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Profiling Students' Algebraic Numeracy Ability Based on Mathematical Resilience: An Exploratory Case Study at Junior High School in Majene, Indonesia

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ABSTRACT:

Background: Students' difficulties in algebraic numeracy remain a persistent challenge in mathematics education because algebra requires abstract reasoning, conceptual understanding, and persistence when encountering complex problems. Existing studies have largely examined mathematical achievement from cognitive perspectives, while affective factors influencing students' engagement and persistence, such as mathematical resilience, remain less explored, particularly in junior high school algebra learning.

Aims: This study aims to explore students' algebraic numeracy profiles based on different levels of mathematical resilience and to identify the factors contributing to variations in students' responses when solving algebraic problems.

Method: This research employed an exploratory case study design using an embedded mixed-**methods**: This study employed an exploratory case study design with an embedded mixed-methods approach involving 32 eighth-grade students from SMP Negeri 2 Majene, Indonesia. Data from the Mathematical Resilience Scale, algebraic numeracy tests, interviews, and observations were analyzed using thematic analysis and cross-case comparison.

Results: The findings indicate that students with higher mathematical resilience demonstrated greater persistence, strategic flexibility, and willingness to engage with challenging algebraic tasks, although their conceptual mastery was not always optimal. The Struggle dimension emerged as the most distinguishing characteristic among resilience categories, while growth mindset became more meaningful when supported by concrete learning experiences. Teacher scaffolding, family support, and peer interaction were identified as important factors shaping students' mathematical resilience.

Conclusion: The study highlights that improving algebraic numeracy requires an integrated approach combining cognitive development with affective support. Strengthening mathematical resilience through supportive learning environments may provide a foundation for improving students' engagement and performance in algebra learning.

Keywords: Algebraic numeracy, Exploratory case study, Junior high school mathematics education, Mathematical resilience, Minimum Competency Assessment.

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INTRODUCTION

Mathematical competence is widely recognized as a fundamental component of students' intellectual development because it supports logical reasoning, analytical thinking, problem-solving capacity, and decision-making in real-life contexts. In contemporary education systems, mathematics learning is no longer viewed merely as the mastery of procedures and formulas but as the development of students' ability to interpret, reason, and apply mathematical concepts in unfamiliar situations (OECD, 2023). Despite its importance, international assessments continue to reveal persistent challenges in students' mathematical performance, particularly among learners in developing educational contexts. The results of the Programme for International Student Assessment (PISA) 2022 indicated that Indonesian students' mathematics achievement remained below the OECD average, reflecting substantial difficulties in applying mathematical knowledge to complex problems (OECD, 2023). These conditions highlight the need to examine not only what students know mathematically but also the internal factors that influence how they engage with mathematical challenges.

One critical area within mathematics learning that continues to present substantial difficulties is algebraic numeracy. Algebra represents a transition from concrete arithmetic thinking toward abstract mathematical reasoning, requiring students to understand variables, relationships, patterns, and symbolic representations (Alam & Mohanty, 2024; Sun et al., 2023; Ünal et al., 2023). Many junior high school students experience difficulties in interpreting algebraic symbols, constructing mathematical models, and connecting algebraic concepts with contextual problems (Edo & Tasik, 2022; Sibgatullin et al., 2022). Recent studies have shown that students often develop misconceptions regarding the meaning of variables, frequently perceiving letters as fixed labels rather than dynamic mathematical representations (Ayeh, 2025; Taranto et al., 2026; van der Werf et al., 2024). Within the Indonesian educational context, these challenges are reflected in students' performance on the Minimum Competency Assessment (AKM), where numeracy requires not only computational skills but also reasoning, interpretation, and problem-solving abilities (Annisa et al., 2024; Purnomo et al., 2022; Siregar & Siregar, 2025). Therefore, understanding the factors underlying students' difficulties in algebraic numeracy has become an essential concern for mathematics educators.

Although cognitive ability remains an important determinant of mathematical achievement, increasing evidence suggests that affective factors significantly influence how students respond to mathematical difficulties. Students with similar levels of cognitive ability may demonstrate different learning outcomes because they differ in persistence, confidence, motivation, and emotional regulation when encountering challenging mathematical tasks. One psychological construct that has received increasing attention in mathematics education is mathematical resilience, defined as students' capacity to maintain engagement, overcome setbacks, and continue learning despite experiencing mathematical difficulties (Xenofontos & Mouroutsou, 2023). Recent research has demonstrated that mathematical resilience contributes to students' problem-solving performance, learning persistence, and willingness to engage with challenging mathematical activities (Akkan & Horzum, 2024; He et al., 2026). This perspective indicates that students' algebraic numeracy difficulties cannot be fully understood through cognitive analysis alone, as affective dispositions may shape the processes through which students approach, interpret, and overcome mathematical obstacles.

