How do Math Anxiety and Self-Confidence Affect Mathematical Problem Solving?

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Abstract **–Problem-solving performance requires both cognitive and affective aspects related to math anxiety and self-confidence. This study aims to determine the effect of math anxiety and self-confidence on geometry problem-solving skills and then explore students' geometry problem-solving based on their level of math anxiety and self-confidence. This study utilized a mixed-methods approach with a sequential explanatory design and involved 106 students. The quantitative portion of the study employed a multiple linear regression test to examine the influence of math anxiety and self-confidence on problem solving. Furthermore, qualitative research was done to thoroughly examine the effect through in-depth interviews. The results demonstrate that math anxiety and self-confidence influenced geometry problem-solving (R = 0.476; p = 0.000) and contributed 22.6% based on the value of R-square. Furthermore, the present study also found differences in the performance of a subject with low math anxiety and high self-confidence and a subject with high math anxiety and low self-confidence.**

Keywords **– Math anxiety, self-confidence, problem solving, mix method.**

1. Introduction

Problem-solving is central to 21st century learning, becomes an educational goal, and is a fundamental skill that must be possessed [1], [2], [3].

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Therefore, solving math problems is the most crucial part of learning mathematics. Furthermore, mathematical problem-solving of students has also been one of the research interests in mathematics education research for several decades [4], [5], [6], as well as being a central topic in teaching mathematics in Germany and other countries [7]. This is due to the fact that problem-solving is essential for students to understand many mathematical concepts and operations well. Problem- solving is an effort to find the appropriate solution to a problem, and there are many abilities involved in it that students must master [8], [9]. However, not all students master problem-solving well.

Low mathematics learning outcomes can cause students' ability to solve mathematical problems low. There are several factors causing the low ability of mathematical problem-solving experienced by students: the learning process has not explored students' abilities to understand and solve problems well [10]; around 71% of students do not reach the minimum level of competence in mathematics [11]; students have difficulty identifying relevant solutions in solving problems [12]; even though problem-solving can help students' daily lives, develop thinking skills, and help learn geometry [13], [14]. One of the materials considered difficult in mathematics is geometry, even though it is an essential branch of mathematics that studies various shapes and parts [15]. Geometry is an essential material because, through learning it, students can become more confident in their abilities to solve problems, become competent problem-solvers, and able to communicate and reason mathematically [16], [17]. Moreover, studies show that difficulties in learning geometry result in exam failures and decreased student performance.

Students can become good problem solvers if they have the proper problem-solving schemes and strategies based on their experience [18], [19] so that the quality of everyone's problem-solving is different [20]. In this study, the phases of Polya are used to solve mathematical problems: analyzing the problem, making a strategy for problem-solving, implementing the plan, and reflecting [21].

Students' attitudes can be developed through learning how to solve problems [7], [22]. These attitudes include motivation, persistence, very high curiosity, and confidence in various unfamiliar situations [23], [24]. Several studies have revealed that the affective aspect also influences problem-solving performance. Moreover, it can be noted that interests in affective variables and their roles in learning mathematics have increased [25], [26], [27], [28].

Mathematics anxiety has become a concern in education, as many students still struggle with fear and anxiety towards mathematics [29], [30], [31]. Various studies have shown that this phenomenon often occurs among students from elementary school to university [32], [33], [34], [35]. Excessive fear and anxiety about mathematics can hinder their achievement [36], [37]. Someone who has high anxiety in mathematics tends to avoid mathematics because of their weak mathematical competence [38], as well as difficulties in learning and applying mathematical concepts [39], [40]. Many researches have been conducted on math anxiety. Juniati and Budayasa have researched undergraduate students' working memory capacity and math anxiety, and their effect on mathematical achievement [41]. Zhang, Zhao, and Kong examined the relationship between math anxiety and math performance and found negative correlation between the two [42]. In addition, Daker *et al.* [43] examined math anxiety in first-year students related to STEM performance, and Bekdemir [44] studied math anxiety among prospective teachers. To fill the gap in the literature regarding this problem, this research examines math anxiety at the college level.

