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The Students' Mathematical Concept Understanding in Introductory Mathematics Course

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Abstract. The Introductory Mathematics Course is a crucial foundation for students to advance into more complex courses. However, many students still a crucial foundation for students to advance into more complex courses in this course. This study aims to analyze the level of mathematical concept understanding among students in Introductory Mathematics Course. This study utilized a descriptive qualitative approach and involved three mathematics education students from an Islamic Higher Education in Jambi, Indonesia. Each student was classified as having high, medium, and low ability based on their mathematical concept understanding test results. Furthermore, the students were interviewed to validate their test responses. The data was analyzed descriptively using the method-triangulation. The results of the study revealed that the students' mathematical concept understanding in the Introductory Mathematics Course is, on average, in the medium category. Additionally, more effective learning methods are required to hone their ability to understand mathematical concepts.

Keywords: Introductory Mathematics Course; Mathematical Concept Understanding; Pre-Service Teacher Students

Abstrak. Mata Kuliah Pengantar Dasar Matematika merupakan dasar yang sangat penting bagi mahasiswa untuk bisa melanjutkan ke mata kuliah yang lebih kompleks. Namun, masih banyak mahasiswa yang kesulitan untuk memahami sepenuhnya konsep-konsep yang disajikan dalam mata kuliah ini. Penelitian ini bertujuan untuk menganalisis tingkat pemahaman konsep matematis mahasiswa pada mata kuliah Pengantar Dasar Matematika. Penelitian ini merupakan penelitian kualitatif deskriptif dan melibatkan tiga mahasiswa pendidikan matematika dari salah satu Perguruan Tinggi Islam di Jambi, Indonesia. Setiap mahasiswa diklasifikasikan memiliki kemampuan tinggi, sedang, dan rendah berdasarkan hasil tes pemahaman konsep matematis mereka. Selain itu, para mahasiswa diwawancarai untuk menvalidasi jawaban tes mereka. Data dianalisis secara deskriptif dengan menggunakan triangulasi metode. Hasil penelitian menunjukkan bahwa pemahaman konsep matematis mahasiswa pada mata kuliah Pengantar Dasar Matematika berada pada kategori sedang secara rata-rata. Mahasiswa dengan kemampuan tinggi dapat menjawab semua pertanyaan dengan benar, sedangkan mahasiswa dengan kemampuan sedang dan rendah masih mengalami kesulitan dalam beberapa soal. Untuk meningkatkan pemahaman mereka, mahasiswa dengan kemampuan sedang dan rendah perlu lebih banyak berlatih dan dibiasakan menyelesaikan soal pemahaman konsep. Selain itu, metode pembelajaran yang lebih efektif dibutuhkan untuk mempertajam kemampuan mereka dalam memahami konsep matematika.

Kata kunci: Mahasiswa Calon Guru; Pemahaman Konsep Matematis; Pengantar Dasar Matematika

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INTRODUCTION

Mathematics is a subject that provides a variety of benefits to students, including the development of reasoning, character, and thinking patterns. According to Dewi and Yulia (2018), studying mathematics can help students develop an objective, honest, systematic, critical, and creative attitude, which is vital for making conclusions in science. Additionally, mathematics teaches students to use logic when checking and justifying the information they receive, as highlighted by Nasution et al. (2021). Furthermore, Yulia and Ningsih (2018) note that studying mathematics encourages students to solve mathematical problems honestly and systematically, which can help them develop essential soft skills that are useful in various areas of life.

Aside from the soft skills that can be gained from studying mathematics, the subject also offers practical advantages in students' daily lives. Mathematical concepts, algorithms, and modeling can be used to solve problems in different fields, including economics, social sciences, and natural sciences (Yulia, 2016). Additionally, mathematics is a crucial field for preparing students for the modern era, which is based on information and communication technology. Thus, Ratnasari and Yulia (2018) assert that mathematics education is a vital aspect of advancing human civilization.

However, studying mathematics at the tertiary level can be more challenging for students. The initial courses contain a range of mathematical concepts that must be mastered before students can move on to more complex subjects. For example, the Introductory Mathematics Course provides undergraduate-level lectures on basic courses, such as set theory and logic, which are essential for studying other courses (Agustina et al., 2021). Since this course forms the foundation for learning other subjects, it is crucial for students to master the basic concepts to succeed in their future studies.

