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The Anxiety Levels and Mathematical Literacy of the Eighth Grade Indonesian Students on Quantity Content

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Abstract:

Mathematical literacy is essential for students' academic success and real-life problem-solving. However, math anxiety remains a significant barrier affecting students' performance, particularly in the "quantity" content of mathematical literacy. Despite extensive research, limited studies have explored how varying levels of math anxiety influence students' mathematical literacy in specific content domains. This qualitative descriptive study investigates the impact of math anxiety on the mathematical literacy of the eighth-grade students in the "quantity" content. Using purposive sampling, six students from State Junior High School 26 Makassar were selected. The data collection involved a math anxiety questionnaire, a mathematical literacy test, and interview guidelines. The Miles, Huberman, and Saldana model was applied for data analysis. The findings indicate that math anxiety levels strongly influence students' mathematical literacy. Students with low anxiety demonstrated strong conceptual understanding, effective problem-solving strategies, and accurate calculations. Those with moderate anxiety managed simpler tasks but struggled with complex problems, consistent with the Yerkes-Dodson law. The students experiencing high anxiety exhibited the poorest performance faced challenges in understanding instructions and applying appropriate strategies. The study highlights the necessity of addressing math anxiety through interactive teaching approaches and targeted support to enhance students' mathematical literacy, suggesting practical interventions for educators.

Abstrak:

Literasi matematika sangat penting untuk keberhasilan akademik siswa dan pemecahan masalah dalam kehidupan nyata. Namun, kecemasan matematika tetap menjadi hambatan signifikan yang memengaruhi kinerja siswa, terutama dalam konten "kuantitas" literasi matematika. Meskipun penelitian yang luas telah dilakukan, hanya sedikit studi yang mengeksplorasi bagaimana tingkat kecemasan matematika yang berbeda memengaruhi literasi matematika siswa dalam domain konten tertentu. Studi deskriptif kualitatif ini menyelidiki dampak kecemasan matematika terhadap literasi matematika siswa kelas delapan dalam konten "kuantitas". Melalui teknik purposive sampling, enam siswa dari SMP Negeri 26 Makassar dipilih sebagai responden. Pengumpulan data melibatkan kuesioner kecemasan matematika, tes literasi matematika, dan pedoman wawancara. Model Miles, Huberman, dan Saldana digunakan untuk analisis data. Hasil penelitian menunjukkan bahwa tingkat kecemasan matematika sangat memengaruhi literasi matematika siswa. Siswa dengan tingkat kecemasan rendah menunjukkan pemahaman konsep yang kuat, strategi pemecahan masalah yang efektif, dan perhitungan yang akurat. Siswa dengan tingkat kecemasan sedang mampu menangani tugas-tugas sederhana tetapi kesulitan dengan masalah yang lebih kompleks, sesuai dengan hukum Yerkes-Dodson. Siswa dengan tingkat kecemasan tinggi menunjukkan kinerja terburuk, menghadapi kesulitan dalam memahami instruksi dan menerapkan strategi yang sesuai. Studi ini menyoroti pentingnya mengatasi kecemasan matematika melalui pendekatan pengajaran interaktif dan dukungan yang ditargetkan untuk meningkatkan literasi matematika siswa, serta merekomendasikan intervensi praktis bagi para pendidik.

Keywords:
Mathematical Literacy, Quantity Content, Math Anxiety

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Introduction

Education is a crucial tool in shaping individuals to become better, more civilized, and capable of adapting to modern life (Schwartz & Tilling, 2023). One of the essential disciplines in education is mathematics. This is because mathematics is not only taught at the elementary and secondary levels but also at the higher education level. Moreover, mathematics is known to play a significant role in supporting the advancement of science and technology (Jackson & Johnson, 2013; Incikabi & Serin, 2017). Mathematics also helps students developing logical thinking, analytical skills, and problem-solving abilities, which are crucial in dealing with everyday challenges, such as in commercial activities and computer programming (Atallah, 2003; Dahiya, 2014; Mumcu, 2018; Sharma, 2021). However, mathematics often induces anxiety among students, especially when they feel pressured or fearful about facing mathematical problems (Kyttälä & Björn, 2014; Tan & Guita, 2018; Mononen, Niemivirta, Korhonen, Lindskog, & Tapola, 2022).

Mathematics anxiety refers to the discomfort that arises when students encounter mathematical materials or tasks (Khasawneh, 2021; Iannacchione, 2023). This anxiety can hinder students' concentration and ability to understand and solve mathematical problems, which in turn affects their mathematical literacy (Kyttälä & Björn, 2014, 2021). Mathematical literacy is the ability of students to apply, interpret, and formulate mathematical concepts in various real-life contexts. Despite its importance, Indonesian students' mathematical literacy remains low, as reflected in the data from the Program for International Student Assessment (PISA), which shows that Indonesia's mathematical literacy scores have consistently been below the OECD average from 2003 to 2022

(OECD, 2023). The concept of mathematical literacy from PISA has influenced thinking and practices in mathematics education across various countries (Stacey, Almuna, Caraballo, Chesné, Garfunkel, Gooya, Kaur, Lindenskov, Lupiáñez, Park, Perl, Rafiepour, Rico, Salles, & Zulkardi, 2015).