The investigation of mathematical resilience within algebraic numeracy contexts is particularly important because algebra learning frequently involves uncertainty, cognitive struggle, and repeated attempts before conceptual understanding is achieved. Students who perceive difficulty as a natural part of learning are more likely to explore alternative strategies, seek assistance, and persist in solving complex problems, whereas students with low resilience may develop avoidance behaviors and disengagement (Enderle, 2025). The four dimensions of mathematical resilience, namely value, struggle, growth, and reaching out, provide a comprehensive framework for understanding how students construct responses toward mathematical challenges (Panaoura, 2025). However, the relationship between these dimensions and students' actual algebraic numeracy behaviors remains insufficiently explored, particularly through in-depth qualitative investigations. In Indonesian junior high schools, where algebra constitutes a major component of AKM numeracy assessment, examining students' resilience profiles may provide meaningful insights for designing learning environments that support both mathematical competence and psychological readiness.

Previous studies have provided valuable evidence regarding mathematical resilience and mathematics achievement; however, several limitations remain apparent. Quantitative investigations have generally dominated the field by examining correlations between mathematical resilience, self-efficacy, motivation, and mathematical performance using large-scale surveys (Qi, 2025). These studies have consistently reported that students with stronger resilience tend to demonstrate better problem-solving abilities and higher mathematical engagement. Similarly, research on algebraic numeracy has primarily focused on identifying students' misconceptions, cognitive obstacles, and problem-solving strategies rather than exploring the affective mechanisms influencing those processes (Mathaba et al., 2024; Mildret & Kakoma, 2025). Although these findings contribute important theoretical understanding, they provide limited explanations regarding how students with different resilience levels actually experience and respond to algebraic difficulties during learning activities.

Furthermore, existing literature indicates a significant gap concerning the integration of cognitive and affective perspectives in understanding algebraic numeracy development. Studies examining AKM-based numeracy have largely emphasized achievement levels, assessment characteristics, and students' cognitive profiles (Mufidah et al., 2023), while research on mathematical resilience has rarely investigated specific mathematical domains such as algebra. In addition, many previous studies have relied on quantitative approaches that are unable to capture students' personal experiences, coping strategies, classroom interactions, and contextual influences shaping resilience development. Limited attention has also been given to local educational contexts outside major Indonesian regions, particularly in Sulawesi Barat, where students' mathematical experiences may be influenced by unique social and educational conditions. Therefore, an exploratory investigation that connects algebraic numeracy performance with mathematical resilience profiles is needed to provide a more comprehensive understanding of how cognitive competence and affective characteristics interact in mathematics learning.

Based on these considerations, this study aims to explore students' algebraic numeracy profiles based on different levels of mathematical resilience and to identify the factors contributing to differences in students' responses when solving algebraic problems among junior high school students. Employing an exploratory case study approach, this research contributes theoretically by extending the understanding of mathematical resilience as an affective dimension that interacts with

algebraic numeracy development rather than functioning as an independent psychological trait. Practically, the findings provide insights for mathematics teachers and educational stakeholders in designing instructional strategies that integrate cognitive scaffolding with resilience-oriented learning environments. By examining students' experiences across different resilience categories, this study offers a contextual perspective on how persistence, struggle management, and social support influence students' engagement with algebraic learning challenges.

METHOD

Research Design

This study employed an exploratory case study design with an embedded mixed-methods approach to investigate the relationship between students' algebraic numeracy abilities and mathematical resilience profiles. The exploratory case study was selected because the research focused on understanding students' experiences, behaviors, and contextual factors that cannot be fully explained through numerical achievement data alone. The embedded mixed-methods framework enabled the researchers to integrate quantitative information from mathematical resilience measurement and algebraic numeracy assessment with qualitative evidence from interviews and observations. Such integration is appropriate when a research problem requires both pattern identification and deeper interpretation of individual experiences within a specific educational context (Creswell & Clark, 2017). The quantitative component functioned as a basis for identifying resilience categories and selecting focal participants, whereas the qualitative component was used to explain how students responded to algebraic challenges during learning processes. This methodological approach allowed the study to capture the interaction between cognitive performance and affective characteristics within authentic mathematics learning situations.

Research Setting and Time

The research was conducted at SMP Negeri 2 Majene, Majene Regency, West Sulawesi, Indonesia, during the 2025 academic period. The research site was selected purposively because the school represented an educational context where students experienced challenges related to numeracy achievement, particularly in algebraic content. The selection of this setting was also based on preliminary information from school-level educational reports indicating that students' numeracy performance required further investigation. Data collection was conducted during regular mathematics learning activities to ensure that students' responses reflected their actual learning experiences. The school context provided an appropriate environment for examining how mathematical resilience developed through interactions among students, teachers, and their surrounding learning environment. Understanding the research setting in detail is essential in qualitative and mixed-methods studies because contextual characteristics influence the interpretation and transferability of research findings (Creswell & Clark, 2017).

