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Analysis of Mathematical Reasoning Ability Reviewed Based on the Level of Mathematical Anxiety

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Abstrak

Kemampuan penalaran matematika merupakan kemampuan dasar yang harus dimiliki oleh siswa. Oleh karenanya guru sebagai pendidik, harus dapat meningkatkan kemampuan penalaran matematika selama proses pembelajaran sekaligus mengurangi hambatan siswa dalam belajar matematika. Namun demikian kenyataanya ada hambatan kecemasan yang dialami oleh siswa yang tidak diketahui. Tujuan penelitian ini adalah untuk menganalisis dan mendeskripsikan kemampuan penalaran matematika siswa ditinjau berdasarkan tingkat kecemasan matematika. Penelitian ini adalah penelitian kualitatif dengan metode deskriptif. Subjek dalam penelitian berjumlah 6 orang siswa yang dipilih dari tiap kategori kecemasan matematika. Instrumen pendukung dalam penelitian ini meliputi: 1) Angket Kecemasan Matematika; 2) Tes Kemampuan Penalaran matematika; 3) Pedoman Wawancara. Dari hasil analisis diketahui bahwa siswa dengan tingkat kecemasan matematika rendah yaitu S1 dan S2 dapat memenuhi 3 dari 4 indikator penalaran matematika; siswa dengan tingkat kecemasan matematika sedang yaitu S6 mampu memenuhi 1 dari 4 indikaor penalaran matematika dan S16 tidak mampu memenuhi semua indikator penalaran matematika; siswa dengan tingkat kecemasan matematika tinggi yaitu S11dan S20 tidak mampu memenuhi semua indikator penalaran matematika. Hasil penelitian ini diharapkan dapat menjadi referensi dan pertimbangan bagi peneliti lain dan guru dalam memilih strategi pembelajaran sehingga dapat meningkatkan kemampuan penalaran matematika sekaligus mengurangi tingkat kecemasan siswa.

Kata kunci: Analisis Matematika, Kemampuan Penalaran Matematika, Kecemasan Matematika

Abstract

Mathematical reasoning ability is a basic ability that must be possessed by students. Teachers as educators must be able to improve to learning mathematics. However, in reality there are anxiety barriers experienced by students who are not known. The purpose of this study was to analyze and describe students' mathematical reasoning abilities in terms of their level of math anxiety. This research is a qualitative research with descriptive method. Supporting instruments in this study include: 1) Mathematical Anxiety Questionnaire; 2) Mathematical Reasoning Ability Test; 3) Interview Guidelines. The Result known that students with low levels of math anxiety, namely S1 and S2, can fulfill 3 of the 4 indicators of mathematical reasoning; students with a moderate level of math anxiety, namely S6 were able to fulfill 1 of 4 indicators of mathematical reasoning and S16 were not able to fulfill all indicators of mathematical reasoning; students with high levels of math anxiety, namely S11 and S20, were unable to fulfill all indicators of mathematical reasoning. The results of this study are expected to be a reference for other researchers and teachers in

choosing learning strategies so that they can improve mathematical reasoning abilities while reducing students' anxiety levels.

Keywords: Analysis of Mathematical*, Mathematical Reasoning Ability, Math Anxiety*

1. INTRODUCTION

Mathematics education taught in schools is part of the cognitive domain (Effendi R, 2017). One of the subjects that plays an important role in developing the potential of students in school is mathematics. Mathematics is a science that forms the basis for the development of natural science and information technology and plays an important role in the development of students' thinking skills (Saraswati, et al, 2020) . According to Andamon & Tan (2018) mathematics is very important and useful for solving problems in various fields such as astronomy, business, computer science, economics, navigation, physics, and statistics. Mathematics is a living subject which seeks to understand patterns that permeate both the world around us and the mind within us (Schoenfeld, 2016). This is in accordance with the Basic and Secondary Education Content Standards, that mathematics subjects must be taught to all students starting from the elementary school level (Hadiana D, 2017). So, that students have the ability to think logically, systematically, analytically, creatively and critically, as well as the ability to work together (BSNP, 2006) . Mastery of mathematical material is important to support the development of academic success, because students who master mathematics have a strong foundation for studying other subjects both at the same educational level and at the university level (Yaseer, 2014).

