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ANALYSIS OF HIGH SCHOOL STUDENTS MISTAKES IN COMPLETING THE TOPIC LIMIT FUNCTION TYPE HIGHER ORDER THINKING SKILL

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ABSTRACT

The ability to think higher order is one of the curriculum demands that can train students' ability to solve problems and improve their experience in doing HOTS questions.The purpose of this study was to analyze student mistake in solving HOTS-type limit function questions. This research is a qualitative descriptive study, and the subjects of this study consisted of 24 students in class XI consisting of students with high, medium, and low abilities at SMA N 2 Bangkinang Kota. Data collection techniques obtained from tests and documentation. The analysis technique carried out involves grouping students based on high, medium, and low abilities. Based on the results and discussion, this study shows that there are three types of student errors: comprehension errors, transformation errors, and skill errors. Factors of student error in solving HOTS questions In the function limit problem, students have not been able to absorb information well, they have not been able to understand the meaning of the questions given, and they are not careful and less thorough in the process.
Keywords: Student Errors, Functional Limits, HOTS

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PRELIMINARY

Learning in schools, especially in mathematics subjects, must be directed at learning objectives that must be achieved in accordance with the attainment of basic competency standards by students. The teacher functions as a facilitator in the teaching and learning process, assisting students in finding new ideas about the material they are studying and automatically finding new information according to their level of understanding. (Ginting et al., 2021). Students' ability to learn mathematics increases their critical thinking and mathematical problem solving, their mathematical communication and collaboration, their creativity and innovation, their familiarity with constitutional issues,

and their capacity for media and information literacy (Gradini, 2019). In the world of education, students are highly demanded to be more active and participate actively, because the learning process can be said to be successful if students participate directly in learning. With that, students will remember and understand more if they participate and not just wait for the teacher to do so.

One of the challenges of learning mathematics is thinking, which also affects higher-order thinking skills, also known as Higher Order Thinking Skills (HOTS). It can be said that the assessment carried out regarding HOTS is not very visible. This assessment is carried out to catch up and address underdevelopment in the world of Indonesian education because in HOTS-based learning, the most important thing is understanding. Understanding the correct concept of a problem will allow students to develop subsequent problems with a more difficult level of thinking. This is characterized by students' ability to explore mathematical structures or patterns and the relationships that underlie them (Pasandaran & Kartika, 2019).

This also opens up the possibility that teachers' skills in constructing and creating HOTS-type questions need to be updated. The questions contained in the exam questions provided do not fully apply many of the HOTS principles themselves. Another reason why students do not have higher-order thinking skills is that teachers and students are not very familiar with how to answer HOTS questions, even though HOTS questions are widely known or have appeared in several mathematics textbooks at school (Gradini et al., 2018).

According to Astuti (2017), the process of teaching and learning in schools should be able to direct students to the world of education in the future. Higher-order thinking skills should be honed in schools, especially in math classes, where problems related to context-related issues can help students think more clearly. Another way to achieve this is to use assessment questions of the HOTS type. Students should be asked HOTS questions regularly to become more familiar with them, which will help them develop their higher-order thinking skills. Giving questions to students with the HOTS type has a significant impact on their readiness to enter the 21st century in the future (Himmah, 2019).

High-Order Thinking Skill (HOTS) is a thinking skill that emphasizes students' ability to understand, analyze, categorize, manipulate, create known concepts into new knowledge, and use it efficiently and appropriately. The indicators used to analyze students' High Order Thinking Skills (HOTS) are: (1) analysis, which relates to aspects or elements with various verbs such as comparing, examining, criticizing, and testing, is one of the indicators used to assess students' abilities. students' higher-order thinking (HOTS);

(2) evaluate, which relates to making their own decisions and uses verbs such as evaluate, assess, argue, decide, choose, and support, (3) create, which relates to creating ideas or ideas, with verbs such as construction or build, design, create, develop, write, and formulate.

In every mathematics lesson, one of the important things is knowing when students make mistakes in trying to solve problems. One of them is conceptual error, because for an educator, it is something that can be emphasized in terms of explanations and practice questions, improving the learning methods used, and evaluating the use of language when learning takes place. Errors made by students include several things, such as understanding and thinking that are not based on correct information, both in solving problems by students and in the teaching process provided by educators (Yunarti & Almira, 2022).

This is in line with research conducted by Mahayukti et al. (2020) which discusses the analysis of student errors in solving high-level thinking skills questions in the algebraic limit function material, which results in students making conceptual errors, namely their lack of thoroughness in understanding questions. The principle is the error in writing the formula, and the operation error is the lack of precision in multiplication. Factors causing students to make mistakes because they do not understand the concept of limits The procedure has the nature of a limit and lacks accuracy in the calculations. In line with research conducted by Santari et al. (2018) who conducted research on the analysis of student errors in solving HOTS questions, from this study it was found that students made mistakes, students were not able to complete the questions according to the expected steps, and students were only able to complete a few steps.

Many subjects are contained in learning mathematics, one of which is calculus mathematics, which has begun to be taught in high schools. Calculus is one of the important materials that students must learn because it is the basis for the development of other sciences. One of the calculus materials is the limit of algebraic functions. The importance of studying limit functions is because of the benefits of its application in everyday life, as it is widely used in the fields of engineering, natural science, economics, and business. In that case, limit function material needs to be mastered, but in reality, many students still experience difficulties in mastering the material (Kulsum, 2020).

The problem in this study is to observe and analyze the level of students' thinking ability through questions about function limits with the HOTS type in the aspects of analysis, evaluation, and creation, which will be carried out based on the level of students' abilities, namely high, medium, and low abilities.

METHODS

This study uses a qualitative and descriptive methodology, in which this research examines the condition of natural objects, and the results of qualitative research emphasize meaning rather than generalization. This research describes some of the information collected regarding error analysis according to Newman's theory. This research was carried out in several stages, including the planning stage, namely that this research will be carried out at SMA N 2 Bangkinang Kota, class XI MIPA 1, consisting of 24 students. Students are divided into three groups with high, medium, and low abilities. Second, the implementation stage is in the form of data collection techniques in this study, in the form of a HOTS test with a total of three questions. The HOTS type questions given are modified questions that have been validated for reliability, discriminating power, and level of difficulty by researchers (Faradisa, 2021). In the third stage, namely the report preparation stage, the results of student worksheets are analyzed based on the level of student ability obtained based on student test scores. Student test scores were analyzed using a scale of four. According to Iryanti (2004), an analytic rubric is a guide or reference used to assess based on certain criteria. The level of student ability is seen through several criteria, namely high, medium, and low ability levels, with the following references:

Table 1. Criteria Based on Students Comprehension Level

Criteria	Student Scores
High Level Ability	$80 \leq$ Value < 100
Medium Level Ability	$60 \leq$ Value < 80
Low Level Ability	$0 \leq$ Value < 60

Source: Modification Arikunto 2013

Based on Table 1, the results of the assessment described above can be used to determine the level of student ability; that is, students who meet the criteria have low or high abilities, concepts, and ability levels. The error indicators to be analyzed are indicators from Newman's theory, namely (1) reading errors, (2) understanding errors, (3) transformation errors, (5) skills errors, and (5) answer writing errors. To ensure that the analysis carried out in this study was accurate, the population analyzed included students with various abilities. Students were divided based on criteria for their abilities. The analysis to be carried out is in HOTS-type questions with three indicators, namely the analyzing indicator in question number one, the evaluating indicator in question number two, and the creating indicator in question number three. Analysis will be carried out on

each question based on the ability of students, namely students with high, medium, and low abilities, based on the types of errors in Newman's theory.