Previous research has demonstrated that math anxiety significantly impacts students' academic performance. A cross-national study by Yuan, Tan, & Ye (2023) revealed that math anxiety affects students' global performance in mathematical literacy, as evidenced by PISA data. Furthermore, a study by D'Agostino, Spagnolo, & Salvati (2022) using PISA data analyzing the relationship between anxiety and school achievement showed that high levels of anxiety substantially reduce students' ability to understand and solve mathematical problems. Contextual factors such as the school environment and social support were also found to play a crucial role in influencing students' levels of math anxiety (Radišić, Videnović, & Baucal, 2015). Although numerous studies have broadly examined this relationship, only some specific research focuses on math anxiety in the context of Indonesian students. An interview with a mathematics teacher at State Junior High School 26 Makassar, Indonesia, for example, revealed that mathematics anxiety contributes to students' low ability to comprehend and solve mathematical literacy problems, particularly those involving the translation of problems into mathematical forms. Students tend to hesitate in asking teachers for help, opting instead to remain silent or seek assistance from their peers when they encounter difficulties (Rubinsten, 2010; Doz, 2024).

One of the mathematical literacy contents measured in PISA is "quantity," which involves understanding numbers and number patterns (OECD, 2023). This research aims to describe the mathematical literacy of the eighth-grade students in the "quantity" content, viewed from the perspective of their mathematics anxiety levels. The focus on the "quantity" content within the PISA mathematical literacy framework was selected for several compelling reasons. First, this content encompasses fundamental concepts such as numbers, arithmetic operations, and numerical patterns, which serve as the foundation for mastering more complex mathematical concepts. Without a solid understanding of quantity, students may struggle with other topics such as algebra, geometry, and data analysis. Second, the quantity content is often considered challenging by students because it requires accurate calculation skills and a deep understanding of numerical relationships. This makes quantity a relevant area for examining the impact of mathematics anxiety in greater depth. Third, previous PISA data have consistently shown that Indonesian students perform poorly in the quantity content compared to other areas such as data representation, change, and relationships. Hence, this study is expected to provide insights for teachers and schools in addressing mathematics anxiety and improving students' mathematical literacy.

Research Method

This study employed a descriptive research design with a qualitative approach. It was conducted at UPT SPF SMP Negeri 26 Makassar during the even semester of the

2023/2024 academic year. The research subjects were selected purposively and comprised six eighth-grade students categorized based on their levels of math anxiety: high, moderate, and low. Two students with the highest scores in each anxiety category were chosen as representatives to solve mathematical literacy problems related to the content of quantity and to participate in interviews regarding their test results. Selecting two subjects per category was deemed sufficient to capture the variation in responses at each anxiety level. This approach enabled the researchers to explore the characteristics of math anxiety in depth while ensuring data remained manageable. Additionally, the inclusion of two subjects allowed for comparisons of common patterns and specific differences in mathematical literacy performance and interview responses within each anxiety level. This number of subjects also facilitated comprehensive interviews without overly complicating the data, as might occur with more subjects, or limiting the findings, as could happen with fewer subjects. Thus, this selection balanced the depth of qualitative analysis with the validity of the findings.

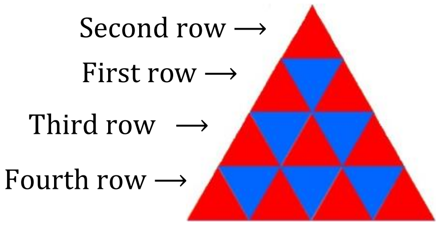
The research began with observations at the school where the study was conducted, followed by the formulation of the background, research problems, and objectives. The researchers then conducted a literature review to delve into the theory underlying this study. Afterward, the research instruments were developed. The instruments used included a math anxiety questionnaire, a mathematical literacy test, and interview guidelines. These instruments were validated by experts, and after being declared valid, they were used to collect data from the research subjects. The data obtained were then analyzed and tested for validity before conclusions were drawn.

The data collection techniques were carried out through three methods: the math anxiety questionnaire, the mathematical literacy test on the content of quantity, and interviews. The math anxiety questionnaire was administered to determine the students' anxiety levels, which were then categorized into three levels: high, moderate, and low. Categorizing math anxiety into three levels (high, moderate, and low) is crucial for several reasons. First, it allows educators and researchers to identify students who may require different levels of intervention, ensuring personalized support. Second, the categorization facilitates data analysis by simplifying complex emotional responses into manageable data. Third, it helps track progress over time, enabling the evaluation of educational strategies aimed at reducing math anxiety. Lastly, such categorization promotes targeted instructional design, helping educators create learning environments that address students' specific emotional and academic needs.