Mathematics has an important position in school education in accordance with the objectives of learning mathematics. In Permendiknas No. 22 of 2006 concerning SMA/MA qualification standards (Ministry of National Education: 2006), the objectives to be achieved in learning mathematics are as follows; 1) understanding of mathematical concepts, explaining relationships between concepts and applying concepts or algorithms in a flexible, careful, effective and accurate manner in mathematical communication; 2) Reasoning about formulas and properties, performing mathematical manipulations in generalizations, preparing evidence or explaining mathematical ideas and statements; 3) completing assignments, which include the ability to understand problems, draw mathematical models, complete models and interpret solutions obtained; 4) convey ideas through symbols, tables, diagrams or other means used to explain situations or problems; 5) having an attitude of appreciating the usefulness of mathematics in life, namely curiosity, concern and interest in learning mathematics as well as persistence and confidence in mathematical communication. Based on this goal, mathematical reasoning ability is an ability that must be possessed by students in the learning process.

Reasoning is a basic ability that students should have (Lithner, 2008) . Reasoning has an important role in mathematics because it serves as a rhythm for other standard processes (Kusumawardani DR, 2018). This is also emphasized by the existence of reasoning abilities that must be mastered by students as stated in the Minister of Education and Culture Regulation No. 21 of 2016. By reasoning one can find a way out of a problem then produce an accurate decision (Jäder et al., 2017). A theory put forward by scientists and mathematicians greatly determines their reputation. The truth of the theory put forward is obtained by associating one fact with another through valid reasoning (Atmajaya, 2017) .

Reasoning is an act or process of thinking to conclude and make a new statement based on previous statements that have been proven true (Green et al., 2017). According to Boesen et al., (2010) the reasoning in question is a way of thinking, a flow of thought that is adopted to produce affirmations and reach conclusions. Through reasoning, one can think logically and critically. One's foundation for gaining mathematical knowledge is to have reasoning abilities. Through reasoning abilities, one can decide and conclude things related to everyday life (Kurnia Putri et al., 2019). Thus it can be

concluded that mathematical reasoning ability is the ability to solve mathematical problems by thinking logically and critically through the activities of gathering facts, analyzing, giving arguments, compiling and testing conjectures, and drawing conclusions.

The importance of reasoning abilities in building mathematical knowledge is inversely proportional to the condition where students' mathematical reasoning abilities, especially in Indonesia, are low. Even though reasoning ability is considered a successful solution in solving mathematical tasks (Boesen et al., 2010). Another fact that shows low mathematical reasoning ability can be seen from the ranking of Indonesian students in the PISA (Program for International Student Assessment) event which was ranked 74 out of 79 participating countries in 2018 (OECD, 2019b). One of the focuses of the PISA assessment according to the OECD (2019a) is mathematical literacy which includes individual capacities to formulate, use, and interpret mathematics in various contexts, as well as mathematical reasoning and the use of mathematical concepts, procedures, facts and tools to describe, explain, and predict phenomena. Thus, there must be knowledge or anticipatory action to find out students' obstacles in mathematical reasoning. The reasoning ability referred to in this study is the mathematical reasoning ability proposed by Gustiadi et al (2021) including: (1) making conjectures; (2) perform mathematical manipulation; (3) compiling evidence, providing reasons or evidence against the correctness of the solution; and (4) draw conclusions.