RESULT AND DISCUSSION

Based on the results of the criteria for students' conceptual understanding abilities, the following are obtained:

Table 2. Criteria Based on Students' Concept Understanding Ability

Criteria	The Number of Student
High	7
Medium	10
Low	7

Based on Table 2, it was found that students were divided into three ability categories: high, medium, and low. An analysis of errors made by students in response to HOTS questions will be carried out. The results of the following student responses are explained:

Table 3. Description of Student Answer Results

Question Number	Correct				Wrong			
	High	Medium	Low	Percentage	High	Medium	Low	Percentage
1	5	4	1	41,67%	2	6	6	58,33%
2	4	3	2	37,50%	3	7	5	62,50%
3	3	1	1	20,83%	4	9	6	79,17%

Based on Table 3, it was found that students made more mistakes when trying to answer the HOTS-type questions given. The analysis component of the first question has an error of 58.33%; the second question about evaluation has an error of 62.50%; and questions about aspects of creation have an error of 79.17%. Newman's error categories, including student errors in reading, student errors in understanding, student errors in transformation, student errors in process skills, and student errors in writing answers, will be used to analyze student errors in responding to these questions. The following is an analysis of student errors in each question based on Newman's error category.

Table 4. Percentage of Student Errors Based on Newman Error Categories

Question Number	Error Percentage				
	Reading Error	Misunderstanding	Transformation Error	Skill Error	Wrong Writing Answers
1	0%	75%	12,5%	12,5%	0%
2	0%	86,67%	13,33%	0%	0%

Question Number	Error Percentage				
	Reading Error	**Misunderstanding**	**Transformation Error**	**Skill Error**	**Wrong Writing Answers**
3	0%	50%	17,86%	32,14%	0%

Based on table 4, it can be obtained that in question number one, which is about the aspect of analyzing, students make an understanding error of 75%; for the transformation error in question number one, students make an error with a percentage of 12.5%; and for errors made on the type of student skills, students get a percentage of 12.5%. Whereas for questions on the aspect of evaluating students, there were misunderstandings with a total percentage of 86.67%, while for student errors on the type of transformation, that was equal to 13.33%. As for questions on the creative aspect, students made a misunderstanding with a total percentage of 50%, while for the type of transformation, the percentage that was obtained was 17.86%, and for skills errors, the total percentage was 32.14%. After explaining the mistakes made by students, several student work sheets will be selected, and errors will be checked, including analysis and evaluation. The following explanation and analysis are presented:

1. Analyzing Aspects (C4)

The aspect of analyzing is one in which students must know and understand the information contained in a problem and know the appropriate steps in solving the questions The questions with indicators of aspects of analysis are as follows:

Problem 1: A butterfly is observed perched on a flower plant. Under certain conditions and time intervals. Suppose the butterfly flies following the following function:

$$f(x) = \begin{cases} t & if\ t < 0 \\ t^2 & if\ 0 \leq t \leq 1 \\ 2 - t & if\ t > 1 \end{cases}$$

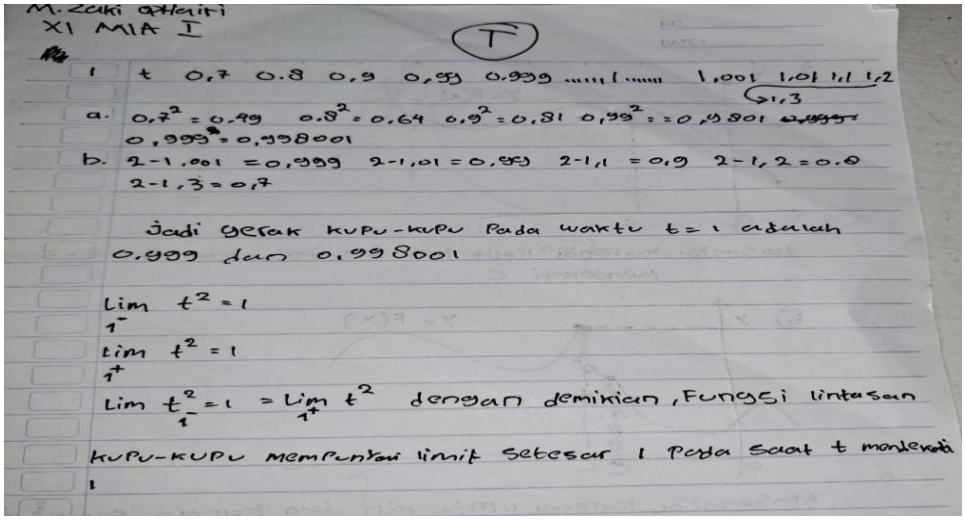
Analyze the motion of the butterfly at time t = 1

The following is an explanation and analysis of the mistakes made by students in the aspects of analyzing, evaluating, and creating based on the categories of students with high, medium, and low abilities.

a. High Ability Subject

This can be seen based on the subject's work as follows:

Students make numbers that are close to 1 from the left and numbers that are close to 1 from the right and substitute these numbers according to known intervals.



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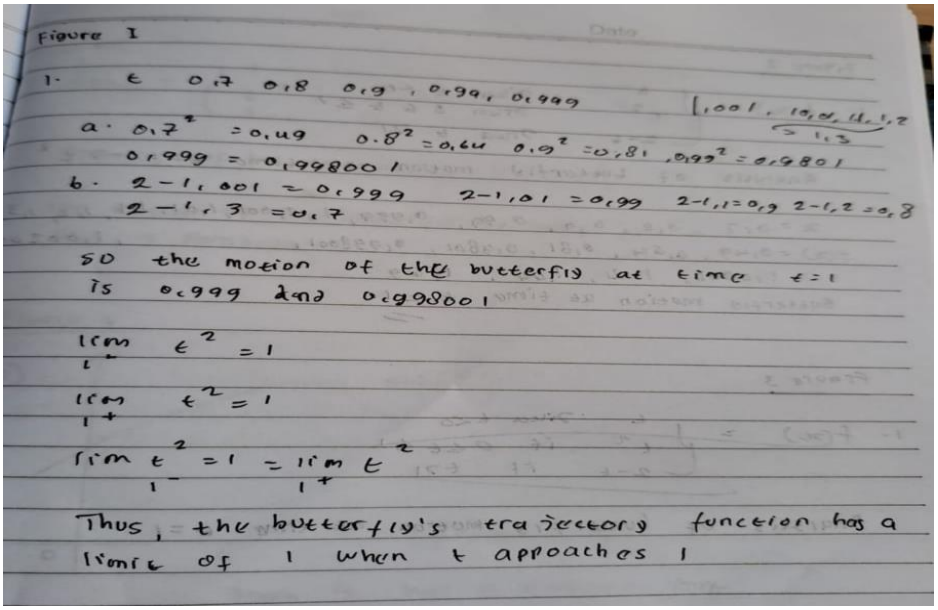


