

Association and Impact of Mathematics Anxiety Levels on the Quality of Students' Understanding Based on Skemp's Theory

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Abstract

This study aimed to examine the association between math anxiety and students' comprehension quality based on Skemp's Theory and describe the impact of math anxiety level on students' comprehension quality. This survey research with a quantitative approach involved a population of grade 8 students in junior high schools in Bantul Regency. The sample size was 386 students using stratified proportional random sampling technique. Math anxiety and the quality of student understanding were measured using a questionnaire instrument and description questions tailored to the ratio and proportion material. This instrument has been declared valid and reliable. The data analysis technique is correspondence analysis using cross tabulation to see the frequency distribution in each category and chi-square test to check whether or not there is an association. The results of the study with a 5% significance level showed that (1) the chi square value was 0,36 (< 0,05) which means that there is an association between math anxiety and the quality of students' understanding; (2) the higher the level of math anxiety experienced by students, the lower their tendency to build relational understanding and vice versa, students with high math anxiety tend to develop instrumental understanding or even experience incomprehension of the material.

Keywords: Math Anxiety; Quality of Understanding; Relational; Instrumental; Skemp's Theory

Introduction

Mathematics anxiety is considered one of the important issues in mathematics learning due to its significant impact on student performance (Demedts et al., 2022). Mathematics anxiety is a form of a person's feelings in the form of feelings of fear, tension or anxiety in facing problems and learning mathematics with various forms of symptoms caused (Saputra, 2014). This anxiety can cause reluctance in dealing with mathematical situations, which in turn can reduce students' academic achievement in the subject (Irfan, 2018). Research shows that students who experience math anxiety tend to show weaker math skills, as well as avoid situations that ask them to solve math problems (Irfan, 2018). As Buckley et al. (2016) noted that math anxiety has a direct relationship with students' inability to cope with

mathematical challenges, as well as correlating with lower academic achievement, where more anxious students tend to score worse in math exams.

This is because anxiety can increase in each individual and affect whether or not understanding is difficult, because the level of understanding between students is different (Munasiah, 2015). There are students who can easily understand when they receive an explanation, but there are students who must be repeatedly explained before they understand. A study by Auliya (2016) found that students with higher levels of anxiety tend to have weak comprehension. The higher the degree of anxiety in learning mathematics, it will automatically lead to a dislike of mathematics lessons and as a result will affect the level of student understanding of the mathematical concept itself (Muchyidin et al., 2020).

In contrast to the results of research by Latip and Yulianti (2023) showed a negative correlation between concept understanding and students' math anxiety level. This is in line with the results of research conducted by Demedts et al. (2022) in Belgium who found that students' math anxiety and math performance had a negative correlation. In contrast to research conducted by Kaba and Şengül (2018) found there is a high level of positive and significant correlation between middle school students' mathematical understanding and students' mathematics anxiety. In line with this, Rosander and Backstrom (2014) showed their support for the existence of anxiety in the classroom by suggesting that the components of anxiety and vulnerability are important for academic performance in relation to the fear of failure. As Skemp, (1987) states that a certain amount of anxiety can be a useful stimulus for education to learn how to use it.

Furthermore, Skemp (1987) classified the quality of students' mathematical understanding into relational and instrumental understanding. The concept of instrumental and relational understanding developed by Skemp (1987) explains the differences in the quality of students' understanding based on how they build conceptual structures. This is because good understanding is not only determined by the amount of knowledge resources possessed, but also by the relationship between these resources (Weiland et al., 2021). Instrumental understanding focuses on procedural knowledge, where students understand the steps to solve a problem without delving deeper into the reasons why or how the procedure is used. Relational understanding, on the other hand, includes a deeper understanding, which is the ability to link various mathematical concepts and apply the knowledge in a broader context. Students with strong relational understanding tend to be more flexible and adaptive in solving mathematical problems (Giriansyah et al., 2023).

The CCSM (The Common Core State Standards for Mathematics) sets ratio and proportion as one of the five important topics in the 7th grade mathematics curriculum. However, the concept of ratio is much more difficult than many people realize, as students often struggle to compare ratios and use them to solve problems (Kilpatrick et al., 2001). The poor performance of students in school, their failure to master and handle tasks involving ratios and proportions (Arican, 2019; Ezaki et al., 2024) calls for research to examine the quality of students' understanding of ratio and proportion problems.

