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Analysis of Mathematical Problem Solving Ability of Junior High School Students Based on Polya's Stages in View of Math Anxiety Levels

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Abstract
This study aims to describe mathematics anxiety, the factors that cause it, and the mathematical problem solving ability of junior high school students based on Polya's stages and the level of mathematics anxiety. Using a case study approach with qualitative methods, the research involved 66 eighth-grade students at SMP Negeri 24 Padang, with 14 selected as subjects representing low, moderate, and high levels of anxiety. The instruments used include math anxiety questionnaire, math problem solving test, and interviews. The results showed that: (1) 68.2% of students experience moderate anxiety, 18.2% low, and 13.6% high; (2) Students' math anxiety is due to difficulty understanding formulas, exam pressure, and low self-confidence and doubts about abilities which affect motivation and performance; (3) Students' abilities at Polya's stages vary, with 61% able to understand the problem, 44% able to devise a plan, 8% able to carry out the plan, and 6% able to look back; (4) Students with low math anxiety able to follow all stages of Polya. Cognitively they are able to strategize logically, somatically there is no physical disturbance, and attitudinally they show high self-confidence; (5) Students with moderate anxiety show variations in ability. They understand the problem, but procedural errors often occur. Somatic symptoms such as tension disrupt focus, and attitudinally appear hesitant and lack confidence; (6) Students with high anxiety are only able to understand the problem. Their cognition is limited, somatic symptoms such as trembling, and attitudinally they tend to be afraid of failure and reluctant to try.

INTRODUCTION

Education is an important aspect of human life because it plays a role in shaping the quality of a country's Human Resources (HR). In the era of information and technology that continues to develop, education is the foundation in dealing with changes in various fields of life. One of the fundamental subjects that must be mastered by students from elementary to college level is

mathematics, because mathematics plays a role in developing thinking power and is the basis for various disciplines.

Mathematics not only serves as a science of arithmetic, but also as a means to train students in thinking logically, critically, and systematically. The National Council of Teachers of Mathematics (NCTM) emphasizes five important standards that must be mastered in learning mathematics, namely problem solving, reasoning and proof, communication, connection, and representation. This is also reinforced by the OECD through PISA which mentions eight competencies that students need to have, and by the Ministry of Education and Culture with 21st century competencies known as 4C (Critical thinking, Creativity, Communication, Collaboration).

One of the important competencies in learning mathematics is problem solving ability. Problem solving is at the core of effective mathematics learning because it allows students to apply knowledge in real situations. Through problem solving, students are trained to understand the problem, develop a strategy, implement the plan, and review the solution obtained, as described in Polya's problem solving stages.

Problem solving skills remain a challenge for many students, including in Indonesia. These skills are essential to face the challenges of the 21st century and contribute to the economic and social progress of society. The results of international studies such as PISA show that the problem solving skills of Indonesian students are still relatively low. This is also in line with the findings of various studies that show that many students have difficulty in solving math problems that require problem solving.

This condition is reinforced by data from PISA Indonesia in 2022 which shows a decrease in math scores from 379 to 366. In addition, studies conducted by Utami & Wutsqa (2017), Holidun et al. (2018), and Azzahra & Pujiastuti (2020) also show that students' mathematical problem solving skills are still low. This finding shows the need for serious attention in improving these abilities.

The results of observations made by the author in one of the VIII classes at SMP Negeri 24 Padang showed that only about 20% of students were able to solve problem solving problems, while the rest had difficulty in understanding the problem because they did not write the known and questioned information completely. The results of students' answers also show weaknesses in the initial stages of problem solving, namely understanding the problem, which has an impact on the entire solution process.

One factor that is thought to influence low problem-solving skills is math anxiety. This anxiety is defined as a feeling of fear or anxiety when dealing with math, which can interfere with the learning process and student performance. Research shows that students with high math anxiety tend to have lower problem-solving skills than those without anxiety.

The theoretical model that links math anxiety as a cognitive construct is the processing efficiency theory proposed by Eysenck & Calvo 1992 in Mammarella et al. (2019). In this theory, worry is considered to be an internal process that fills consciousness during anxiety. Critically, this worry is predicted to reduce the capacity of the limited Working Memory system. Therefore, math anxiety affects cognitive functions such as working memory, which is important in problem solving. Cabanero et al., (2023) stated that math anxiety can create a negative cycle, where anxiety leads to poor performance which further increases anxiety. Cavanagh & Sparrow (2010) classified math anxiety into three aspects: somatic, attitudinal, and cognitive. In addition, they also classified math

anxiety into three levels of anxiety: low, moderate and high. All three can affect students in solving problems effectively.