Figure 1. The Results of the High-Ability Subject's Work on Question Number 1

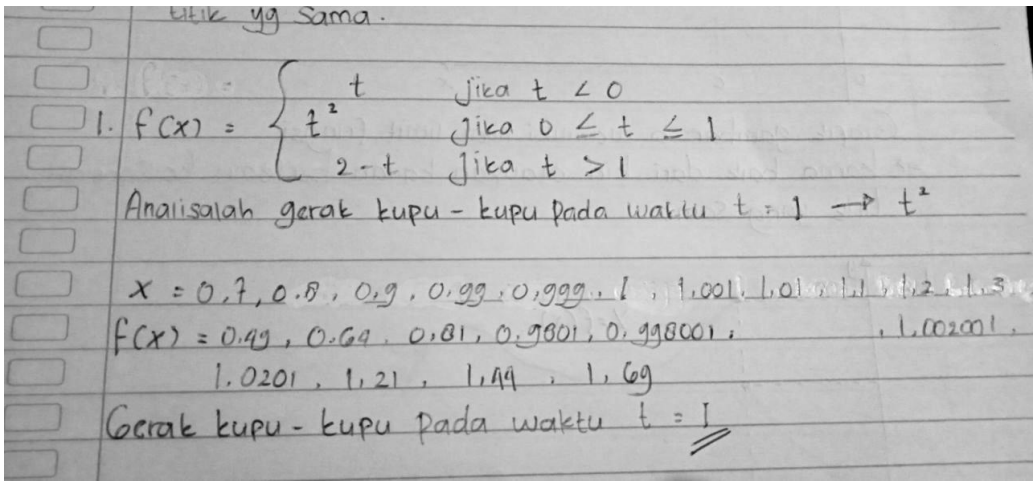
Based on Figure 1, They already know that the functions used are $f(x) = 2 - t$ and $f(x) = x^2$and are able to analyze the motion of the butterfly when t approaches 1.

According to Badjeber et al. (2018), one of the factors that causes students to be able to answer questions well is that they are able to analyze the intent of the questions properly and well and are familiar with questions that use thinking analysis. Providing HOTS-based learning is one of the factors that makes students able to answer questions effectively because they can analyze the meaning of questions correctly and well and are used to

questions that use thinking analysis. The knowledge they already have, if honed and trained often, will be better.

b. Medium Ability Subject

This can be seen based on the subject's work as follows:



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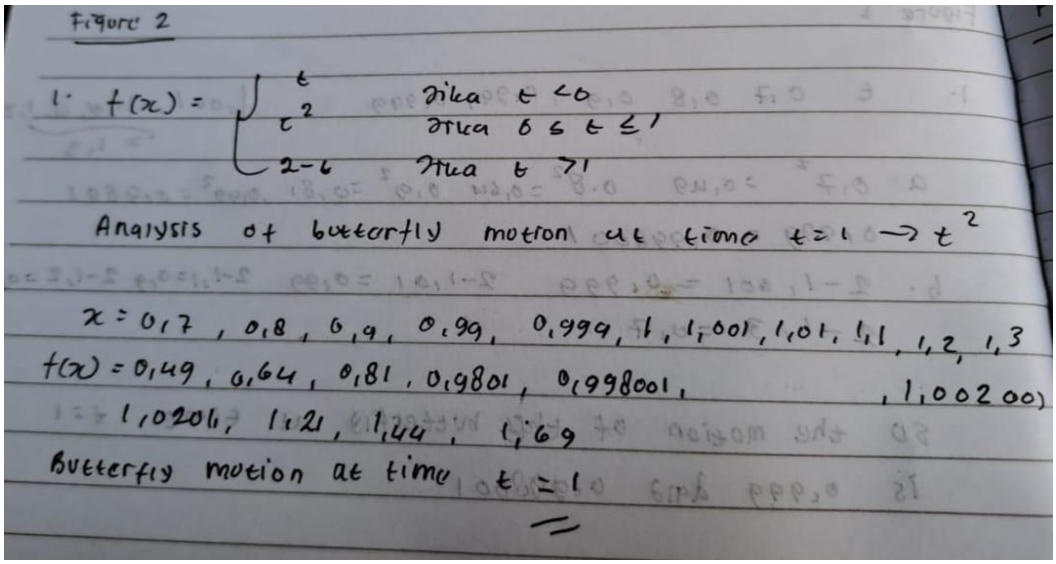


Figure 2. The Work Results of the Moderate Ability Subject on Question Number 1

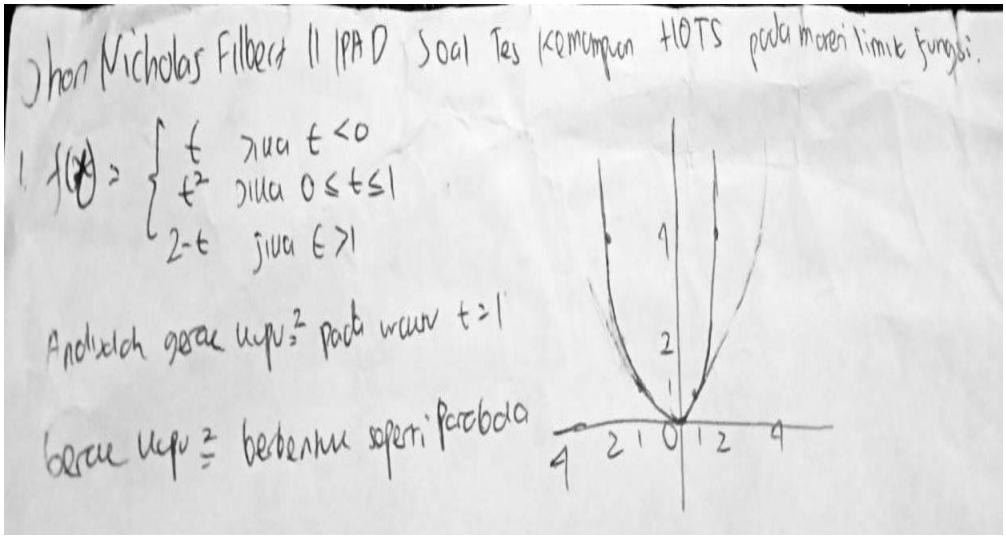
Based on Figure 2, students made a mistake in understanding the analyzing aspect question (C4) because in this question students were asked to determine the movement of the butterfly. To determine this, students had to determine the limit value of f(t) when t approached 1 from the right and the limit value of f(t) when t approached 1 from the left, but students only looked for the value of the function without knowing the meaning of the problem. This is in line with Fitriatien's research (2019), which stated that student errors in HOTS questions were caused by students' carelessness when reading the questions. They also failed to write down what was known from the question and what was asked from the question, leading to another error. Because if students realize what is needed to solve a

problem, they will begin to consider the best solution so that it can be done properly and correctly.

c. Low Ability Subject

The following criteria can be used to evaluate this based on student work:

Students draw a graph of the function $f(t) = t^2$ substitute point x into the function, and draw the graph