An essay-type mathematical literacy test was given to those six selected students. The interviews were conducted to confirm the data from the mathematical literacy test results, allowing the researcher to explore the students' abilities in greater depth. The research instruments used in the data collection included primary and secondary instruments. The primary instrument was the researchers themselves, acting as the data collectors and analysts. The researchers reflected on their personal role and maintained academic integrity and transparency in obtaining data from the subjects. Meanwhile, the secondary instruments included the math anxiety questionnaire, the mathematical literacy test adapted from PISA items, and interview guidelines developed based on mathematical literacy indicators. The instruments were validated by two mathematics education experts from the Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, who confirmed that the instruments were valid and reliable for use in collecting data.

The literacy test administered is as follows:

1. Alex drew the following pattern of red and blue triangles. There are four rows of the pattern as shown below.



What would be the percentage of blue triangles in all four rows of the pattern?

2. Mount Fuji is a famous active volcano in Japan. One of the hiking trails on Mount Fuji is the Gotemba trail, which has a length of 9 km. Toshi used a pedometer to count his steps along the Gotemba trail. His pedometer showed that he took 22,500 steps while hiking. Estimate the average length of Toshi's steps for walking on the Gotemba trail. Give your answer in centimeters (cm)!

3. Jean Baptiste is a wildlife photographer who travels on an annual expedition and takes several photos of penguins and their chicks. He is particularly interested in tracking the growth of different penguin colonies. Jean wonders how the size of a penguin colony will change over the years. To determine this, he makes the following assumptions:

- At the beginning of the year, the colony consists of 10,000 penguins (5,000 pairs).
- Each pair of penguins produces one chick during the spring each year.
- By the end of the year, 20% of all penguins (both adults and chicks) will die.

How many penguins (adults and chicks) will remain in the colony at the end of the first year?

The indicators of math anxiety provided through the questionnaire are presented in the following table.

Table1. Indicators of Math Anxiety

Indicators	Subindicators
Mathematical Knowledge/ Understanding	Understanding of mathematical concepts
Somatic	1. Physical and emotional changes while learning mathematics 2. Experiencing cold sweats while studying mathematics 3. Having a racing heartbeat during mathematics learning
Cognitive	1. Feeling frustrated when studying mathematics 2. Facing difficulty concentrating during mathematics learning 3. Being anxious about others' reactions
Attitude	1. Feeling restless while studying mathematics 2. Experiencing fear during mathematics learning 3. Lacking self-confidence in mathematics-related tasks

Source: Cooke, Cavanagh, Hurst, & Sparrow (2011)

Meanwhile, the indicators of students' mathematical literacy are presented in the following table.

Tabel 2. Mathematical Literacy Indicators from the Lowest to the Highest Levels

Level	Mathematical Literacy Indicators
1	The ability to identify information and perform common procedures based on clear instructions.
	The ability to answer questions within familiar and general contexts where all relevant information is readily available and the questions are clearly stated.
2	The ability to filter relevant information from a single source and use a single representation method.
	The ability to apply algorithms, formulas, procedures, or basic conventions to solve problems.
3	The ability to execute procedures effectively, including those requiring sequential decision-making.
	The ability to solve problems by applying simple strategies.
4	The ability to work effectively with concrete but complex models and situations that may involve constraints requiring assumptions.
	The ability to select and integrate different representations, including symbolic ones, and connect them to real-life situations.
	The ability to provide explanations and communicate them with arguments based on interpretation and actions taken.
5	The ability to develop and work with models for complex situations, recognizing constraints, and establishing assumptions.
	The ability to select, compare, and evaluate appropriate problem-solving strategies to address complex issues related to models.
6	The ability to conceptualize, generalize, and utilize information based on investigation and modeling of complex situations, applying above-average knowledge.
	The ability to formulate and communicate findings accurately and argue them appropriately in real-life contexts.

Source: OECD (2019)

The data analysis followed the Miles, Huberman, and Saldana (2014) model, which consists of three main stages: data condensation, data display, and conclusion drawing/verification. During the data condensation, the researchers selected, simplified, abstracted, and transformed the raw data from questionnaires, tests, and interviews. The relevant data were organized systematically, focusing on themes related to math anxiety and mathematical literacy. In the data display stage, the findings were presented in descriptive summaries and matrices enabling clearer interpretation. Finally, the conclusion drawing/verification stage involved identifying patterns, exploring relationships between the data, and verifying to ensure the accuracy of the findings.

Results and Discussion

Results

The results of this study focus on the analysis of mathematical literacy levels based on mathematical anxiety levels, adopting the qualitative data analysis model of Miles, Huberman, and Saldana (2014), which comprises data condensation, data display, and conclusion drawing/verification. The data obtained includes results from a mathematical literacy test on quantity content and interview findings from research subjects representing three levels of mathematical anxiety: high, moderate, and low.