Based on the explanation above, it can be seen that math anxiety in the classroom has a good impact and a bad impact. Thus, the researcher is interested in conducting a study related to the association and impact of math anxiety on the quality of student understanding. Most of the research on math anxiety focuses on its relationship with student learning outcomes. However, there is still a lack of research on the relationship between math anxiety and the quality of understanding in terms of instrumental and relational understanding. This research will answer the following questions: (1) is there an association between the level of math anxiety and the quality of students' understanding in working on ratio and proportion problems? And (2) what impact does the level of math anxiety have on the quality of student understanding?

Methods

This study is a survey research with a quantitative approach that aims to examine the association and impact of comprehension quality with students' math anxiety level. Through the correspondence analysis method, the association between categorical variables can be determined from the chi-square test results while the frequency distribution of students can be determined from the crosstabulation results. The frequency distribution was used to obtain information about the impact of math anxiety level on the quality of students' understanding. The type of data analyzed is categorical data, namely high, medium and low categories of mathematics anxiety level, as well as categories in the quality of understanding, namely relational and instrumental.

The population of this study were all grade VIII junior high school students in Bantul Regency. The research sample was determined as many as 386 students using *stratified proportional random sampling* technique. The number of students in each class ranged from 24-36 students, so the researcher took 12 junior high schools in Bantul Regency. Furthermore, the sample class of students was determined randomly from the 12 selected schools. The research instruments were in the form of questionnaires and description questions that had been declared valid and reliable. The math anxiety questionnaire contains 20 statement items related to the symptoms of math anxiety when students work on ratio and proportion problems. The math anxiety indicators measured can be seen in table 1 below.

	rable 1. indicators of main anxiety measured				
Indicator	Indicator				
Somatic	Uncomfortable when working on ratio and proportion problems				
	Sweating while working on ratio and proportion problems				
	Heart palpitations when working on ratio and proportion problems				
	Trembling when working on ratio and proportion problems				
	Biting fingernails when working on ratio and proportion problems				
Cognitive	Easily frustrated when working on ratio and proportion problems				
	Have negative thoughts about ratio and proportion material				
	Unable to think clearly when working on ratio and proportion problems				
	Blank mind when working on ratio and proportion problems				
Affective	Fear of looking stupid when doing ratio and proportion problems				
	Fidgeting when working on ratio and proportion problems				
	Anxiety in facing and working on ratio and proportion problems				
Attitude	Reluctant to do something when working on ratio and proportion problems				
	Avoid working on ratio and proportion problems				

Table 1. Indicators of math anxiety measured

Meanwhile, the description questions were developed based on the indicators of relational and instrumental understanding by Herheim (2023) to assess the quality of students' understanding. The test consists of 3 items, where each item contains 1 problem that requires instrumental understanding and 1 problem that requires relational understanding. The quality of understanding indicators measured can be seen in Table 2.

Quality of Understanding	Indicator		
Instrumental	Perform calculations algorithmically.		
	Apply the procedure appropriately.		
	Write the concept/formula correctly.		
Relational	Apply concepts to new problems with different situations		
	Able to associate prior knowledge		
	Use the help of other mathematical concepts and principles		
	to solve problems correctly.		
	Determine the final solution with logical reasoning		

Table 2. Indicators of measured quality of understanding

Results and Discussion

Results

1. Math Anxiety and Students' Comprehension Quality

Students' math anxiety levels in this study were assessed to see how math anxiety is distributed among students. The measurement was done by categorizing the math anxiety scores into three groups, namely low, medium, and high. Students' math anxiety level was determined using the ideal standard deviation method by Azwar (2017) so that the distribution of students' math anxiety level was obtained as follows.



Figure 1. Distribution of students' math anxiety levels

Based on the results of the analysis, the distribution of students' math anxiety levels is obtained as shown in Figure 1. Most students are in the *moderate* category with a percentage of 43%. Meanwhile, 30% of students were classified in the *high* category, which means that one-third of all students experience math anxiety at a serious level. On the other hand, 27% of students were classified in the *low* category, indicating that only a small proportion of students experienced relatively no emotional barriers when facing ratio and proportion problems. Overall, this data indicates that the level of math anxiety in working on ratio and proportion problems among students is still quite concerning, with around 73% of students experiencing anxiety in the moderate to high categories.

