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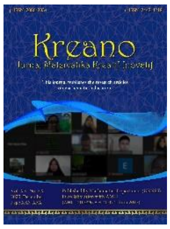

Analysis of Students' Conceptual Understanding of Logarithm Application Problems Based on Self-Efficacy

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Abstract

Understanding the concept of logarithms is an essential perspective of self-efficacy gaps, as it influences students' problem-solving confidence and willingness to learn. This research utilizes a descriptive-qualitative approach to describe the differences in understanding mathematical concepts as viewed through students' self-efficacy. The research strategy employs a case study approach, where the observed phenomenon is the understanding of mathematical concepts. The research subjects consist of third-grade middle school students selected based on self-efficacy instrument results, focusing on students with high and moderate levels of self-efficacy. Data collection involves self-efficacy questionnaires, tasks on understanding mathematical concepts, interviews, and documentation. Data analysis follows the approach described by Miles et al. (2018), including data reduction, data presentation, and data verification to conclude. Research findings indicate that students who have a high level of self-efficacy are generally more adept at restating ideas, categorizing objects in difficulties, expressing ideas mathematically, and selecting the best course of action to solve issues. Furthermore, the implication suggests that fostering students' self-efficacy is crucial for enhancing their learning experience in mathematics, particularly in topics like logarithms and their applications. By recognizing the significant influence of self-efficacy on mathematical learning, educators can tailor teaching strategies to boost students' confidence and problem-solving abilities in these areas. Additionally, monitoring students' self-efficacy growth over time enables educators to adapt instructional methods effectively, ensuring that students are adequately supported in their mathematical journey. Ultimately, prioritizing the development of students' self-efficacy contributes to creating a more conducive learning environment where students feel empowered and motivated to engage with mathematical concepts and challenges.

Keywords: Conceptual understanding, logarithms, self-efficacy

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Abstrak

Memahami konsep logaritma merupakan perspektif penting dari kesenjangan efikasi diri, karena mempengaruhi kepercayaan diri siswa dalam memecahkan masalah dan kemauan untuk belajar. Penelitian ini menggunakan pendekatan deskriptif-kualitatif untuk mendeskripsikan perbedaan pemahaman konsep matematika dilihat melalui self-eficacy siswa. Strategi penelitian menggunakan pendekatan studi kasus, dimana fenomena yang diamati adalah pemahaman konsep matematika. Subyek penelitian terdiri dari siswa kelas III SMP yang dipilih berdasarkan hasil instrumen self efikasi, dengan fokus pada siswa yang memiliki tingkat efikasi diri tinggi dan sedang. Pengumpulan data meliputi angket efikasi diri, tugas pemahaman konsep matematika, wawancara, dan dokumentasi. Analisis data mengikuti pendekatan yang dijelaskan oleh Miles et al. (2018), meliputi reduksi data, penyajian data, dan verifikasi data untuk menyimpulkan. Temuan penelitian menunjukkan bahwa siswa yang memiliki tingkat efikasi diri yang tinggi umumnya lebih mahir dalam menyatakan kembali ide, mengkategorikan objek yang mengalami kesulitan, mengungkapkan ide secara matematis, dan memilih tindakan terbaik untuk memecahkan masalah. Hal ini menunjukkan bagaimana pembelajaran tentang logaritma dan menyelesaikan masalah penerapan logaritma dipengaruhi secara signifikan oleh efikasi diri siswa. Kesimpulan penelitian ini menyiratkan bahwa efikasi diri penting untuk proses pembelajaran matematika. Oleh karena itu, melacak pertumbuhan efikasi diri siswa dan menyesuaikannya dengan pendekatan pengajaran yang dipilih sangatlah penting.

INTRODUCTION

Mathematics plays a central role in transforming human civilization; thus, mathematics should be well mastered by all learners at every level (Ebony O. McGee, 2015; Jojo et al., 2013). However, the reality found is that several cases in mathematics indicate quite serious issues such as low learning achievement (Hoogland & Tout, 2018) and lack of student interest in learning mathematics (Muyassaroh & Dewi, 2021). In this regard, mathematics is perceived as difficult for most students because the subject lacks meaning for them (Thurm & Barzel, 2020). Therefore, to eliminate such perceptions, mathematics should be introduced to students in an easily understandable manner (Lee, 2017). The level of understanding of a subject by students is also very important in learning, as it helps to avoid rote memorization among students (Ekowati et al., 2021). This indicates that a high level of student understanding signifies that students truly grasp the concepts well.

The understanding of mathematical concepts is important for students to develop during the learning process (Haciomeroglu et al., 2009; Ratnayake et al., 2020). This is because in understanding concepts, students are required to interpret, classify, explain, formulate, and calculate a subject matter in a flexible, accurate, efficient, and precise manner (Jones, 2018; Luria et al., 2017). In this context, students are not merely expected to know or remember a few concepts learned but can express them in other easily understandable forms (Verzosa, 2020). This indicates that understanding mathematical concepts involves a comprehensive grasp of both fundamental concepts and the algorithms behind mathematics operations (Scheiner, 2016).

