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Relationship between Algebraic Thinking Ability and Student's Mathematical Resilience

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ABSTRACT

Algebraic thinking ability and mathematical resilience are two essential elements that support each other in the mathematics learning process. This study aims to determine the relationship between students' algebraic thinking ability and their mathematical resilience. A quantitative correlational method with a cross-sectional design was employed. The population included all seventh-grade students at MTs Al-Musthofa Garut, with a sample of 30 students selected through purposive sampling. Research instruments consisted of an algebraic thinking ability test based on Lew (2004) indicators and a mathematical resilience questionnaire based on Sumarmo (2015) indicators. The validity of both instruments was verified through content and face validity by expert judgment from mathematics teachers, while reliability was calculated using Cronbach's Alpha coefficients, yielding coefficient reliability 0.700 for the algebraic thinking test and coefficient reliability 0.832 for the mathematical resilience questionnaire. Data were collected in a single classroom session and analyzed using Spearman's correlation as the data were not normally distributed. The results showed a positive and significant relationship between algebraic thinking ability and mathematical resilience, with a correlation coefficient of 0.571 and a significance value of 0.001. These findings indicate that a higher level of algebraic thinking ability corresponds to a higher level of mathematical resilience. Practically, this study confirms that strengthening algebraic thinking skills through gradual and systematic practice can be an effective strategy to enhance students' resilience in learning mathematics.

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Introduction

Mathematics plays a vital role as a foundation for developing logical, analytical, creative, and systematic thinking skills required to face 21st-century (Fazriansyah et al., 2025). The

primary goal of mathematics education is to develop students' intellectual intelligence, foster systematic problem-solving abilities, improve learning outcomes, and train skills in expressing and documenting ideas scientifically (Pajow et al., 2024). In line with 21st-century demands, mathematics learning no longer focuses solely on calculation skills but emphasizes the development of Higher Order Thinking Skills (HOTS) (Lestari, 2020).

Within the HOTS development framework, algebraic thinking is a fundamental higher-order thinking skill in mathematics education. Algebra serves as a means to understand patterns, relationships, and structures in mathematics and acts as a basis for advanced topics (Masnia et al., 2023). Algebraic thinking is not limited to symbol manipulation but encompasses generalization, abstraction, organization, modeling, analytical thinking, and dynamic thinking (Lew, 2004). This ability helps students develop flexible and systematic thinking, allowing them to connect mathematical ideas and solve problems through various approaches (Nurhana & Mulbar, 2025). Thus, algebraic thinking ability becomes an important indicator of students' readiness to face reasoning-based learning and problem-solving challenges. Furthermore, algebraic thinking is not only important in the academic realm but also relevant for addressing daily life problems (Saputro & Mampouw, 2018).

Despite its importance, several studies indicate that the algebraic thinking ability of Indonesian students remains low. Farida & Hakim (2021) found that only about 20% of students reached the high category in algebraic thinking, while most still struggled with generalization and concept abstraction. Ismayanti et. al. (2022) revealed that students frequently make procedural errors in solving systems of linear equations, and Munthe & Hakim (2022) stated that many students have not reached the Minimum Mastery Criterion (MMC) in algebra materials. This condition indicates a gap between curriculum goals demanding high-level thinking and the actual abilities of students in the field.

One cause of low algebraic thinking ability relates not only to cognitive aspects but also to affective factors such as motivation, self-confidence, and resilience in facing learning difficulties (Salsabila et al., 2024). Algebra is often perceived as difficult because it demands abstract thinking and complex symbol manipulation. When facing failure in understanding or solving problems, students tend to experience stress, anxiety, and loss of learning motivation (Andani et al., 2025). Thus, success in understanding algebra is determined not only by cognitive ability but also by mathematical resilience (Akkan & Horzum, 2024) the ability of students to remain persistent, not give up easily, and recover from difficulties in learning mathematics (Sumarmo, 2015).

Mathematical resilience reflects students' ability to maintain learning enthusiasm despite obstacles, as well as the ability to manage pressure and emotions when facing mathematical challenges (Rahmatiya & Miatun, 2020). Students with high resilience tend to be optimistic, persistent, and courageous in trying new strategies when facing difficult problems (Alifiahaqsya et al., 2025; Kuncoro & Juandi, 2023). Conversely, students with low resilience give up easily and show negative attitudes toward mathematics learning (Kurniawan et al., 2023). Therefore, resilience plays an important role in helping students develop a growth mindset and maintain perseverance in complex mathematical thinking processes.