Other research shows that math anxiety is negatively related to problem solving strategies. Research by Safitri et al. (2022) shows that students with low anxiety are able to complete all stages of problem solving, from understanding the problem, planning solutions, solving problems, to checking back. Conversely, students with moderate or high anxiety are only able to complete some of these stages. Students with high anxiety tend to choose simpler and less effective strategies, and are more easily stressed when facing complex problems. Meanwhile, students with low anxiety tend to be able to complete all stages of problem solving more thoroughly.

Based on this explanation, it is clear that it is important to further analyze students' problem solving abilities by considering the level of mathematics anxiety. Thus, this research aims to describe students' mathematics anxiety, identify the factors that cause it, describe the mathematical problem solving ability of junior high school students based on Polya's stages, and to describe students' mathematical problem solving ability in terms of the level of mathematics anxiety.

METHODS

This research is a qualitative research with a case study approach that aims to describe in depth the mathematical problem solving ability of students in terms of the level of mathematical anxiety. The research was conducted at SMP Negeri 24 Padang in the 2024/2025 academic year, with the subject of class VIII students who had studied the material of Number Patterns and Object Configurations. The selection of subjects was carried out by purposive sampling, totaling 66 students who were then reduced to 14 subjects based on the category of math anxiety level (high, moderate, low) and mathematical problem solving ability (high, moderate, low).

Mathematical problem solving ability in this study refers to Polya's steps: understanding the problem, device a plan, carry out the plan, and looking back. Kargar et al (Casty et al., 2021) suggested that mathematics anxiety may influence mathematics attitude towards mathematics problems directly or indirectly where students develop avoidance behaviors towards mathematics. Thus, math anxiety is defined as a negative emotional response to mathematical activities. According to Cavanagh & Sparrow (2010a), a person's math anxiety can be seen through three indicators, namely attitude, cognitive, and somatic.

The main instrument of this study was the researcher himself, while the auxiliary instruments consisted of tests, questionnaires, and interview guidelines. The test was in the form of a story problem to measure mathematical problem solving ability; the math anxiety questionnaire was adopted from Cavanagh & Sparrow (2010b) translated by Agusantia (2023); and the interview was conducted in a semi-structured manner to dig deeper into the test results and the causes of students' math anxiety. The following is a table of math anxiety indicators according to Cavanagh & Sparrow (Hakim & Adirakasiwi, 2021).

Table 1. Math Anxiety Indicators

Math Anxiety Indicators			
Level of Anxiety	*Attitudinal*	*Cognitive*	*Somatic*
High Anxiety	Feeling scared to do something	Worrying about what people think they can't do	Difficulty breathing

Moderate Anxiety	Not wanting to do what has been done	Blank mind	Heart rate increased from normal
Low Anxiety	Expecting to get into trouble	Feeling confused	Feeling uncomfortable during learning

To determine the students' math anxiety level, the mean and standard deviation of the overall questionnaire score were calculated. Then, the scores were classified into three groups as listed in Table 2.

Table 2. Math Anxiety Level Category

Interval	Category
$x < M - SD$	Low
$M - SD \leq x < M + SD$	Moderate
$x \geq M + SD$	High

Keterangan:

x : Students' math anxiety score

M : Mean

SD : Standart deviation

Data were analyzed using the Miles and Huberman model Sugiyono (2012) which includes data collection (tests, questionnaires, interviews, and documentation), data reduction (selection of important data and categorization based on learning styles and anxiety), data presentation in narrative and tabular form, and conclusion drawing. Data from interviews were converted into written form and linked to test results. The number of subjects interviewed included 4 students with low anxiety (R1-R4), 6 with moderate anxiety (S1-S6), and 4 with high anxiety (T1-T4).

RESULT AND DISCUSSION

1. Students' Math Anxiety

Data on students' math anxiety were collected through a questionnaire consisting of 21 statements with a 4-point Likert scale, covering three components: cognitive (9 items), somatic (6 items), and attitudinal (6 items). The math anxiety questionnaire was administered to 66 Grade VIII students face-to-face. After collecting the questionnaire data, the data were analyzed based on table 2 to determine the category of mathematics anxiety of each student. Thus, the category of students' math anxiety is obtained as follows.