Data Condensation

In this study, data condensation involved written test results from six subjects and in-depth interviews conducted afterward. During the data condensation stage, there was a process of selecting, simplifying, abstracting, and transforming raw data to filter out the most relevant information and process it into structured and meaningful data. This data condensation phase included the following key steps.

First, Data Selection: the data selection process in this research involved identifying which data were relevant to the research focus, namely: mathematical literacy based on the level of math anxiety. From the test results and interviews involving six subjects (ST1, ST2, SS1, SS2, SR1, and SR2), the selected information included their performance on three mathematical literacy questions and their responses in interviews regarding math anxiety. Only the data demonstrating a relationship between anxiety levels and mathematical literacy were selected for further analysis. The results of this data selection stage are as follows: (1) subjects with high anxiety (ST1 and ST2) showed difficulty in correctly solving the problems, particularly those requiring an understanding of percentages and simple subtraction; (2) subjects with moderate anxiety (SS1 and SS2) were able to correctly solve most of the problems but made errors in questions that required deeper conceptual understanding; and (3) subjects with low anxiety (SR1 and SR2) solved all the problems correctly, indicating a higher level of mathematical literacy. Further, the comparison of students' mathematical literacy in the content area of quantity across levels of math anxiety (high, moderate, and low) is presented below.

Table 3. Comparison of Students' Mathematical Literacy in the Content Area of Quantity with High Math Anxiety

Level	Mathematical Literacy Indicators	ST1	ST2
1	The ability to identify information and perform common procedures based on clear instructions.	-	-
	The ability to answer questions within familiar and general contexts where all relevant information is readily available and the questions are clearly stated.	-	-
2	The ability to filter relevant information from a single source and use a single representation method.	✓	-
	The ability to apply algorithms, formulas, procedures, or basic conventions to solve problems.	-	-
3	The ability to execute procedures effectively, including those requiring sequential decision-making.	✓	-
	The ability to solve problems by applying simple strategies.	✓	-
4	The ability to work effectively with concrete but complex models and situations that may involve constraints requiring assumptions.	-	-
	The ability to select and integrate different representations, including symbolic ones, and connect them to real-life situations.	-	-
	The ability to provide explanations and communicate them with arguments based on interpretation and actions taken.	-	-
5	The ability to develop and work with models for complex situations, recognizing constraints, and establishing assumptions.	✓	✓
	The ability to select, compare, and evaluate appropriate problem-solving strategies to address complex issues related to models.	-	-
6	The ability to conceptualize, generalize, and utilize information based on investigation and modeling of complex situations, applying above-average knowledge.	-	-
	The ability to formulate and communicate findings accurately and argue them appropriately in real-life contexts.	-	-

Table 4. Comparison of Students' Mathematical Literacy in the Content Area of Quantity with Moderate Math Anxiety

Level	Mathematical Literacy Indicators	SS1	SS2
1	The ability to identify information and perform common procedures based on clear instructions.	-	-
	The ability to answer questions within familiar and general contexts where all relevant information is readily available and the questions are clearly stated.	-	-
2	The ability to filter relevant information from a single source and use a single representation method.	✓	✓
	The ability to apply algorithms, formulas, procedures, or basic conventions to solve problems.	-	-
3	The ability to execute procedures effectively, including those requiring sequential decision-making.	✓	✓

	The ability to solve problems by applying simple strategies.	✓	✓
4	The ability to work effectively with concrete but complex models and situations that may involve constraints requiring assumptions.	-	-
	The ability to select and integrate different representations, including symbolic ones, and connect them to real-life situations.	-	-
	The ability to provide explanations and communicate them with arguments based on interpretation and actions taken.	-	-
5	The ability to develop and work with models for complex situations, recognizing constraints, and establishing assumptions.	✓	✓
	The ability to select, compare, and evaluate appropriate problem-solving strategies to address complex issues related to models.	-	-
6	The ability to conceptualize, generalize, and utilize information based on investigation and modeling of complex situations, applying above-average knowledge.	✓	✓
	The ability to formulate and communicate findings accurately and argue them appropriately in real-life contexts.	-	-

Table 5. Comparison of Students' Mathematical Literacy in the Content Area of Quantity with Low Math Anxiety

Level	Mathematical Literacy Indicators	SR1	SR2
1	The ability to identify information and perform common procedures based on clear instructions.	-	-
	The ability to answer questions within familiar and general contexts where all relevant information is readily available and the questions are clearly stated.	-	-
2	The ability to filter relevant information from a single source and use a single representation method.	✓	✓
	The ability to apply algorithms, formulas, procedures, or basic conventions to solve problems.	-	-
3	The ability to execute procedures effectively, including those requiring sequential decision-making.	✓	✓
	The ability to solve problems by applying simple strategies.	✓	✓
4	The ability to work effectively with concrete but complex models and situations that may involve constraints requiring assumptions.	-	-
	The ability to select and integrate different representations, including symbolic ones, and connect them to real-life situations.	-	-
	The ability to provide explanations and communicate them with arguments based on interpretation and actions taken.	-	-
5	The ability to develop and work with models for complex situations, recognizing constraints, and establishing assumptions.	✓	✓
	The ability to select, compare, and evaluate appropriate problem-solving strategies to address complex issues related to models.	✓	✓
6	The ability to conceptualize, generalize, and utilize information	✓	✓

	based on investigation and modeling of complex situations, applying above-average knowledge.		
	The ability to formulate and communicate findings accurately and argue them appropriately in real-life contexts.	✓	✓