Participants and Sampling Procedure

The participants of this study were eighth-grade students at SMP Negeri 2 Majene who represented the target population of junior high school learners experiencing algebra learning activities. The initial participant screening involved 32 students selected from four eighth-grade classes using purposive sampling to obtain variation in mathematical resilience characteristics. All students completed the Mathematical Resilience Scale (MRS), and their scores were categorized into

high, medium, and low resilience groups based on the distribution of obtained scores. From these categories, six students were selected as focal participants through maximum variation purposive sampling, consisting of two students from each resilience category. This sampling strategy was applied to obtain information-rich cases that could provide diverse perspectives regarding students' algebraic reasoning processes and responses to mathematical difficulties (Yan & Jin, 2026). In addition to student participants, two mathematics teachers and six parents were involved as supporting informants to strengthen contextual understanding and enhance data triangulation.

Research Instruments

Three primary instruments were utilized to collect research data: the Mathematical Resilience Scale (MRS), an algebraic numeracy diagnostic test, and semi-structured interview protocols. The MRS was adapted from the mathematical resilience framework consisting of four dimensions: value, struggle, growth, and reaching out, which represent students' beliefs, persistence, adaptive responses, and willingness to seek support during mathematical challenges. The algebraic numeracy diagnostic test was developed based on the Minimum Competency Assessment (AKM) framework, focusing on three cognitive processes: knowing, applying, and reasoning within algebra-related contexts (Osei & Agyei, 2024). The test consisted of open-ended problems covering algebraic concepts, including patterns, functions, and linear equations, to examine students' conceptual understanding and problem-solving strategies. The interview protocol was designed to explore students' thinking processes, emotional responses, learning experiences, and environmental influences related to mathematical difficulties. Observation guidelines were also prepared to document students' behaviors during problem-solving activities, including persistence, strategy changes, and help-seeking actions.

Instrument Validity and Reliability

The quality of the research instruments was ensured through systematic validity and reliability procedures before data collection. The content validity of the instruments was evaluated through expert review involving mathematics education specialists who examined the relevance, clarity, and alignment between instrument items and research objectives. The validation process focused on ensuring that the Mathematical Resilience Scale, algebraic numeracy test, and interview questions appropriately represented the intended constructs. The diagnostic test was reviewed to confirm its alignment with AKM numeracy competencies and algebraic reasoning indicators. The readability and comprehensibility of the instruments were also examined through preliminary trials with students outside the research sample to identify unclear instructions or ambiguous items. Reliability evaluation for the MRS was conducted using Cronbach's alpha coefficient, while qualitative data credibility was strengthened through triangulation and systematic documentation procedures (Creswell & Clark, 2017).

Data Collection Procedures

Data collection was conducted through several sequential stages beginning with administrative preparation and coordination with the school. After obtaining research permission, the researchers administered the Mathematical Resilience Scale to 32 students to identify their resilience profiles. Based on the categorization results, six focal participants were selected and invited to complete the algebraic numeracy diagnostic test under standardized classroom conditions. Following the test administration, semi-structured interviews were conducted using students' written responses as

discussion stimuli to explore their reasoning processes and experiences when solving algebraic problems. Classroom observations were carried out to record students' engagement patterns, persistence, and interactions during mathematical activities. Additional interviews with teachers and parents were conducted to obtain complementary information regarding instructional practices, family support, and social factors influencing students' mathematical resilience.

Data Analysis

Data analysis followed an integrated mixed-methods procedure that combined descriptive quantitative analysis with qualitative thematic interpretation. The quantitative data obtained from the Mathematical Resilience Scale and algebraic numeracy diagnostic test were analyzed descriptively to identify resilience categories and compare students' performance patterns across cognitive levels. The qualitative data from interviews and observations were analyzed using thematic analysis through the stages of data familiarization, initial coding, theme development, theme refinement, and interpretation (Saunders et al., 2023). The coding process focused on identifying patterns related to students' persistence, struggle management, growth beliefs, help-seeking behaviors, and contextual support systems. Cross-case analysis was then conducted to compare similarities and differences among students with high, medium, and low mathematical resilience profiles. The final integration stage connected quantitative patterns with qualitative themes to develop a comprehensive explanation of how mathematical resilience was associated with students' algebraic numeracy experiences.

Ethical Considerations

This study was conducted by following ethical principles applicable to educational research involving human participants. Before participation, students and their parents or guardians received information regarding the research objectives, procedures, confidentiality measures, and their rights as participants. Participation was voluntary, and participants were allowed to withdraw from the study without any academic consequences. To protect privacy, students' identities were replaced with codes during data analysis and reporting. All collected information from students, teachers, and parents was used exclusively for academic research purposes and stored securely by the researchers. Ethical considerations were maintained throughout the research process to ensure responsible data management, participant protection, and academic integrity (Creswell & Clark, 2017).