One of the affective factors that is able to influence math anxiety is self-confidence, which is students' belief regarding their abilities [45]. Research has found that the emotional intelligence component is related to problem-solving. A person's emotions can affect their performance in learning mathematics. One study has demonstrated that students' emotions correlate with their academic achievement [46]. Typically, positive emotions such as self-confidence demonstrate a stronger positive relationship with mathematics achievement [47] and are associated with cognitive achievement for students in a study conducted in Slovenia and Serbia [48]. In addition, negative emotions such as math anxiety negatively correlate with math knowledge and achievement [49], [50]. Pierce and Stacey define math confidence as how students perceive their ability to achieve good results and their belief that they are able to overcome difficulties in learning mathematics [51]. Research on self-confidence has been carried out a lot, including exploring the relationship between cognition, self-confidence, and attitudes [52], [53], [54], fifth and eighth- grade students' self-confidence based on gender in Finland [55], and the effect of self-confidence on mathematics achievement in 76 countries [47].

Research on the relationship and influence of math anxiety and self-confidence has also been widely conducted. One study showed how math self-confidence and anxiety affect students' math performance [56]. Another study also found that the emotional intelligence component was positively correlated with problem-solving [57]. Many students experience math anxiety, have little confidence in learning mathematics, get failed or low grades in mathematics [56], and are afraid and worried when they have to solve complex math problems, making themselves insecure [41]. Low self-confidence causes increased math anxiety [58], and students with high math confidence believe their efforts are worthwhile, are unconcerned with challenging subjects, expect good grades, and enjoy math as a subject and vice versa [59]. However, not much research has examined the effect of math anxiety and self- confidence on junior high school students' problem-solving and how these aspects affect students' geometry problem-solving. Previous research has focused more on the relationship between affective aspects and math performance for students and prospective teachers.

Based on the explanation above, previous research has yet to link problem-solving with affective aspects of math anxiety and self-confidence in junior high school students. In addition, this study is also based on the relevance of math anxiety and self-confidence in several cognitive processes, including problem-solving. Therefore, the current research has conducted a survey as a way to investigate math anxiety, self-confidence, and geometry problem-solving in students studying at the secondary school level. This study aims to 1) determine the effect of math anxiety and self-confidence on geometry problem-solving abilities and 2) explore students' geometry problem-solving abilities based on their level of math anxiety and self-confidence.

2. Methodology

A mixed-method sequential explanatory research approach was used in the current research. Gathering and analyzing quantitative data based on the outcomes obtained is the first step in sequential explanatory design, followed by collecting and analyzing data, and qualitatively summarizing the findings reached [62]. This study was conducted in two stages: first, quantitative data were collected to determine the influence of math anxiety and self-confidence on students' problem solving.

Following a multiple linear regression test, semi-structured interviews were used to obtain qualitative data to explain in further depth the problem solving of students with varying math anxiety and self-confidence.

In this case, the geometric problem solving test for quantitative data consists of three questions on the Pythagorean theorem, circles, and polyhedron; to analyze more deeply using qualitative methods, one question is chosen. The random sampling approach was utilized in this study, and the sample comprised 106 students aged 13 to 15. In addition to seeing how the descriptions of math anxiety and self- confidence affect students' geometry problem-solving, qualitative methods were also used. In this stage of the research, subjects were selected based on these research categories: high math anxiety, low math anxiety, high self-confidence, and low self-confidence.

Furthermore, take two students who represent the categories, one subject has low math anxiety and high self- confidence while the other student has high math anxiety and low self-confidence. These subjects were interviewed to see how they solve geometry problem-solving test. The problem-solving assignment given in the interviews consists of one question on geometry material. The problem is demonstrated as follows. Serena has a 10-meter-long wire that will make three shapes: cubes, cuboid, and rectangular pyramids. The volume of the cube is 15625 cm^3, and the length of the side of the cube is 10 cm longer than the edge of the cube, while the width and height of the cuboid are the same as the length of the side of the cube. A rectangular pyramid has the length of the side of the base equal to the length of the side of the cube, and the length of the side of the upright is 5 cm shorter than the length of the side of the cube. Only cubes and cuboid will be wrapped in wrapping paper. Help Serena work out the steps so she can figure out how much wire is left and how much wrapping paper is needed, and what can you conclude from the finishing process that has been done? Furthermore, this study also utilized the math anxiety test that was developed by Juniati and Budayasa containing 15 items: four items about anxiety in learning mathematics, five about anxiety in taking math lessons, and six about anxiety about math tests [41]. The math anxiety questionnaire instrument used a Likert scale of 1–4 from never to always. Meanwhile, the self-confidence test used in this study is an extension of theories [47], [55], consisted of 34 items, namely 12 items about believing in mathematical abilities, 12 about students' interest in learning mathematics, and 10 about believing in success. The self-confidence questionnaire instrument used a Likert scale of 1–5, from strongly disagree to strongly agree.