Second, Data Simplification: after data selection, simplification was carried out by filtering information from the test results and interviews, making it easier to analyze. At this stage, the data were categorized into several main groups: performance on Question 1 (percentage of blue triangles), Question 2 (average steps), and Question 3 (20% subtraction of penguins), as well as interview results regarding math anxiety. The outcomes of this stage are as follows: (1) ST1 and ST2 made errors in calculating percentages and subtraction, and they were unable to answer the second question due to anxiety; (2) SS1 and SS2 made mistakes in calculating the average but succeeded in percentages and subtraction with the help of a calculator; and (3) SR1 and SR2 successfully solved all the problems correctly and demonstrated a good understanding of basic concepts.

Third, Data Abstraction: the purpose of data abstraction is to highlight key patterns from the test results and interviews. At this stage, abstraction was carried out by identifying the relationship between math anxiety and mathematical literacy skills. From the data obtained, it was evident that subjects with high anxiety tended to make more mistakes, especially on questions involving simple concepts, while subjects with low anxiety excelled in understanding and solving the problems. Data abstraction also involved constructing a deeper understanding of the impact of anxiety on students' abilities. The results of data abstraction were as follows: (1) ST1 and ST2 tended to be confused and struggled even with relatively simple questions, due to anxiety disrupting their thought process; (2) SS1 and SS2 performed better but still encountered difficulties in certain concepts, particularly when under pressure; and (3) SR1 and SR2 demonstrated good understanding and effective problem-solving strategies, with anxiety not hindering their thought process.

Fourth, Data Transformation: the final stage of data condensation is data transformation. Data transformation refers to converting raw data into structured and organized information. In this case, the data from the test results and interviews were processed into a table that compares each subject's performance in solving mathematical literacy problems. This data transformation also included key findings from the interviews regarding math anxiety and its impact on each subject's performance. The transformation of data into a table to visualize the relationship between anxiety levels and mathematical literacy can be seen in Table 6.

Table 6. The Relationship Between Anxiety Levels and Mathematical Literacy

Subject	Anxiety Level	Question 1 (Percentage)	Question 2 (Average)	Question 3 (Subtraction)	Notes on Interview
ST1	High	Incorrect	Not attempted	Not attempted	Feeling confused and having difficulty in thinking clearly when faced with math problems (failed to understand the basic question)
ST2	High	Incorrect	Not attempted	Incorrect (wrong reduction)	Experiencing significant mental pressure when faced with problems, making it difficult to focus (difficulty in focusing on the question)
SS1	Moderate	Correct	Incorrect (average was wrong)	Correct (with a calculator)	Being able to solve problems with the help of a calculator but still lacking confidence with more complex questions (using procedures, lacking conceptual understanding)
SS2	Moderate	Correct	Incorrect (average was wrong)	Correct (with a calculator)	Being anxious only about questions that require deeper understanding but being capable of solving simpler ones (anxious with more complex questions)
SR1	Low	Correct	Correct	Correct	Being confident when solving problems, not experiencing significant anxiety, and managing time well (good understanding, appropriate strategy)

SR2	Low	Correct	Correct	Correct	Being calm and focusing when solving problems, having a good understanding of fundamental mathematical concepts (being confident, understanding the concepts well)

By conducting structured data condensation, this research has successfully filtered and summarized complex raw data into relevant and easily analyzable information. The results of this process reveal a strong correlation between mathematics anxiety and students' mathematical literacy, where high levels of anxiety hinder performance, while lower levels of anxiety facilitate better problem-solving abilities. This condensation phase is crucial to ensuring that the analyzed data is truly relevant to the research focus and provides deep insights into the phenomenon being studied.

Data Display

After the condensation process, the data were presented systematically in the form of descriptive narratives and summary tables, enabling the researchers to identify emerging patterns and draw conclusions from the data. This data presentation includes detailed descriptions of the results from the mathematics literacy tests and interview responses for each subject, which are then correlated with the indicators of mathematical literacy at various levels. The purpose of this data presentation is to illustrate the relationship between mathematics anxiety and mathematical literacy, based on the test and interview data from six subjects (ST1, ST2, SS1, SS2, SR1, and SR2).

Narratively, based on Table 6, the data can be presented as follows. First, the subjects with high anxiety (ST1 and ST2) experienced significant difficulty in solving mathematical problems, particularly the first one, which involved percentages. Both subjects answered this question incorrectly, with the same wrong answer. Furthermore, they were unable to complete the second and third problems due to their heightened anxiety, which hindered their ability to think clearly and solve problems. From the interviews, it was revealed that ST1 felt extremely anxious when facing mathematical questions, which led to confusion and an inability to focus. Similarly, ST2 displayed strong signs of anxiety, feeling pressured and unable to perform well on the tasks.