However, studies specifically linking algebraic thinking ability with mathematical resilience are still very limited. Most previous studies only highlight the relationship between mathematical resilience and other cognitive abilities, such as problem-solving, reasoning, and numerical intelligence (Attami et al., 2020; Dewi & Handayani, 2025; Fatimah et al., 2021; Maesaroh et al., 2020; Puspita et al., 2024). Based on the literature review, empirical research directly testing the link between algebraic thinking ability and mathematical resilience has not been found. Studies mentioning the relationship between the two, such as those by Alifiahaqsya

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et al. (2025) and Kurniawan et al. (2023), are limited to systematic literature reviews and do not provide quantitative evidence based on field data.

Consequently, there is a research gap regarding the lack of quantitative empirical evidence testing the relationship between algebraic thinking ability and mathematical resilience, particularly at the Junior High Schoollevel using Lew (2004) algebraic thinking indicators and Sumarmo (2015) mathematical resilience dimensions. Therefore, this study aims to fill that gap by analyzing the relationship between students' algebraic thinking ability and mathematical resilience. Theoretically, the results of this study are expected to enrich the literature regarding the link between cognitive and affective aspects in mathematics learning. Practically, these findings are expected to provide pedagogical recommendations for teachers in designing lessons that develop algebraic thinking while building students' resilience in facing mathematics learning difficulties.

Method

Type or Research

This study is a quantitative research with a correlational approach using a cross-sectional design. The correlational approach was used because the study aims to identify the degree of relationship between algebraic thinking ability and students' mathematical resilience without testing causal relationships; thus, the analysis focuses on mapping connections based on empirical data. Furthermore, a cross-sectional design was chosen because all data were collected at a specific point in time simultaneously across all participants in the sample. This design does not involve repeated treatments or longitudinal observations but is conducted in a single data collection session (Sofya et al., 2024). The choice of this design is relevant to the research objectives, given that data collection was performed only once through an algebraic thinking ability test and the distribution of mathematical resilience questionnaires.

Population and Sample

The population of this study consisted of all seventh-grade students at MTs Al-Musthofa Garut for the Even Semester of the 2024/2025 Academic Year, divided into three classes. From this population, one class was selected as a sample using purposive sampling. This technique was chosen based on specific considerations: the class with stable attendance and a relatively balanced distribution of academic scores compared to the other two classes, based on information from the subject teacher. These criteria were set to ensure representation of population characteristics and minimize potential bias. The selected sample was class VII-A, consisting of 30 students with varying individual mathematical abilities covering low, medium, and high categories.

Instrument

This study utilized two types of instruments: an algebraic thinking ability test and a mathematical resilience questionnaire. The algebraic thinking ability test was developed based on six indicators according to Lew (2004): generalization, abstraction, analytical thinking, dynamic thinking, modeling, and organization. The test consisted of three main essay problems, each developed into several sub-questions. From these three problems, six core sub-questions were obtained as analysis items, each specifically designed to represent one of the six indicators. Regarding validity, the test instrument was evaluated through content and face validity using expert judgment by mathematics teachers. The instrument reliability was calculated using

Cronbach's Alpha coefficient based on the primary research data, yielding a value of $\alpha = 0.700$, indicating a high level of reliability.

The second instrument was a mathematical resilience questionnaire based on indicators proposed by Sumarmo (2015), consisting of 30 items (15 positive and 15 negative statements). The questionnaire covers six indicators: (1) perseverance, self-confidence, hard work, and persistence in facing problems, failure, or uncertainty; (2) social interaction skills, willingness to help, peer discussion, and adaptation to the environment; (3) tendency to find new ideas/methods and seek creative solutions; (4) utilizing experience from failure as a means to foster self-motivation; (5) curiosity, reflection skills, research ability, and resource utilization; and (6) communication skills, self-control, and emotional awareness. This instrument used a Likert scale: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). Validity was obtained through expert judgment, and reliability yielded $\alpha = 0.832$, indicating very high reliability.

Table 1. Essay Test Instrument

Question	Indicator
A shopkeeper sells two boxes of pencils and two erasers for a total price of IDR 24,000. It is known that the price of one eraser is IDR 2,000. a. Present the given information from the problem above in the form of a table. b. Construct a mathematical model representing the relationship. c. What is the price of one box of pencils?	***#a.*** *Organization* The problem-solving process carried out by organizing and sorting data into a table through a logical deduction strategy. ***#b.*** *Modelling* The process of representing a complex situation using mathematical expressions. ***#c.*** *Analytical Thinking* The process of determining unknown values in written expressions that are treated as known, or applying inverse operations.

