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Research Article

Analysis of student's mathematical thinking in solving HOTs problems viewed from mathematics anxiety

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ABSTRACT

This study aims to describe students' mathematical thinking processes in terms of math anxiety. The method used in this research is descriptive qualitative. Data collection techniques were carried out through tests, documentation and interviews. The determination of the subject used a purposive sampling technique by taking 5 student level subjects who had very high, high, medium, low, and very low levels of math anxiety. The results showed that in the process of working on the test instrument in the form of HOTS questions, subjects with very low levels of anxiety were able to solve the first and second problems correctly. In the entry phase, the subject fulfills the I know, I want, and introduce rubik. And in the attack phase it fulfills the rubik's try, may be, and why. In the review phase it only fulfills the Rubik's check, and does not meet the rubik reflect and extend. This can be seen from the results of work that does not use a general formula.

Keywords: mathematical thinking; HOTS; mathematics anxiety

1. INTRODUCTION

Thinking is an individual's ability to create mental abilities by analyzing, comparing information, and reasoning to reach a conclusion. Thinking can be interpreted as an effective, functional, and directed action. According to contemporary psychologists (Nedim et al., 2021), thinking starts with problems. So it can be concluded that the thinking process is the ability to determine the solution to a problem, thus the thinking process begins with the problem. One of the basic sciences that promotes problem solving and thinking skills is mathematics. Mathematics is given to all students to acquire logical, analytical, systematic, critical, and creative thinking skills as well as the ability to collaborate. Not every way of thinking is mathematical, but the contribution of mathematical thinking in problem solving is undeniable. Mathematical thinking defines how an individual prefers to understand, think, and present mathematical facts and connections with certain internal images or external representations (Nedim et al., 2021). In other words, mathematical thinking is the investigative process one goes through when solving a problem. Every individual can think mathematically, which can be developed through mathematical thinking and reflection.

The ability to think mathematically, especially high-level mathematical thinking (high order mathematical thinking)very important in elementary school, middle school, even at the college level.This is with the need for students to solve the problems they face everyday. Mathematical thinking skills, can be seen by tests associated with certain materials. One thing that can be done to find out students' mathematical thinking processes is to complete the Higher Order Thinking Skills (HOTS) questions. The test format in the form of a description can be useful in assessing how students' mathematical thinking processes solve problems.

Mathematical thinking according to Mason is a dynamic process that makes it easier for us to understand complex structures by combining our ideas. Mathematical thinking is the use of mathematical techniques, concepts and processes to solve problems directly or indirectly (Celik & Furkhan, 2020). Mathematical thinking is needed by every individual to solve problems throughout his life at school, at work and in everyday life. According to Tall in (Celik & Furkhan, 2020) states that thinking mathematically includes components such as abstraction, synthesis, generalization, modeling, problem solving, and proof.Stacey, Burton and Mason (2010) justify and convince the components of mathematical thinking, namely specialization and generalization. Problem solving in mathematics (by the nature of mathematics) is the elimination of problems using the necessary information and processes through mental (reasoning) processes.So that it can be concluded, thinking mathematically is how an individual prefers to understand, think, and present mathematical facts and connections with certain internal images or external representations.

Table 1. Masonic frame of mind

Phase	Rubik	Activity
Entry	I know	Understand the problem thoroughly Identify the information contained in the question to understand what is being asked
	I want	Classify the information found appropriately Reconstruct questions to solve problems
	Introduce	Choose a part that can be exemplified by a symbol to represent the element in question Write down what is known in the problem
attack	try	Make assumptions about the solution to the problem / problem solving Turn wrong assumptions into true
	May be	Trying to guess/assume whether it can solve the problem in the problem
	why	Have a logical reason when accepting or rejecting an allegation Giving confidence to other people orally or in writing, that each settlement step is correct, with settlement steps presented systematically
Reviews	Check	Checking the suitability of the count Checking the suitability of the reasons for the settlement steps Check whether the completion steps used and questions are appropriate
	Reflect	Thinking about the ideas that happened, what is the most difficult part of what can be learned from the solutions done and realizing the need for systematic calculations Reflect on provisional conjectures or use further specialization to check conjectures
	Extend	In order to be used in a broader context, it is necessary to make a general form of the results obtained Find another solution Trying to solve a similar problem by changing the facts and what to ask