Based on a preliminary study of students by analyzing the results of daily tests, it is known that most students have not been able to fulfill all indicators of mathematical reasoning. The inability of students to fulfill all indicators of mathematical reasoning is allegedly influenced by students' mathematical anxiety. Feeling worried, tense, nervous and afraid when faced with math problems is called math anxiety (Nugroho & Widjajanti, 2019). Meanwhile, Milovanović (2020) explains math anxiety as a negative response as long as it is related to content or things related to mathematics. Thus, it can be concluded that mathematics anxiety is a condition in which a person, in this case a student, feels nervous, uncomfortable, and has negative prejudice towards anything related to mathematics both in the classroom and in the everyday environment (Qausarina, 2016). The results of other studies also show that students with low achievement, poor math abilities and skills are caused by high levels of anxiety (Musa & Maat, 2021).

The anxiety referred to in this study is stated by Cavanagh & Sparrow (2010) that math anxiety is divided into 3 aspects, namely: 1) Somantic; 2) Cognitive; and 3) Attitude. Each aspect has several categories of anxiety, including high anxiety, moderate anxiety, and low anxiety. From several studies that have been conducted, the research approach used is quantitative and the research focus is only on seeing the extent to which anxiety affects reasoning abilities. Thus, the researcher considers that qualitative research using descriptive methods with regard to mathematical reasoning abilities in terms of the level of mathematical anxiety is important to do as knowledge or anticipatory action to find out students' obstacles in mathematical reasoning. So, the results of this study can be an illustration and reference for teachers to design learning that can minimize anxiety, and anticipate learning obstacles experienced by students.

2. METHOD

This study uses a qualitative approach with descriptive methods. According to Hardani et al (2020) qualitative research seeks to understand in depth and more broadly about social situations and also to produce new knowledge and hypotheses from the subjects studied which are carried out naturally or naturally in accordance with what is without manipulation. Meanwhile, the descriptive method seeks to describe, explain, describe and explain the problem in more detail (Hardani et al., 2020). The problem referred to in this study is regarding mathematical reasoning abilities in terms of students' mathematical anxiety. The research was conducted at a private high school in the city of Sukabumi on November 10-29 2022. The subjects in this study were 21 grade 12 students who had received distance learning material in three dimensions. Furthermore, the research selects subjects

to be studied in more depth according to the level of math anxiety by paying attention to students' communication skills so that they are able to convey information properly so that researchers can obtain in-depth information. The selection was made by reducing 21 students based on the results of a questionnaire with different levels of anxiety. The subjects selected were 6 subjects consisting of 2 students with a high level of math anxiety, 2 students with a moderate level of math anxiety, and 2 students with a low level of math anxiety. Supporting instruments in this study were anxiety questionnaires, reasoning tests, and interview guides.

The research data was obtained by administering an anxiety questionnaire and a mathematical reasoning ability test. The questionnaire instrument consists of 18 statements consisting of positive and negative statements using a Likert scale with 4 answer choices (Strongly Agree, Agree, Don't Agree, Strongly Disagree) adopted from Putri et al (2020). For positive statements, they were given a score of SA = 1, A = 2, DA = 3, SD = 4 and for negative statements, they were given the opposite score. After the data is collected, it is then analyzed using the data analysis proposed by Miles & Huberman (1992:20) which includes data collection, data reduction, data presentation, and drawing conclusions. The data collection stage includes dissemination, filling out an anxiety questionnaire, and administering a mathematical reasoning ability test. The data reduction stage includes the activities of sorting and reducing where the main data is needed and data that is not needed by selecting data that is relevant to the research objectives. The data presentation stage includes displaying data in the form of narrative text, images, and tables of student questionnaire results, and student test results. The conclusion drawing stage is a researcher's activity in answering the problem formulation that was described earlier in the hope that there will be new findings that have never existed. At this stage, it was concluded that the results of the descriptive analysis regarding the ability to understand concepts and mathematical reasoning abilities were reviewed based on the level of students' mathematical anxiety.