If students build and reconstruct concepts' objects repeatedly, they will eventually grasp the material. When students construct and reconstruct objects, the APOS theory is utilized to assess their level of comprehension (Dubinsky & McDonald, 2001). The acts, procedures, objects, and schemes that pupils mentally create when building concepts are described by this theory. The constructivist theory of mathematical learning is derived from Piaget's theory of cognitive development (Arnon et al., 2014a). This theory states that a sequence of procedures known as the Action-Process-Object-Schema, which Dubinsky introduced, is thought to be responsible for the process of creating mathematical knowledge (Dubinksy, 2000). As an action follows a certain stimulus, things that have been stored in a person's memory as knowledge will be processed.

This theory varies from the assumption that an individual's mathematical knowledge is a person's propensity to respond to and comprehend mathematical problem situations by thinking in a social context, acting out actions, processes, and "objectivization," and then organizing those mental constructions in a scheme that works for the problem at hand (Dubinsky et al., 2005; Arnon et al., 2014b). An individual's mental creation of concepts like action, process, object, and scheme is an attempt to understand a mathematical concept. Based on this hypothesis, an individual attempting to understand a mathematical notion will first act on the idea mentally before coming up with a plan about a specific mathematical concept that is part of the provided problem (Arnon et al., 2014b).

Understanding concepts is also necessary in assessing the curriculum implemented in the learning process (Bieda, 2010). Wherein, fundamentally, students will gain experience using the knowledge and skills they already possess to apply them to the problems they encounter (Nolte & Pamperien, 2017). However, students’ understanding of mathematical concepts specifically remains low, as can be seen from the examination results data shown in the following Table 1.

Table 1: Data on National High School 3 Luwu students' National Examination results in 2019

No	Tested indicators	Mark (%)
1	Determine the coefficient values of the quadratic function formula	29,03
2	Solve contextual problems related to systems of linear equations in two variables	67,74
3	Determine the solution area for system problems Linear inequalities in two variables	74,19
4	Determine the constraint function of a solution area. Linear programming problems	70,97
5	Determining optimum value problems and problems with Certain constraint functions	48,39
6	Solving contextual problems related to logarithms	30,65
7	Solving contextual problems related to series Arithmetic and Geometry	51,61
8	Solve problems related to infinite geometric series	35,48
9	Determine the origin of a function	29,03
10	Determine the formula for the function f(x) if the composition is known Log(x) function	9,68
11	Determines the value of f-1(c), an integer for a function f(x)	25,81
12	Solving problems related to inverses Matrix	22,58

Based on the data, we specifically highlight that the percentage related to logarithm material is still insufficient. Therefore, it can be inferred that students' understanding of solving logarithm problems is still low. Furthermore, based on initial observations conducted by researchers by providing problems related to logarithm applications, the results show that most students can solve the problems. However, their mathematical modeling is still inaccurate. Thus, students are said to have a low understanding of mathematical concepts, especially in presenting concepts in various forms of mathematical representation (Ikram et al., 2020; Marufi et al., 2021, 2022). The low understanding of mathematical concepts is also supported by interviews with several students, where some of them express confusion when modeling problems into mathematical forms. Additionally, students perceive that for every example given, it represents a logarithm problem, meaning they only memorize the given examples without understanding the concept.

The next finding is the impact of the affective domain, which is equally important in supporting the success of mathematics learning, namely self-efficacy (Ebony O. McGee, 2015; Ndlovu et al., 2020; Yu & Singh, 2018). Self-efficacy is a person's personal belief about their ability to learn or perform actions at a certain level (Renninger et al., 2011). High self-efficacy can therefore drive learning success (Kaskens et al., 2020). Thus, students with good self-efficacy will have the initiative to learn based on their own beliefs, making them more prepared to face various situations.

From the initial observations conducted by the researcher, it is evident that students with low self-efficacy are less capable of solving logarithm application problems. This is indicated by the students' work, which only includes known information in the given problems. On the other hand, students with moderate and high self-efficacy demonstrate good performance in solving logarithm application problems. Based on the outlined description, the researcher is interested in describing the Understanding of Mathematical Concepts of Students in Solving Logarithm Problems Viewed from high and low self-efficacy. Thus, the formulation of the problem in this study is: What are the differences in understanding mathematical concepts in solving logarithm application problems based on high and low self-efficacy?

The results of this research contribute to providing knowledge and insights into students' understanding of mathematical concepts viewed from students' self-efficacy and serve as a reference for further research. Practically, the contribution of this research provides information to teachers about students' understanding of mathematical concepts based on their self-efficacy, thus serving as a consideration for teachers in designing instructional models that can develop students' understanding of mathematical concepts. Furthermore, this research can serve as a reference for assessing students' understanding of concepts in solving logarithm problems.