Anderson and Krathwohl (2001) suggest that the dimensions of cognitive processes are divided into 6 levels based on the Taxonomy Bloom Revision book, namely remembering, understanding, applying, analyzing, evaluating, and creating. Brookhart in (Dwi & Jasilin, 2020) categorizes the last three of them as HOTS namely analyzing, evaluating, and creating. According to Anderson and Krathwohl, the higher order thinking approach is divided into learning to remember and learning to transfer. HOTS includes critical, logical, reflective, metacognitive and creative thinking that is activated when individuals are faced with unknown problems, uncertainties, questions or dilemmas. According to the National Council of Teachers of Mathematics HOTS requires non-routine problem solving. According to Anderson and Krathwohl in (Sa'dijah et al., 2021) HOTS is a process of analyzing, evaluating, and creating. HOTS thinking occurs when a person takes in new information and relates to, rearranges, and expands on their information to achieve a goal or find possible answers in a confusing situation. So, it can be concluded that HOTS thinking is thinking that refers to the 3 highest cognitive levels of the revised Bloom's Taxonomy, which includes analyzing (C4), evaluating (C5), and creating (C6). Where analyzing is breaking information into several parts to explore understanding and relationships, compare, organize, deconstruct, interrogate, and find. Evaluating is justifying a decision or action, checking, hypothesizing, criticizing, experimenting, and assessing. Creating or making is generating new ideas, products, or ways of seeing things, designing, building, planning, producing, and creating.

The results of the 2018 PISA survey on mathematics achievement show that Indonesia is ranked 7th from the bottom. This proves that the quality of mathematics education in Indonesia is still relatively low, which means that students' mathematical thinking skills are also low. One that affects mathematical thinking is math anxiety. Anxiety is a feeling of worry, tension, and fear when facing something. According to most people anxiety is something normal, especially in learning activities. According to Peplau, the anxiety experienced by each individual has four levels, namely mild anxiety, moderate anxiety, severe anxiety, and panic (Lisma, 2019). First, mild anxiety is anxiety related to the tension experienced in everyday life. In mild anxiety, individuals are still relatively aware of their perceptions and are still open, usually indicated by closing their eyes. Second, moderate anxiety, in this phase of anxiety, the individual is focused only on the thoughts that are of concern to him, there is a narrowing of the field of perception. Third, severe anxiety, that is, the individual's field of perception is very narrow, focuses his attention on small (specific) details and he can't think of anything else. Fourth, panic is when the individual loses self-control and attention to detail because he loses control, unable to do anything even with orders. Mathematical anxiety is associated with students' feelings of tension or anxiety in working on numbers or solving problems in mathematics (Guita & Tan, 2018).Math anxiety refers to feelings of tension, confusion, and helplessness that students experience when asked to solve complex math problems, carry out math assignments in front of their classmates, and make mistakes in math (Da Zhou et al., 2022). From these definitions,This means that students who experience anxiety in mathematics do not necessarily experience anxiety in other subjects. Anxiety in Maths is easy to explain. This can be manifested through feelings of discomfort and distraction that some individuals may face when experiencing problems in learning mathematics.

According to Cavanagh and Sparrow, math anxiety is divided into three dimensions: attitudinal aspects, cognitive aspects, and somatic aspects (Dinawati & Siswono, 2020). The attitude aspect describes math anxiety based on a person's perspective or attitude towards mathematics, such as a lack of confidence to carry out activities related to mathematics. The cognitive aspect defines anxiety as a change in one's cognitive processes or knowledge of mathematics, such as confusion when faced with mathematical problems and the inability to think clearly when faced with mathematics. While the somatic aspect describes the anxiety that occurs in a person's cognitive processes or knowledge when interacting with mathematics, which is indicated by the emergence of feelings of tension, sweating in the hands and body. Students' anxiety about mathematics can trigger various cognitive, affective, and physical reactions (Nida et al., 2020).Cognitive reactions are shown in the form of negative self-talk, blank thoughts, and avoidance of mathematics. Affective reactions are shown in the form of lack of confidence, fear of looking stupid and losing identity. Physical reactions include sweating, impulses in the heartbeat, tension, and nausea. Based on the description above, this study aims to analyze the mathematical thinking processes of students of Tadris Mathematics at State Islamic University Kiai Haji Achmad Siddiq Jember in solving Higher Order Thinking Skills (HOTS) questions based on mathematical anxiety.