RESULTS AND DISCUSSION

Results

Mathematical Resilience Profile of Participants

The initial screening was conducted on 32 eighth-grade students to identify their mathematical resilience profiles before selecting focal participants for deeper investigation. Based on the Mathematical Resilience Scale (MRS) scores, students were classified into three categories: high, medium, and low mathematical resilience. The distribution showed that most students were categorized within the medium resilience group, while only a smaller proportion demonstrated high or low resilience characteristics. This pattern indicates that students generally possessed moderate levels of persistence and adaptive responses toward mathematical difficulties, although considerable variation remained among individuals. From the screening process, six students were selected as focal participants, consisting of two students from each resilience category, to represent different

patterns of engagement with algebraic learning challenges. The profile distribution and participant selection are presented in Table 1.

Table 1. Distribution of Students' Mathematical Resilience Categories

Mathematical Resilience Category	Number of Students	Percentage (%)	Selected Participants
High	5	15.6	S1, S2
Medium	23	71.9	S3, S4
Low	4	12.5	S5, S6
Total	32	100	

Table 1 presents the distribution of students according to their mathematical resilience categories. The dominance of the medium category indicates that most students showed neither strong persistence nor complete disengagement when encountering mathematical challenges, providing a meaningful basis for comparing different resilience profiles.

Algebraic Numeracy Performance Across Mathematical Resilience Categories

The algebraic numeracy diagnostic assessment revealed differences in performance patterns among students with different mathematical resilience profiles. Students categorized with high mathematical resilience obtained higher overall scores compared with students in the medium and low categories, although their achievement remained below the expected mastery level. S1 obtained the highest score among the focal participants with 61 out of 120 points (50.8%), followed by S2 with 54 points (45.0%). Students in the medium resilience category demonstrated lower performance, with S3 achieving 43 points (35.8%) and S4 achieving 38 points (31.7%). Meanwhile, students with low resilience obtained the lowest scores, with S5 scoring 32 points (26.7%) and S6 scoring 31 points (25.8%). These findings indicate a consistent pattern in which higher mathematical resilience was accompanied by stronger engagement and relatively better algebraic numeracy performance.

Table 2. Algebraic Numeracy Performance of Focal Participants

Participant	Resilience Category	MRS Score	Algebraic Numeracy Score	Percentage
S1	High	77/80	61/120	50.8%
S2	High	76/80	54/120	45.0%
S3	Medium	72/80	43/120	35.8%
S4	Medium	71/80	38/120	31.7%
S5	Low	46/80	32/120	26.7%
S6	Low	43/80	31/120	25.8%

Table 2 illustrates the relationship between students' resilience categories and algebraic numeracy achievement. Although the difference between categories is visible, the findings also show that high mathematical resilience does not automatically indicate complete algebra mastery, suggesting that persistence and conceptual understanding represent interconnected but distinct dimensions.

Cognitive Performance Patterns in Algebraic Numeracy Tasks

Analysis of students' responses across the AKM cognitive domains showed different patterns among resilience categories. The largest performance gap was identified in the knowing domain, where students with high resilience demonstrated stronger foundational understanding compared with students with low resilience. Students in the high resilience category achieved approximately

80.0% performance on knowing-level tasks, whereas students in the low resilience category achieved approximately 46.7%. Differences were also observed in applying and reasoning tasks, although the performance gap became narrower because all participants experienced difficulties when dealing with complex algebraic representations. High-resilience students tended to continue exploring alternative strategies even when their initial solutions were unsuccessful, whereas low-resilience students frequently stopped after encountering obstacles. The comparison of students' cognitive performance patterns across AKM domains is summarized in Figure 1.

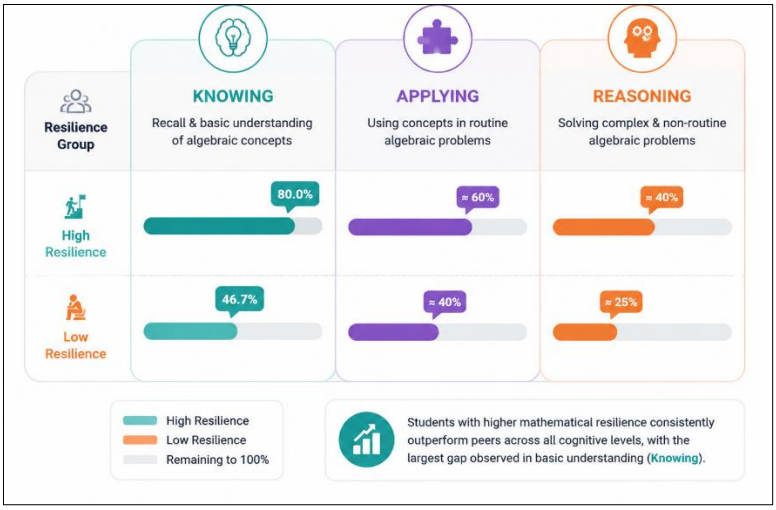


Figure 1. Pattern of Algebraic Numeracy Performance Across AKM Cognitive Levels

Figure 1 demonstrates that the strongest difference between resilience categories appeared in basic algebraic understanding. The pattern suggests that resilience differences were reflected not only in final answers but also in students' ability to maintain engagement when processing mathematical information.