Table 3. Math Anxiety Level Category

Interval	Category
$x < 45{,}21$	Low
$45{,}21 \leq x < 64{,}69$	Moderate
$x \geq 64{,}69$	High

Based on data analysis, the distribution of students according to the level of math anxiety is presented in Table 4 below:

Table 3. Math Anxiety Level Category

No.	Math Anxiety Level Category	Total
1.	Low	12 Students

2.	Moderate	45 Students
3.	High	9 Students

The analysis showed that most students (68.2%) had moderate math anxiety, followed by low (18.2%) and high (13.6%) categories. In the cognitive aspect, the most agreed statement was "I am worried that I will not be able to understand mathematics because I am aware of previous failures", indicating a learning trauma that forms negative beliefs towards oneself. In somatic aspects, the highest response was for the statement "My heart beats faster when I am asked to explain formulas during lessons", which describes spontaneous physical reactions when facing academic situations. Whereas in the attitudinal aspect, many students admitted to "worrying about what is expected of me in the future", reflecting the pressure of future expectations.

This finding is in line with Agusantia (2023) which shows the dominance of the moderate anxiety category. In terms of cognition, Hunt & Maloney (2022) revealed that negative learning experiences can decrease mathematical thinking resilience. A significant somatic response is also supported by Priyanto (2017), who mentioned that students feel their heart beat faster and sweat when asked to work on problems in front of the class. Meanwhile, the attitudinal aspect is reinforced by the findings of Tobias in(Kurniawati & Siswono (2014) and Asif & Khan (2011), which state that math anxiety has an impact on low self-confidence and a tendency to avoid math.

2. Causes of Students' Math Anxiety

The results showed that math anxiety in students arises due to various factors, both from within students and from the surrounding environment. Based on the results of interviews with students with varying levels of anxiety (low, moderate, and high), several main causes that contribute to math anxiety were found.

Students with low anxiety levels indicated that anxiety usually only arises in certain situations, such as facing difficult problems (R1: "*If there is a difficult problem, Ms., I get confused*"), problems that are different from the example, or when asked to come to the front of the class. Nevertheless, they had positive coping strategies, such as rereading the problems, discussing with friends, or asking the teacher. Subject R4 even stated: "*I like math, Ms.. It's like a challenge*" which suggests that high interest can be a protective factor against math anxiety. This is in line with the findings of Zhang et al. (2019) who mentioned that self-concept and interest in mathematics have a big role in reducing anxiety.

Meanwhile, students with a moderate level of anxiety showed anxiety when asked to answer in front of the class, mainly due to fear of being wrong and being judged by friends. S1 said: "*Afraid of getting the answer wrong, especially if asked directly in class*," while S4 revealed: "*I am anxious when I go to the front, Ms. Afraid of being seen by my friends.*" This reflects the affective component of math anxiety related to social pressure, as explained by Luttenberger et al. (2018), that anxiety often arises in evaluative situations such as presentations or when seen by others.

Subject S2 experienced anxiety due to confusion over the difference in formulas between school and tutoring, which caused hesitation and fear of mistakes. He stated: "*Sometimes the formulas taught at school and at the tutoring center are different, ma'am. I don't know which one is right*." This suggests that inconsistencies in learning can trigger cognitive stress, as described in Ramirez et al. (2018), that conflicting information and low confidence in concept understanding contribute to anxiety.

Subject S3 experienced anxiety when he saw a long story problem. He said: "*It's dizzying to see, especially if the problem is difficult*." This shows that the complexity and length of the problem can create a cognitive load that increases anxiety, especially if students feel they do not have enough solution strategies.

More intense anxiety was seen in students with high anxiety levels. Subject T1 said: "*I don't feel good, Ms. There are many formulas. If I am told to do the problem, I will be confused.*" He had tried to study, but still felt that he did not understand, even when he had asked friends. Subject T2 said: "*I can still do other subjects. But when it comes to math, I'm really scared. Afraid of getting bad grades, then my parents get angry*." This shows that low self-confidence, pressure from the environment (such as parents), and previous experiences of failure reinforce anxiety. This is reinforced by Ramirez et al. (2018) who explained that negative experiences in math learning and performance pressure can exacerbate academic anxiety levels.

In general, the factors causing math anxiety that emerged from the interviews included difficult or different problems from examples, pressure when performing in public, uncertainty due to differences in methods or formulas, feelings of inadequacy and previous failed experiences, and pressure from parental expectations.

3. Students' Mathematical Problem Solving Ability Based on Polya's Stages

The mathematical problem solving ability of junior high school students based on Polya's stages shows striking variations in each step. Based on the test results of 66 students on five description questions, it was found that most students had not achieved optimal performance at all stages.