2. RESEARCH METHOD

This study is a descriptive qualitative research with the aim of knowing students' inquiry thinking processes when solving Higher Order Thinking Skill (HOTS) questions which require qualitative data in expressing oral and written mathematical evidence. Qualitative research method is a research method in which the researcher acts as an instrument, purposive sampling and snowball, data analysis is qualitative/inductive, collection techniques are triangulation (combined), and the results of qualitative research emphasize meaning rather than generalization. Qualitative research is based on the philosophy of postpositivism and is used to study natural object conditions (Sugiyono, 2016). This study was conducted at Kiai Haji Achmad Siddiq State Islamic University Jember. The research subjects were 6th semester students majoring in Tadris Mathematics. The subject determination technique used was purposive sampling in which the researcher took samples according to the research objectives. Purposive sampling is a sampling technique for data sources with certain considerations (Sugiyono, 2016). The researcher took one class of subjects who were students of class 1 mathematics, given a math anxiety test instrument to measure student anxiety levels which were then categorized based on the test result classification guidelines (Hakim & Alpha, 2021).

Table 2. Category of Mathematicsl Anxiety Level

Anxiety Level Category	Score Criteria
Very high	Skor > M + 1,5 S
Tall	M+0,5 S< Skor ≤ M +1,5 S
Currently	M-0,5 S< Skor ≤ M +0,5 S
Low	M-1,5 S< Skor ≤ M - 0,5 S
Very low	Skor ≤ M - 1,5 S

Data collection in this study was carried out by looking at students' mathematical thinking processes with test questions, documentation, and interviews.Data validity in this qualitative research was carried out through triangulation. The instrument used in this research is questionsHigher Order Thinking Skill(HOTS)from research (Annizar, et. al., 2020) which has been modified. Data analysis was carried out by looking at the results of the subject's work and interview transcripts. The process of data analysis uses the Miles and Huberman model, namely data reduction, data presentation, and drawing conclusions (Suhiyono, 2006). Analysis of mathematical thinking processes using Mason's mathematical thinking indicators. The study procedure in this study includes 4 stages, namely preparation, implementation, analysis, and preparation of reports (in Mawardi et al., 2020). In the preparatory stage, the researcher prepared math questions and Higher Order Thinking Skill (HOTS) questions that would be given to the subject. Implementation stage, (1)the researcher gave a math anxiety instrument which was given to math tadris students in math class 1 to find out the level of student math anxiety, (2) the researcher took five subjects who hadmath anxiety level is very high, high, medium, low, and very low,(3)the researcher gave Higer Order Thinking Skill (HOTS) questions to the subjects to do in writing and orally (think aloud or talk while working). In the analysis phase, the researcher analyzed the mathematical thinking processes of each subject. And in the fourth stage, the researcher compiled a research report.

3. RESULTS AND DISCUSSION

To find out the mathematical thinking processes of students who have very high, high, medium, low, and very low math anxiety in solving HOTS questions, the researchers gave HOTS-based test questions adapted from research (Annizar et. al., 2020) and modified. Then, the data obtained from the work of the 5 subjects (very high, high, medium, low, and very low anxiety levels), think aloud, and interview results (which were used as a complement) were processed and analyzed. The test instrument used is as follows!

Table 3. Tes Instrumen

Bacteria	65	130	260
Time	0 minute	,75 minute	1,5 hours

How many bacteria after 6 hours?

How long does it take for the bacteria ^{x} reach 1.064.960?

