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Concept Understanding Analysis Reviewed from Metacognition

Susi Sutarni[1]*, Mimih Aminah[2], Yusfita Yusuf[3]

[1,2,3]April Eleven University

E-mail: susiakun700@gmail.com

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Abstract

This research intends to explore the understanding of mathematical concepts among seventh-grade students in relation to their metacognitive skills. Employing a qualitative descriptive approach, three students were selected according to their metacognitive levels—high, moderate, and low. Data were gathered through written assessments, in-depth interviews, and observations. The analysis was conducted using indicators of mathematical concept comprehension, including the ability to restate concepts, classify objects, develop conceptual terms, and select and apply appropriate procedures. The findings reveal that students with high metacognitive abilities exhibit deep, consistent, and effective conceptual understanding, particularly in practical applications. Those with moderate metacognitive skills demonstrate a fairly good grasp of concepts but lack consistency across various indicators. Conversely, students with low metacognitive abilities struggle significantly in understanding and implementing mathematical concepts. These results underscore the pivotal role of metacognition-based instructional strategies in enhancing students' conceptual understanding in mathematics.

Keywords: concept understanding, metacognition, mathematics learning

1. Introduction

Education is a very important thing for the progress of a nation. Through education, a person can develop their potential, Gain the knowledge and abilities necessary to live autonomously, and contribute to community development. As stated in Article 1, Number 1 of Law Number 20 of 2003 (Permendikbud, 2016) regarding the National Education System, which mentions that, "Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and the skills they need, society, nation, and state".

One of the subjects that is very important and always related to daily life is mathematics. According to (Zagoto, 2018) said that Mathematics is one of the basic sciences that has a very high influence on life, because mathematics can develop and prepare students' abilities in logical thinking, and is appropriate to solve a problem that occurs in their own lives. According to (Ruseffendi, 1991), Mathematics is a deductive science that rejects inductive proof, a language of symbols, and the study of ordered structures and regular patterns. In line with that, James

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and James (Rahmah, 2018) Algebra, analysis, and geometry are the three main areas of mathematics, which is defined as the science of logic with reference to shapes, arrangements, quantities, and concepts that are related to one another. The objectives of mathematics learning as stated in Permendikbud Number 22 of 2016 (Permendikbud, 2016) include: 1) understanding concepts, explaining and applying concepts accurately, precisely and efficiently. 2) Reasoning, formulating and formulating patterns of mathematical properties in composing arguments and statements, 3) solving mathematical problems, 4) communicating arguments and ideas into other languages. In the 2013 curriculum, it is stated that the purpose of mathematics learning is that students are able to understand concepts and apply mathematical procedures in daily life. Even in the independent curriculum, students can solve students' contextual problems by using the mathematical concepts and skills learned in this phase. The objectives of mathematics learning (Aminah, 2014) include: (1) Grasp of mathematical concepts, (2) the use of reasoning, (3) problem solving, (4) mathematical communication, and (5) an attitude of appreciating the usefulness of mathematics. Among these goals, understanding mathematical concepts is the main foundation that determines the success of achieving other goals.

Understanding concepts is an important aspect of the learning process, especially in mathematics subjects that require logical and analytical thinking skills. Grasping mathematical concepts is the crucial factor for success in studying mathematics. According to (Putri et al., 2020) understanding concepts is the foundation for comprehending theories and principles, hence in order for students to comprehend theories and principles, they must first comprehend the concepts that comprise them. Understanding concepts plays a crucial role (Puspitasari et al., 2019) in helping students throughout their lives between one concept and another, as well as in applying these concepts to various daily situations or problems. Without a good understanding, students only tend to memorize procedures without understanding the essence of the concepts learned. In the context of mathematics education, Comprehending concepts not only helps students solve mathematical problems more easily, but also equips them with critical and adaptive thinking skills (Saputri et al., 2019).

Humans can experience changes in both thinking ability, attitude, and behavior through education. One of the important aspects of education An essential aspect of education is students' ability to grasp the concepts being taught, especially in the field of mathematics. A strong understanding of concepts not only allows students to solve math problems, but also equips them with critical, logical, and analytical thinking skills that are useful in everyday life.