All collected data were examined using a mixed explanatory sequential method, with quantitative analysis first and followed by qualitative analysis. The influence of mathematical anxiety and self-confidence on solving geometric problems was analyzed based on significance values for multiple regression test where the dependent variable is the value of a geometry problem-solving test. Qualitative data, i.e., results of solving mathematical problems and interview protocols, were analyzed according to analytical models [60], i.e., data were reduced, presented, and conclusions were drawn. The results of solving geometry problems were analyzed by comparing the results of each subject: the high math anxiety group and the low math anxiety group; the group with high self-confidence and the group with low self-confidence.

3. Results-The Effect of Math Anxiety and Self-Confidence on Geometry Problem-Solving

One hundred and six junior high school students filled out a math anxiety questionnaire, and self-confidence questionnaire, then answered a geometry problem-solving test. The test results are demonstrated in Table 1.

Table 1. Descriptive statistics of problem solving, math anxiety, and self-confidence

	N	Mean	Std Dev
Problem Solving	106	64.1505	14.38663
Math Anxiety	106	39.1509	7.42812
Self-Confidence	106	119.0566	18.02106

From Table 1, the average math anxiety of the subjects is 39.1509, and the average self- confidence is 119.0566. The result yields that students often feel anxious when participating in mathematics lessons, and they need to be more confident in solving geometric problems. Based on the average math anxiety and self-confidence, it impacts their problem-solving; the average obtained is 64.1505. A multiple regression statistical test was utilized to determine the impact of math anxiety and self-confidence on solving geometric problems. Geometry problem-solving is assessed based on student answers referring to the scoring guidelines for Polya problem-solving. Statistical tests were carried out using SPSS software.

Before using the multiple regression test, the classical assumption test must be fulfilled first, including normality, linearity, homoscedasticity, and no multicollinearity.

The regression residuals must have a normal distribution, which may be met by employing a normal distribution and predictable probability plots. Figure 1 is a normal prediction probability (PP) data plot on geometry problem-solving values. In Figure 1, it can be seen that the dots move along a diagonal line. It shows that the geometry problem-solving data is normally distributed.

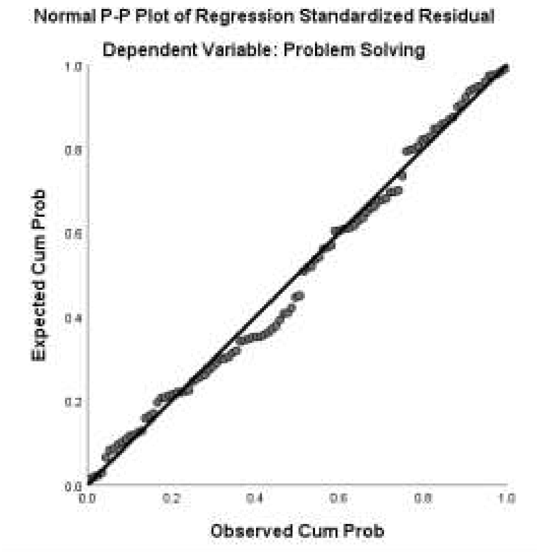


Figure 1. Normal predicted probability plot

Homoscedasticity refers to the points evenly distributed, and a scatter plot of the residues examines this condition. Figure 2 shows that a clear pattern is not present in the scatterplots, and the points spread above and below the number 0 on the Y axis; as a result, the homoscedasticity criteria is fulfilled. Because the residuals are regularly homoscedastic and distributed, it shows that the predictor variable has a linear relationship with the outcome variable in the regression.