Then it will be explained how to develop the mathematical thinking process used by the subject to observe, investigate, find patterns from objects presented in the problem, how to use strategies and how to find results from strategies applied in solving problems. According to Meidawati in (Annizar et. al., 2020), students are emphasized to seek and find answers to a problem through their thinking processes. The 5 subjects' mathematical thinking processes in solving HOTS questions are as follows:

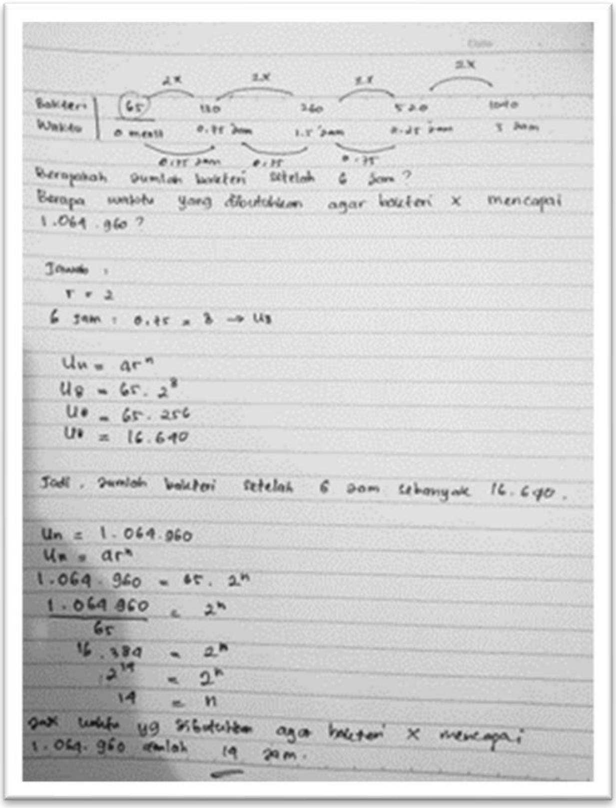

Figure 1. S1 work result

The first phase of the mathematical thinking process is Entry. At the entry stage, the indicators measured include I know, I want, introduce. When the S1 is given the HOTS question instrument, the first thing the S1 does is read and understand the questions carefully then the S1 finds things related to the questions, namely they are known and asked. Even though what is known and asked is not written down in full, when working on the S1 it is stated that the information is in the problem. Then to be able to solve the problem, S1 groups information from bacterial patterns and time including arithmetic or geometric sequences. S1 then writes down what is known in each pattern, such as ratios.

In the second phase is attack. In this phase the indicators that are measured are try, maybe, and why. At this stage, the first thing S1 did was determine the guess by looking for a value n, the way S1 divides 6 hours by 0.75 produces 8. Then S1 tries to guess what the value is n = 8 those who have been searched can solve the first problem, namely determining the number of bacteria after 6 hours. S1 can determine the number of bacteria ie 16.460. Even though in the first question, S1 was able to answer the questions correctly, the steps used were not quite right. Not only that, the general formula Un for the geometric sequence that S1 wrote wrong, it should be $U_n = ar^{n-1}$. However the answer is correct because it is in specifying the value n, S1 directly divides 6 hour with 0,75 (the difference) that produces 8. Should n = 9 because Un was at minute 0 and Un used by S1 is $U_n = ar^n$, so the answer is correct because of the value n in the formula used S1 is not reduced by one. In question 2, the first step used by S1 is correct, namely looking for a value n. But formula Un which is used incorrectly so the value n generated is wrong. S1 answered value n = 14 should be right n = 15 by formula $U_n = ar^{n-1}$.

Then job S1 stops until the value n course, and replied that the time needed is 14 hours. It should still continue to determine the time needed, namely by formula $U_n = a + (n-1)b$ because when it satisfies the conditions of an arithmetic sequence. In this case S1 does not understand the geometric sequence formula. The 3rd phase is a review which includes check, reflect, and extern. S1 does not meet the indicators in this phase because S1 does not check the accuracy of the suitability of the completion steps with the questions and does not look for other solutions.