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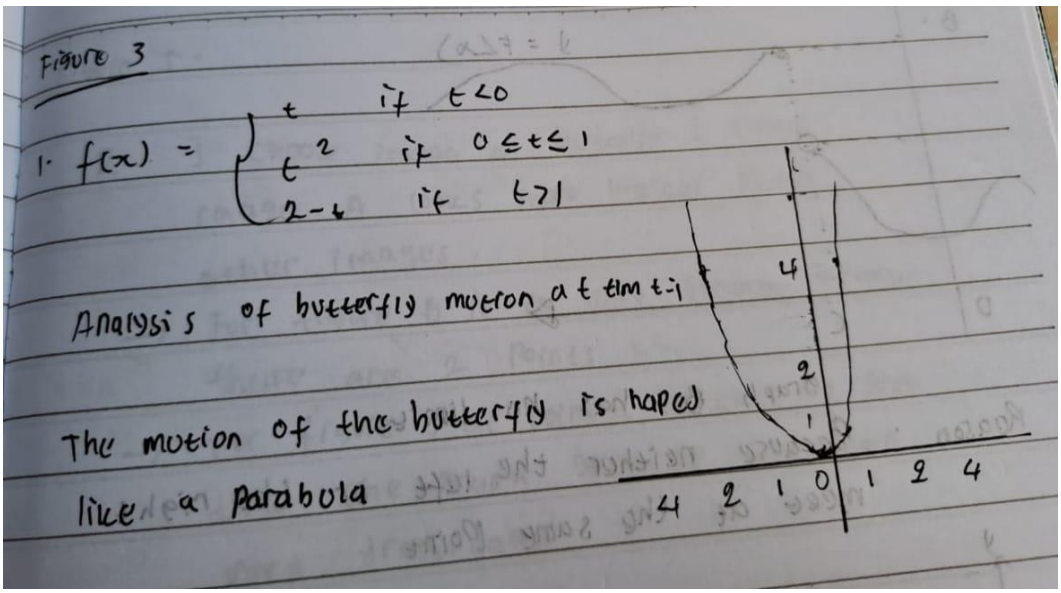


Figure 3. The Results of the Subject's Low Ability in Question Number

Based on the results of student work in Figure 3, it can be seen that the image that students made misunderstandings and transformation errors. It can be seen in the images that students did not understand the correct concept to use in solving the problem. Students did not use the limit concept to make it easier to find answers. Students drew a function, namely ork in Figure 3, it can be seen from the image that students made

misunderstandings and transformation errors. It can be seen in the images that students did not understand the correct concept to use in solving the problem. Students did not use the limit concept to make it easier to find answers. Students drew a function, namely f(t) = t2, without knowing the purpose of the drawing. Students only state that the movement of the butterfly is like a parabola drawn.. According to (Anugrah & Pujiastuti, 2020), several factors are among the reasons and causes of students experiencing transformation errors in solving HOTS questions, namely because they are not thorough and are always in a hurry, causing mistakes. This is supported by research conducted by (Saraswati & Agustika, 2020),which found that students had difficulty with HOTS questions because they were difficult to convert into mathematical form and because they rarely worked on story problems or problems, making it difficult for them to develop the skills needed to complete the given questions.

2. Evaluating Aspects (C5)

In this aspect of evaluating students, they are required to make decisions about the steps to be used in solving the questions correctly, be able to check answers again, and be able to provide criticism and reasons for determining the answers to be written.

Problem 2: Observe the following function:

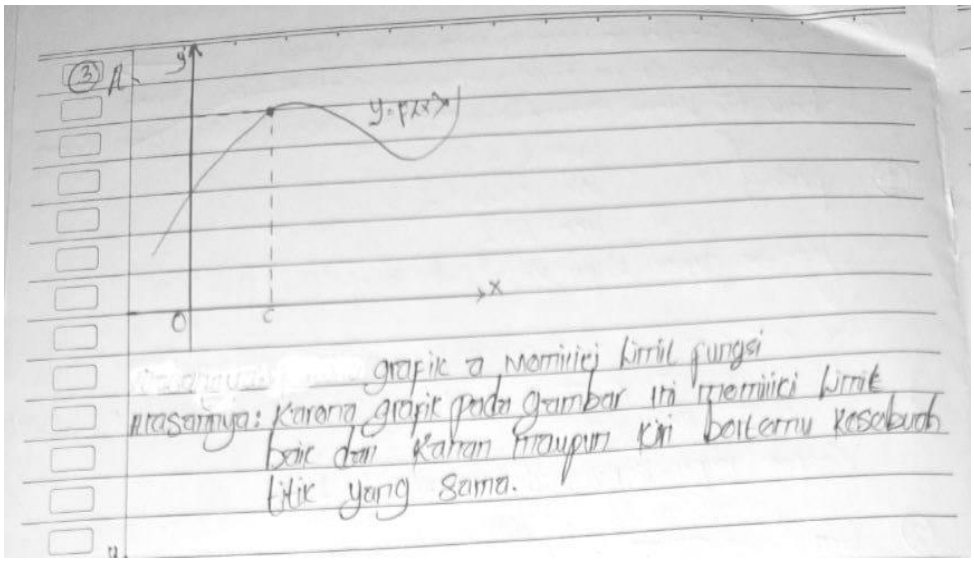
$$:f(x)\begin{cases}\frac{2\sqrt{2}\sqrt{x}-4}{x-2} & if\ x>2\\ \frac{x^2-4}{x+2} & if-2\le x\le 2\\ 3x+1 & if\ x<-2\end{cases}$$

Of the several functions above, which will you use to analyze whether f(x) has a limit when x approaches 2 and draw the graph accordingly? The following is a presentation of the results of student worksheets based on predetermined ability categories.

a. High Ability Subject

This can be seen based on the subject's work as follows:

In the picture below, students draw a graph on the problem and explain why the picture has a limit or not