Second, the subjects with moderate anxiety (SS1 and SS2) were able to answer the first question correctly. However, both of them made mistakes on the second problem, which required them to calculate the average number of steps. This suggests that their moderate level of anxiety may have impacted their performance on more complex problems. Nevertheless, they managed to solve the third problem with the help of a calculator. This indicates that they were still able to cope with their anxiety when provided with additional tools. During the interviews, SS1 and SS2 expressed that they felt somewhat anxious when faced with more challenging questions but were able to handle simpler problems quite well.

Third, the subjects with low anxiety (SR1 and SR2) demonstrated excellent performance on all tasks. They correctly answered the first question, accurately calculated the average number of steps, and completed the subtraction problem without any mistakes. From the interviews, SR1 and SR2 stated that they felt calm and confident while working on the problems and did not experience any significant anxiety. Both had a solid understanding of basic mathematical concepts and were able to solve the problems efficiently.

To further clarify the relationship between anxiety levels and test outcomes, the following table presents a matrix diagram, offering the data in a more visual format.

Table 7. Summary of the Relationship Between Anxiety and Test Results

Anxiety Level	High Anxiety (ST1 and ST2)	Moderate Anxiety (SS1 and SS2)	Low Anxiety (SR1 and SR2)
Question 1 (Percentage)	Incorrect	Correct	Correct
Question 2 (Average)	Not attempted/incorrect	Incorrect (average not accurate)	Correct
Question 3 (Subtraction)	Not attempted/incorrect	Correct (with calculator)	Correct
Interview	High anxiety level, hindering thinking ability	Moderate anxiety, being able to handle simple questions	Confident, calm, managing time and tasks well

The presentation of this data helps to illustrate that mathematical anxiety has a clear impact on students' performance in solving mathematical literacy problems. The subjects with high anxiety tend to make more mistakes, particularly on questions involving fundamental concepts. In contrast, the subjects with low anxiety demonstrate better performance across all tasks, as supported by interviews that reveal their confidence and calmness. By presenting the data systematically, the researchers can more easily identify patterns and trends among the subjects, which can then be used to draw conclusions relevant to the research objectives.

Drawing Conclusions/Verification

Based on the condensed and presented data, conclusions were drawn and verified. This process involved identifying patterns, exploring relationships between the data, and verifying to ensure the accuracy of the findings. The stages of conclusion drawing and verification are as follows.

First, Initial Conclusion Drawing: after the data was condensed and presented, the initial conclusion that can be drawn is that there is a significant relationship between the level of math anxiety and mathematical literacy skills. From the results of tests and interviews with six subjects (ST1, ST2, SS1, SS2, SR1, and SR2), it was found that the subjects with high anxiety (ST1 and ST2) tended to struggle with solving relatively simple mathematical literacy problems. Their anxiety interfered with their ability to think clearly and solve mathematical problems. Meanwhile, the subjects with moderate anxiety (SS1 and SS2) performed better but still made errors on problems requiring deeper conceptual understanding. Their anxiety impacted their performance on more complex problems. The subjects with low anxiety (SR1 and SR2) demonstrated higher mathematical literacy, successfully solving all problems and better coping with challenges in mathematical tasks.

Second, Pattern Identification and Data Relationships: the pattern identified from the research results shows that the lower the level of math anxiety, the better the students' ability to solve mathematical literacy problems. Another pattern observed is that anxiety has a more significant impact on problems involving basic concepts typically considered simple, such as percentages and subtraction. The anxiety also diminished students' ability to think strategically, as evidenced by the highly anxious subjects who frequently failed to solve problems due to basic errors or an inability to focus. The relationship found is a direct link between anxiety levels and students' success in solving mathematical problems. The higher the anxiety, the more difficult it became for students to process mathematical information and apply it effectively.

Third, Conclusion Verification and Validation: verification was conducted by revisiting the findings from the tests and interviews to ensure that the conclusions drawn were justified by the data. The verification process involved data triangulation from both test results and interviews to ensure consistency between students' performance in the mathematical literacy test and their statements regarding math anxiety. In the case of ST1 and ST2, the interviews revealed that their math anxiety was very high, which was consistent with their poor performance on the test. These interviews validated the conclusion that anxiety hindered their performance. SS1 and SS2 expressed moderate anxiety, which was reflected in fairly good test results, though they still made mistakes on more challenging questions. Meanwhile, SR1 and SR2, with low anxiety, showed consistency in both interviews and test results, where they were more confident and able to solve problems well. Furthermore, verification also involved identifying data that might contradict or deviate from the expected pattern. In this study, no subjects had test results or interviews that contradicted the main pattern found, which is that anxiety affects mathematical literacy.