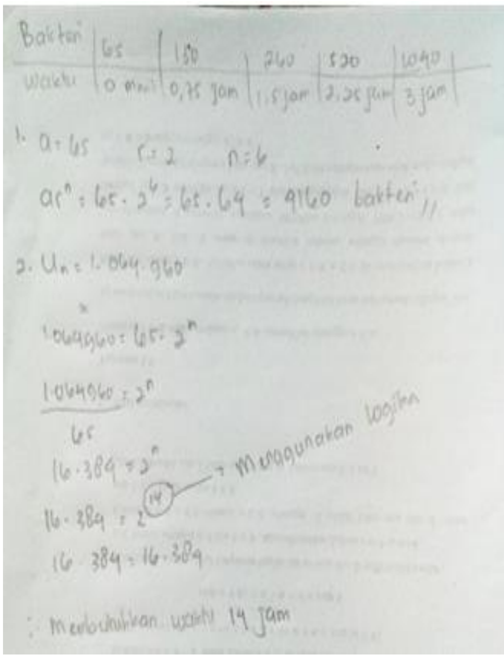

Figure 2. Masters Work Result

In the first phase of entry, S2 did not understand the questions carefully. S2 is able to determine what is known and asked. This is proven by, S2 is able to write r = 2, n = 6 and a = 65. However, S2 assumes that the ratio between time and bacteria is the same, namely 2. Conjecture in the first problem n = 6 wrong. This is of course wrong, because of the value 6 here is not a value n but value U_n. In the attack phase, after making assumptions about the first problem, S2 uses these assumptions to solve the first problem by substituting what S2 has written into the formula U_n for geometric sequences. The formula written by S2 is $U_n = ar^n$, this should be wrong $U_n = ar^{n-1}$. In question 2, the first step used by S2 is correct, namely finding the value n. But formula U_n which is used incorrectly so the value n generated is wrong. S2 answers value n = 14 should be rightn = 15 by formula $U_n = ar^{n-1}$.

Then job S2 stops until the value n course, and replied that the time needed is 14 hours. It should still continue to determine the time needed, namely by formula $U_n = a + (n-1)b$ because at time it satisfies the conditions for an arithmetic sequence so that the answer is correct 10,5 o'clock. In this case S2 does not understand the geometric sequence formula. In phase 3 of the review, S2 did not meet the check, reflect, and extend indicators, because S2 did not check the accuracy of the suitability of the completion steps with the questions and did not look for other solutions.

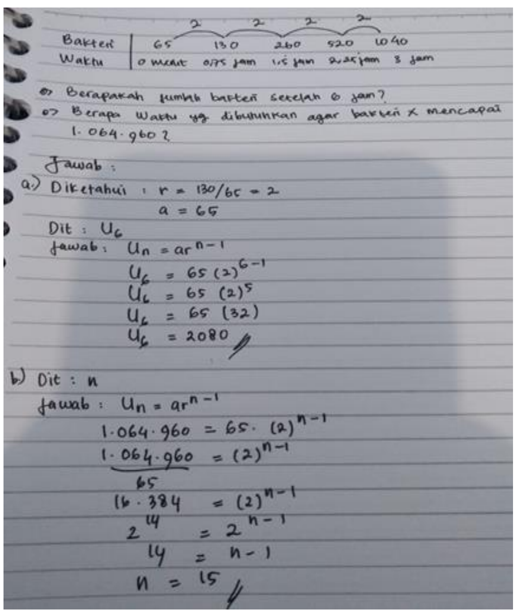

Figure 3. S3 Work Results

S3 in the first phase, namely Entry, S3 does not understand the problem carefully. S3 is able to determine what it knows and asks. This is proven by, S3 is able to write r = 2 and a = 65. However, S3 does not write down b (different) from time. S3 said that the ratio between time and bacteria was the same, namely 2. This was said when S3 was working.