The Introductory Mathematics Course is a fundamental course that requires various mathematical abilities from students. In this course, students need to understand mathematical concepts, which is essential to avoid difficulties in learning mathematics (Yulia et al., 2020). Conceptual understanding is vital in mastering learning material, where students need to not only know and memorize the concepts but also be able to re-express them in a simpler form that is easier to understand and apply (Sari et al., 2018). To achieve a proper understanding of mathematical concepts, students must be able to formulate solving strategies, use symbols to represent concepts, perform simple calculations, and transform one form to another.

Having a good understanding of mathematical concepts can help students perform both algorithmic and non-routine calculations, which require the link between different concepts or principles (M. L. Nasution & Hafizah, 2020). However, many students still need to improve their

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conceptual understanding, especially those who have been taught conventionally and struggle with non-routine calculations (Syahbana, 2013).

Students who do not understand how formulas are formed may encounter difficulties in developing primary mastery of further learning and comprehending the concepts (Indrawati & Hartati, 2017). These students tend to rely on common calculations/computational understanding to solve mathematical problems, and they may need assistance when faced with questions that require functional understanding.

Therefore, it is crucial to prioritize students' ability to understand mathematical concepts in the Introductory Mathematics Course. Neglecting the students' conceptual understanding may lead to more complex misconceptions (Irawan, 2012). This study aims to analyze the students' understanding of mathematical concepts in the Introductory Mathematics Course, as it is an essential foundation for students to learn other mathematical subjects.

METHOD

This study utilizes a qualitative research design to investigate a problem that has not been thoroughly explored (Anggito & Setiawan, 2018). Specifically, it employs a descriptive qualitative approach to examine the mathematical concept understanding of 17 undergraduate students enrolled in the Mathematics Education program at an Islamic Higher Education institution in Jambi, Indonesia during the odd semester of 2021. The participants were selected using purposive sampling and were categorized into high, medium, and low levels of mathematical concept understanding.

To gather data, the researchers used a mathematical concept understanding test and an unstructured interview guide. The test consisted of five essay questions with three different indicators. In the first indicator, students were asked to present mathematical concepts in various forms of representation. This included listing the elements of a given set, determining the number of subset elements, and using the formula to determine the number of subsets. The second indicator required students to use and select specific procedures or operations. For instance, they were asked to list the elements of four sets presented in set-forming notation and find the intersection, combination, and complement of the set. In the third indicator, students were asked to apply concepts or algorithms in problem-solving. This involved using Venn diagrams to solve 3 set problems. The validity and reliability of the instrument were established through a try-out involving 15 students. Meanwhile, the interview questions were tailored to the indicators of mathematical concept understanding.

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Data analysis in this study was conducted both during and after data collection (Anggito & Setiawan, 2018). The student responses to the mathematical concept understanding test were evaluated based on a scoring rubric outlined in Table 1.

Table 1. Scoring Rubric Outline of Mathematical Concept Understanding

No	Concept Understanding Indicator	Type of Student Answer	Score
1.	Presenting concepts in various forms of mathematical representation	No answer	0
		Student can express concepts in various forms of mathematical representation correctly but incompletely	1
		Student can express concepts in various forms of mathematical representation correctly and completely	2
2.	Using and selecting specific procedures or operations	No answer	0
		Student can use, utilize and choose specific procedures or operations correctly but not accurately	1
		Student can use, utilize and choose specific procedures or operations correctly and accurately	2
3.	Applying concepts or algorithms in problem-solving	No answer	0
		Student can apply concepts or algorithms in problem-solving but are less accurate	1
		Student can apply concepts or algorithms in problem-solving to arrive at accurate solutions	2

The data on the scores of the students' mathematical understanding were converted into a percentage of the ideal score. The criteria for assessing the students' ability to understand mathematical concepts were adopted from Nursaadah and Amelia (2018) and can be seen in Table 2.

Table 2. The Criteria of Student Mathematical Concept Understanding

Score Range	Criteria
>70	High
55 ≥ 70	Medium
≤ 55	Low

In addition to the test, the researcher also conducted unstructured interviews with three selected subjects who represented the high, medium, and low levels of mathematical concept understanding. The interviews were analyzed to gain further insight into the students' understanding of mathematical concepts. To answer the research question comprehensively, the researcher employed method-triangulation to analyze the data collected from both the test and the interviews.

RESULTS AND DISCUSSION

According to Table 3, there was no prevalent level of mathematical concept understanding among the 17 students, but on average, their understanding fell in the medium category. The range of

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mathematical concept understanding among the students was quite extensive, indicating a high degree of variability in the data.