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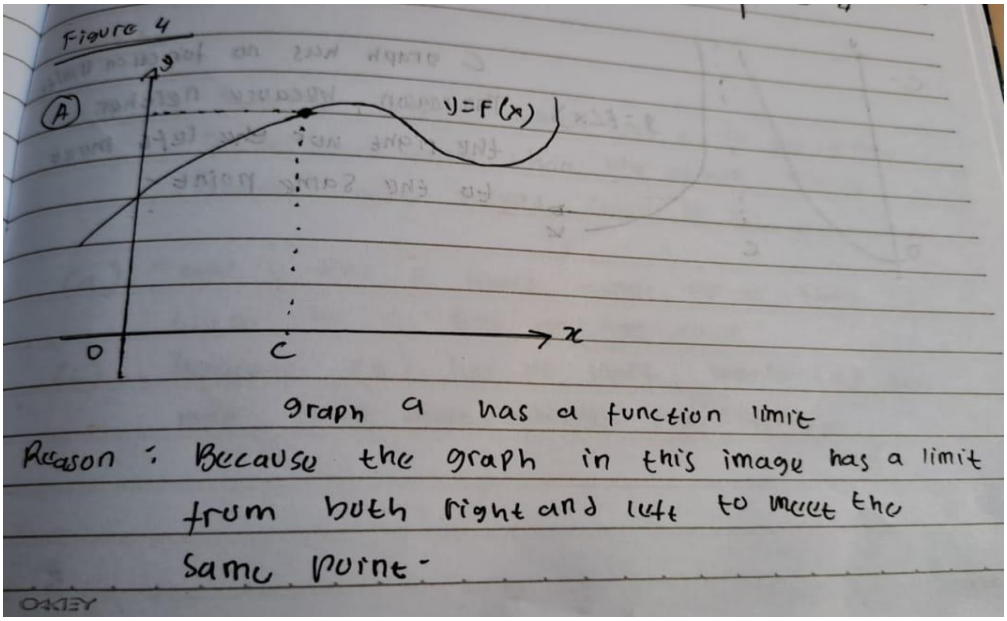
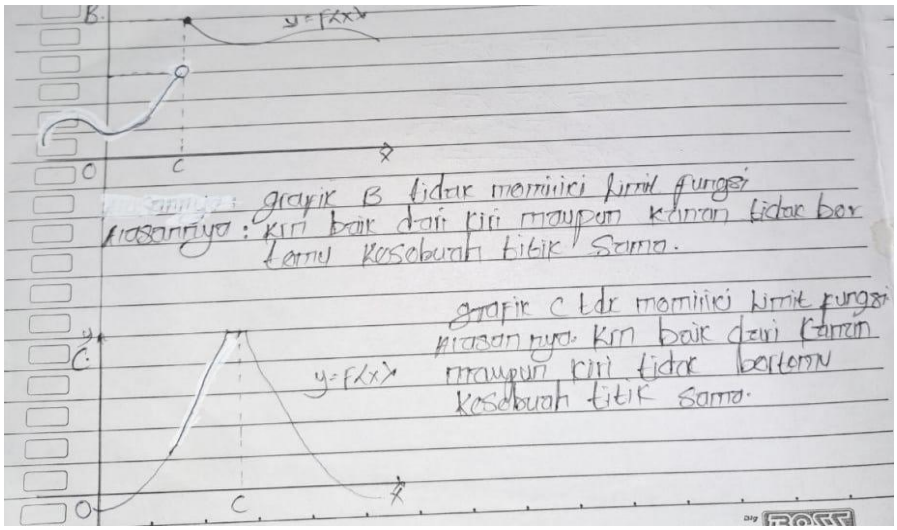


Figure 4(a). The Results of the High Ability Subject's Work on Question Number 2



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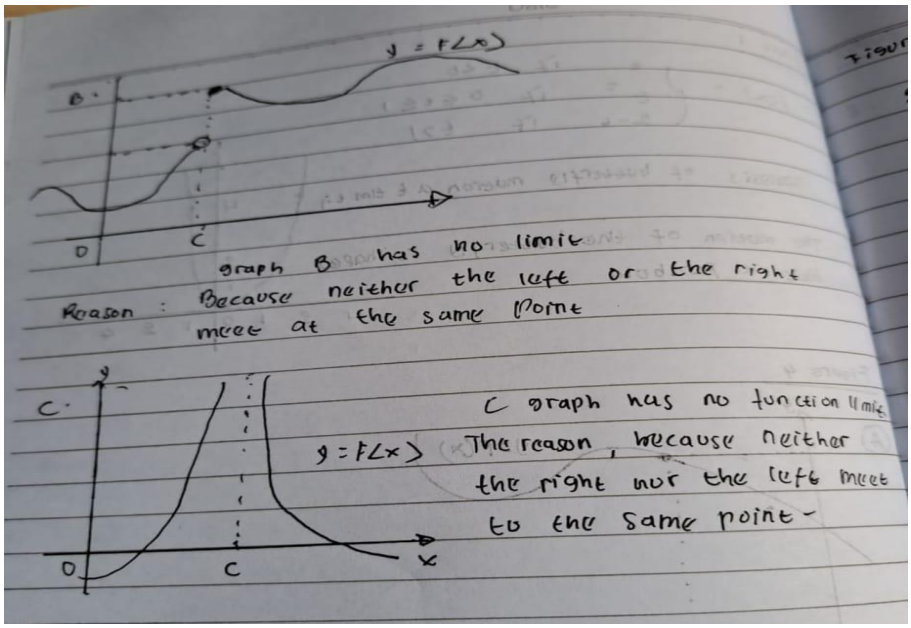
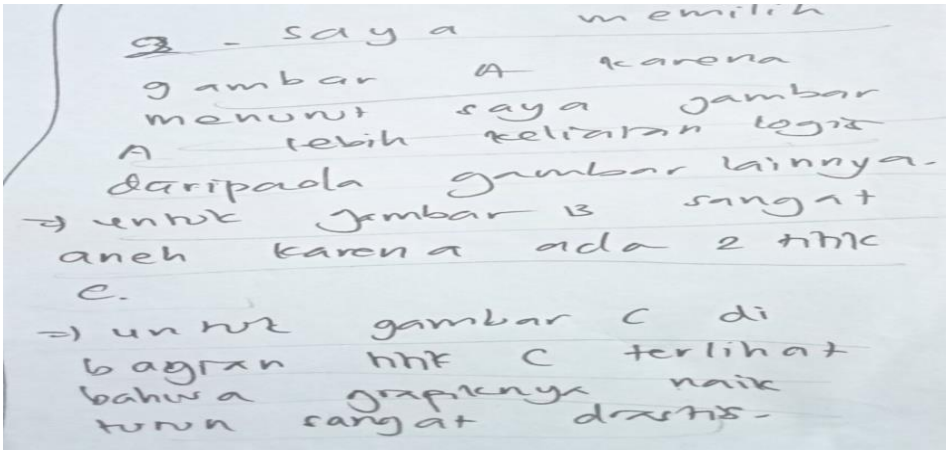


Figure 4(b). The Results of the High Ability Subject's Work on Question Number 2

Based on Figure 4 (a) and (b) , it was found that students were asked to choose images that have limits. As can be seen in the results of student work, students are correct in choosing images that have limits and provide good reasons for determining graphs that have limits. Students are also quite good at giving criticism and reasons for graphs that are not selected. This is consistent with research by Laman et al. (2019), who found that students who had strong conceptual understanding or initial abilities completed HOTS-style questions correctly even though they required higher-order thinking skills. This is in line with research (Erita et al., 2023) showing that students predominantly answer questions in graphic form, which makes it easier for students to demonstrate their higher-order thinking skills.

b. Moderate Ability Subject

This can be seen based on the subject's work as follows:



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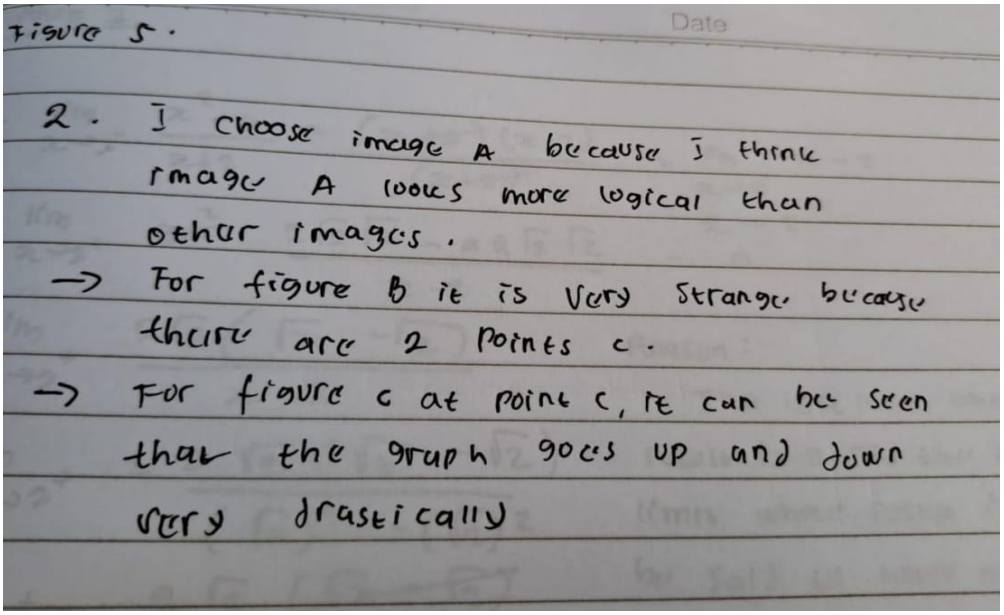
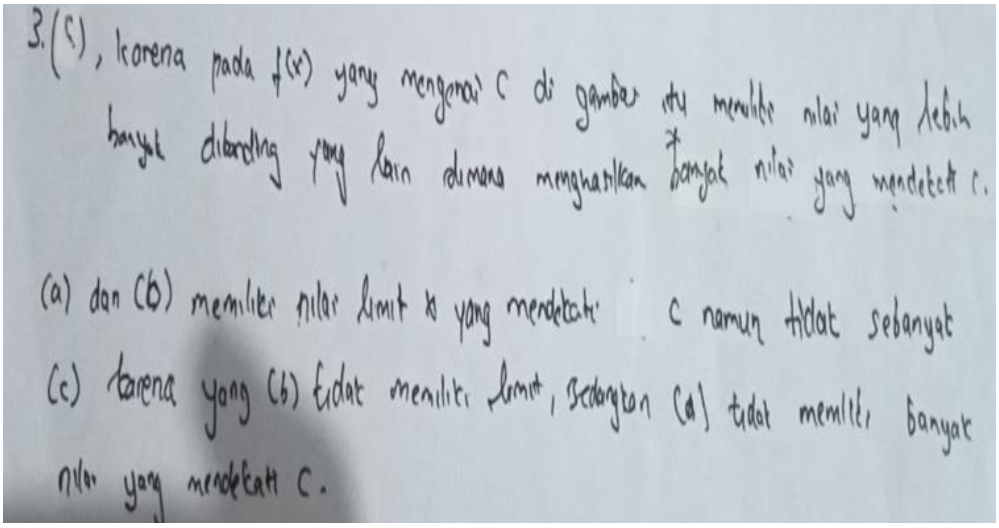


Figure 5. The Work Results of the Moderate Ability Subject on Question Number 2

Figure 5 shows that student responses contain transformation errors. Even though the students' answers to choosing a graph were correct, they made a transformation error on the worksheet because the reason they chose a graph with limits was not in accordance with the concept of limits. This is evident in the work results, which show that students know and understand what is known from the questions and what is asked from the questions. According to research by Febryana et al. (2023), students are able to understand the problem, but they are less able to apply the right solution according to what is learned from the problem.

c. Low Proficiency Subject

This can be seen based on the subject's work as follows:



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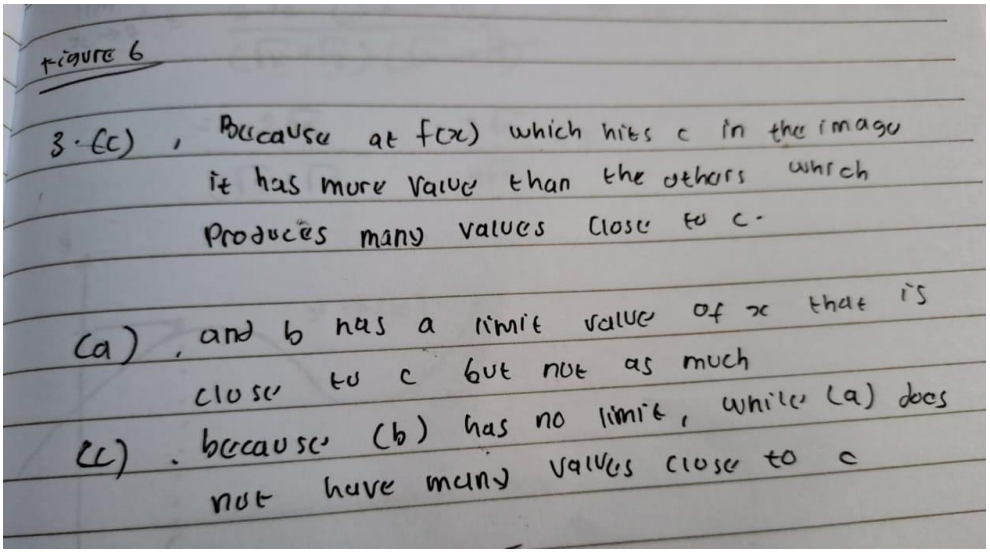


Figure 6. The Work Results of the Moderate Ability Subject on Question Number 2

Figure 6 shows students misunderstood the evaluation questions and chose the wrong graph when asked to choose a graph with a limit value. They also made transformation and comprehension errors; students did not make graphs that would be the subject of comments and reasons; and they were also not aware of the exact reasons for their responses. For transformation errors, students did not know the concepts to be used in selecting and giving reasons for the graph given, namely, by using the limit concept, if a function x from the right approaches c and the function x from the left approaches c, then the graph can be said to have a limit value, but in student work, students give reasons that are not in accordance with the definition of the limit alone. This is in accordance with er's research (2018), which found that students often experience misunderstandings and

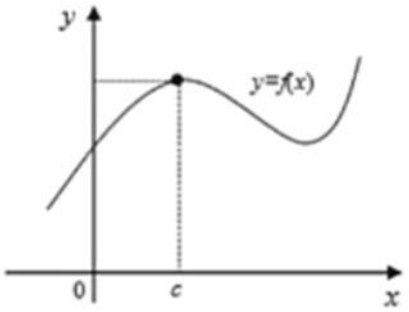
transformations when trying to solve HOTS problems and that one of the causes is a lack of mathematical reasoning abilities, as well as their lack of experience with problem-based learning or activities that support higher-level thinking. student height

3. Aspect of Creating (C6)

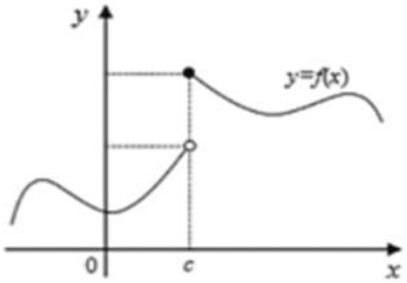
In the aspect of creating, students are required to understand and know the purpose of the questions given and be able to find the right steps or ways to solve the problem. The questions regarding the aspect of creation are as follows:

Problem 3:

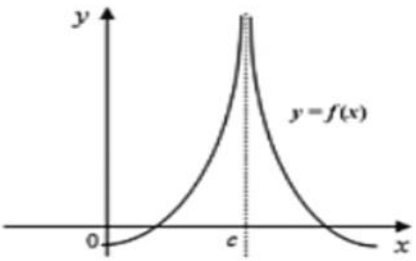
a.



b.