METHOD

Type of Research

To address the research problem, this study employs a descriptive qualitative research approach. The objective is to describe the differences in understanding mathematical concepts viewed from students' self-efficacy. Conceptual understanding of students has high self-efficacy in solving logarithm application problems and conceptual understanding of students have moderate self-efficacy in solving logarithm application problems. The research strategy utilizes a case study research strategy, where the observed phenomenon is students' understanding of mathematical concepts. The researcher acts as the primary instrument in this study, responsible for planning, designing, conducting, collecting data, drawing conclusions, and compiling the report. In this study, data are obtained in the form of records of students' work in solving written mathematical concept understanding problems and transcripts of interviews with research subjects after working on these problems.

Participants and Research Subjects

The subjects of this research are middle-level students currently in the 3rd grade who have gone through a series of materials, including logarithm topics. Furthermore, the subjects in this study are selected based on the results of filling out the self-efficacy instrument. Students with high and moderate self-efficacy are chosen as potential subjects for this study. Subsequently, students belonging to both

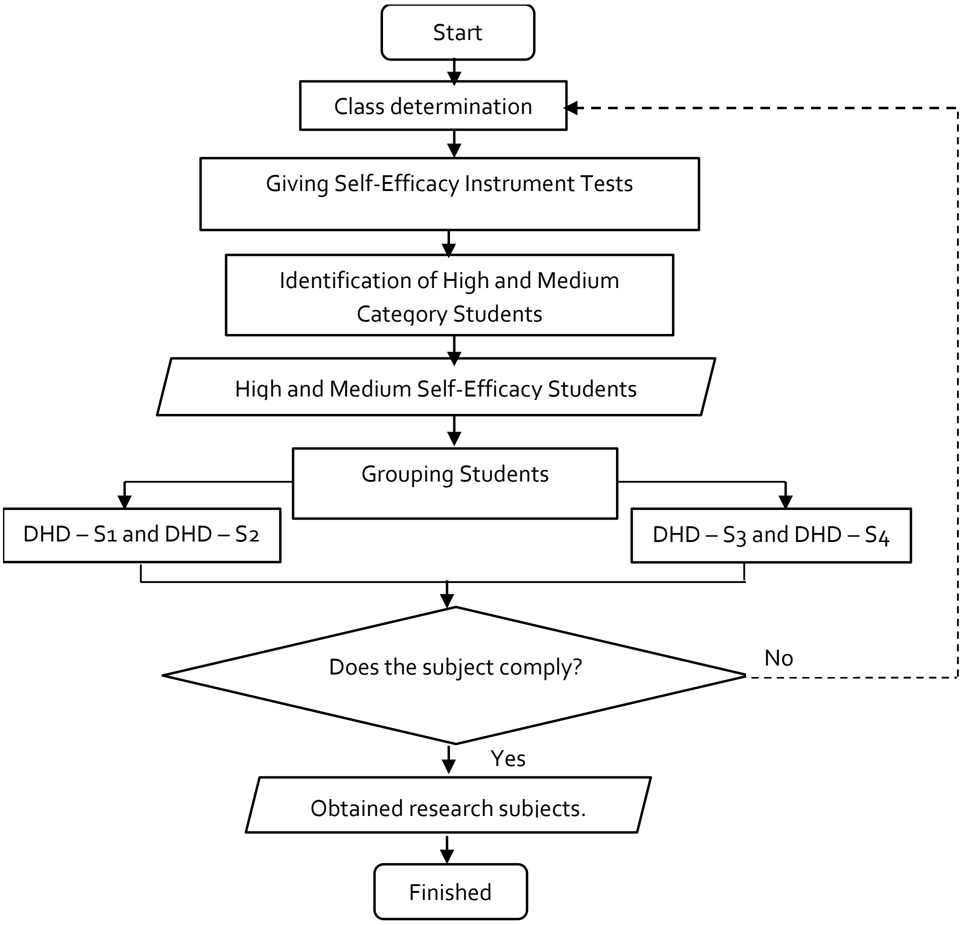

Figure 1. Flow diagram for selecting research subjects.

categories are given logarithm application problems to ensure that selected students have knowledge related to concepts found in logarithm application problems. From the research results, the researcher selects two subjects representing high self-efficacy and two subjects representing moderate self-efficacy for further interviews. To prevent actual naming, a code was assigned to each research subject: S1 (DHD-S1), S2 (DHD-S2), S3 (DHD-S3), and S4 (DHD-S4). Figure 1 shows the flow diagram for choosing research subjects.

Research Instruments and Data Collection

The data collection techniques include self-efficacy questionnaires, mathematical concept understanding tasks, interviews, and documentation, which are then analyzed. Firstly, the self-efficacy questionnaire is used to categorize students into high and moderate self-efficacy levels. Secondly, the mathematical concept understanding tasks are used to describe students' understanding of concepts while solving logarithm problems. Thirdly, interviews are conducted to clarify the consistency between the work results and the subjects' expressions during data collection. Fourthly, documentation is used to reinforce the research data. The research instruments are shown in the Table 2.

Table 2. Self-efficacy Instrument

No	Question
	Magnitude dimension
1	I always complete every mathematics task related to logarithm functions that is assigned to me.