Furthermore, the quality of students' understanding of the ratio and proportion material was grouped into three categories, namely not understanding, instrumental understanding, and relational understanding. Categorizing the quality of students' understanding using the criteria of Ebel and Frisbie (1991, p. 281) so that the distribution of the quality of students' understanding is obtained as follows.



Figure 2. Frequency distribution of students' comprehension quality

Based on the results, the majority of students (47%) fall into the category of not understanding. This means that almost half of the students showed an inability to understand the concepts of ratio and proportion well, both procedurally and conceptually. As many as 24% of students are classified as having instrumental understanding, which is mechanical and procedural understanding. Meanwhile, 29% of students showed relational understanding. This result shows that the proportion of students with relational understanding is still lower than students who do not understand, but slightly higher than students with instrumental understanding.

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2. Association between the Level of Math Anxiety and the Quality of Students' Understanding

To determine the relationship between the level of math anxiety and the quality of students' understanding, an analysis was conducted using the chi-square test. The results showed that there was an association between the level of math anxiety and the quality of students' understanding as shown in Table 3.

Table 3. Chi-square test results							
	Asymptotic Significance						
Pearson Chi-Square	10,268 ^a	4	0,036				
N of Valid Cases	386						

Based on the chi-square test, it can be seen that with a significance level of 5%, the asymptotic significance value is $0,036 \ (< 0,05)$, which means that there is an association between the level of math anxiety and the quality of students' understanding. This means that the level of math anxiety contributes to the quality of understanding that students have in working on ratio and proportion problems. Furthermore, Symmetric Measures were conducted to determine the contingency coefficient of the association between the level of math anxiety and the quality of students' understanding that students have in working on ratio and proportion problems.

Table 4. Contingency coefficient of association					
	Value	Approximate Significance			
Contingency Coefficient	0,161	0,036			
N of Valid Cases	386				

The results show that the contingency coefficient obtained is 0.161. This value indicates a weak strength of association between the two variables. Thus, although there is a significant relationship, the strength of the relationship between the level of *math anxiety* and the quality of students' understanding is not strong

3. The Impact of Math Anxiety Level on the Quality of Student Understanding

To see the impact of the level of *mathematics anxiety* on the quality of students' understanding, cross tabulation analysis and visualization in the form of two-dimensional plots were conducted. The results of the cross tabulation can be seen in table 5 below.

Table 5. Results of Crosstabulation								
Quality		- Total						
Understanding		Low	Medium	High	Total			
Not	f	43	86	53	182			
Understood	%	41.7%	51.5%	45.7%	47.2%			
Instrumental	f	22	32	37	91			
Instrumental	%	21.4%	19.2%	31.9%	23.6%			
Deletionel	f	38	49	26	113			
Kelational	%	36.9%	29.3%	22.4%	29.3%			
Total	f	103	167	116	386			
10(a)	%	3.9%	47.2%	25.6%	23.3%			

Based on table 5, it can be seen that most students who have moderate levels of math anxiety tend to be in the "Do not understand" category, with a percentage of 51.5%. Students with high math anxiety were also in the "Not Understanding" category (45.7%), but slightly lower than the moderate math anxiety group. In the "Instrumental Understanding" category, it can be seen that the largest proportion came from students with high math anxiety, at 31.9%. This indicates that students with high levels of

math anxiety tend to understand the material procedurally without really understanding the concepts in depth. Meanwhile, students with low math anxiety were more likely to be in the "Relational Understanding" category, at 36.9%. This means that students who have low math anxiety tend to be able to build a deeper and more meaningful understanding of mathematical concepts. This is supported by the visualization in the following two-dimensional plot.



Figure 3. Two-dimensional plot of the frequency distribution

On the graph, the "Relational" point is located closer to the "Low" group, suggesting an association between low levels of math anxiety and the quality of relational understanding. In contrast, the "No Understanding" point is located closer to the "Medium" group, and "Instrumental" is closer to "High", indicating that higher levels of anxiety are associated with more superficial or procedural understanding. Thus, it was found that students' level of math anxiety was related to the quality of their understanding. The lower the anxiety level, the higher the tendency for students to have relational understanding.