Table 3. The Distribution of Students' Mathematical Concept Understanding

Parameters	Number of Students	Percentage
High	4 students	23%
Moderate	6 students	35%
Low	7 students	42%
Max Score	100	
Min Score	25	
Mean Score	62 (scale 0-100)	

High Ability Students

The researcher selected a student with the highest score, S1, to conduct an in-depth analysis of their test answers. On the indicator of presenting concepts in various forms of mathematical representation, S1 was able to accurately list the elements of a given set, determine the number of subset elements, and apply the formula to determine the number of subsets. S1 correctly answered all questions related to this indicator.

For the indicator of using, utilizing, and choosing specific procedures or operations, students were asked to list the elements of four sets presented in set-forming notation and find the intersection, combination, and complement of the set. S1 was able to answer all questions related to this indicator accurately. In addition, in the indicator of applying concepts or algorithms in problem-solving, the questions were related to applying Venn diagrams to solve problems involving three sets. S1 was able to correctly answer questions related to this indicator as well.

Medium Ability Student

One student from the medium category, S2, was selected for an in-depth analysis of his test answers. On the indicator of presenting concepts in various forms of mathematical representation, S2 made a mistake while listing the elements of set A. S2 mistakenly thought of the set of odd numbers instead of prime numbers and included 9 as a member of set A. Consequently, S2 was incorrect in determining the number of elements in set A. Moreover, S2 also had difficulty applying the formula to determine the number of subsets. During the interview, S2 stated that they initially knew what prime numbers were but made an error while listing the set's elements. S2's response to the first question is shown in Figure 1.

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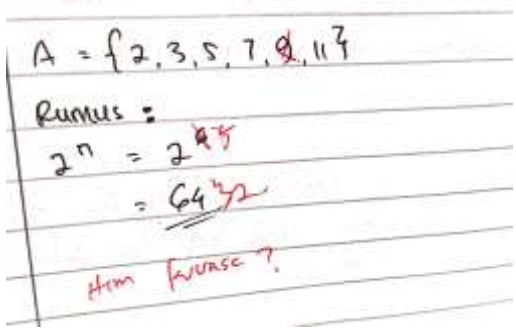

Figure 1. S2 Includes 9 as Prime Numbers

In the "using, utilizing, and selecting specific procedures or operations" indicator, students were asked to work with four sets presented in set-forming notation. They were required to list the elements of each set, and then determine the intersection, combination, and complement of the sets. However, during the interview, it was found that S2 had made errors in listing the elements of sets A and B. As a result, when performing operations on sets, such as determining the intersection, combination, and complement, errors also occurred. Figure 2 shows S2's work, indicating the errors made.