However, based on the results of interviews with some students, they considered that mathematics lessons were difficult and after being given basic problems, it turned out that students still had difficulty working on the problems because of the basics that they had not mastered. This can be seen from the results of the repetition on the integer operation material, there are still many students who are confused in number signs, especially negative signs, in addition to that they are still confused in the order of operation priority so that they often miscalculate, and have difficulty translating story problems into integer operations, such as problems about temperature rising or falling, or debts and receivables. According to Fitriani and Yuliani (Fitriani & Yuliani, 2016), The reason behind students' inability to comprehend mathematical concepts is that they do not reflect on what they have learned, which makes the concepts short-lived. Additionally, students are reluctant to comprehend practice problems at

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first because they believe they are challenging. such that there are numerous errors when attempting to solve mathematical issues. The low understanding of this concept is caused by various factors, including: (1) learning that is still procedural, (2) lack of connection between mathematical concepts and real life, (3) lack of awareness of students' own thought processes, and (4) less effective learning strategies (Buyung et al., 2022).

The understanding of mathematical concepts according to John Flavell (Atmaja, 2021) is influenced by several factors including: (1) initial mathematical ability, (2) learning motivation, (3) learning style, (4) learning environment, and no less important is (5) metacognition ability. Metacognition has received great attention in various types of mathematics education research, and is believed to be one of the important parts of the learning process due to its significant role in the mathematics learning process. According to Medula (Suryaningtyas & Setyaningrum, 2020), metacognition is a person's thinking process about how he or she will build a strategy that will be used to solve a problem. The concept of assessing one's knowledge and ideas is the foundation of metacognition, which also has to do with the practice of keeping an eye on and managing one's own mental processes. Knowledge of cognitive tasks and self-awareness are both components of metacognition (Aminah, 2014). Metacognitive strategies are among the factors that can influence students' success or failure in solving mathematical problems. Metacognitive is a word related to what is known about him as a learning individual and how he controls and adjusts his behavior (Purba et al., 2021).

According to (Mazzolini, B., & Morley, 2006) Indicators of metacognition include reading critically, constructing meaning, extending beyond text, and tracking comprehension. The extension beyond text indicator refers to the ability of students to provide responses that prove understanding beyond the text, for example by underlining, coloring, or summarizing the text. The read critically indicator reflects students' ability to respond critically to the content of the text, such as expressing opinions, making decisions, or analyzing texts. Finally, the monitor comprehension indicator describes the ability of students to use certain tactics to aid comprehension, such as visualizing, clarifying, and re-examining reading to deepen understanding.

Education plays a central role in a nation's progress, as it enables individuals to fully develop their potential And gain the knowledge and skills required to make a contribution to society. According to Law Number 20 of 2003 on the National Education System, education is a conscious and planned effort to create a learning environment that allows students to develop their abilities to form intelligent, independent, and character-driven individuals.

Mathematics is one of the most essential disciplines in daily life. It serves not only as a tool for solving quantitative problems but also as a means to train logical and analytical thinking skills. According to (Ruseffendi, 1991), mathematics is a deductive science that rejects inductive proof and functions as a symbolic language used to understand patterns and structures. Similarly, James and James in Rahmah (Rahmah, 2018) explain that mathematics encompasses various fields such as algebra, analysis, and geometry, aiming to develop an understanding of logical concepts, structures, and quantitative relationships.

In the context of education, understanding mathematical concepts is a fundamental aspect that determines the success of learning. Conceptual understanding not only facilitates problem-solving but also equips students with critical and adaptive thinking skills (Saputri et al., 2019).

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Previous studies have shown that mathematical concept comprehension correlates with various factors, including teaching strategies, educational background, and students' metacognitive abilities (Suryaningtyas & Setyaningrum, 2020); (Kusuma & Baskara, 2022). However, research specifically investigating the relationship between metacognition and mathematical concept comprehension with a comprehensive approach remains limited. Therefore, This study aims to address this gap by examining how different levels of metacognitive ability affect students' understanding of mathematical concepts.