No	Question
	Magnitude dimension
2	I always have ideas on how to tackle mathematics assignments, especially on the topic of logarithm functions.
3	I am not confident that I can follow math lessons well.
4	Tomorrow during the exam, I prefer studying rather than watching my favorite TV shows.
5	I am not confident in solving problems in front of the class.
6	I am confident that I can complete the assignment on time.
7	I feel challenged when facing difficult problems with confidence.
8	I am confident that I can complete mathematics assignments well.
9	I will always try to solve difficult mathematics assignments.
10	I am happy when there is no math class or assignment.
11	I will work even harder on the problems given by the teacher.
12	I feel pessimistic about being able to solve difficult mathematics assignments.
13	I can solve easy problems, but I cannot solve difficult ones.
14	I am not confident that I can get good grades in every mathematics assignment.
15	I feel lazy to work on difficult math problems.
16	I give up when facing difficult problems.
17	I spend most of my free time playing rather than studying.
Dimension of Strength	
18	I often submit assignments late.
19	I have good abilities in mathematics.
20	I never procrastinate in doing assigned tasks.
21	I always try to use different methods when I fail to solve math problems.
22	If all math problems are difficult, I will get a bad grade.
23	I feel hopeless when I cannot find the answer to the problem I am working on.
24	I can overcome every difficulty in mathematics well.
25	When I am unable to solve a problem, I choose to copy my friend's work.
Dimension of Generally	
26	When my grades are good, I am more motivated to study so that I can achieve even better grades.
27	If I encounter difficulties in mathematics, I can usually overcome them well.

No	Question
	Magnitude dimension
28	I become pessimistic when my math grades are poor.
29	I will not give up before trying to solve a math problem, no matter how difficult it is.
30	I enjoy reading math books to gain new information.

Table 3. Logarithm Application Problem Instrument

No	Instrumen
1	An insect expert monitors the presence of insect swarms in the affected area. The formula for the area being monitored is expressed as A(n) = 1000 x $2^{0,7m}$, where n is the number of weeks since the monitoring began. If in the past few weeks, the area affected by insects is 5,000 hectares, then the nearest time when the insects attacked is... weeks.
2	An earthquake has a strength expressed on the Richter Scale ${}^{2}\log(278 - x)$. If x is expressed in miles from the epicenter of the earthquake, then at a radius of how many miles does the area experience an earthquake of 7 RS?

The data obtained and collected in the field must be ensured for its validity and accuracy. Therefore, the validity in this research is obtained through triangulation. The triangulation used in this study involves method triangulation by comparing the results of student work and interview transcripts.

Data Analysis

The data analysis technique in this research refers to Miles et al., 2018. The activities in qualitative data analysis, firstly, involve data reduction by summarizing, selecting key points, focusing on important aspects, identifying themes and patterns. The reduced data will provide a clearer picture and facilitate the researcher to collect further data. Secondly, data presentation in the form of brief descriptions, charts, relationships between

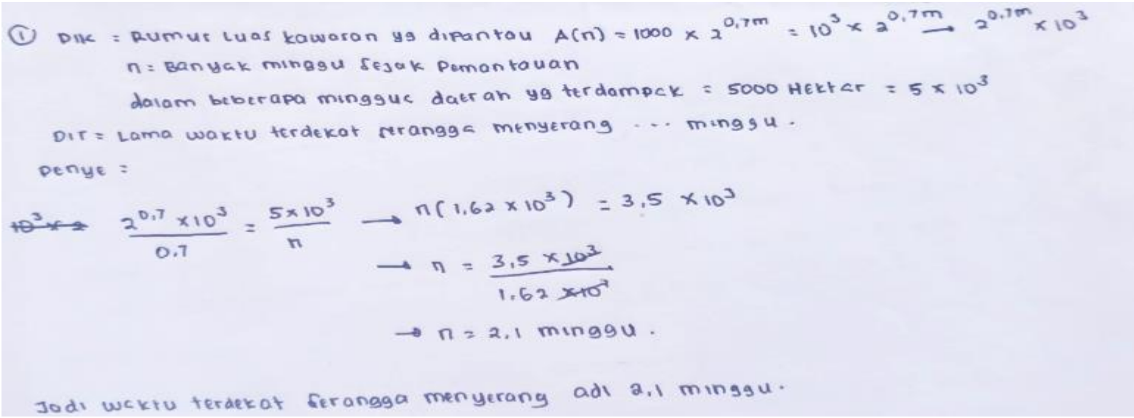

Figure 2. The results of the DHD-S1 mathematical concept understanding test

categories, flowcharts, and the like. Based on this, it can facilitate understanding of what has happened and planning further work based on what has been inspired. Thirdly, data verification and drawing conclusions to facilitate the interconnected flow of analysis from start to finish (conclusions).

