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Mathematical Resilience in AI-Assisted Mathematics Learning Among Junior High School Students

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ABSTRACT

Purpose: This study aims to explore students' mathematical resilience in overcoming learning barriers through AI-assisted mathematics learning at SMP Negeri 2 Tombolopao. **Methods:** This study employed a qualitative case study design involving junior high school students with varying levels of mathematical ability. Data were collected through semi-structured interviews, classroom observations, field notes, and documentation of students' interactions with Artificial Intelligence-based learning systems. The data were analyzed using thematic analysis through coding, categorization, and theme identification to examine learning barriers, adaptive strategies, and the role of Artificial Intelligence in supporting mathematical resilience. **Findings:** The findings revealed that students experienced multidimensional learning barriers, including difficulties in conceptual understanding, mathematics anxiety, low self-confidence, and weak self-regulation. AI-assisted learning supported students by providing immediate feedback, flexible learning opportunities, and emotionally safe environments that encouraged persistence, reflective thinking, and adaptive problem-solving strategies. Students demonstrated increased confidence and willingness to retry mathematical tasks after interacting with Artificial Intelligence-based learning support. **Research Implications:** This study contributes theoretically to the development of mathematical resilience in digital learning contexts and provides practical implications for integrating Artificial Intelligence into mathematics instruction to support adaptive and student-centered learning at the junior high school level.

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INTRODUCTION

Education in the 21st century is expected not only to develop students' academic competence but also to strengthen their adaptive capacity in facing increasingly complex learning challenges. Rapid technological advancement has transformed the way students access information, interact with learning resources, and construct knowledge in digital learning environments (Barokah et al., 2025; Rustamovna, 2024). Modern education therefore emphasizes not only cognitive achievement but also higher-order thinking, learning flexibility, and resilience in responding to academic difficulties. In mathematics education, these demands become increasingly relevant because students are required to learn independently, think critically, and adapt to technology-supported learning systems. Educational quality is consequently measured not merely by academic outcomes but also by students' ability to manage learning challenges constructively (UNESCO, 2020). Recent studies further highlight that digital learning environments require students to possess stronger self-regulation and emotional adaptability to sustain meaningful learning engagement (Yoshida et al., 2025; Pakala & Guniganti, 2026).

Mathematics is recognized as an essential subject for developing logical, analytical, and systematic thinking skills (Ibrahim & Ch, 2024). However, mathematics learning is still frequently perceived by students as difficult, stressful, and cognitively demanding. Difficulties in understanding abstract concepts, mathematical symbols, and problem-solving procedures often trigger mathematics anxiety, low self-confidence, and avoidance behaviors during learning activities (Mayani, 2024). According to Ashcraft & Krause (2007), mathematics anxiety negatively affects students' working memory performance and interferes with effective problem-solving processes. Hiebert & Grouws (2007) further emphasize that mathematics instruction focusing excessively on procedural achievement without conceptual understanding may intensify learning difficulties. Recent studies also indicate that students' disengagement from mathematics learning is strongly influenced by emotional pressure and negative classroom experiences (İnci Kuzu, 2025; Ntumi et al., 2026). These conditions suggest that mathematics learning involves not only cognitive dimensions but also affective and psychological aspects that influence students' learning persistence.

Learning barriers in mathematics are multidimensional phenomena involving cognitive, affective, motivational, and strategic dimensions. Students frequently experience difficulties in connecting mathematical concepts, interpreting word problems, and applying procedures appropriately in unfamiliar situations (Serin, 2023). These challenges are often accompanied by fear of making mistakes, low self-efficacy, and weak self-regulation during learning processes (Al-Sayed et al., 2024). In addition, ineffective learning strategies and limited reflective thinking skills further hinder students' ability to overcome mathematical difficulties independently (Fitriani & Widjajanti, 2024). Research on self-regulated learning demonstrates that students who lack monitoring and evaluation skills tend to experience persistent learning obstacles and low academic engagement (Bastian et al., 2026; Ntumi et al., 2026). Such conditions indicate that learning barriers cannot be viewed merely as deficiencies in intellectual ability but must also be understood through emotional and metacognitive perspectives.

The concept of mathematical resilience has emerged as an important framework for understanding how students persist and adapt when facing challenges in mathematics learning. Mathematical resilience refers to students' capacity to maintain confidence, regulate negative emotions, and continue engaging with mathematical tasks despite experiencing difficulties (Joe et al., 2023). This concept encompasses cognitive, affective, and metacognitive dimensions that collectively influence students' responses to learning challenges (Meilani & Meiliasari, 2024). Students with strong mathematical resilience tend to interpret mistakes as opportunities for improvement rather than indicators of failure. Previous studies have also emphasized that resilience contributes significantly to students' persistence, optimism, and willingness to engage in reflective problem-solving processes (Trejo-Macotela et al., 2026a). Therefore, strengthening mathematical resilience is considered essential for supporting sustainable and meaningful mathematics learning experiences.

A preliminary study conducted at SMP Negeri 2 Tombolopao revealed that students experience various forms of learning barriers during mathematics instruction. Students demonstrated difficulties in understanding mathematical concepts, solving contextual problems, maintaining motivation, and regulating their learning strategies independently. Several students also showed anxiety and hesitation when asked to explain mathematical reasoning during classroom activities. These conditions indicate a discrepancy between the expectation of student-centered mathematics learning and the actual classroom situation, where students still struggle to cope with learning difficulties effectively. This situation highlights the importance of developing instructional approaches that support not only conceptual understanding but also students' emotional readiness and adaptive learning capacity (Schuetze, 2025). Contextual and responsive learning environments are therefore needed to help students develop resilience in facing mathematical challenges (Yeribatuah & Boateng, 2026;Khotimah et al., 2026).