Fourth, Strengthening or Modifying the Conclusion: after the verification, the initially tentative conclusions could be reinforced into final conclusions. At least three main conclusions were drawn from this study: (1) math anxiety significantly impacts students' mathematical literacy. In this case, the students with high anxiety levels performed poorly in mathematical literacy problems, especially on problems involving basic concepts such as percentages and subtraction; (2) lower levels of anxiety are associated with better performance in solving mathematical literacy problems. In this case, the students with low anxiety demonstrated better problem-solving abilities and were more successful in solving the given problems, including more difficult ones; and (3) math anxiety has a more significant effect on problems that require an understanding of basic concepts. In this case, students with high anxiety tend to struggle with problems that are generally considered easy, indicating that anxiety hinders their cognitive ability to perform tasks that should be manageable.

Fifth, Final Conclusion: this study concludes that math anxiety has a significant impact on students' mathematical literacy, with a more pronounced effect on students with high anxiety levels. The conclusion drawing process, supported by the verification stage, ensures that these findings are consistent with the data obtained, and the conclusion can serve as a basis for developing educational interventions aimed at reducing math anxiety among students.

Discussion

Understanding math anxiety is crucial in addressing students' learning challenges and improving mathematical literacy globally. This study highlights the relationship between anxiety and performance, emphasizing the need for supportive learning environments that reduce stress and promote effective learning. This foundational insight provides context for interpreting the findings of this study. The findings of this study are directly related to at least four key areas: the theory of mathematics anxiety; the Yerkes-Dodson Law and Cognitive Performance; Mathematical Literacy and the PISA Framework; and Problem-Solving Strategies within the framework of Information Processing Theory. These four points are discussed in relation to the study's findings, followed by a discussion on the implications of the results and the limitations of the study.

The Theory of Mathematics Anxiety

Mathematics anxiety is a specific form of anxiety related to mathematical activities. Ashcraft & Ridley (2005) define mathematics anxiety as fear, worry, and discomfort when individuals are confronted with mathematical tasks. This aligns with research findings indicating that students with high levels of anxiety experience difficulty in understanding mathematical concepts and solving problems, particularly those requiring the application of logic and appropriate strategies. The theory suggests that anxiety reduces the working memory capacity necessary for processing mathematical information (Ashcraft & Krause, 2007), which directly affects student performance. The results of this study support this theory, as students with high anxiety (ST1 and ST2) frequently made errors in understanding problems, struggled to identify relevant information, and used less effective strategies. In contrast, students with low anxiety demonstrated better comprehension and were more accurate in solving problems.

The Yerkes-Dodson Law and Cognitive Performance

The research findings, which reveal differences in performance among students with high, moderate, and low anxiety levels, can be explained through the Yerkes-Dodson Law (1908). This law posits a curvilinear relationship between anxiety levels and performance, where both low and excessively high anxiety tend to impair cognitive performance, while moderate anxiety can enhance performance in certain tasks. In this study, students with moderate anxiety (SS1 and SS2) were able to solve simple problems fairly well but encountered difficulties with more complex questions. This aligns with the Yerkes-Dodson Law, which states that moderate anxiety can boost performance in less complex tasks, but as task complexity increases, anxiety can become a hindrance. Previous research by Tobias (1993) also supports this finding, asserting that both excessively high and low anxiety levels are suboptimal for learning performance. This is relevant to the results of SS1 and SS2, who successfully answered the first question but failed on more complex ones. It means that cognitive factors influence mathematics anxiety and students' performance Schmitz, Jansen, Wiers, & Salemink (2023).

Mathematical Literacy and the PISA Framework

This research aligns with the concept of mathematical literacy developed within the PISA framework. According to the OECD (2013), mathematical literacy involves the ability to formulate, use, and interpret mathematics in various contexts to solve real-world problems. Mathematical literacy not only measures procedural skills but also conceptual abilities in understanding and applying mathematics contextually. The findings of this study indicate that math anxiety significantly affects students' literacy skills. Students with low anxiety levels (SR1 and SR2) were able to apply mathematical concepts effectively in real-life contexts, such as questions involving the percentage of a blue triangle, which required an understanding of percentage concepts and their application in a visual context. In contrast, students with high anxiety tended to struggle in linking concepts with context, indicating lower mathematical literacy. This is further supported by OECD (2016), which highlights that math anxiety is a crucial factor in students' mathematical literacy across different countries. High anxiety often hinders students from optimally using their cognitive abilities to solve problems in various situations.

Problem-Solving Strategies within the framework of Information Processing Theory

The findings of this research can also be explained through information processing theory, which posits that students who are able to use appropriate problem-solving strategies tend to perform better in mathematical literacy. According to this theory, the problem-solving process involves several stages, from problem identification, organizing information, to applying the correct strategy to solve the problem (Hmelo-Silver & Eberbach, 2011; Hung, 2011; Carm, 2013). In this study, students with high anxiety often struggled to organize relevant information and select suitable strategies. For instance, ST1 made an error in determining the total number of blue triangles to be counted for the percentage calculation, indicating a mistake at the information organization stage. On the other hand, students with low anxiety were more capable of using systematic and logical approaches, such as SR1, who accurately applied the steps for percentage calculation. Research by Ravenscroft (2001) and Friedman & Deek (2002) suggests that effective problem-solving strategies require a deep understanding of basic mathematical concepts and skills in organizing information. This aligns with the research findings, where students with low anxiety were better able to use conceptual strategies to solve the problems.