At the stage of understanding the problem, about 61% of students were able to identify known information and questions from the problem. However, errors were still found in interpreting the problem or mentioning information unspecifically. This finding is in line with Firda et al. (2023) who stated that students with low understanding often fail to recognize key elements of the problem, which has an impact on errors in the next stage.

At the stage of devising a plan, only 44% of students can develop appropriate strategies. Common errors include inappropriate formula selection, unsystematic steps, and inability to connect information with the solution strategy. This is consistent with the findings of Erviana et al. (2020), who noted that middle and low ability students tend to understand mathematical concepts partially but have difficulty integrating them in planning.

The most striking difficulty arose at the problem-solving stage, where only 8% of students were able to carry out the plan correctly. Many students made mistakes in substitution of values, calculations, and implementation of planned strategies. As reported by Manah et al. (2017), weak procedural skills are the main inhibiting factor, reinforced by Sari et al. (2022) who highlighted the influence of negative self-concept on students' hesitation in taking the solution step.

At the looking back, only 6% of students showed the ability to reflect on their answers. Most are not accustomed to double-checking their work, so mistakes that could have been corrected are overlooked. Rosiyanti et al. (2021) asserted that reflection is still an aspect that students pay less attention to, while Taneo & Kusumah (2021) emphasized that students with lower-middle ability often ignore the process of verifying results, which has an impact on the low accuracy of answers.

Overall, these results reflect that students' mathematical problem solving skills are still dominated by limitations in planning and executing thorough problem solving. In addition, the low

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awareness of looking back the answers indicates the need to strengthen the culture of reflection in learning mathematics at school.

4. Students' Mathematical Problem Solving Ability Based on Polya's Stages in View of Math Anxiety Levels

Based on the math anxiety questionnaire, students were grouped into three anxiety levels, namely low, moderate and high math anxiety. After being analyzed and grouped based on the level of mathematics anxiety, each category of mathematics anxiety is analyzed again on mathematical problem solving ability which is also classified into three categories, namely high, moderate, and low. The results of students' mathematical problem solving ability at each anxiety level can be seen in the following table.

Table 4. Recapitulation of Students' Mathematical Problem Solving Ability in Response to Math Anxiety Levels

No.	Math Anxiety Level Category	Mathematical Problem Solving Ability Category	Total
1.	Low	Low	0 Students
		Moderate	0 Students
		High	9 Students
2.	Moderate	Low	8 Students
		Moderate	31 Students
		High	8 Students
3.	High	Low	9 Students
		Moderate	3 Students
		High	0 Students

Based on the table, it is known that all students who are in the high math anxiety category show mathematical problem solving skills at a low level, namely 9 students. There are no students with high anxiety who show problem solving skills in the moderate or high category. Furthermore, students with moderate anxiety levels mostly have moderate problem solving skills, namely 31 students, with 8 students each in the high and low categories. Meanwhile, students with low anxiety levels tend to have higher problem solving skills, namely 9 students in the high category and 3 students in the moderate category, with none in the low category. These results indicate a negative trend pattern between math anxiety levels and students' mathematical problem solving skills, where the lower the level of math anxiety, the higher the tendency for students to show good problem solving skills.

Furthermore, of the 66 students, reduction was carried out by selecting students with the required categories to be interviewed more in-depth about their mathematical problem solving skills. From the required categories, 4 students with the highest level of math anxiety and low problem solving ability were selected, 2 students with moderate math anxiety and low problem solving ability, 2 students with moderate math anxiety and moderate problem solving ability, 2 students with moderate math anxiety and high problem solving ability, 1 student with low math anxiety and moderate problem solving ability, and 3 students with the lowest level of math anxiety and high problem solving ability. The selected subjects can be seen in Table 5 below:

Table 5. List of Research Subjects

No.	Students Code	Math Anxiety	Math Anxiety Level Category	Mathematical Problem Solving	Mathematical Problem Solving	Subject Code

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		Score		Ability Score	Ability Category	
1.	PD45	32	Low	100	High	R1
2.	PD55	32	Low	96	High	R2
3.	PD60	42	Low	87	High	R3
4.	PD38	45	Low	62	Moderate	R4
5.	PD27	53	Moderate	96	High	S1
6.	PD9	53	Moderate	93	High	S2
7.	PD47	59	Moderate	67	Moderate	S3
8.	PD23	55	Moderate	67	Moderate	S4
9.	PD40	58	Moderate	44	Low	S5
10.	PD57	54	Moderate	45	Low	S6
11.	PD49	81	High	27	Low	T1
12.	PD6	80	High	27	Low	T2
13.	PD20	74	High	35	Low	T3
14.	PD39	74	High	27	Low	T4