RESULTS AND DISCUSSION

Description of Research Results Data Towards Subjects with High Self-efficacy (DHD-S1)

Based on the results of the concept comprehension test conducted by S1, it is evident that they can solve all logarithm problems, although the results obtained may be less accurate. S1 can present concepts in various forms of mathematical representation, where they substitute what is obtained in the problem. Furthermore, S1 develops what has been obtained previously, and they also use and select their own procedures and operations to achieve the desired results. This is reinforced by the interview results, where "Q: Why did you write $A(n) = 1000\ x\ 2^{0,7\ n} = 10^3 x\ 2^{0,7\ n}$ and then change it to the form $2^{0,7\ n}\ x\ 10^3$?? A: Because that is what is known in the problem. Then, what is known is changed to exponential form so that the obtained form is the same as the form of what is known in the problem, making it easier to carry out the solving process." Following Figure 2 are the results of the DHD-S1 mathematical concept understanding test. Figure 2 are the results of the DHD-S1 mathematical concept understanding test.

Based on the results of the mathematics concept comprehension test on the second problem, S1 has solved the given problem to obtain a result, although the result obtained may be less accurate. In this second problem, S1 can restate the basic concept of logarithms, where the basic concept intended by S1 is alog b = c. Then, S1 can clarify the obtained object based on the properties of logarithms, where S1 substitutes what is obtained from the problem and then applies one of the properties of logarithms, which is alog (b.c) = alog(b) + alog(c). Furthermore, S1 presents the concept in the form of mathematical representation. Then, S1 develops and performs certain procedures and applies the concepts used to obtain the desired result. This is in line with the interview test results: "Q: What do you do after you know what is known and asked in the given problem? A: I substitute the known values and then apply the basic concept of logarithms, then apply the properties of

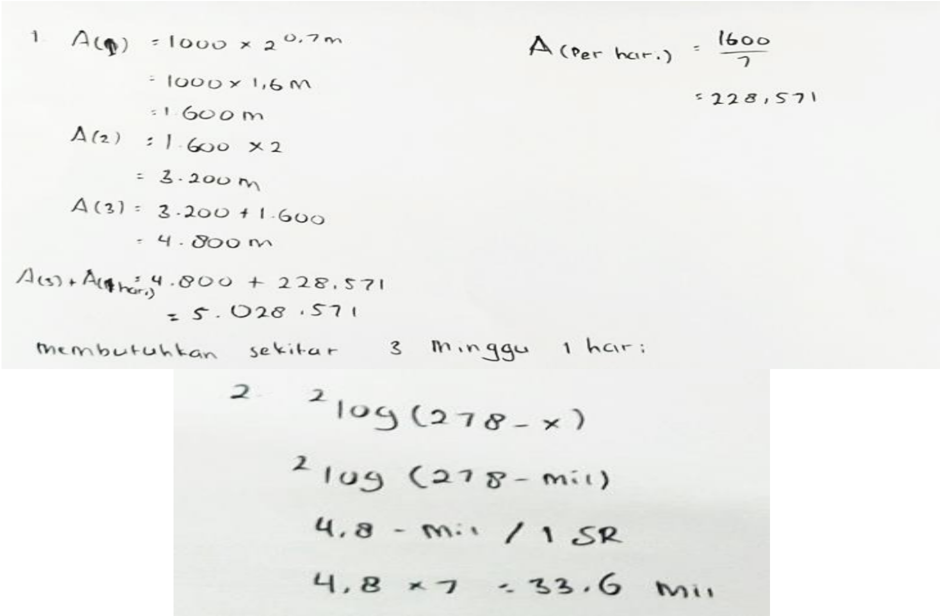

Figure 3. The results of the DHD-S2 mathematical concept understanding test

logarithms according to the steps taken until the final result is obtained." In this case, S1 is classified as having high self-efficacy because S1 can apply every indicator of students' mathematical understanding.

Description of Research Results Data for Subjects with High Self-efficacy (DHD-S2)

Based on the results of the students' concept comprehension test on the first problem, S2 can solve the given problem to obtain the result. S2 can present the concept in various forms of mathematical representation, where S2 substitutes what is obtained from the problem. Furthermore, S2 develops what has been obtained previously, and S2 also uses and selects their own procedures and operations to obtain the desired result. This is reinforced by the interview results: "Q: Why didn't you write down what is known and asked first? A: To be faster in solving the problem. Q: Why did you test the value of n? A: Because by testing the value of n, the result will be easier to obtain. Where the result will only be added from the value of A (3) and A (per day). Until the desired final result is obtained." Following Figure 3 are the results of the DHD-S2 mathematical concept understanding test.

Based on the results of the students' concept comprehension test on the second problem, S2 can solve the given problem. S2 can present the concept in various forms of mathematical representation, where S2 substitutes what is obtained from the problem. Furthermore, S2 develops what has been obtained previously, and S2 also uses and selects their own procedures and operations that will be used to obtain the desired result. This is in line with the interview results: "Q: Why did you only write down what is in the problem? S2: Because to speed up the problem-solving process. And the problem is already clear, so to speed up the solving process, students write down what is obtained and then develop it until the final result is obtained." S2 is classified as having moderate self-efficacy because S2 only uses some indicators of students' mathematical concept comprehension.