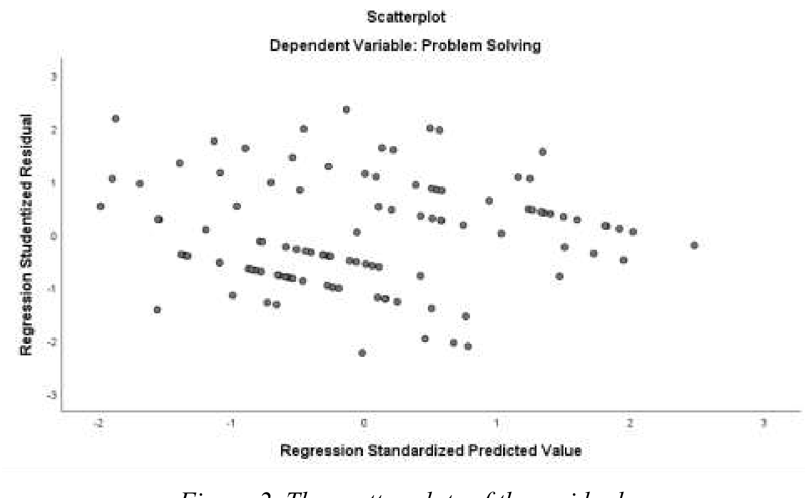


Figure 2. The scatter plots of the residuals

Multicollinearity was carried out to see whether each independent variable (mathematical anxiety and self-confidence) is independent or has a relationship. The condition of multicollinearity occurs when the independent variables are significantly associated with one another. It should be noted that this condition is not anticipated in multiple linear regression. The criteria for not having multicollinearity can be seen based on the tolerance value, which have to be greater than 0.8, and the VIF (Variance Inflation Factor) value of less than 10 [20].

Table 2. Collinearity statistics of problem solving

Collinearity Statistics	Math Anxiety	Self-Confidence
Tolerance	.837	1.195
VIF	.837	1.195

a. Dependent Variable: Problem Solving

Based on the above table, it is apparent that the tolerance value for math anxiety is 0.837 and for self-confidence is 1.195, and based on the VIF value, it is found that math anxiety is 0.837 and self-confidence is 1.195.

Based on the tolerance and VIF values, it can be concluded that there is no multicollinearity. Thus, the classical assumption test has been fulfilled so that it can be continued with multiple regression tests.

A partial t-test (multiple regression) was conducted to see how the independent variable partially influences the dependent variable. In this research, it was seen how math anxiety and self-confidence partially affected geometric problem-solving in Table 3.

Table 3. Multiple linear regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	72.079	13.654		5.279	.000
Math Anxiety	-.692	.183	-.357	-3.769	.000
Self-Confidence	.161	.076	.201	2.127	.036

Table 3 shows that the Sig (Math Anxiety) value is 0.000 and the Sig (Self-Confidence) value is 0.036. Based on the formula, if the Sig value is < 0.05, then it can be said that the independent variable (X) partially affects the dependent variable (Y).

Therefore, it can be concluded that:

- Math Anxiety (X1) has a negative effect on solving geometric problems. This result is in line with the statement that said negative emotions such as math anxiety show a negative relationship with mathematical knowledge and mathematical achievement [49], [50].
- Self-Confidence (X2) has a positive effect on solving geometric problems. Generally, positive emotions such as self-confidence demonstrate a stronger positive relationship with mathematics achievement [47] and are associated with cognitive achievement for students in Slovenia and Serbia [48].

After seeing how the influence of each independent variable (mathematical anxiety and self-confidence) partially affects the solving of geometric problems, it can be stated how the two independent variables simultaneously affects the geometry problem-solving using the F test. If the value of Sig. is <0.05, then the independent variable (X) simultaneously influences the dependent variable (Y) in Table 4.