The Implications of the Results and the Limitations of the Study

The findings indicating that math anxiety significantly impacts mathematical literacy hold important implications for mathematics education. The findings confirm that students with lower math anxiety demonstrated better conceptual understanding, while those with higher anxiety struggled with complex tasks. This suggests that interventions targeting anxiety management could enhance mathematical literacy. By identifying the impact of math anxiety on mathematical literacy, this study underscores the need for tailored instructional strategies. Teachers should adopt supportive teaching models to alleviate anxiety and enhance students' confidence in mathematics. It is crucial for teachers to design learning environments that can alleviate students' math anxiety (Irmayanti, Chou, & Anuar, 2024). Inclusive and supportive teaching strategies, such as scaffolding (Vygotsky, 1978), can assist students in overcoming difficulties in grasping fundamental concepts. Project-based learning or cooperative learning approaches may also help enhance students' mathematical literacy by creating an atmosphere where they feel more comfortable experimenting and making mistakes without fear. This aligns with research conducted by Smith & Morgan (2016); Geiger, Stillman, Brown, & Galbraith (2018); Chavez & Lapinid (2019); and Attard & Holmes (2019), which indicates that more collaborative and actively engaged learning in real-world problem-solving can boost students' confidence and reduce anxiety. Families, particularly parents, also need to play a role in reducing children's mathematics anxiety, enhancing their mathematical performance, and fostering positive attitudes toward mathematics from an early age (Cheng, Huang, & Yang, 2023).

In terms of limitations, one of the primary constraints of this study is the relatively small sample size, which may not fully represent the broader student population. This limitation is consistent with criticisms raised by Cohen, Manion, & Morrison (2017) regarding the generalizability of findings in educational research with small samples. Therefore, further research with larger sample sizes and a broader range of student conditions is recommended. Additionally, the methods used to measure anxiety in this study were limited to observation and interviews, which may not adequately capture the full dynamics of the anxiety experienced by students. More comprehensive research employing a wider variety of measurement methods, such as the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), could provide a more accurate portrayal of the impact of anxiety on mathematical performance to validate and extend these findings.

Conclusion

This research reveals that the mathematical literacy of the eighth-grade students in the "quantity" content is influenced by their level of math anxiety. Students with low math anxiety demonstrated better mathematical literacy. They were able to comprehend fundamental concepts, such as percentages and arithmetic operations, and correctly apply them when solving problems. Moreover, they were more effective in employing problem-solving strategies, organizing information, and performing accurate calculations, indicating that low anxiety supports students' abilities to formulate, apply, and interpret mathematical concepts in real-world contexts.

Students with moderate anxiety exhibited adequate mathematical literacy on simpler problems but faced difficulties with more complex ones. They were generally able to understand instructions and identify relevant information, but were less effective in applying problem-solving strategies to tasks requiring higher-order thinking. Students with high anxiety showed lower levels of mathematical literacy. They often struggled to comprehend instructions, organize information, select and apply appropriate problem-solving strategies. High anxiety reduced their cognitive capacity to optimally process information, hindering their problem-solving abilities and leading to frequent errors.

Overall, math anxiety has a significant impact on mathematical literacy in the "quantity" content. Students with low anxiety were better at solving real-world problems, while those with high anxiety faced substantial barriers in understanding and completing tasks. Math anxiety must be recognized as a critical factor in improving students' mathematical literacy, particularly in the eighth grade. Therefore, as recommendations, this research highlights the importance of designing teaching strategies that can reduce students' math anxiety. Teachers are encouraged to adopt more interactive and supportive approaches, as well as to provide additional guidance and clarification for students with high anxiety when solving problems.

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Ethical Statements

This research adheres to the ethical standards set by Universitas Negeri Makassar. All participants provided informed consent, and the research protocol was reviewed and approved by The Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar. Confidentiality and anonymity of all participants were strictly maintained.

CRediT Authorship Contribution Statement

The authors of this study have contributed collaboratively to the development and completion of this research. The specific contributions of each author are outlined as follows:

- **Author 1:** Conceptualization, Methodology, and Writing (Original Draft Preparation as well as Review & Editing).
- **Author 2:** Data Curation, Formal Analysis, Validation.

- **Author 3:** Supervision
- **Author 4:** Writing (Original Draft Preparation as well as Review & Editing), Funding Acquisition, Resources, and Project Administration.

Conflict of Interest

The authors declare that they have no conflict of interest in the publication of this research.

Data Availability

The datasets generated and analyzed during the current study are available upon reasonable request.

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