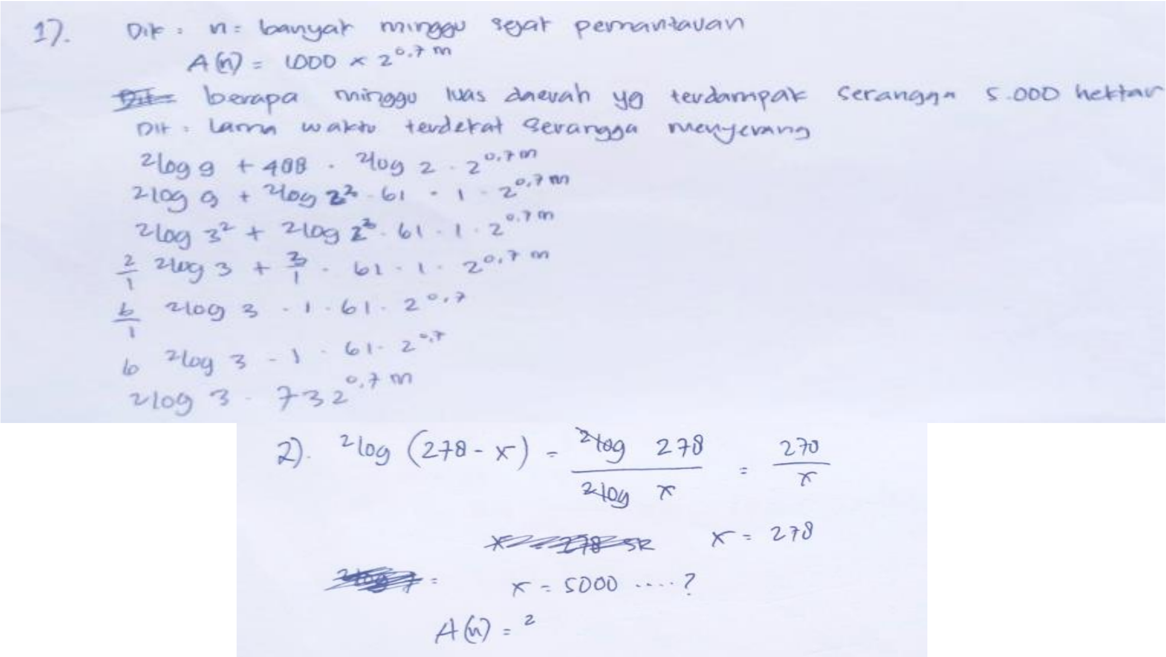

Figure 4. The results of the DHD-S3 mathematical concept understanding test

Description of Research Data Results for Subjects with Moderate Self-Efficacy (DHD-S3)

Based on the results of the mathematical concept comprehension test on the first problem, S3 solved the given problem to obtain the result. In this case, S3 was able to restate the basic concept of logarithms, where the basic concept meant is $a \; log \;\; b = c$. Then, S3 was able to clarify the objects obtained based on the properties of logarithms, where S3 substituted what was obtained from the problem and then applied one of the logarithmic properties, alog $b.c =$ alog b + alog c. Furthermore, S3 presented the concept in the form of mathematical representation. Then, S3 developed and performed certain procedures and applied the concepts used to obtain the desired result. This is in line with the interview results: "Q: Why did you write $2 \log 9 + 488 \,.2 \log 2 = 2^{0,7n}$ and then change it to the form $2 \log 9 + 2 \log 2^3 \,.61.1.\, 2^{0,7n}$ and so on? S3: Because that is what was known in the problem. Then, what is known is changed into the form of an exponent so that the form obtained is the same as the form of what is known in the problem, making it easier to solve the problem." Following Figure 4 are the results of the DHD-S3 mathematical concept understanding test.

Based on the results of the mathematical concept comprehension test on the second problem, S3 was able to solve the given problem. S3 could present the concept in various forms of mathematical representation, where S3 substituted what was obtained in the problem. Furthermore, S3 developed what had been obtained previously, and S3 also used and selected procedures and operations even though they did not obtain the result. This is in line with the interview results: "Q: Why did you immediately substitute what was known in the problem? A: To directly carry out the calculation process and obtain the final result." In this case, S3 falls into the category of moderate self-efficacy level as S3 performed some of the indicators of mathematical concept comprehension.

Description of Research Data Results for Subjects with Moderate Self-efficacy (DHD-S4)

Based on the results of the students' conceptual understanding test in the first problem, S4 was able to solve the given problem, although the obtained result was not entirely accurate. S4 could restate a concept, specifically the basic concept of logarithm $a \log b$, and applied the elimination method if the resulting logarithm values were the same. Furthermore, S4 presented the concept in various forms of mathematical representation, substituting the given values from the problem. Additionally, S4 developed the obtained information further and employed specific procedures and operations, although the outcome was not achieved. This aligns with the interview results: "Q: Why did you directly outline what you obtained from the problem? A: To simplify the resolution process." Following Figure 5 are the results of the DHD-S4 mathematical concept understanding test.