The research I conducted focused on the analysis the understanding of mathematical concepts based on the level of metacognition. This study aims to examine how metacognitive ability influences students' understanding of mathematical concepts. By understanding this relationship, it is hoped that more effective learning strategies can be designed to improve the quality of students' understanding of concepts at various ability levels. Unlike previous studies that tend to focus on specific learning strategies, this study analyzes concept understanding based on specific indicators, such as the ability to restate concepts, classify objects, and develop the conditions of a concept. In addition, this study also pays special attention to the variation of students' abilities (high, medium, low) in utilizing metacognition during mathematics learning.

2. Methods

This research will use a descriptive qualitative method, namely to analyze and describe students' ability to understand concepts reviewed from their metacognition skills. This method was chosen because it can delve deeply into how students think in understanding mathematical concepts, including how they plan, integrate, and implement problem-solving strategies by focusing on the relationship between the level of metacognition of students who are categorized as high, medium, and low and their ability to meet the concept comprehension indicators. Data was obtained through tests, in-depth interviews, and observations, then analyzed to find patterns and differences among groups of students. With this approach, the research aims to provide a deep and detailed understanding of the influence of metacognition on the process of understanding students' mathematical concepts. The subject of this study is junior high school students in grade VII in junior high schools in the Sumedang Regency area. The sample will be selected as many as 3 people, namely those who have high, medium, and low metacognition abilities. The subjects were taken using the purposive sampling method, where the subjects were selected based on the criteria put forward by (Mazzolini, B., & Morley, 2006) which can be seen in Table 1.

Table 1. Measurement of metacognition

Indicators	Value range	Category
Construct meaning	0 - 2	Low
	3 - 4	Medium
	5 – 6	High

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Extention beyond text	0 - 3	Low
	4 - 6	Medium
	7 – 9	High
Reads critically	0 - 3	Low
	4 - 6	Medium
	7 – 9	High
Monitors understanding	0 - 3	Low
	4 - 6	Medium
	7 – 9	High
Total score	0 - 11	Low
	12 – 21	Medium
	21+	High

The scoring criteria for assessing students' understanding of mathematical concepts and the grouping standards applied in this study were based on the guidelines set by (Mawaddah & Maryanti, 2016). Table 2 shows the criteria for evaluating pupils' comprehension of mathematical ideas. Meanwhile, Table 3 displays the grouping criteria.

Table 2. Guidelines for Scoring Students' Ability to Understand Mathematical Concepts

Concept Comprehension Indicators	Information	Score
Restating a concept	Blank answer	0
	Cannot restate the concept	1
	Can restate concepts but still many errors	2
	Can restate a concept but is not yet precise	3
	Can restate concepts appropriately	4
Providing examples and not examples of a concept	Blank answer	0
	Can't give examples and not examples	1
	Can provide examples and not examples but there are still many errors	2
	Can provide examples and not examples but not yet precise	3
	Can provide examples and non-examples appropriately	4
Classifying objects according to certain properties according to their concept	Blank answer	0
	Unable to classify objects according to their concept	1
	Get mention traits according to the concept but there are still many mistakes	2

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	Get mention properties according to the concept but not yet appropriate	3
	Get Mention the properties according to the concept exactly	4
Presenting concepts in the form of Mathematical representation	Blank answer	0
	Can present a concept in the form of a mathematical representation (picture) but is not precise and does not use a ruler	1
	Can present a concept in the form of a mathematical representation (picture) but is not yet precise	2
	Can present a concept in the form of a mathematical representation (picture) but does not use a ruler	3
	Able to present a concept in the form of mathematical representations (figures) accurately	4
Developing the necessary conditions / sufficient conditions of a concept	Blank answer	0
	Unable to use or select the procedure or operation used	1
	Can use or select the procedure or operation used but there are still many errors	2
	Can use or choose the procedure or surgery used but still not appropriate	3
	Can use or select the procedure or operation used appropriately	4
Use, utilize, and select specific procedures or operations	Blank answer	0
	Unable to use, utilize, and select procedures or surgeries	1
	Can use, utilize, and select procedures or operations but still many errors	2
	Can use, utilize, and choose procedures or surgeries but not yet appropriate	3
	Be able to use, utilize, and select procedures or surgeries appropriately	4
Applying concepts or algorithms in problem-solving	Blank answer	0
	Unable to apply formulas according to procedures in solving solving problems Problem	1
	Can apply formulas according to procedures in solving problem-solving problems but there are still many mistakes	2
	Can apply formulas according to procedures in solving problem solving problems but not right	3