Table 2. Questionnaire Instrument

Questionnaire item	Indicator
Item #1. I review mathematics material that I did not master in the previous test to prepare for the upcoming test..	Perseverance, self-confidence, hard work, and resilience in facing problems, failure, and uncertainty..
Item #2. I feel disturbed when I am asked to help a friend who is experiencing difficulties in learning mathematics	Social interaction skills, willingness to help, peer discussion, and adaptability to the learning environment.

Data Collection

Data collection was conducted in a single face-to-face session in the classroom for 70 minutes. First, students completed the algebraic thinking ability test. Immediately after, they filled out the mathematical resilience questionnaire. The session was supervised by the subject teacher and the researcher to ensure students worked independently.

Data Analysis

Analysis was performed using Microsoft Excel 2013 and SPSS version 20. The stages included:

1. Descriptive Analysis**:** Calculating minimum, maximum, mean, median, and standard deviation.
2. Prerequisite Testing**:** Shapiro-Wilk normality test. If Sig. < 0.05, the data is not normally distributed.

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3. Hypothesis Testing**:** Spearman Rank Correlation was used due to non-normal distribution.
   H_0 : There is no significant relationship between algebraic thinking ability and mathematical resilience.
   H_a : There is a significant relationship between algebraic thinking ability and mathematical resilience.

Table 3. Correlation Strength Classification (Michali, 2021 dalam Hendi et al., 2025)

Coefficient Interval	Strength of Relationship
0,800 – 1,000	Very Strong
0,600 – 0,799	Strong
0,400 – 0,599	Moderate
0,200 – 0,399	Low
0,000 – 0,199	Very Low

Research Findings

Based on Table 4, it can be observed that the sample size for both algebraic thinking ability and mathematical resilience is identical, totaling 30 students. The scores for algebraic thinking ability yielded a mean of 50.56 and a median of 47.92, with a maximum score of 100, a minimum score of 12.50, and a standard deviation of 17.87. Meanwhile, the mathematical resilience scores showed a mean of 80.23 and a median of 82.46, with a maximum score of 93.67, a minimum score of 57, and a standard deviation of 9.70. Furthermore, the categorization in this study is divided into three levels: high, moderate, and low.

Table 4. Statistical Results of Algebraic Thinking Ability and Mathematical Resilience

Variabel	N	Mean	Median	SD	Min	Max
Algebraic Thinking Ability	30	50,56	47,92	17,87	12,50	100
Mathematical Resilience	30	80,23	82,46	9,70	57	93,67

Level of Algebraic Thinking Ability

The algebraic thinking ability scores were derived from three essay problems consisting of six sub-questions. The maximum possible score was 24 points, and all raw scores were transformed into a 0–100 scale using the following formula:

$$\text{score} = \frac{obtained\ score}{24} \times 100$$

Categories were determined proportionally, as displayed in Table 5.

Table 5. Algebraic Thinking Ability Categories

Score	Kategori
Score≥ 59,49	High
41,62 ≤ Score < 59,49	Moderate
Score < 41,62	Low

The frequency distribution of students' algebraic thinking ability levels is presented in Table 6.

Table 6. Algebraic Thinking Ability Levels

Category	Frequency	Percentage (%)
High	6	20
Moderate	20	66,67
Low	4	13,33

The results in Table 6 show that the majority of students fall into the moderate category at 66.67%, followed by 20% in the high category and 13.33% in the low category. These findings indicate that the overall algebraic thinking ability of the students is at a moderate level.

Mathematical Resilience Levels

The mathematical resilience instrument consists of 30 statements, comprising 15 positive statements and 15 negative statements using a 4-point Likert scale. The total scores were subsequently classified into three categories: high, moderate, and low.

Table 7. Mathematical Resilience Levels

Category	Frequency	Percentage (%)
High	11	36,67
Moderate	13	43,33
Low	6	20

Referring to Table 7, the majority of students are in the moderate category at 43.33%, followed by the high category at 36.67%, while the remaining 20% are in the low category. These findings indicate that the students' mathematical resilience is at a moderate level.