Table 4. Anova test

ANOVA[a]					
Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	4,915.354	2	2,457.677	15.053	.000[b]
Residual	16,817.034	103	1,63.272		
Total	21,732.388	105			

a. Dependent Variable: Problem Solving
b. Predictors: (Constant), Self-Confidence, Math Anxiety

If the $F_{count} > F_{table}$, then it can be inferred that the independent variable (X) simultaneously affects the dependent variable (Y). As seen in Table 4, it is found that F_{count}= 15.053 and $F_{table} = (k; n - k)$ = (2; 104) = 3.08. Because $F_{count} > F_{table}$, the math anxiety and self- confidence simultaneously affects the geometry problem-solving. From Table 3, it is obtained that $y = 72.079 - 0.692x_1 + 0.161x_2$, where y =problem solving, x_1 = math anxiety, and x_2 = self-confidence. The sig. value for math anxiety is 0.00 and for self-confidence is 0.036. Both are less than 0.05; math anxiety and self- confidence affect problem-solving. Therefore, it can be stated that math anxiety and self- confidence simultaneously influence geometry problem-solving of the subjects.

Learning geometry can increase self-confidence, as it is an important material to learn. Because of this, students can be more confident regarding their mathematical skills, become good problem solvers, and communicate and reason mathematically [16], [17].

Table 5. Model summary math anxiety, self-confidence and problem solving

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.476[a]	.226	.211	12.77780	1.541

a. Predictors: (Constant), Self-Confidence, Math Anxiety
b. Dependent Variable: Problem Solving

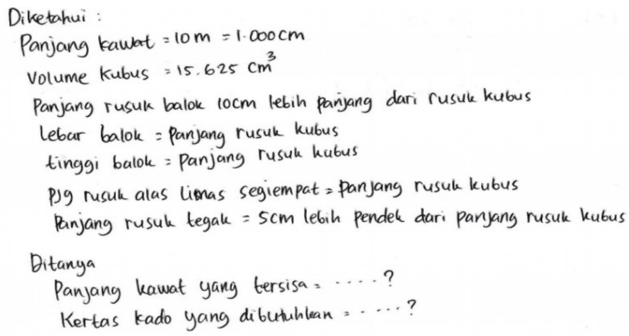
Based on Table 5, the effect of math anxiety and self-confidence on solving geometry problems for junior high school students is 22.6% based on the value of R square. Qualitative research was carried out by giving geometry problems to eight students to find out these factors for problem-solving. Students were selected based on the criteria of high or low math anxiety and high or low self-confidence. Based on the results of this categorization, one student with low math anxiety and high self-confidence and one student with high math anxiety and low self-confidence were recruited for interviews.

The following is an analysis of solving geometric problems based on Polya's problem-solving steps.

Description of the Effect Math Anxiety and Self-Confidence on Geometry Problem-Solving

Subject with Low Math Anxiety and High Self-Confidence (MRST)

At the stage of understanding the problem, the first step taken by the MRST subject is to read and understand the problem carefully. He states and writes down all the information about the problem completely and sequentially, as shown in Figure 3.



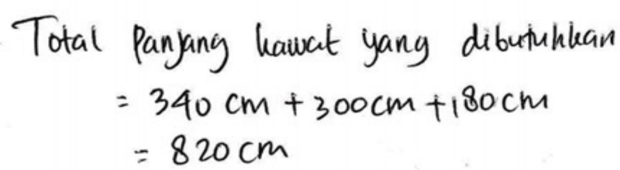
Known: Wire length = 10 m = 1000 cm
Cube volume = 15.625 cm^3
Cuboid length = 10 cm longer than the edge of the cube
= 10 cm + cube length
Cuboid width = cube length
Cuboid height = cube length
Base length of the pyramid = cube length
Lateral edge = cube length – 5 cm
Asked: remaining wire length and wrapping paper needed?

Figure 3. MRST's answer regarding information on the problem

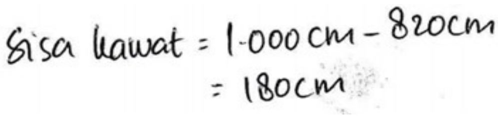
In the planning stage, MRST looked for the total length of wire needed to make cubes, cuboids, and rectangular pyramids. After that, it looks for the remaining wire by subtracting the available wire length from the total wire needed, and then MRST looks for the area of wrapping paper needed to cover the cubes and cuboid so that the amount of wrapping paper needed is obtained by dividing the surface area of the cubes and cuboid by the area of one piece of wrapping paper.