3. RESULT AND DISCUSSION

Data on student anxiety was obtained by administering a math anxiety questionnaire with the aim of grouping students based on the level of math anxiety into the categories of low anxiety, medium anxiety, and high anxiety. This math anxiety questionnaire consists of 30 statements with 4 answer choices adapted from the anxiety questionnaire developed by Putri et al (2020) then the researchers reduced them as needed to 18 statements representing each indicator of math anxiety which is attached in Appendix 3. This math anxiety questionnaire is given to 21 grade 12 students face to face. Before students filled out the math anxiety questionnaire, the researcher first gave an explanation of how to fill out the math anxiety questionnaire. The time given to students to fill out the math anxiety questionnaire is approximately 20 minutes. All of the answers from the students that have been collected are then entered into the Microsoft Excel 2010 application to be converted into interval data scores using the Method of Successive Interval (MSI) application. The data that has been changed is then summed and analyzed to determine the category of math anxiety for each student. The criteria for determining the category of math anxiety are in table 1.

Table 1. Criteria for Mathematics Anxiety Level

Criteria	*Deskription*
$X < 42$	Low
$42 \leq X < 54$	Medium
$X \geq 54$	Hight

Adopted from Azwar (2015)

The results of grouping class 12 students according to the level of math anxiety are presented in Figure 1 below.

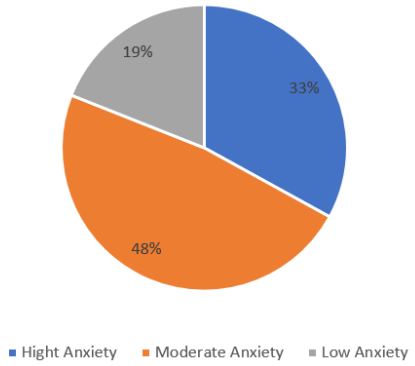


Figure 1. Percentage of Mathematics Anxiety Level

Based on Figure 1 it is known that students have various levels of math anxiety. The level of math anxiety that most students feel is moderate, namely as many as 10 students (10%). There were 7 students (33%) with low levels of math anxiety and 4 students (19%) with high levels of anxiety.

After analyzing the results of the math anxiety questionnaire and grouping them based on the level of math anxiety, the researchers chose 12 students as research subjects based on the results of the achievement indicators of mathematical reasoning. The selected subjects consisted of 2 students with a low level of math anxiety, 2 students with a moderate level of math anxiety, and 2 students with a high level of math anxiety. The selection of subjects to be studied is based on students who have good communication. It is intended that in digging up information from research subjects and researchers obtaining in-depth information. In fulfilling these criteria the researcher observed each student from starting to fill out the math anxiety questionnaire. The following is a list of selected research subjects, presented in table 2.

Table 2. Selected Research Subjects

Anxiety Category	*Subject Code*	*Sum*
Low Anxiety	S1, S2	2
Moderate Anxiety	S6, S16	2
Hight Anxiety	S11, S20	2

After the test results were collected, interviews were then conducted with 6 selected subjects with the aim of obtaining in-depth information and confirming the results of the mathematical reasoning test answers. From the 6 selected subjects, the results of the analysis of mathematical reasoning abilities that meet each indicator based on the level of mathematical anxiety are presented in table 3.

Table 3. Achievement of Mathematical Reasoning Indicators

Kategori Kecemasan	*Subject Code*	*mathematical reasoning indicator to-*				*Percentage*
		1	*2*	*3*	*4*	
Low Anxiety	S1	√	√	√	-	75%
	S2	-	√	√	√	75%
Moderate Anxiety	S6	-	√	-	-	25%
	S16	-	-	-	-	0%
Hight Anxiety	S11	-	-	-	-	0%
	S20	-	-	-	-	

Based on table 3, it can be seen that students with low anxiety levels are able to fulfill 75% of the indicators of reasoning, students with moderate levels of anxiety are only able to fulfill 25% of the indicators of reasoning, and students with high levels of anxiety are unable to fulfill all indicators of mathematical reasoning.