Relationship Between Algebraic Thinking and Mathematical Resilience

The primary objective of this study is to determine the relationship between students' algebraic thinking ability and their mathematical resilience. Prior to conducting the correlation test, the data from both variables underwent prerequisite testing through the Shapiro-Wilk normality test. The results of the normality test are presented in Table 8.

Table 8. Shapiro-Wilk Normality Test Results

	Statistic	df	Sig.
Algebraic Thinking Ability	0,869	30	0,002
Mathematical Resilience	0,906	30	0,012

Based on the results of the Shapiro-Wilk normality test, the significance values obtained were 0.002 for algebraic thinking ability and 0.012 for mathematical resilience. Since the significance value for each variable is $p < 0.05$, it indicates that both datasets are not normally distributed. Therefore, the analysis of the relationship between variables was conducted using a non-parametric test, specifically the Spearman Rank correlation test. The results of the data analysis are presented in Table 9.

Table 9. Spearman Rank Correlation Results

Correlation Coefficient	Sig. (2-tailed)	N
0,571	0,001	30

Based on the statistical calculations, a significance value of $0.001 < 0.05$ was obtained; thus, Ho is rejected. This indicates that there is a significant relationship between students' algebraic thinking ability and their mathematical resilience. Furthermore, the correlation coefficient obtained is 0.571, which indicates a positive relationship with moderate strength. This means that the higher the students' algebraic thinking ability, the higher their level of

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mathematical resilience. The results of this study can also be visualized through the scatterplot presented in Figure 1.

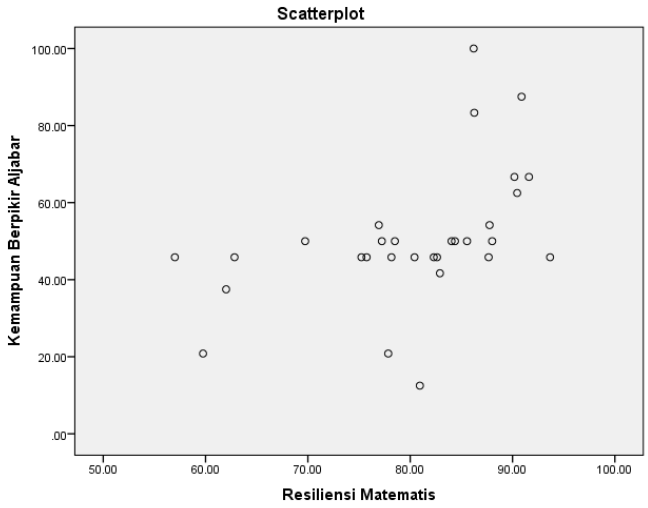

Figure1. Scatterplot of Algebraic Thinking and Mathematical Resilience Scores

Visually, the data points in the scatterplot above indicate a positive relationship trend, where an increase in mathematical resilience scores is followed by an increase in algebraic thinking ability scores. This pattern is consistent with the results of the Spearman correlation analysis, which shows a positive relationship of moderate strength. Although there are several outliers deviating from the main trend, the majority of the data points are concentrated within the resilience range of 75–90 and the algebraic thinking range of 40–60. This aligns with the descriptive findings that the majority of students fall into the moderate category for both variables. The points within this range form a relatively linear upward (monotonic) pattern, although they do not form a perfect straight line, as is common with non-parametric data. For further clarity, the relationship between students' algebraic thinking ability and mathematical resilience is presented below.

Discussion

The primary finding of this study is the existence of a positive and significant relationship between students' algebraic thinking ability and their mathematical resilience. The Spearman correlation coefficient of 0.571 indicates that the relationship is in the moderate category, meaning that while the connection between the two variables is quite strong, it is not entirely dominant. Based on this correlation coefficient, a coefficient of determination of $(0.571)^2$ x 100\% = 32.60% was obtained. This means that algebraic thinking ability contributes 32.60% to students' mathematical resilience, while the remaining 67.40% is influenced by other factors outside of algebraic thinking, such as learning motivation, the learning environment, instructional strategies, and students' affective and social factors. This suggests that while algebraic thinking ability does contribute to the formation of mathematical resilience, it is not the sole determining factor.

Empirically, the results of this study support Piaget's theory that junior high school students are in transition toward the formal operational stage, where abstract and symbolic thinking abilities begin to develop (Aini & Hidayati, 2017). Algebraic thinking activities (such

as generalization, abstraction, organization, and modeling) require self-regulation, patience, and mental endurance in facing errors and failures. This explains the psychological mechanism behind the relationship between algebraic thinking ability and mathematical resilience: practicing symbol manipulation and abstract reasoning serves as a means of strengthening students' mental toughness.