Discussion

Based on the test and interview results, students' mathematical problem solving skills show significant variations depending on the level of math anxiety they experience. Students with low math anxiety show predominantly high problem solving skills, namely high and moderate so that they are able to solve problems by following all of Polya's stages systematically and effectively. They have high confidence in understanding and solving problems, and show a positive attitude towards mathematics. research by Hidayatuloh et al. (2023) and Irawadi et al. (2025)emphasized the importance of the self-confidence factor in mediating the negative impact of anxiety on problem solving ability. This is in line with the interview results of subjects R1-R3 who showed confidence when explaining the contents of the problem. Research by Setiawan et al. (2021) and Millania & Fauziyah (2024) also strengthen the evidence that low math anxiety allows students to undergo the entire mathematical thinking process in a structured and logical manner.

In terms of cognition, participants such as R1-R4 were able to filter out important information, convert it into appropriate mathematical representations, and explain the reasoning behind the symbolization. Somatically, they did not show physiological symptoms such as trembling, sweating, or palpitations that interfered with the thinking process. In terms of attitude, they were open, calm, and motivated in facing math problems. At the planning stage, they were able to choose the right solution strategy, use the appropriate formula, and arrange it logically. When carrying out the solution, these participants showed high accuracy and accurate results. Finally, in checking back, they were able to draw mathematical conclusions logically and confidently. This finding is in accordance with Kartikasari & Kurniasari (2021) that low anxiety strengthens students' reflective ability, and is supported by Fadila et al.'s research (2024) which states that students with low anxiety are more consistent in completing all stages of Polya's problem solving optimally. This finding shows that students with low anxiety are able to activate their cognitive, somatic, and attitudinal aspects optimally in solving problems, as described in the indicators of mathematics anxiety, namely cognitive, somatic, and attitudinal aspects.

Furthermore, students with moderate levels of math anxiety displayed variations in problem solving ability, namely high (S1 and S2), moderate (S3 and S4), and low (S5 and S6). Participants with high ability (S1 and S2) can still understand the problem well, but sometimes do not symbolize information mathematically. They could plan and execute the solution, although sometimes there

were doubts that caused them not to write the conclusion at the recheck stage. From the cognitive aspect, there is a blank mind or forgetting the formula. In terms of somatics, students are shaky when planning to work on the problem so that it has an impact on the problem solving stage. While in terms of attitude, they look hesitant and tend to be unsure of their own answers.

Meanwhile, participants with low ability (S5 and S6) experienced interference in planning and solving problems. They often stopped at the stage of understanding the problem. Cognitively, there were difficulties in understanding the context of the problem and developing a solution strategy. Somatically, they experienced symptoms such as muscle tension and feelings of discomfort. In terms of attitude, they seemed resigned, lacked initiative, and showed expressions of frustration. This diversity is in line with the findings of Anggarawati et al. (2023) who stated that moderate anxiety causes students' responses to be unstable and tend to be inconsistent between Polya stages.

Participants with moderate ability (S3 and S4) were generally able to solve problems up to the implementation stage, but often made procedural and calculation errors. From the cognitive aspect, there were errors in choosing or applying formulas. Somatically, they seemed hurried and unfocused. In terms of attitude, they looked anxious and impatient in solving the problem. This is in line with Himawan & Sulaiman (2021) who found that moderate anxiety often triggers procedural errors in Polya's stages.

CONCLUSIONS

This study concludes that higher levels of math anxiety are associated with lower problem-solving abilities across Polya's stages. Students with low anxiety demonstrated confidence, focus, and success in all steps, while those with moderate anxiety often faced procedural errors, concentration issues, and hesitation. Students with high anxiety showed the weakest performance, marked by cognitive difficulties, physical symptoms, and fear of failure. These findings highlight the need for teachers to design supportive and emotionally sensitive learning approaches.

CONFLICTS OF INTEREST STATEMENT

Regarding this study, the author declares that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

Study concept and design: Ulfa Lutfiah. Acquisition of data: Yarman Yarman. Analysis and interpretation of data: Ahmad Fauzan. Drafting the manuscript: Elita Zusti Jamaan. Critical revision of the manuscript for important intellectual content: Elita Zusti Jamaan. Statistical analysis: Ulfa Lutfiah.

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