Based on the results of the mathematical concept understanding test in the second problem, S4 has successfully solved the given problem to obtain the correct result. In this second problem, S4 was able to restate the basic concept of logarithm, where the basic concept refers to $a log \ b = c$. Furthermore, S4 clarified the obtained object based on the properties of logarithms, where S4 substituted what was obtained from the problem and then applied one of the logarithmic properties, namely $a \log b.c = a \log b + a \log c$. Subsequently, S4 presented the concept in mathematical representation form. S4 then developed and executed specific procedures, applying the concepts used until achieving the desired result. This is consistent with the interview results: "Q: What do you do after you know what is known and asked in the given problem? A: Substituting the known values, then applying the logarithmic properties according to the steps used by converting the values in the problem into logarithmic form, which is used to simplify the resolution process." In this case, S4 belongs to

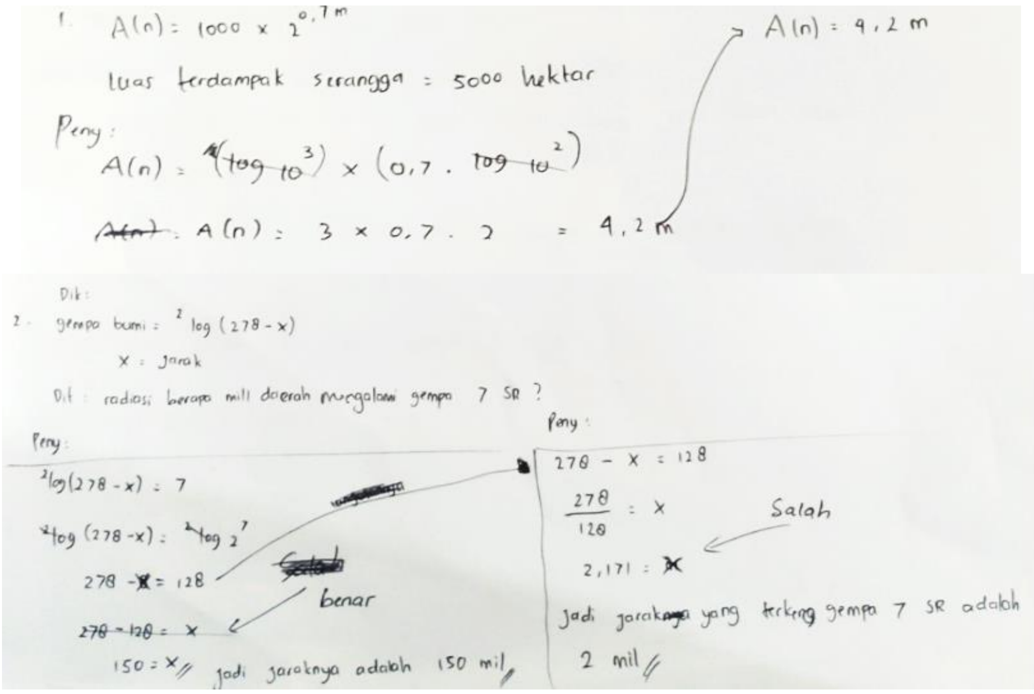

Figure 5. The results of the DHD-S4 mathematical concept understanding test

the moderate self-efficacy category as S4 can apply some indicators of students' mathematical understanding.

Based on the findings of the research above, the researcher found that there were 4 research subjects who performed indicators of conceptual understanding. This is presented in the form of research findings. The research findings are shown in Table 4.

Table 4. Findings from High Self-efficacy Research Results

Inisial	Level of Self-efficacy	Implementation of Indicators
S1	Tall	• Restating a concept found in the given problem. • Classifying objects according to the properties of logarithms. • Presenting concepts in various forms of mathematical representation. • Using, utilizing, or selecting a particular procedure or operation.
S2	Tall	• Restate a concept contained in the problem given. • Can classify objects according to logarithmic properties. • Presenting concepts in various forms of mathematical representation. • Using, utilizing, or selecting a particular procedure or operation.

Table 5. Research Findings of Moderate Self-efficacy

Inisial	Level of Self-efficacy	Implementation of Indicators
S3	Currently	• Presenting some concepts in various forms of mathematical representation. • Can apply some logarithm concepts.
S4	Currently	• Restate some of the concepts contained in the problem given. • Presenting some concepts in various forms of mathematical representation. • Can apply some logarithm concepts.

Understanding Mathematical Concepts for Students with High Self-efficacy

The research findings indicate that students' understanding of concepts who have high self-efficacy is demonstrated as follows. First, students can restate the concepts found in the given problems by writing down the known information and what is being asked. Second, students can classify objects in problems based on the properties of logarithms, such as ${}^{a}\log b = c$, ${}^{a}\log b \,.\, c = {}^{a}\log b + {}^{a}\log c$. Third, students can present concepts in mathematical representations. Fourth, students can select procedures to solve problems, such as substituting values into logarithmic models. This shows that during the problem-solving process, students with high self-efficacy can transfer their ideas from previous experiences conditioned with the problems they face. This indicates that high self-efficacy has an impact on students' understanding of concepts (Kaskens et al., 2020). Additionally, students with high self-efficacy have a deep understanding of concepts, so they do not encounter obstacles in problem-solving (Bishop et al., 2014). Therefore, students' success in problem-solving and recalling ideas from previous reasoning is due to their high self-confidence.