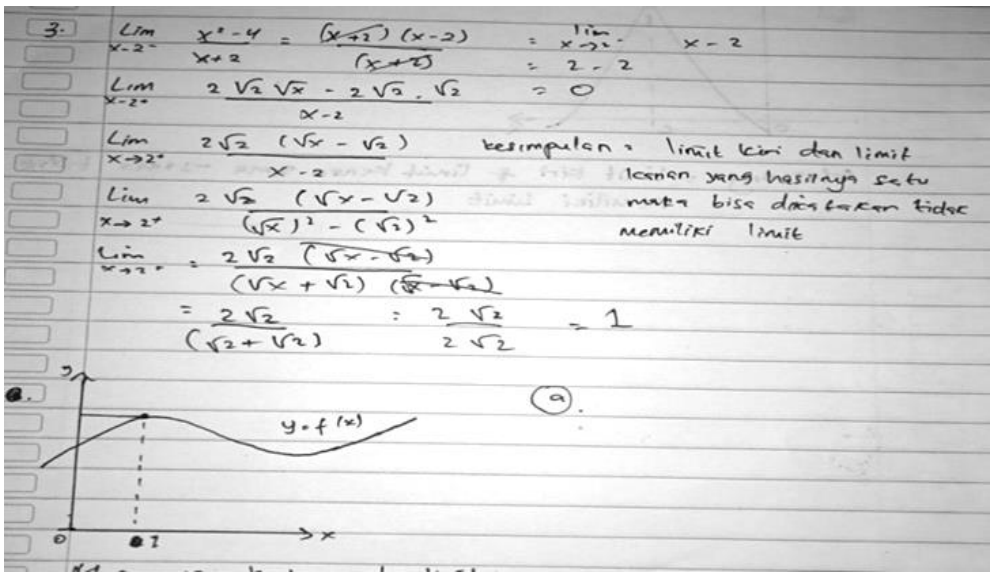
c.



From the three pictures y=f(x) above, choose the picture that has a limit value when x approaches c! Give reasons for choosing the picture and criticism for the picture you didn't choose! The following is a presentation of the results of student worksheets based on high, medium, and low abilities.

a. High Ability Subject

This can be seen based on the subject's work as follows:



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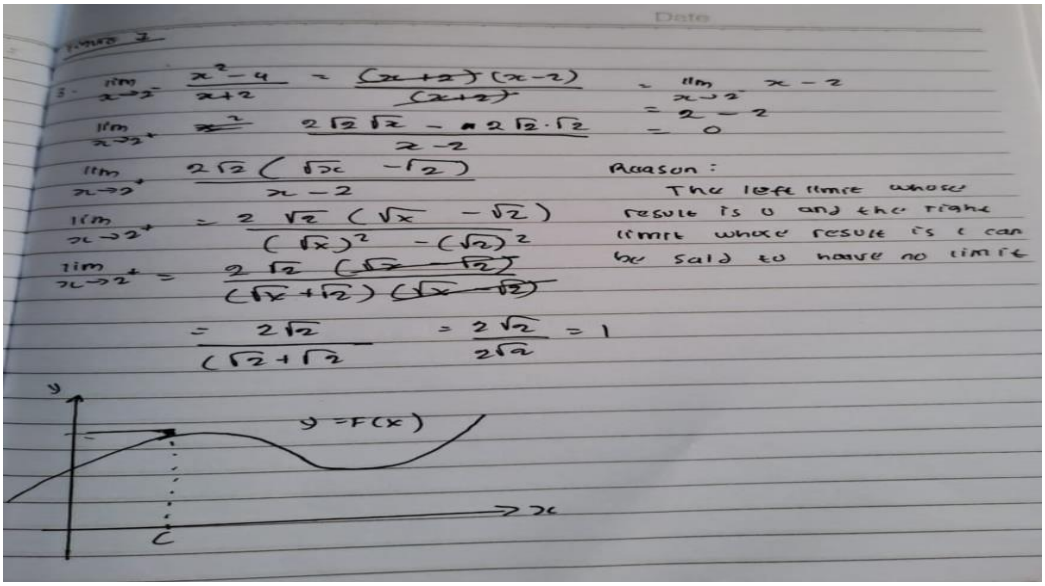

Figure 7. The Results of the High Ability Subject's Work on Question Number 3

Based on Figure 7, students are asked to choose two functions from the three provided functions to determine the limit value when x approaches 2, and they are asked to draw the function. For this problem, students are able to choose two functions, namely $f(x) = \frac{2\sqrt{2}\sqrt{x}-4}{x-2}$ when approaching x from the right and $f(x) = \frac{x^2-4}{x+2}$ when approaching x from the left, but when drawing a graph that matches the function used, the student makes an error. This error includes understanding and transformation errors, where the student chooses the wrong function to use when creating the graph. According to research by

Sa'adah et al., (2019), one of the factors that causes students to make mistakes when solving problems is their inability to interpret the meaning of the problem correctly. Another reason why students make mistakes is that they struggle to translate problems into proper mathematical concepts. Students make mistakes. These errors include understanding and transformation errors, where students choose the wrong function to use when creating a graph.

This is also in line with Hadi's research (2021), which found that student errors in solving questions indicated that students had difficulty solving HOTS questions, as well as other factors such as difficulty identifying the meaning of questions, which led to student errors in solving problems.

b. Moderate Ability Subject

This can be seen based on the subject's work as follows:

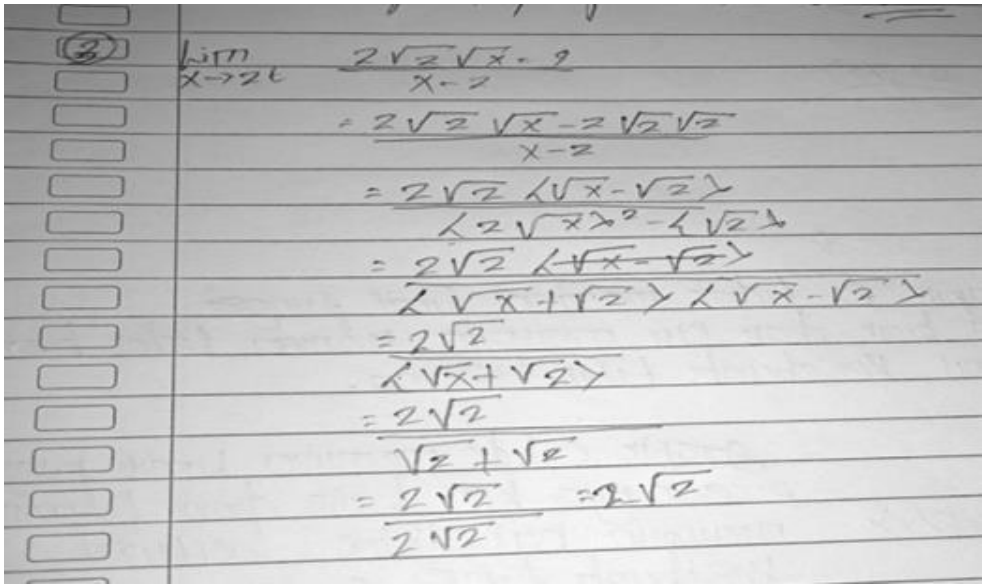

Figure 8. The Work Results of the Moderate Ability Subject on Question Number 3

Based on Figure 8, it can be obtained that students are only looking for one function of the limit. For this problem, students make understanding errors, transformation errors, and skill errors, and in understanding errors, students have not been able to understand the meaning of the question. When students are asked to determine the limit value when x approaches 2 and draw a graph, they must choose two of the three functions provided. For transformation errors, students must be able to determine the function used when x approaches 2 from the right and the function used when x approaches 2 from the left from the student's answer, but as can be seen above, students only directly look for the limit value of one function, and the final result is that students make skill mistakes, in