R: What will you do to solve this problem?
S: Many sizes are unknown; I think I have to find the cube's side length first, ma'am. R: Why is that?
S: Because if the length of the cube's edge is known, then we can find other sizes in the shape of the cuboid and the cube.
R: Ok, after that, what are you going to do?
S: I am looking for the length of wire needed for each cube, cuboid, and rectangular pyramid to get the remaining wire.
R: Have you finished what you did?
S: Not yet, ma'am. Who was asked how much wrapping paper is needed? So I also have to figure out how much wrapping paper I need to cover the cubes and cuboid.

In the next step, MRST implemented the plan that had been made in the previous stage to get an answer to the given geometry problem.



Total length of wire required
$= 340cm + 300cm + 180cm$
$= 820\ cm$



Remaining wire $= 1.000cm - 820cm$
= 180 cm

Lots of wrapping paper needs
$= \frac{3.750+4.750}{1.350} = 6,2 \approx 7$

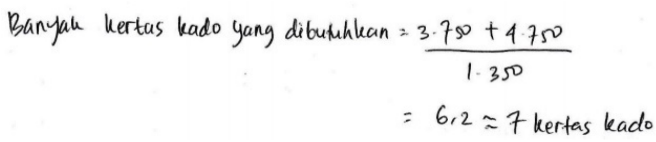


Figure 4. MRST's answer on implementing geometry problem-solving

MRST solved the problem orderly and systematically; every step was done well. He could apply the concept of flat-sided shapes well and solve the given problems well. After solving the problem, MRST checked the results of the answers. MRST checked everything, from the written information to all his calculations. He ensured that what had been done was under the appropriae problem-solving procedure.

Subject with High Math Anxiety and Low Self-Confidence (MTSR)

MTSR only focuses on mentioning information that had been known about the question without mentioning what the question was asking when reading the problem. MTSR also did not convert meter to centimeter at the beginning, as shown in Figure 5.

Known:
Wire length = 10 m
Cube volume = 15.625 cm^3
Cube length = 10 cm
Cuboid width and height = cube length
Base length of the pyramid = cube length
Lateral edge = cube length – 5 cm

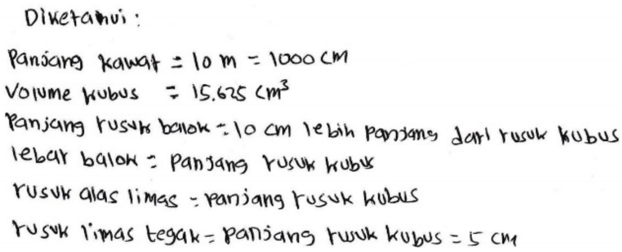
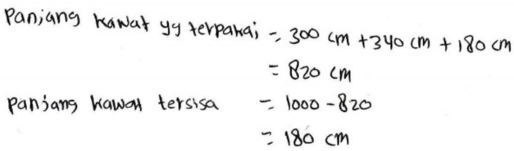


Figure 5. MTSR's answer is about information on the problem

In the planning stage of solving the problem, MTSR looked for the length of the edge of the cube through the known formula of its volume, then found the cuboid length, cuboid width, cuboid height, base length of the pyramid, and lateral edge of the pyramid through the edge of the cube that had been obtained. After that, MTSR found the wire length of the cube, cuboid, and rectangular pyramid. Therefore, MTSR found the remaining wire length by subtracting the available wire length from the total wire used. Finally, MTSR looked for the amount of wrapping paper needed to cover the cubes and cuboids.

Furthermore, MTSR carried out the plan that had been previously made; MTSR solved the geometry problem according to the planned procedure.



$$Total\ length\ of\ wire\ require = 340cm + 300cm + 180cm = 820\ cm$$

$$Remaining\ wire = 1.000cm - 820cm = 180\ cm$$

Figure 6. MTSR's answer on implementing geometry problem-solving

The final stage was re-checking. At this stage, MTSR only checked the information he has provided; the subject did not double-check the results of his calculations. At this last stage, MTSR could not complete the final result in determining how much wrapping paper was needed, and he could not recheck all the procedures he had done. Therefore, MTSR cannot ensure that their answers are correct or that there are errors, as shown in Figure 6. Excessive fear and anxiety about mathematics can be an obstacle to their achievement [36], [37].