Mathematical Resilience Dimensions and Students' Problem-Solving Behaviors

The analysis of mathematical resilience dimensions revealed that Struggle represented the most distinctive characteristic differentiating students across resilience categories. Students with high resilience consistently demonstrated willingness to remain engaged with difficult algebraic tasks by attempting multiple strategies, reviewing errors, and seeking alternative solutions. In contrast, students with low resilience tended to display avoidance behaviors, including abandoning unfamiliar problems and reducing effort after experiencing initial failure. The Value dimension showed relatively similar patterns across participants, indicating that most students recognized the importance of mathematics regardless of their resilience category. Differences were more apparent in students' responses toward difficulty, persistence, and beliefs about their ability to improve. The comparison of resilience dimensions among categories is presented in Table 3.

Table 3. Relative Differences Across Mathematical Resilience Dimensions

Mathematical Resilience Dimension	Pattern Observed
Value	Relatively similar across resilience categories
Struggle	Largest difference between high and low resilience groups
Growth	Higher among students with successful learning experiences
Reaching Out	Influenced by willingness to seek support and classroom interaction

Table 3 highlights the qualitative patterns emerging from students' mathematical resilience dimensions. The findings indicate that resilience differences were primarily reflected in how students responded to difficulty rather than simply how much they valued mathematics.

Contextual Factors Influencing Students' Mathematical Resilience

Interview and observation data identified three contextual factors associated with students' mathematical resilience profiles: teacher scaffolding, family support, and peer interaction. Mathematics teachers reported providing temporary instructional support by simplifying complex tasks, breaking problems into smaller steps, and encouraging students to view mistakes as part of the learning process. Students with stronger resilience frequently described classroom support and previous successful learning experiences as important factors that encouraged them to continue solving difficult problems. Family interviews indicated that emotional encouragement was generally present among participants, although differences appeared in academic assistance and availability of learning support at home. Peer relationships also influenced students' willingness to seek help, as some students considered classmates as accessible sources of explanation while others avoided asking questions due to concerns about negative evaluation. These findings illustrate that students' mathematical resilience developed through interactions between individual characteristics and their surrounding learning environment.

Discussion

The findings of this study demonstrate that mathematical resilience provides an important lens for understanding variations in students' algebraic numeracy performance, particularly among junior high school students encountering abstract algebraic concepts. Although students' resilience categories were not directly equivalent to their achievement levels, the observed pattern showed that students with higher resilience tended to demonstrate stronger engagement, persistence, and strategic flexibility when solving algebraic problems. This finding supports the conceptualization of mathematical resilience as a dynamic capacity that influences how learners respond to difficulty rather than merely representing a fixed personal characteristic (Xenofontos & Mouroutsou, 2023). Previous research has similarly indicated that resilient students are more likely to maintain effort, regulate negative emotions, and continue problem solving when confronted with mathematical challenges (Akkan & Horzum, 2024; He et al., 2026). However, the present study extends these findings by demonstrating that resilience operates within a specific mathematical domain, namely algebraic numeracy, where conceptual abstraction and symbolic reasoning create distinctive learning barriers. Therefore, mathematical resilience should be considered not only as a predictor of mathematical achievement but also as a mechanism that shapes students' willingness to engage with cognitively demanding algebraic tasks.

The differences observed between resilience categories indicate that students' responses to mathematical struggle represent a critical factor influencing algebraic learning processes. The strongest distinction among students was found in the Struggle dimension, suggesting that persistence during challenging situations may be more influential than students' general appreciation of mathematics. This finding aligns with the theoretical perspective that mathematical resilience develops through students' interpretations of difficulty, where productive struggle can become a pathway toward deeper mathematical understanding (Panaoura, 2025). Previous studies have reported that students with stronger resilience tend to perceive errors and unsuccessful attempts as learning opportunities rather than indicators of inability (Enderle, 2025). Nevertheless,

the present findings provide a more nuanced interpretation by showing that persistence alone does not guarantee complete conceptual mastery, as students with high resilience still demonstrated limitations in algebraic achievement. This suggests that resilience functions as a supportive condition for mathematical development, but it must interact with effective instructional support and conceptual learning opportunities.