Then in phase 2 for the first alignment, S3 made a guess at the solution regarding the number of bacteria after 2 o'clock. S3 suspects that what was asked in the first question is U_6. This is of course wrong because of value 6 here is not a value n but value U_n. Then S3 tries the conjecture that has been made to solve the problem using the formula $U_n = ar^{n-1}$ with value n = 6, a = 65, and r = 2. The formula used by S3 is correct for the first problem, namely finding the number of bacteria, but S3 is not careful in reading what is known so that he thinks6 as value n, should be value n can be determined by the formula $U_n = a + (n-1)b$ with U_n = 6, a = 0, and b = 0, 74 then value n = 9.

For the second question, in the S3 entry phase write down what is asked is the value n. This is of course wrong because in the second question asked is U_n time, that is how long it takes for the bacteria to x reach 1.064.960. For the first step in the second problem solving stage, S3 answered correctly, namely looking for a value n first before searching U_n with n = 15. However, S3 stops here, not continuing to look for values $U_n = a + (n-1)b$. This is because S3 did not understand what was asked in the second question. In phase 3, S3 did not fulfill the check, reflect, and extend indicators, because S3 did not check the accuracy of the suitability of the completion steps with the questions and did not look for other solutions.

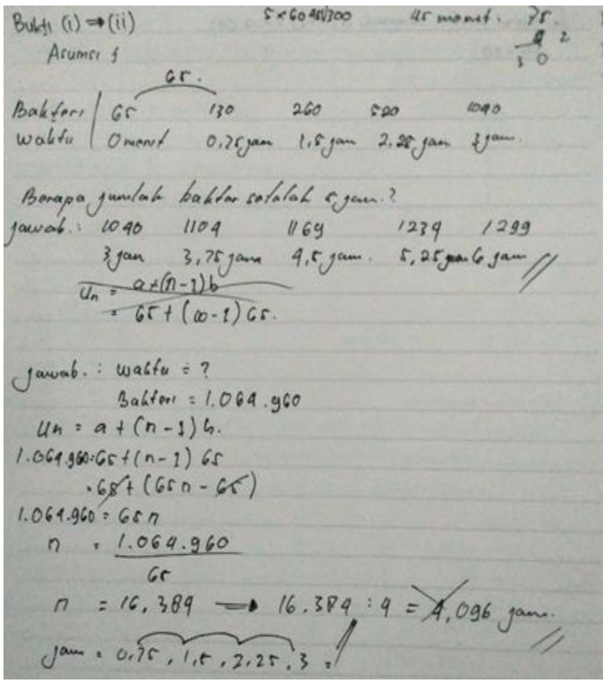

Figure 4. S4 Work Results

In the first phase of entry, S4 did not understand the questions, especially on sequences (geometry and arithmetic) and was not careful in finding things that were known and asked. This can be seen when S4 writes the ratio of bacteria, S4 writes b = 65, for the difference U_1 to U_2 65 right, but henceforth wrong. This is because S4 does not identify from what is known (bacteria and time) included in an arithmetic or geometric sequence. The ratio in bacteria should be $r = \frac{U_2}{U_1} = \frac{130}{65} = 2$ because the bacterial sequence is a geometric sequence. In the second phase of the attack in solving the first problem, S4 does not use geometric sequence formulas or arithmetic sequences but uses a known pattern. However, S4's answer regarding the bacterial count after 6 hours is 1299, this is of course wrong. This happens because when S4 determines the guess, S4 is wrong, namely the guess about b = 65 when it should be r = 2 because of the geometric sequence.

In solving the second problem, S4 has written down what it knows, namely bacteria U_n = 1.064.960. However, the formula used by S4 is wrong, because S4 uses a formula $U_n = a + (n-1)b$ should use the geometric sequence formula $U_n = ar^{n-1}$. Not only that the S4 suspects on the second issue it asks is value n even though what is asked is the value U_n (arithmetic sequence because the time series pattern is an arithmetic sequence), with answers n = 16,384. Should n = 15 find the geometric sequence formula. In this case S4 is not careful in identifying geometric sequences and arithmetic sequences. In addition, S4 did not understand what to look for in the questions. In phase 3, S4 did not fulfill the check, reflect and extend indicators, because S4 did not check the accuracy of the suitability of the completion steps with the questions and did not look for other solutions.