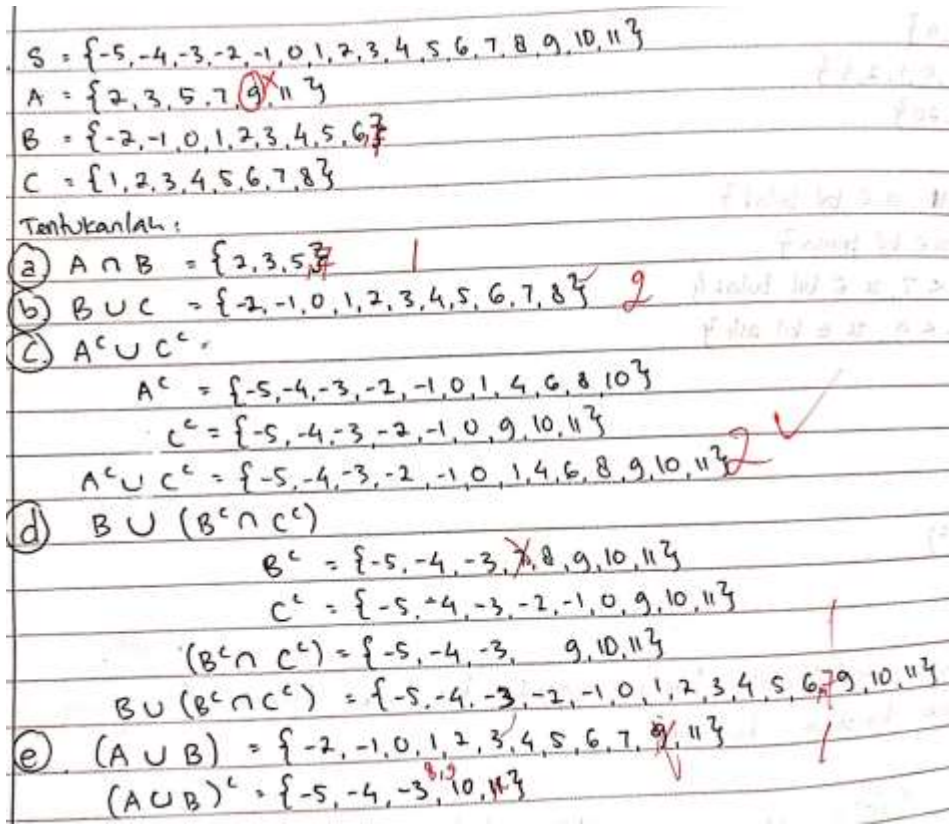

Figure 2. S2 had Made Errors in Listing the Elements of Sets A and B

In the indicator of applying concepts or algorithms in problem-solving, students were required to apply Venn diagrams to solve three-set problems. However, S2 made an error while adding up the number of whole elements, resulting in an incorrect final result. Through interviews,

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it was revealed that S2 mistakenly used subtraction when counting the number of students, leading to an incorrect answer. Figure 3 illustrates S2's work, indicating the mistake made.

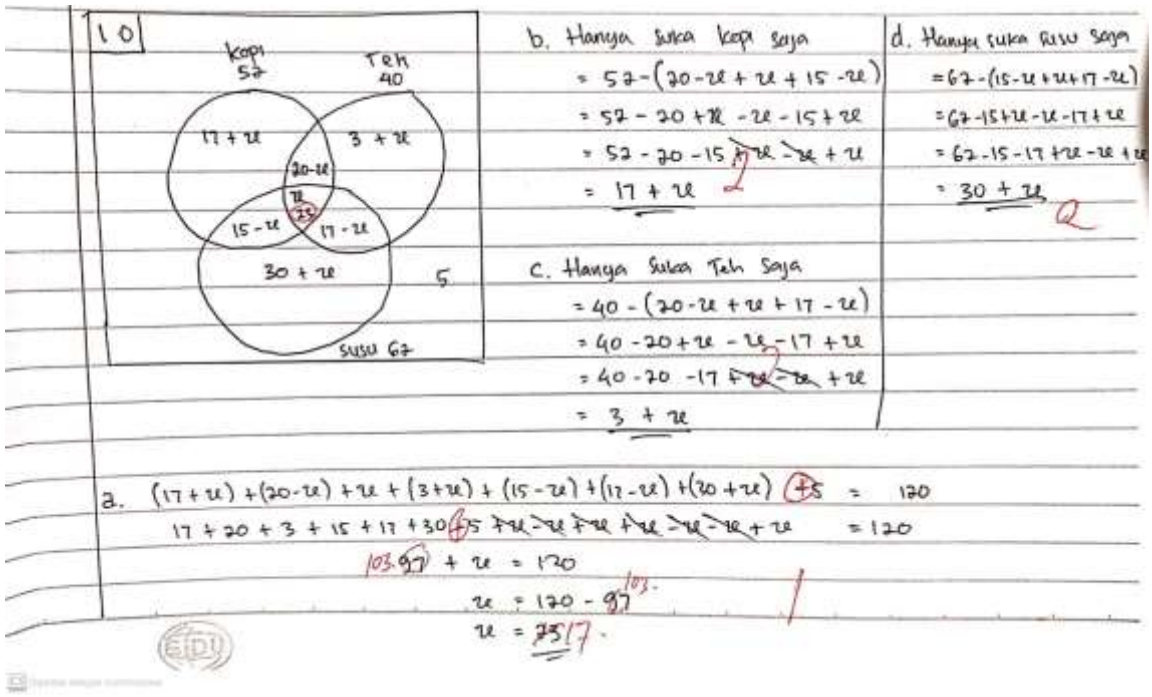

Figure 3. S2 Mistakenly Used Subtraction

Low Ability Students

Of the seven students with low understanding of mathematical concepts, the researcher selected one student, S3, for an in-depth analysis of their answers. The first indicator focuses on presenting mathematical concepts in various forms of representation. S3 made a mistake in listing the elements of a set by including 1 as a prime number, which resulted in an incorrect number of elements for the set. According to the interview results, S3 believed that 1 was a prime number, which was the reason for the error. Additionally, S3 could not recall the formula for determining the number of subsets in a set, and could only list the elements of a subset whose elements were 2. Figure 4 shows S3's mistakes.