The study also reveals that differences in mathematical resilience were particularly visible in students' approaches toward algebraic problem solving rather than only in their final test scores. Students with higher resilience demonstrated greater willingness to explore alternative strategies, revise solutions, and continue reasoning after encountering difficulties, whereas students with lower resilience showed tendencies toward avoidance and reduced engagement. These behavioral patterns are consistent with research emphasizing that mathematical learning involves not only cognitive processing but also students' beliefs about their capability to overcome challenges (Qi, 2025). In algebra learning, where students must coordinate symbolic representations, relationships, and abstract reasoning, such behavioral differences become especially important because unsuccessful attempts are common parts of the learning process (Alam & Mohanty, 2024; Ünal et al., 2023). The findings therefore expand previous algebra research that has primarily focused on misconceptions and cognitive barriers by highlighting the role of affective regulation during mathematical reasoning. This perspective suggests that improving algebraic numeracy requires instructional approaches that intentionally cultivate productive responses toward difficulty.

The relationship between mathematical resilience and algebraic numeracy performance observed in this study also contributes to the broader discussion regarding the interaction between cognitive and affective dimensions in mathematics education. Previous studies on algebra learning have mainly examined students' conceptual difficulties, such as misunderstanding variables, symbolic representations, and mathematical relationships (Edo & Tasik, 2022; Mathaba et al., 2024). While these studies provide valuable explanations of cognitive obstacles, they provide limited insight into why some students persist in overcoming these obstacles while others disengage. The present study addresses this limitation by showing that students' resilience profiles are associated with differences in how they experience and respond to algebraic challenges. This finding supports the argument that mathematical achievement cannot be fully explained through cognitive competence alone because emotional responses, confidence, and persistence influence students' opportunities to engage with mathematical ideas. Consequently, the integration of affective perspectives into algebraic numeracy research provides a broader framework for understanding students' mathematical development.

The contextual factors identified in this study further indicate that mathematical resilience is not developed independently within students but emerges through interactions with their learning environment. Teacher scaffolding appeared to play an important role in supporting students' willingness to continue working with difficult algebraic problems, particularly when teachers provided structured guidance and encouraged students to interpret mistakes as part of learning. This finding corresponds with previous research emphasizing the importance of supportive classroom environments in developing students' mathematical confidence and adaptive learning behaviors (Akkan & Horzum, 2024; Panaoura, 2025). Family encouragement and peer interaction also contributed to students' resilience development by providing emotional and academic support during challenging learning experiences. However, the influence of these contextual factors appeared

differently among students, indicating that external support does not automatically produce resilience without students' active engagement. Thus, the findings extend existing resilience frameworks by emphasizing that mathematical resilience should be understood as an interaction between individual dispositions and surrounding educational ecosystems.

The findings of this study provide a critical perspective on previous quantitative investigations that have often positioned mathematical resilience as a measurable predictor of mathematical achievement. Large-scale studies have generally demonstrated positive associations between resilience-related constructs and mathematics performance (Qi, 2025), yet such approaches provide limited explanation of the processes through which resilience influences students' actual mathematical behaviors. Through an exploratory case study approach, this research reveals that resilience operates through specific practices, including persistence after failure, strategy adjustment, and willingness to seek assistance. This evidence complements previous research on AKM-based numeracy, which has largely emphasized students' achievement levels and assessment outcomes rather than the psychological processes underlying performance differences (Mufidah et al., 2023). The contribution of this study lies in positioning mathematical resilience as a contextual and process-oriented construct within algebraic numeracy learning. Therefore, the findings provide a conceptual extension by suggesting that resilience should be examined through students' experiences and actions, not only through scale-based measurement.

Overall, this study contributes theoretically and practically by demonstrating that mathematical resilience represents an important dimension for understanding students' algebraic numeracy development in junior high school contexts. The integration of resilience profiles with algebraic performance patterns provides a more comprehensive explanation of why students with similar mathematical learning opportunities may demonstrate different responses toward challenging tasks. Unlike previous studies that have separately investigated numeracy achievement or resilience characteristics, this research connects both dimensions within a specific mathematical domain and a localized educational setting in Indonesia. The findings suggest that mathematics instruction should move beyond strengthening procedural knowledge by also developing students' capacity to manage struggle, seek support, and maintain engagement during problem solving. For teachers, this implies the importance of designing algebra learning environments that combine conceptual scaffolding with resilience-oriented practices. Although the exploratory nature and limited number of focal participants restrict broad generalization, the study provides valuable evidence for future research investigating how affective and cognitive factors interact in mathematics learning across diverse educational contexts.

Implications

The findings of this study provide several implications for mathematics education, particularly in designing algebra learning environments that integrate cognitive development with affective support. The results indicate that improving students' algebraic numeracy should not focus solely on strengthening procedural knowledge and problem-solving skills but also on developing students' capacity to manage difficulties, persist during challenging tasks, and seek appropriate support. For mathematics teachers, the findings emphasize the importance of implementing instructional strategies that promote productive struggle, provide adaptive scaffolding, and create opportunities for students to experience mathematical success. At the theoretical level, this study contributes to the understanding of mathematical resilience by positioning it as a contextual and process-oriented

factor that interacts with students' algebraic learning experiences rather than merely as an individual psychological attribute. The integration of resilience profiles with algebraic numeracy performance offers a broader perspective for understanding how affective characteristics shape students' engagement with abstract mathematical concepts.