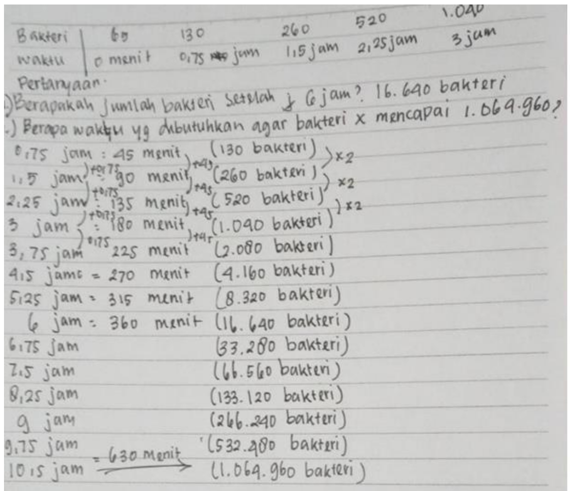

Figure 5. S5 Work Result

In the first phase of entry, S5 was able to understand the questions thoroughly and was able to find out what was known and what was being asked. S2 wrote down r = 2 for bacteria and write down the difference in time ie 0,75. In this case S5 is able to answer the first and second problems correctly. For the first problem, namely the number of bacteria after 6 hours, S2 answered 16.640 and for the second problem which is the time it takes for the bacteria to reach 1.064.960, S2 replied 10,5 It's just that in solving the problem, S2 does not use geometric and arithmetic sequence formulas.

4. CONCLUSION

Based on the results of the research and discussion, it shows that students with very high math anxiety fulfill the entry phase with the I know, I want, and Introduced rubik. Fulfilling the attack phase which includes try, may be, why. However, it does not meet the review phase which includes check, reflect, and extend. This is evidenced by S1 correctly answering the first question and incorrectly answering the second question. This is because S1 wrote the wrong formula, besides that S1 also did not continue the work to determine the time needed for the bacteria to form x reach 1. 064.960. As shown in Figure 1, the S1 job stops until the value n just. The second subject (S2) with a high level of math anxiety. In the entry phase, S2 fulfills the I know and I want rubik, but does not meet the introduce rubik, the proof is that S2 assumes that the ratio between bacteria and time is the same. In the attack phase, S2 fulfills the try, may be, and why rubik. However, S2's answer to the first and second questions is wrong, this is because S2 wrongly guessed that n = 6 and the formula used is wrong. S2 in the review phase does not meet the check, reflect, and external phases.

The third subject (S3) with a moderate level of anxiety. In the entry phase, S3 fulfills the I know and I want rubik. But on rubik I know S3 doesn't understand the problem well. However, S3 does not fulfill the Rubik's introduce, the proof is that S3 assumes that the ratio between bacteria and time is the same. In the attack phase, S3 fulfills the try, maybe, and why rubik. However, S3's answer to the first question is incorrect due to grades nwrongly used. But S3's answer to the second question is correct in the initial step of determining values n. But S3 does not proceed to the next step to find the required time. This is because S3 doesn't quite understand the question. So in this case S3 does not meet the review phase. Fourth subject (S4) with a low level of anxiety. In the entry phase, S4 fulfills the I know and I want rubik even though it is only in the activity of understanding the questions, but S4 does not fulfill the introduce rubik. It can be seen that S4 did not write down clearly what was known in the problem. In the attack phase, S4 fulfills the try, may be, and why rubik, even though the answers to the second and third questions are wrong. In the review phase, S4 does not meet the check, reflect, external indicators.

The fifth subject (S5) has a very low level of math anxiety. In the entry phase, S5 fulfilled the I know, I want, and introduce indicators, even though S4 did not clearly write down what was asked and what was known. In the attack phase, S5 fulfills the try, may be, and way indicators. This is proven by S5 being able to solve the first and second questions. In the review phase S5 fulfills the Rubik's check with evidence that S5's answers are correct, but S5 does not fulfill the Reflect and Extern Rubik. This is proven by S5 not writing down the general form or the general formula for geometric and arithmetic sequences.

AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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