Based on the qualitative research results, both subjects carried out the problem-solving stages, including understanding the problem, planning problem-solving, carrying out the problem- solving plan, and checking again. At the stage of understanding the problem, MRST could understand the problem correctly and carefully. MRST could mention and write down all the information in the problem coherently and systematically.

At the same time, MTSR focused on mentioning only known information on the problem without mentioning what was being asked about the problem. MTSR also did not convert meters to centimetres at the start.

In the stages of preparing and implementing plans, both subjects utilized the same problem-solving steps. The difference lies in the fact that MRST solved the problem systematically, starting by finding the length of the cube's edge and then finding the length of wire needed to make the cube, finding the size of the cuboid and the length of wire needed to make the cuboid; and finding the size of the rectangular pyramid and the length of the wire needed to make the pyramid rectangular. Then, MRST looked for the remaining length of wire and the amount of wrapping paper needed. For a full explanation, see Figure 4. On the other hand, MTSR solved the problem, starting with finding the cube's ribs, the cuboid's size, and the pyramid's size.

After that, MTSR looked for the length of wire needed to make a cube, cuboid, and rectangular pyramid. In this section, MTSR was unsystematic in solving problems. MTSR went back and forth between looking at sizes and finding the required wire length. The next step for MTSR was to do the same as MRST had done: find the remaining wire and the amount of wrapping paper needed. MTSR could not solve the problem to the end and could not find the amount of wrapping paper needed; this can be seen in Figure 6. In the re-checking stage, MRST re-checked the results of the answers. MRST checked everything, from the written information to all calculations. MRST ensured that what has been done is under the problem-solving procedure, while MTSR only checked the information it has made; MTSR did not double- check the results of its calculations.

4. Discussion

Based on the study's results, it was found that math anxiety and self-confidence affected junior high school students' geometry problem-solving with a percentage of 22.6% based on the R square value. A person's emotions can affect their performance in learning mathematics; previous research has demonstrated that the emotions of students are related to their academic achievement [46]. Mathematics anxiety partially has a negative effect on students' geometry problem-solving; this is in line with self-confidence, which partially has a positive effect on students' geometry problem-solving.

The results of this research suggest that students with low anxiety and high self-confidence could complete problem-solving procedures properly and systematically. It was seen that they were able to solve problems perfectly according to the procedure and get reasonable solutions. Mathematical self-confidence and anxiety affect students' mathematical performance [56]. Students with high math confidence believe their efforts are worthwhile, are unconcerned with challenging subjects, expect good grades, and enjoy math as a subject, and vice versa [59]. Mathematical anxiety occurs at almost all levels of education and is a concern in mathematics education. This is because many students are still grappling with fear and anxiety when learning mathematics [29], [30], [31], and many students also experience anxiety when learning mathematics and are unaware of the advantages of the topic being studied [61].

In addition, the findings also show that students with high anxiety and low self-confidence cannot complete the final result of solving a given problem. Many students are afraid and worried when they have to solve math problems, which makes them insecure [41]. According to Stuart [58], a lack of confidence can cause math anxiety, which can be seen as a fear of embarrassment and avoidant behaviour during mathematics lessons.

Previous studies have also claimed that affective aspects also influence problem-solving performance, and there has been an increase in the interest regarding research on the role of affective variables in learning mathematics [25], [26], [27], [28]. Students can become good problem solvers if they have the proper problem-solving schemes and strategies based on their experiences [18], [19].

5. Conclusion

In conclusion, mathematics anxiety and self-confidence affect junior high school students' geometry problem-solving, contributing 22.6%. Partially, mathematics anxiety and self-confidence affect solving geometric problems. Mathematical anxiety has a negative effect on solving problems, while self-confidence has a positive effect on solving geometric problems. The higher a person's anxiety, the lower his confidence.

The findings of this study are intended to shed light on the roles of math anxiety and self-confidence in students' geometry problem-solving. In addition, to reveal that low math anxiety and students with great self-confidence are more likely to solve geometry problems successfully, this study also revealed that students with high math anxiety and low self- confidence could hinder their geometry problem-solving performance.

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