Limitations

Although this study provides meaningful insights into the relationship between mathematical resilience and algebraic numeracy, several limitations should be acknowledged. First, the exploratory case study design involved a limited number of focal participants from a single junior high school, which restricts the generalizability of the findings to broader educational populations. Second, the study focused specifically on algebraic numeracy within the AKM framework, meaning that the findings may not fully represent students' resilience patterns in other mathematical domains. Third, although multiple data sources were used to strengthen credibility, students' responses during interviews and observations may still have been influenced by personal perceptions and situational factors. Therefore, the findings should be interpreted as a contextual explanation of students' experiences rather than as evidence of universal patterns across different educational settings.

Suggestions

Future research is encouraged to expand the investigation of mathematical resilience and algebraic numeracy through larger samples and diverse educational contexts to examine whether similar patterns emerge across different regions and school characteristics. Further studies may also employ longitudinal designs to explore how mathematical resilience develops over time and how instructional interventions influence students' persistence and algebraic achievement. Researchers are also encouraged to investigate specific classroom practices that effectively strengthen the Struggle, Growth, and Reaching Out dimensions of mathematical resilience, particularly through intervention-based studies. In addition, future research may integrate other affective variables, such as mathematical self-efficacy, anxiety, and motivation, to develop a more comprehensive model explaining the interaction between psychological factors and mathematical learning outcomes.

CONCLUSION

This study concludes that mathematical resilience represents an important dimension in understanding students' algebraic numeracy development, particularly in how students respond to abstract mathematical challenges. The findings demonstrate that students with higher mathematical resilience generally showed stronger persistence, greater strategic flexibility, and more willingness to engage with difficult algebraic tasks, although resilience alone did not guarantee complete conceptual mastery. The Struggle dimension emerged as the most distinctive aspect differentiating students across resilience categories, indicating that students' responses toward difficulty, failure, and uncertainty play a crucial role in shaping their mathematical learning experiences. Furthermore, the study reveals that students' algebraic numeracy development is influenced by the interaction between individual characteristics and contextual supports, including teacher scaffolding, family encouragement, and peer interaction. These findings extend previous understandings of mathematical resilience by positioning it not merely as an individual psychological characteristic but as a dynamic process that develops through students' engagement with mathematical tasks and their surrounding learning environment. Therefore, strengthening algebraic numeracy requires an

integrated educational approach that combines conceptual instruction with resilience-oriented practices, enabling students to develop both mathematical competence and adaptive responses toward learning challenges. This study contributes to mathematics education research by providing a contextual explanation of how cognitive and affective factors interact within algebra learning, while also offering practical insights for designing more supportive and responsive mathematics classrooms.

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AUTHOR CONTRIBUTION STATEMENT

Hadrawi contributed to the conceptualization of the study, research design, data collection, data analysis, interpretation of findings, and manuscript preparation. Hafiludin Samparadja contributed to the methodological development, validation of research procedures, data interpretation, and critical revision of the manuscript. Ardi Dwi Susandi contributed to the literature review, instrument development, data analysis support, manuscript review, and refinement of the final version.

REFERENCES

Akkan, S. N., & Horzum, T. (2024). Illuminating the landscape of mathematical resilience: A systematic review. *Journal of Pedagogical Research, 8*(1), 312–338. https://doi.org/10.33902/JPR.202426128

Alam, A., & Mohanty, A. (2024). Unveiling the complexities of "Abstract Algebra" in university mathematics education (UME): Fostering conceptualization and understanding through advanced pedagogical approaches. *Cogent Education, 11*(1), Article 2355400. https://doi.org/10.1080/2331186X.2024.2355400

Annisa, A. H., Rejeki, S., & Sugiyanti, S. (2024). An analysis of a junior high school's readiness in optimizing students' numeracy skills to face minimum competency assessment. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 9*(3), 705–722. https://doi.org/10.31943/mathline.v9i3.656

Ayeh, I. G. (2025). Students' mathematics conceptual challenges: Exploring students' thinking, understanding, and misconceptions in functions and graphs. *European Journal of Science and Mathematics Education, 13*(3), 191–206.

Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Edo, S. I., & Tasik, W. F. (2022). Investigation of students' algebraic conceptual understanding and the ability to solve PISA-like mathematics problems in a modeling task. *Mathematics Teaching Research Journal, 14*(2), 44–60.

Enderle, C. (2025). "So that you can feel well": Perspectives of students with social, emotional and behavioral difficulties on factors that support school attendance. *School Mental Health, 17*(3), 935–956. https://doi.org/10.1007/s12310-025-09764-z

He, S., Qi, C., Xiao, L., & Hao, J. (2026). Shaping students' creative problem-solving skills through cognitive activation strategies: The mediating role of mathematics anxiety and perseverance. *Thinking Skills and Creativity, 60*, Article 102083. https://doi.org/10.1016/j.tsc.2025.102083

Mathaba, P. N., Bayaga, A., Tîrnovan, D., & Bossé, M. J. (2024). Error analysis in algebra learning: Exploring misconceptions and cognitive levels. *Journal on Mathematics Education, 15*(2), 575–592.