Figure 2 is the student's answer to question number 4 which contains the ability to give reasons for the correctness of the solution. Students with a low level of anxiety, namely S1 subjects with a little stimulus during the interview, can name the line segment that represents the answer point W to QR and the reason why WR is the line that represents the distance between W and QR. Meanwhile, subjects with code S2 could not say exactly the line segment representing the answer point W to QR. Students with moderate and high levels of anxiety, namely S6, S16, S11 and S20, could not name the line segment that represents the answer from point W to QR.

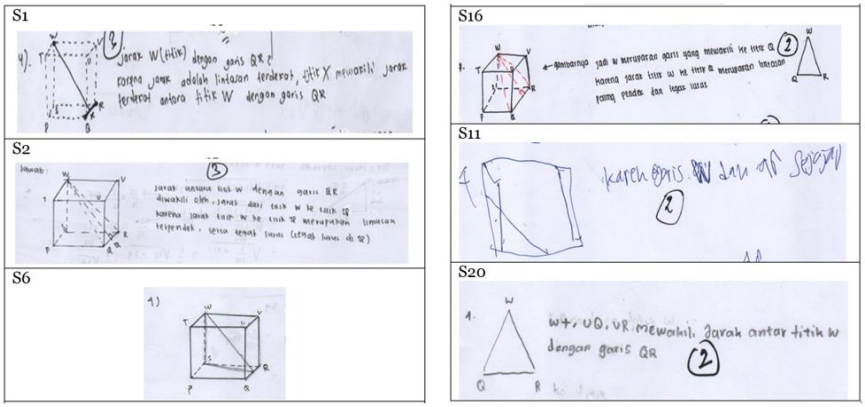


Figure 2. Student Answer Results

Figure 3 is the student's answer to question number 5a which contains the ability to make conjectures. Students with low anxiety levels, namely S1 and S2 Subjects, can determine the triangle formed by writing down the answer that ATC is an equilateral triangle because all sides have a length of 10 cm according to the calculation results. Students with a moderate level of anxiety, namely subject S6, can say that ATC is an equilateral triangle because TA = TC = AC = 10 cm precisely. Meanwhile, S16 states that ATC is an isosceles triangle. Students with high levels of anxiety, namely S11 and S20, could not name the type of triangle in the ATC triangle that was formed.

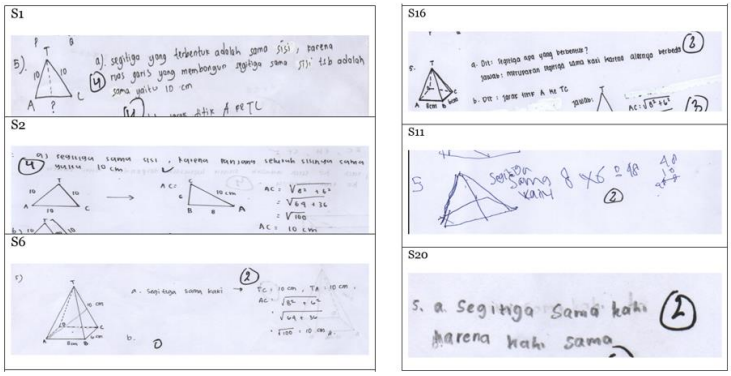
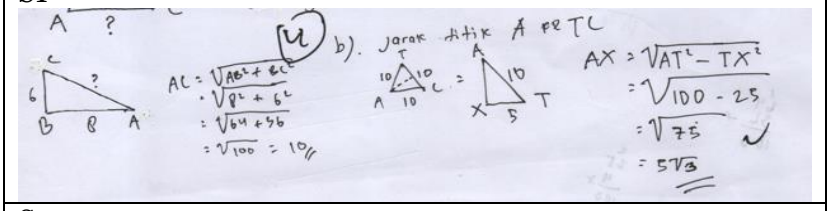


