environment, ultimately leading to better problem-solving skills and increased self-efficacy.

Moreover, the incorporation of these strategies fosters greater awareness among students regarding their learning processes, enabling them to develop effective self-regulation skills. As a result, students not only achieve higher academic performance but also cultivate a more profound motivation for learning.

These insights underline the importance of combining innovative teaching methods with cognitive support strategies to create a conducive learning atmosphere in mathematics education. Future research should focus on exploring the long-term effects of these strategies across various subjects and educational levels, as well as the potential challenges teachers may face in implementing such approaches. Overall, this study contributes to the growing body of evidence supporting the effectiveness of the flipped classroom model enhanced by scaffolding and metacognitive strategies in promoting deeper learning experience

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