which students make mistakes when $\frac{2\sqrt{2}}{2\sqrt{2}}$, the correct answer should be 1, but students write with an answer of $2\sqrt{2}$. This is in line with the research of (Najahah et al., 2022) which states that students who make process skill errors, one of the contributing factors is because students are not careful, think process errors and forget.

c. Low Proficiency Subject

This can be seen based on the subject's work as follows:

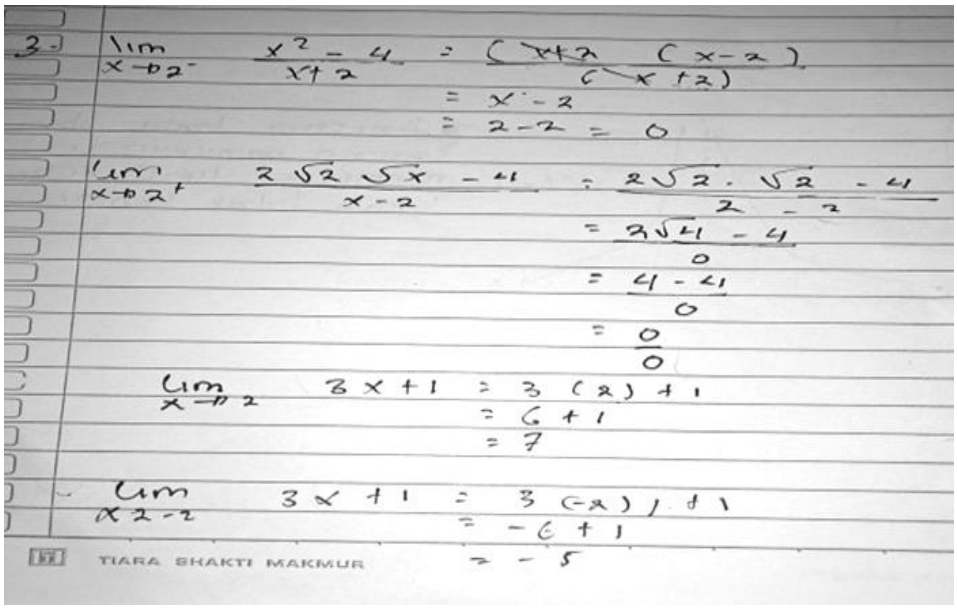

Figure 9. The Results of the Subject's Low Ability in Question Number 3

Based on the student worksheet above, it can be seen that students made misunderstandings, transformation errors, and process skills errors. For understanding errors, students do not understand the purpose of the problem to determine the limit value when x approaches 2. They only use all available functions and look for limits when x approaches 2. For transformation errors, students are wrong in using the concept of completion as a step in determining the answer. The step that must be done by students is to choose the function to be used to determine the limit value of x. Students often make mistakes in number operations due to processing skills errors, such as trying to find the limit value when the denominator is 0, which is not allowed and needs to be simplified first. According to research by Hasyim et al. (2019), students with low abilities have not been able to meet the indicators on HOTS questions, as can be seen in this example where students have not been able to answer questions with indicators of creativity.

In the three aspects of the Hots questions given, for the first question on the aspect of analyzing (C4), ten students answered correctly, namely five students with high

abilities, four students with moderate abilities, and one student with low abilities. The students who answered incorrectly were 14 people: two students with high abilities, six students with moderate abilities, and six students with low abilities. The types of errors for question number one were 75% comprehension errors, 12.5% transformation errors, and 12.5% skill errors. Students who have high abilities make many mistakes in understanding because they do not understand the meaning of the questions given. They are able to complete number operations but misinterpret the meaning of the questions. With this, students have to practice a lot for HOTS questions to be able to solve high-level questions. In accordance with the opinion (Arifin & Retnawati, 2015), students must be given problems with HOTS characteristics because they can hone and train students' higher-order thinking skills to be better.

The second question was on the evaluating aspect (C5), and nine students answered correctly, namely four students with high abilities, three students with moderate abilities, and two students with low abilities. There were 15 students who answered incorrectly, namely three students with high abilities, seven students with moderate abilities, and five students with low abilities. The types of errors made by students were 86.67% understanding errors and 13.33% transformation errors. Students with moderate abilities tend to be unable to complete their work; this is in line with research that was conducted by Hasyim and Andreina (2019), which found that students with moderate abilities have the ability to think, analyze, evaluate, and create; they are able to say what information is known and asked from the questions, but have not been able to complete the work.

The third question on the aspect of creating (C6) students answered correctly as many as five people, namely three students with high ability, one student with medium ability, and one student with low ability. There were 19 students who answered incorrectly, namely four students with high abilities, nine students with moderate abilities, and six students with low abilities. The types of errors made in question number three were 50% in understanding errors, 17.86% in transformation errors, and 32.14% in skills errors. This is in line with research conducted by Mawardi et al. (2020) which found that students tend to work on problems that are given a way to be solved, and when given problems that do not have a solution procedure, they have difficulty working on them.

CONCLUSION

Based on the results of the discussion, it can be concluded that the types of mistakes made by students in solving high-level thinking skills questions, or HOTS, in

limit function material are understanding errors, transformation errors, and skills errors. Students with high abilities make a lot of mistakes in transformation errors; students with medium abilities make lots of mistakes in understanding and transformation errors; and students with low abilities make lots of mistakes in understanding, transformation, and skills mistakes. Students often misunderstand instructions, making them unable to understand the intended meaning of the questions even after solving the problem. Students make mistakes that lead to wrong answers because they don't use the solving steps correctly when making transformation mistakes. In fact, the use of less thorough steps and problem-solving techniques during number operations results in wrong answers.

Based on the discussion and conclusions, the researcher suggests that students be more routine in working on HOTS-based questions in order to train their thinking skills to be better and more thorough in solving questions that require higher-order thinking skills. Educators are expected to be able to provide learning that can provide reflection before continuing the material in order to ensure students understand and know the intent of solving HOTS questions so that they can be understood correctly. In this case the researcher suggests that students be given more HOTS-based problems in order to build students' higher-order thinking skills and it is suggested to further researchers to examine the causes here are differences in thought processes in solving HOTS questions given to students by looking at the same cognitive style.

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