Figure 3. Student Answer Results

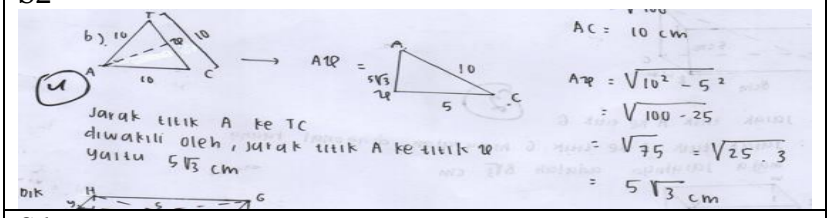
Figure 4 is the student's answer to question number 5b which contains the ability to perform mathematical manipulation. Students with low anxiety levels, namely S1 and S2 subjects, can choose

a method or method to determine the distance from point A to the TC line, namely by using the concept of the Pythagorean theorem. Students with moderate and high levels of anxiety, namely S6, S16, S11 and S20 cannot but determine what method to use to work on question number 5b.

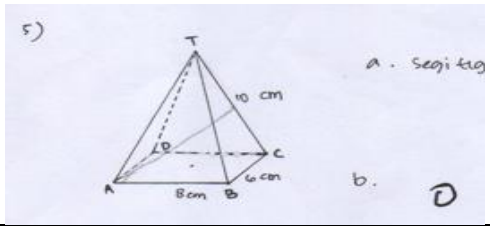
S1



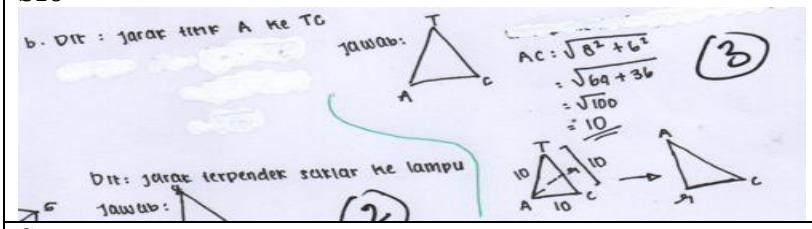
S2



S6



S16



S11

S20

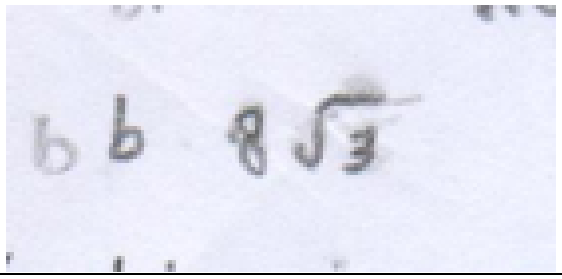
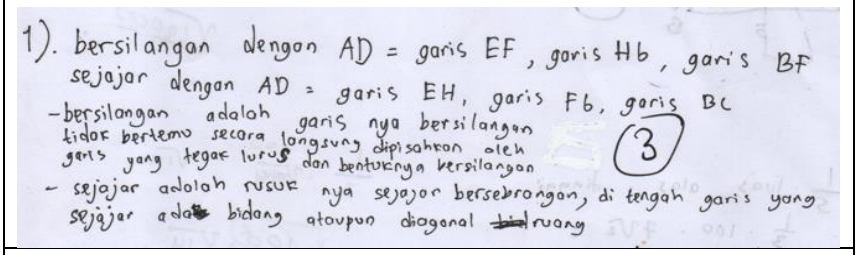