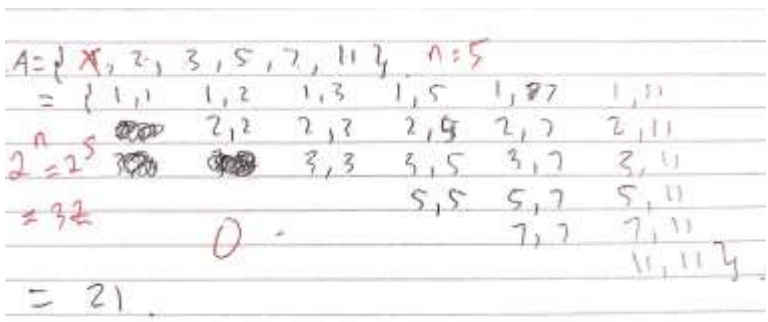

Figure 4. S3 Includes 1 as a Prime Number

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The second indicator focuses on using, utilizing, and selecting specific procedures or operations. S3 also made an error in listing the elements of set A, similar to the previous set of prime numbers. As a result, errors were also made when performing operations on sets of intersection, combinations, and complements. S3's response is shown in Figure 5.

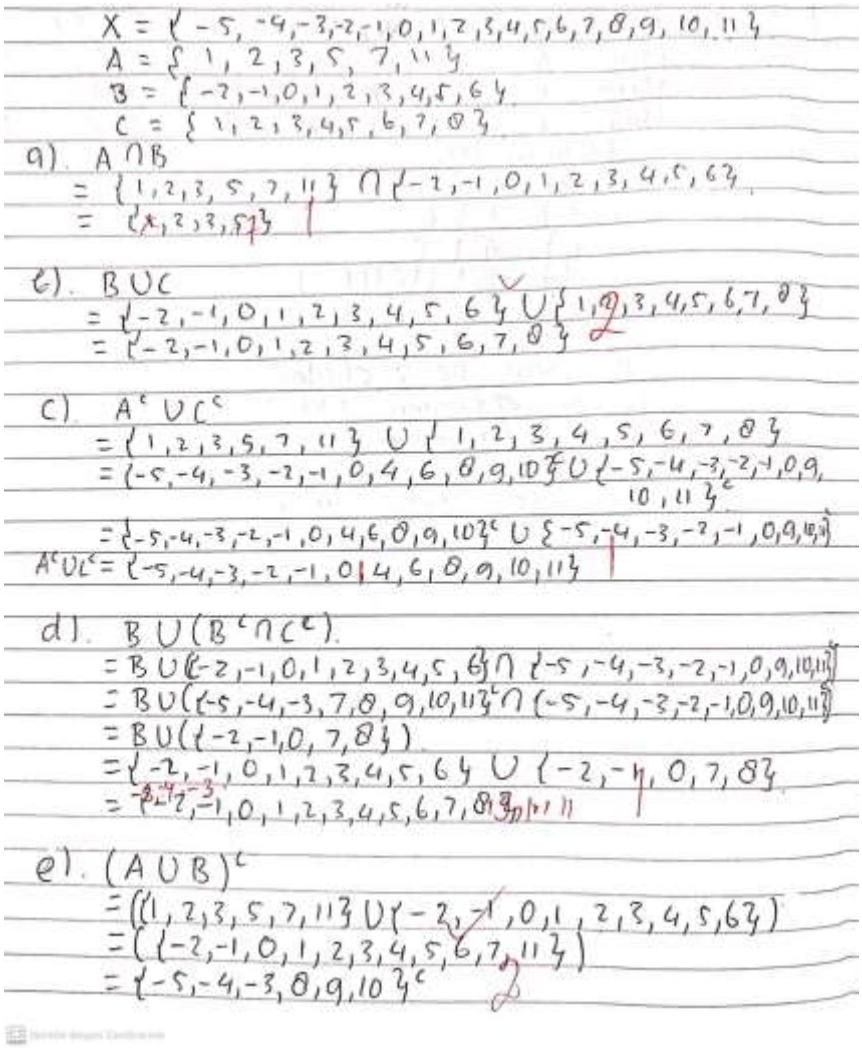

Figure 5. S3 Made an Error in Listing the Elements of Set A

In the last indicator, the focus is on applying concepts and algorithms in problem-solving. However, S3 was unable to provide an answer to the question relating to this indicator because he did not understand how to use Venn diagrams to solve problems. The student's response is included in Figure 6.