Furthermore, the results of this study show that students with high algebraic thinking ability only met four primary indicators: generalization, abstraction, organization, and modeling; meanwhile, the indicators for analytical and dynamic thinking were not optimally achieved. This condition differs from the findings of Munthe & Hakim (2022) and Sari et al. (2020), who reported that students with high-level algebraic thinking ability were able to fulfill all indicators. This difference indicates the influence of contextual factors, such as material complexity, student characteristics, and educational levels.

Moreover, this research confirms the general trend of previous studies emphasizing the importance of resilience in supporting mathematical cognitive abilities. Previous studies have shown a positive relationship between resilience and mathematical performance, such as Maesaroh et al. (2020) who found a link between resilience and mathematical reasoning; Fatimah et al. (2021) and Attami et al. (2020), who demonstrated that mathematical resilience influences problem-solving abilities; Puspita et al. (2024), who concluded that mathematical resilience significantly affects numerical intelligence; and Dewi & Handayani (2025), who found that mathematical resilience significantly impacts students' ability to solve mathematical problems. Thus, this study not only supports existing trends but also adds new context regarding the relationship between mathematical resilience and algebraic thinking at the Junior High School (MTs) level, utilizing a combination of algebraic thinking indicators from Lew (2004) and mathematical resilience dimensions from Sumarmo (2015).

Psychologically, the relationship between algebraic thinking ability and mathematical resilience can be explained through the concepts of self-regulation and mental endurance. Algebraic thinking activities-such as identifying patterns, manipulating symbols, and representing relationships between variables-demand the ability to manage frustration and maintain perseverance in resolving errors. Therefore, algebraic thinking skills are not merely cognitive; they shape students' mental resilience in facing difficulties in learning mathematics. From a pedagogical perspective, the findings suggest that the recommended instructional model is one that requires students to engage in extensive problem-solving practice, allowing their algebraic thinking ability and mathematical resilience to be honed simultaneously. Through diverse and progressively challenging exercises, students become accustomed to facing challenges, developing perseverance, and strengthening their mental resilience in solving mathematical problems. This intensive practice-based approach aligns with the empirical evidence showing that analytical and dynamic thinking indicators have not been optimally achieved; thus, systematic practice can help strengthen these two indicators.

Overall, this study confirms the consistency of the theory and previous research findings while adding new context and a significant theoretical contribution to understanding the interaction between algebraic thinking ability and mathematical resilience in early secondary education. These findings underscore that success in mathematics learning is determined not only by logical thinking abilities but also by the formation of students' mental resilience through continuous and reflective practice in mathematical problem-solving.

Conclusion

The results of this study indicate that there is a positive and significant relationship between students' algebraic thinking ability and their mathematical resilience, with a Spearman

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correlation coefficient of 0.571 and a significance value of $0.001 < 0.05$. This finding implies that the higher a student's algebraic thinking ability, the higher their level of mathematical resilience. Theoretically, this result reinforces Piaget's cognitive development theory and Sumarmo (2015) view regarding the link between abstract thinking skills and resilience in learning, as well as confirming previous research that emphasizes the close relationship between cognitive and affective aspects in mathematics education. This study is limited by a relatively small sample size, a research context restricted to a single school, and data collection methods limited to questionnaires and tests; therefore, the results cannot yet be broadly generalized. Nevertheless, these findings provide practical implications for mathematics education. Teachers are encouraged to implement instructional models based on progressive problem-solving exercises so that students' algebraic thinking ability and mathematical resilience can develop simultaneously. For future research, it is recommended to expand the scope of the study, involve more participants, and utilize a mixed-methods approach to gain a deeper understanding of the interaction between algebraic thinking ability and mathematical resilience.

Conflict of Interest

The researcher revealed that there was no conflict interest.

Authors' Contributions

N.A.R. conducted the research by identifying the background of the presented problems, performing the study, processing and analyzing the data, and drafting the research results. R.S. participated in instrument development, data analysis techniques, and finalizing the journal manuscript. All authors have declared that this paper has been read and approved. The contribution percentages are N.A.R.: 75% and R.S.: 25%.

Data Availability Statement

The authors state that the data supporting the findings of this study will be made available by the corresponding author, [N.A.R.], upon reasonable request.

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