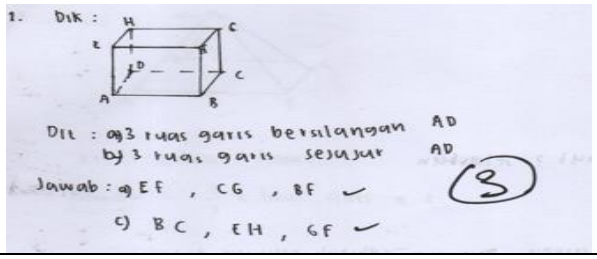
Figure 4. Student Answer Results

Figure 5 is the student's answer to question number 1 which includes the ability to draw conclusions from a statement. Students with a low level of anxiety, namely Subject S1, cannot conclude with respect to crossed lines and parallel lines. While subject S2 can conclude with respect to crossed lines and parallel lines. Students with moderate and high levels of anxiety cannot provide conclusions regarding the two lines that cross and are parallel to each other.

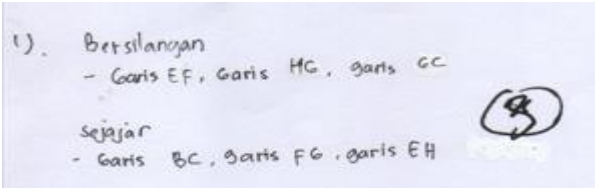
S1



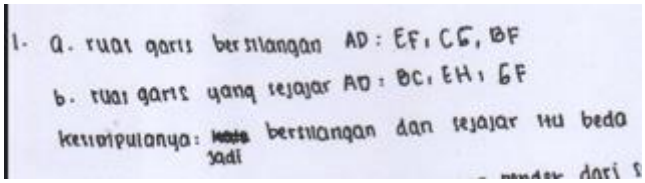
S2



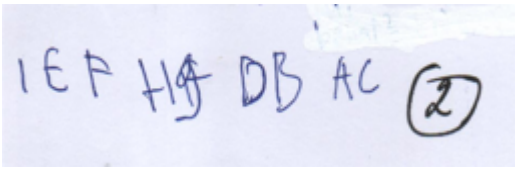
S6



S16



S11



S20

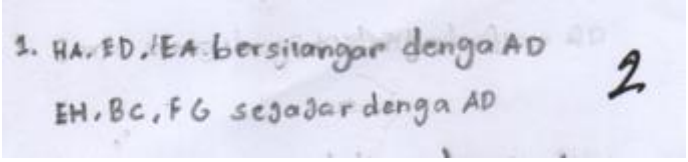


Figure 5. Student Answer Results

Based on the results of the analysis and description it is known that students with low anxiety, namely S1, are able to give reasons for the correctness of solutions, are able to make conjectures, and are able to perform mathematical manipulations. However, the S1 subject was unable to meet the indicators to draw conclusions from a statement. Whereas subject S2 is able to make conjectures, is able to perform mathematical manipulations, and is able to draw conclusions from a statement but is unable to provide reasons for the correctness of the solution. Overall, all subjects were able to fulfill most or even all of the indicators of mathematical reasoning. This is in line with the results of Wafirah's research (2018) which found that students with low anxiety levels were able to fulfill all indicators of reasoning. Students with a moderate level of anxiety, namely S6, are able to make assumptions but are unable to provide reasons for the correctness of the solution, perform mathematical manipulations. However, unable to make conjectures able to draw conclusions from a statement. While subject S16 was unable to fulfill all reasoning indicators. The results of the analysis show that there are students with moderate math anxiety who do not meet the mathematical reasoning indicators. This is contrary to the results of Wafirah's research (2018) that students with moderate anxiety are able to fulfill two indicators of reasoning. Students with high levels of anxiety, namely S11 and S20, are unable to provide reasons for the correctness of solutions, make conjectures, perform mathematical manipulations, and are able to draw conclusions from a statement. but unable to provide reasons for the correctness of the solution. Students with high levels of anxiety tend to have difficulties and have obstacles in giving reasons, making conjectures, doing algebraic manipulation and drawing conclusions from a statement. This is in line with Caglar & Senol (2021) and Samuel & Warner (2021) which state that anxiety about mathematics presents learning barriers for students.