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	Be able to apply formulas according to procedures in solving problem-solving problems correctly	4

Table 3. Interpretation of Grouping Ability to Understand Concepts

No.	Value	Criterion
1.	85,00 – 100	Excellent
2.	70,00 – 84,99	Good
3.	55,00 – 69,99	Enough
4.	40,00 – 54,99	Low
5.	0,00 – 39,99	Very Low

3. Result and Discussion

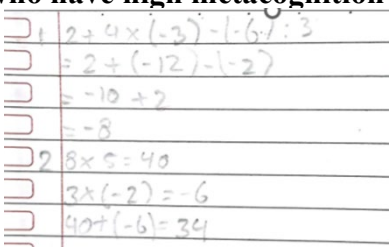
According to the metacognition questionnaire administered to the students, three students with the initials S1 were selected as those demonstrating high metacognitive ability, S2 for students who had moderate metacognition ability, and S3 for students who had low metacognition ability. The results of metacognition can be seen in table 4.

Table 4. Metacognition Value

Student Initials	Categories Metacognition Ability	Metacognition Value
S1	Tall	42
S2	Keep	20
S3	Low	10

From the results of 2 problems of integer counting operation material given to 3 students studied. Then it was analyzed to see the ability to understand the concept carried out by 3 students who had different metacognition skills. Retrieved:

S1 answer image of students who have high metacognition



Based on the results presented in figure 1, it can be seen that S1 students who have high metacognition skills have shown to be able to understand mathematical concepts well. This is reflected in his ability to fulfill systematic and correct steps in answering the given math problems. The S1 answer shows an in-depth understanding of the concept and effective application in solving mathematical problem. It can be seen from the ability of S1 students to restate concepts appropriately, classify objects based on relevant properties, develop the

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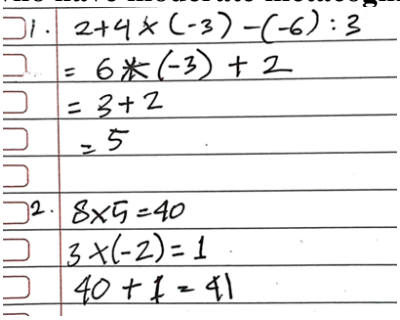
conditions of a concept, and choose and use the right procedures in solving problems. The findings of this study align with the research conducted by (Suryaningtyas & Setyaningrum, 2020); (Shodikin et al., 2022) that students who have high metacognitive abilities are able to write clearly and correctly the problem-solving process. This indicates that metacognitive abilities can help students solve problems (Shodikin et al., 2022). The analysis of three students with different levels of metacognition reveals a significant correlation between metacognitive ability and mathematical concept comprehension. Students with high metacognitive abilities (S1) can understand concepts deeply and apply them consistently in solving mathematical problems. This is evident from their ability to construct systematic and accurate problem-solving steps.

On the other hand, students with moderate metacognitive abilities (S2) demonstrate a fair understanding of concepts, although they are not entirely consistent in meeting all comprehension indicators. They can restate concepts and develop conceptual terms but still make errors in selecting and applying appropriate procedures. This aligns with the findings of (Taufik & Yoga Vandita, 2023), which state that students with moderate metacognitive abilities only master certain indicators of conceptual comprehension.