The research results indicate that students with high self-efficacy demonstrate flexibility in solving logarithm application problems. This flexibility is due to their conceptual understanding stored in long-term memory. In other words, students with high self-efficacy have an understanding that can construct interconnections where the relationship between facts is as important as the facts themselves (Kaskens et al., 2020). Additionally, students are also able to engage in a comprehensive understanding of the basic concepts behind algorithms performed in mathematics (Csíkos & Szitányi, 2020).

Therefore, students with high self-efficacy tend to know more than just the facts of the problem by organizing their knowledge based on new situations with what they have learned previously.

From the research findings, it's evident that students with high self-efficacy exhibit the ability to apply their ideas in solving problems in realistic situations. When someone understands a concept well, from an affective standpoint, they will feel comfortable with the material, confident in their abilities, assured that they can reconstruct the concept whenever needed, and capable of explaining it to others (Best & Bikner-Ahsbahs, 2017). Therefore, the research results can be interpreted as indicating that students with high self-efficacy do not easily give up, have a better mastery of various topics, and perceive failure in problem-solving because of insufficient learning.

Understanding of Mathematical Concepts in Students with Moderate Self-efficacy

The research findings indicate that the understanding of concepts among students with moderate self-efficacy is demonstrated as follows. First, students partially restate the concepts present in the given problems by writing down the known information and what is being asked. Second, they are capable of presenting concepts in mathematical representations. Third, students can partially present logarithmic concepts. This suggests that during the problem-solving process, students with moderate self-efficacy tend to exhibit cautiousness in problem-solving. This is evidenced by the time required by students to solve logarithmic problems, where they spend 30 minutes answering logarithmic questions. This indicates that the understanding of concepts among students with moderate self-efficacy tends to be hesitant, lacking confidence in decision-making (Bicer et al., 2020; Williams & Williams, 2021). Additionally, students with moderate self-efficacy sometimes make wrong decisions at each step of the solution (Menon & Sadler, 2018). This is consistent with studies showing that most pupils struggle to build their mental models and perform the productive and efficient tasks required to solve difficulties (Borji et al., 2018). This contradicts the APOS theory, which states that a person with a greater understanding of a concept may act more appropriately or that the focus of attention can diverge from the provided concept and prevent the expected action from happening (Dubinsky & Wilson, 2013).

The research findings also indicate that sometimes the ideas generated by students with moderate self-efficacy are instrumental in nature. In other words, students sometimes utilize ideas from previously solved problems as a basis for solving new problems (Yiğit Koyunkaya, 2016). These students also occasionally use mathematical procedures or rules without understanding the reasons behind them, but they require time to justify their ideas with the problems they face. This suggests that students with moderate self-efficacy tend to be confused in making decisions when solving a problem (Ebony O. McGee, 2015; Ndlovu et al., 2020; Yu & Singh, 2018). However, based on APOS theory, the process of forming conceptual knowledge occurs if someone is said to experience a process regarding a concept included in the problem at hand if their thinking is limited to the mathematical ideas they encounter and is characterized by the emergence of the ability to discuss or reflect on these mathematical ideas (Dubinsky, 2000; Dubinsky & McDonald, 2001; Arnon et al., 2014a). The results of this research can be interpreted as indicating that students with moderate self-efficacy are unsure of their abilities, fail to solve problems, and feel confused in connecting known elements with the concepts used.

Implication of Research

The implications of understanding the concept of logarithms from the perspective of self-efficacy gaps are very important because they directly influence students' confidence in solving problems and their willingness to learn. This indicates that learning about logarithms and solving problems involving the application of logarithms are greatly influenced by the level of students' self-efficacy. The conclusion of this research emphasizes the importance of self-efficacy in the process of learning mathematics. This implies that improving students' self-efficacy can positively impact their ability to understand and apply mathematical concepts, including logarithms.

Limitations

Based on the explanations provided earlier, there are several limitations in this study that can be addressed in future research. One of the limitations is that the material related to logarithm applications essentially becomes a major problem for students with low self-efficacy. This is evidenced by the inability of students to articulate their ideas in solving such problems. It is deemed necessary for future research to explore the reasons behind students' inability to solve logarithm application problems, especially among those with low self-efficacy.

CONCLUSION

The research findings indicate that students with high self-efficacy demonstrate understanding in solving logarithm application problems by: (1) restating the concepts present in the given problems by writing down the known information and what is being asked; (2) classifying objects in problems based on the properties of logarithms, such as ${}^{a}\log b = c$, ${}^{a}\log b . c = {}^{a}\log b + {}^{a}\log c$; presenting concepts in mathematical representations; and (4) selecting procedures to solve problems, such as substituting values into logarithmic models. Additionally, the understanding of concepts among students with moderate self-efficacy in solving logarithm application problems is demonstrated by: (1) partially restating the concepts present in the given problems by writing down the known information and what is being asked; (2) presenting concepts in mathematical representations; and (3) partially presenting logarithmic concepts.

The results of this research imply that self-efficacy is an important factor in the mathematics learning process. Therefore, it is important to pay attention to the development of student self-efficacy and adapt it to the learning approach used.

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