Overall the mathematical reasoning abilities of students with low math anxiety levels were able to fulfill most of the mathematical reasoning indicators. As for students with moderate levels of anxiety, they are only able to fulfill a small proportion of mathematical reasoning indicators. While students with high levels of anxiety cannot fulfill all indicators of mathematical reasoning.

In order to obtain comprehensive knowledge regarding the results of the analysis of the ability to understand concepts and mathematical reasoning reviewed based on the level of mathematical anxiety, it can be seen in Figure 6.

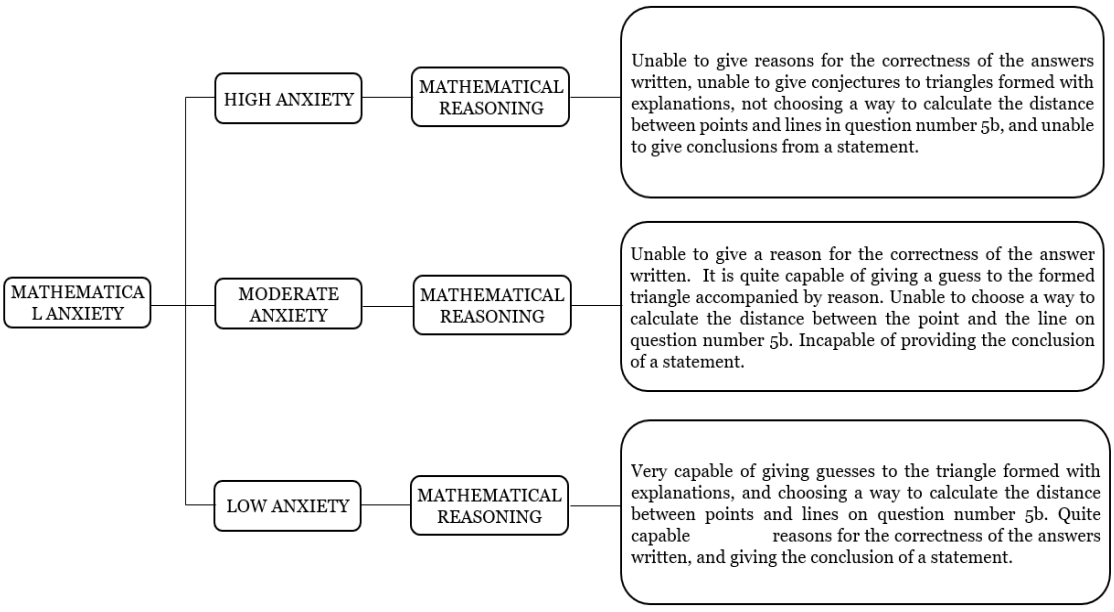


Figure 6. Outline chart of research results

It is hoped that the chart of the results of this study can provide knowledge regarding mathematical reasoning abilities in terms of the level of mathematical anxiety in accordance with the purpose of this study, which is to provide an overview regarding mathematical reasoning abilities in terms of the level of mathematical anxiety.

4. CONCLUSION

Based on the results of the analysis of the findings and discussion, several conclusions were obtained, namely: 1) students with low levels of anxiety were very capable of giving reasons for the correctness of solutions and making conjectures, quite capable of performing mathematical manipulations and drawing conclusions; 2) students with an anxiety level are quite capable of making assumptions but unable to provide reasons for the correctness of solutions, perform mathematical manipulations, and draw conclusions; 3) students with high levels of anxiety are unable to provide reasons for the correctness of the solution, unable to make conjectures, unable to manipulate mathematics, and unable to draw conclusions. In general, only students with a low level of math anxiety tend to be able to fulfill most of the indicators and have no obstacles in achieving the indicators of mathematical reasoning. Meanwhile, students with moderate and high levels of math anxiety were unable to fulfill all indicators and also experienced difficulties and obstacles in fulfilling mathematical reasoning indicators.

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