S2 answer image of students who have moderate metacognition



Based on the results presented in figure 2, it can be seen that S2 students who have moderate metacognition skills have shown to be able to understand mathematical concepts quite well, although not always consistently. S2 students are able to restate concepts and develop the terms of a concept well, but there are still some mistakes in choosing and using the right procedures. The results of this study are in line with the results of research by (Taufik & Yoga Vandita, 2023) which stated that students with moderate metacognitive abilities only mastered a few indicators of concept comprehension ability. Meanwhile, students with low metacognitive abilities (S3) face significant difficulties in understanding and applying mathematical concepts. These difficulties are reflected in their inability to restate concepts, classify objects based on relevant properties, and select appropriate procedures for solving mathematical problems. Thus, a metacognition-based approach can serve as an effective strategy to help students reflect on their thinking processes, allowing for gradual improvement in conceptual understanding.

S3 answer image of students who have low metacognition

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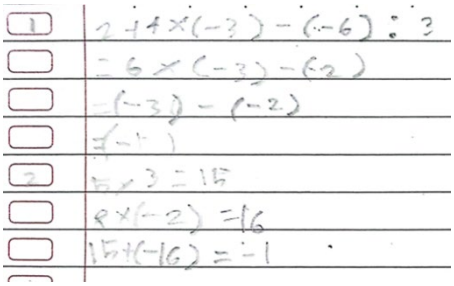

Based on the results presented in figure 3, it can be seen that S3 students with low metacognition skills experience significant difficulties in understanding and applying mathematical concepts. The S3 answer shows that it is not able to restate a concept, classify objects, develop the conditions of a concept, and choose and use the right procedures. So that when compared to S1 and S2 students, students with low metacognition (S3) have lower concept comprehension skills. A metacognition-based approach can be one of the effective strategies to help students reflect on their thinking process, so that their understanding of concepts can be gradually improved.

Overall, these findings emphasize the importance of developing metacognition skills in mathematics learning as one of the effective ways to improve understanding of concepts. The implementation of a learning approach that focuses on metacognition can provide long-term benefits in improving students' critical and analytical thinking skills, which are not only relevant in the context of education but also in facing the challenges of daily life. This is consistent with the study carried out by (Suryaningtyas & Setyaningrum, 2020) (Taufik & Yoga Vandita, 2023) that metacognition ability affects students' mathematical ability. However, understanding basic mathematical concepts such as numbers, arithmetic operations, basic geometry and algebra also needs to be considered before developing The capability to comprehend mathematical concepts.

4. Conclusion

This study found a significant relationship between students' level of metacognitive ability and their comprehension of mathematical concepts. Students with high metacognition demonstrated a deeper conceptual understanding and were able to integrate theoretical knowledge with practical applications in problem-solving. In contrast, students with moderate metacognition showed fairly good comprehension but were inconsistent in fulfilling all concept comprehension indicators. Meanwhile, students with low metacognition faced substantial obstacles in understanding and applying mathematical concepts.

Theoretically, this study reinforces the idea that metacognition is a key factor in integrating conceptual understanding with problem-solving skills. This study also provides practical contributions by emphasizing the importance of initial assessments of students' metacognitive levels before instruction begins. By understanding students' metacognitive abilities, educators can design more suitable teaching strategies to optimize their mathematical concept comprehension.

The novelty of this study lies in its more specific analysis of concept comprehension indicators in relation to variations in students' metacognitive levels. Unlike previous approaches that focused more on the relationship between metacognition and specific learning strategies, this

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study emphasizes how metacognition directly affects various aspects of mathematical concept comprehension. Therefore, this research provides valuable insights for educators, researchers, and practitioners in designing instructional methods that are more metacognitively reflective and adaptive to students' needs.

The metacognitive abilities possessed by students influence the ability to understand concepts. Teachers should know students' metacognitive abilities before conducting learning. So that the learning method used will be appropriate in developing the ability to understand concepts. Apart from that, it is also necessary to carry out an initial test regarding mastery of basic mathematical concepts such as numbers, arithmetic operations, basic geometry and algebra. Where these concepts are very important to master in learning mathematics.

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