Discussion

Based on the results of the chi-square test, it was found that there is a significant association between the level of math anxiety and the quality of students' understanding. This finding indicates that the level of math anxiety contributes to the way students understand mathematical concepts, both superficially (instrumental) and deeply (relational). This result is in line with research by Namkung et al. (2019) who found that math anxiety is negatively correlated with understanding of mathematical concepts. Students who experience high anxiety have difficulty remembering the procedural steps needed to solve problems, or they may not be able to relate relevant concepts in the process of solving mathematical problems (Nurkarim et al., 2024). In other words, anxiety can interfere with cognitive processes that are essential for deep and complex understanding

Students with high anxiety tend to have difficulty in understanding the relationship between concepts, so they rely more on procedural memorization than relational understanding. As Jalal (2020) describes one of the impacts caused by math anxiety is that students have difficulty understanding when the teacher explains, have difficulty doing the tasks given by the instructor, and have difficulty explaining the history of problems with math problems. Students who experience anxiety will have difficulty integrating new information, so that understanding becomes limited to procedural aspects only. In the context of this study, most students with low math anxiety have more relational understanding, while students with high math anxiety are more dominant in the category of not understanding or only having instrumental understanding. This strengthens the argument that math anxiety is a factor that needs to be considered in an effort to improve the quality of student understanding.

The impact of math anxiety level on the quality of students' understanding is evident from the cross-tabulation results and the two-dimensional visual analysis. Students with high math anxiety tend to have difficulty in building relational understanding, and more end up in the category of not understanding or simply mastering procedures without deep understanding. Research by Demedts et al. (2022) corroborates these findings by stating that math anxiety not only affects academic outcomes, but also hinders the development of understanding abstract concepts in mathematics. Students with high anxiety focus more on trying to avoid mistakes rather than understanding the true meaning of the concepts learned.

Furthermore, the results of this study are also in line with the study by M et al. (2021) who found that students with high levels of math anxiety performed worse in tasks that required integration of concepts and application of mathematical logic. They feel overwhelmed more quickly and experience obstacles in the critical thinking process. Based on the two-dimensional visualization in this study, the "Relational" quality of understanding is located close to low mathematics anxiety, while the "Instrumental" and "Not Understanding" qualities are closer to moderate and high levels of mathematics anxiety. This confirms that lower levels of math anxiety provide more cognitive space for meaningful concept understanding.

Thus, it can be concluded that math anxiety is not only associated, but also has a real impact on the quality of students' understanding. The lower the math anxiety experienced by students, the greater the chance that students will develop the relational understanding necessary for long-term academic success. When something triggers a person's anxiety, those who practice emotional coping may have the skills or resources to respond more constructively by showing less avoidance behavior than those who do not (Carlin & Ahrens, 2014). Mathematics anxiety has a negative influence on mathematics learning and student learning achievement, the higher the student's anxiety about mathematics, the lower the learning achievement will be (Tan & Guita, 2018).

Summary

Based on the results of the research conducted, it can be concluded that at the 5% significance level, there is a weak association between the level of math anxiety and the quality of students' understanding. The higher the level of math anxiety experienced by students, the lower their tendency to build a deep relational understanding of mathematical concepts. Conversely, students with lower levels of math anxiety showed more strong relational understanding. In addition, math anxiety also has a clear impact on the quality of students' understanding. Students with high anxiety tend to develop instrumental understanding or even experience a lack of understanding of the material. This indicates that managing math anxiety is an important aspect of improving the quality of student understanding in the mathematics classroom. This research confirms the importance of attention to emotional factors in the process of learning mathematics.

Advice

The association between the level of math anxiety and the quality of students' understanding indicates that there is a contribution from the level of math anxiety to the quality of students' understanding. Therefore, teachers are advised to pay more attention to students' emotional factors in the mathematics learning process, especially by identifying and managing anxiety experienced by students. Teachers can implement learning approaches that are more friendly, supportive and based on increasing students' confidence, such as the use of cooperative learning methods, providing positive feedback, and implementing anxiety reduction strategies such as relaxation or stress management techniques before facing math problems. Thus, it is hoped that students can build a more relational and meaningful understanding of mathematics without being hampered by emotional distress.

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