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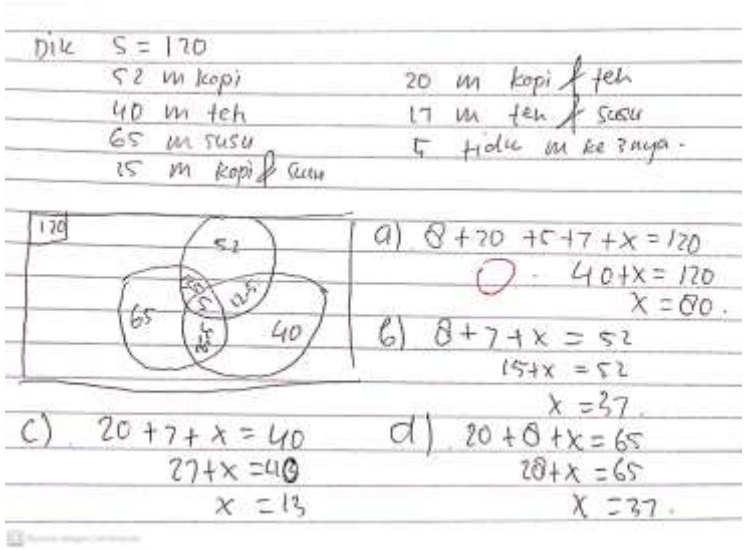

Figure 6. S3 Unable to Provide Right Answer

Based on the findings of the research, the students' abilities to understand mathematical concepts were classified as medium, and low ability was linked to psychological aspects, where students did not invest enough effort in solving problems and relied heavily on the teacher for support (Ramdani & Apriansyah, 2018). Similarly, other studies also found low scores on students' mathematical concept understanding, especially when dealing with algebraic forms, which is attributed to difficulties in basic algebraic knowledge, applying concepts to story problems, and substituting known equations (Kartika, 2018).

On average, students with high abilities demonstrated a better understanding of mathematical concepts and were able to answer questions correctly. Students with moderate abilities, however, still made errors in answering questions due to mistakes in operations or a lack of understanding. For low-ability students, many still required help in answering questions, as they struggled with grasping the concepts. Additionally, students had difficulty expressing and explaining concepts learned and presenting them in mathematical representations. Hence, students require assistance in understanding the concept of sets, including listing elements of a set, determining the number of elements and power set of a set, and using Venn diagrams to solve problems.

These results align with prior research that links students' mathematical concepts understanding to their ability to perform mathematical operations and solve problems (Putra, Syarifuddin, & Zulfah, 2018; Kholid, 2021). To improve their understanding, teachers should focus on developing students' comprehension of mathematical concepts from an early age, using a range of methods and representations such as visual aids (Oktari, et. al., 2018; Ariyanto, Aditya, & Dwijayanti, 2019; Yanti, et al., 2019), hands-on activities (Putra, Syarifuddin, & Zulfah, 2018), and problem-solving tasks (Putra, Ulandari, & Sepnila, 2020). Additionally, providing feedback and opportunities for students to practice and apply mathematical concepts in real-life scenarios is

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crucial (Kemp & Vidakovic; 2021). Teachers should also identify and address misconceptions and errors in students' understanding of mathematical concepts promptly.

Students with moderate and low abilities to understand mathematical concepts need to practice discussing and working on questions that relate to their abilities (Arends, Winnaar, & Mosimege, 2017). To this end, a learning model is required to train and improve their understanding of mathematical concepts in basic introductory mathematics courses.

CONCLUSION

Based on the research results, it can be concluded that the ability of students to understand mathematical concepts is moderate, and low abilities are influenced by the psychological aspects of students. The study suggests that students require additional support in understanding mathematical concepts, specifically in the area of sets. Additionally, it is recommended that teachers utilize various teaching methods, including visual aids, hands-on activities, and problem-solving tasks, to improve students' understanding of mathematical concepts.

To improve the students' mathematical concept understanding, it is essential to provide them with opportunities to practice discussing and working on questions related to their abilities to understand concepts. Teachers should identify and address any misconceptions or errors in students' understanding of mathematical concepts promptly. Moreover, they should focus on developing students' understanding of mathematical concepts from a young age and provide students with feedback and opportunities to practice and apply mathematical concepts in real-life situations. Lastly, a learning model is required to train and improve students' understanding of mathematical concepts in basic introductory mathematics courses.

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