Mildret, N., & Kakoma, L. (2025). Exploring the effectiveness of using erroneous examples to simplify algebraic expressions: Embracing misconceptions as learning opportunities. *International Journal of Science, Mathematics & Technology Learning, 32*(2), 123–147. https://doi.org/10.18848/2327-7971/CGP/v32i02/123-147

Mufidah, I., Kusairi, S., & Arifin, S. (2023). Development of AKM numeracy instruments on numbers, geometry and measurement materials for grade IV elementary school students. *PrimaryEdu: Journal of Primary Education, 7*(1), 45–60. https://doi.org/10.22460/pej.v7i1.3567

Organisation for Economic Co-operation and Development. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Osei, W., & Agyei, D. D. (2024). Transition from knowledge of algebra for teaching (KAT) to technological knowledge of algebra for teaching (T-KAT). *Cogent Education, 11*(1), Article 2369000. https://doi.org/10.1080/2331186X.2024.2369000

Panaoura, R. (2025). Sustainable learning practices in engineering mathematics: Building self-regulation and resilience. *Sustainability, 17*(22), Article 10137. https://doi.org/10.3390/su172210137

Purnomo, H., Sa'dijah, C., Hidayanto, E., Sisworo, Permadi, H., & Anwar, L. (2022). Development of instrument numeracy skills test of minimum competency assessment (MCA) in Indonesia. *International Journal of Instruction, 15*(3), 635–648.

Qi, C. (2025). The impact of adolescent innovation on academic resilience, distance learning self-efficacy, and academic performance. *Scientific Reports, 15*(1), Article 12396. https://doi.org/10.1038/s41598-025-91542-7

Saunders, C. H., Sierpe, A., von Plessen, C., Kennedy, A. M., Leviton, L. C., Bernstein, S. L., Goldwag, J., King, J. R., Marx, C. M., Pogue, J. A., Saunders, R. K., van Citters, A., Yen, R. W., Elwyn, G., & Leyenaar, J. K. (2023). Practical thematic analysis: A guide for multidisciplinary health services research teams engaging in qualitative analysis. *BMJ, 381*, Article e074256. https://doi.org/10.1136/bmj-2022-074256

Sibgatullin, I. R., Korzhuev, A. V., Khairullina, E. R., Sadykova, A. R., Baturina, R. V., & Chauzova, V. (2022). A systematic review on algebraic thinking in education. *Eurasia Journal of Mathematics, Science and Technology Education, 18*(1), Article em2064. https://doi.org/10.29333/ejmste/11430

Siregar, N., & Siregar, R. S. (2025). Analysis of numeracy literacy of junior high school students in AKM questions: Learning strategies based on higher order thinking skills at SMP Negeri 5 Tapung Hilir. *Jurnal Profesi Guru Indonesia, 2*(1), 359–367. https://doi.org/10.62945/jpgi.v2i1.720

Sun, S., Sun, D., & Xu, T. (2023). The developmental progression of early algebraic thinking of elementary school students. *Journal of Intelligence, 11*(12), Article 222. https://doi.org/10.3390/jintelligence11120222

Taranto, E., Bagossi, S., Arzarello, F., & Beltramino, S. (2026). Interdisciplinary conceptualizations of variables and parameters through narratives. *Education Sciences, 16*(2), Article 217. https://doi.org/10.3390/educsci16020217

Ünal, Z. E., Ala, A. M., Kartal, G., Özel, S., & Geary, D. C. (2023). Visual and symbolic representations as components of algebraic reasoning. *Journal of Numerical Cognition, 9*(2), 327–345. https://doi.org/10.5964/jnc.10079

van der Werf, V., Hermans, F., Specht, M., & Aivaloglou, E. (2024). Variables and variable naming in popular programming textbooks for children and novices. In *Proceedings of the 2024 ACM Virtual Global Computing Education Conference V.1 (SIGCSE Virtual 2024)* (pp. 242–248). Association for Computing Machinery. https://doi.org/10.1145/3649165.3690112

Xenofontos, C., & Mouroutsou, S. (2023). Resilience in mathematics education research: A systematic review of empirical studies. *Scandinavian Journal of Educational Research, 67*(7), 1041–1055. https://doi.org/10.1080/00313831.2022.2115132

Yan, T., & Jin, Y. (2026). Enhancing mathematics learning for students with intellectual and developmental disabilities in China: A qualitative study of instructional support. *Journal of Intelligence, 14*(2), Article 18. https://doi.org/10.3390/jintelligence14020018