The advancement of Artificial Intelligence (AI) has opened new opportunities for supporting adaptive mathematics learning. AI-assisted learning systems enable personalized instruction through immediate feedback, flexible learning pathways, and repeated practice opportunities adjusted to students' individual needs (Kanvaria & Srivastava, 2025). AI-based learning environments may also create emotionally safer spaces where students can learn from mistakes without direct social pressure. Karroum et al. (2024) argue that Artificial Intelligence has the potential to support both cognitive and affective aspects of learning when integrated pedagogically. In addition, recent studies demonstrate that AI tutoring systems can improve students' engagement, self-regulation, and learning motivation through adaptive interaction and personalized feedback mechanisms (Hau et al., 2026; Yoshida et al., 2025a). These characteristics suggest that AI may contribute not only to academic achievement but also to the development of students' mathematical resilience.

Previous studies have investigated mathematical resilience and the implementation of technology in mathematics education from various perspectives. Several studies report that mathematical resilience positively influences students' academic achievement and problem-solving abilities (OSZWA, 2022; Ishak et al., 2020). Other studies focus on the effectiveness of Artificial Intelligence in improving cognitive learning outcomes through adaptive learning systems (Yu, 2024; Kurian, 2022). Research by Dembitska et al. (2024) also highlights the contribution of AI tutors to learning motivation and effectiveness. However, most existing studies still emphasize cognitive outcomes and quantitative measurements, while students' emotional experiences, adaptive strategies, and resilience development during AI-assisted mathematics learning remain underexplored. Furthermore, limited studies specifically examine how junior high school students interpret their interactions with Artificial Intelligence when facing mathematics learning barriers through qualitative approaches (Kayes et al., 2022; Kyianovskyi & Pozdniakova, 2026;Mansoor et al., 2026;Yan & Singh, 2026). This gap indicates the need for more contextual and in-depth research exploring the relationship between AI-assisted learning and mathematical resilience.

Based on these considerations, this study aims to explore students' mathematical resilience in overcoming mathematics learning barriers through AI-assisted mathematics learning at SMP Negeri 2 Tombolopao. This study specifically investigates the types of learning barriers experienced by students, the adaptive strategies they develop, and the role of Artificial Intelligence in supporting mathematical resilience. The novelty of this study lies in its qualitative exploration of the interaction between mathematical resilience and AI-assisted learning within real classroom contexts, particularly at the junior high school level. This study is expected to contribute theoretically to the development of mathematical resilience in digital learning environments and practically to the implementation of adaptive and student-centered mathematics instruction. Accordingly, this study addresses the following research questions: (1) What learning barriers are experienced by junior high school students in mathematics learning? (2) How does AI-assisted learning support students' mathematical resilience? and (3) What adaptive strategies do students develop during AI-assisted mathematics learning?

METHOD

This study employed a qualitative approach with a case study design to explore students' mathematical resilience in overcoming mathematics learning barriers through AI-assisted mathematics learning. Qualitative research aims to describe and analyze social phenomena comprehensively by focusing on individuals' experiences, perceptions, and interactions within natural settings. Qualitative research produces descriptive data in the form of written or spoken words derived from observed individuals and behaviors. The study was conducted at SMP Negeri 2 Tombolopao, Gowa Regency, South Sulawesi, during January 2026 at the beginning of the second semester of the 2025/2026 academic year. The timing of the study was selected to ensure that data collection could be conducted optimally when students had started engaging with new mathematics learning materials and classroom activities were relatively stable.

The participants of this study consisted of four junior high school students selected purposively based on their mathematical competence, classroom participation, and experiences in utilizing Artificial Intelligence during mathematics learning activities. The participants represented varying levels of mathematical ability to provide diverse perspectives regarding mathematical resilience and learning barriers. Preliminary observations showed that students actively utilized several AI platforms, including ChatGPT, Gemini, Meta AI, Cici, and Dola, as learning support tools in mathematics learning activities. Based on school data, the highest utilization of AI technology was found among Grade VIII students, where 39 out of 45 students actively used AI-based learning platforms, representing 87% of the class population. In qualitative research, the researcher acts as the primary instrument in collecting and interpreting data directly from the field. To support the data collection process, supporting instruments such as interview guidelines, observation sheets, field notes, documentation, and audio recordings were also utilized.

Data collection techniques consisted of interviews, observations, and documentation. Interviews were conducted using unstructured interview techniques to explore students' experiences in developing mathematical resilience while facing mathematics learning barriers through the utilization of Artificial Intelligence. The interviews began with guiding questions related to the research objectives and were further developed flexibly according to participants' responses. The interview process also explored how students utilized Artificial Intelligence platforms as tools for reflection, problem-solving, immediate feedback, and independent learning support. Observations were conducted during mathematics learning activities to identify students' behaviors, emotional responses, interactions, and adaptive strategies while engaging with AI-assisted learning. Documentation techniques were employed to complement interview and observation data through photographs, written documents, and records of learning activities in order to strengthen empirical evidence and support data triangulation.

To ensure data credibility and trustworthiness, this study applied triangulation techniques, particularly time triangulation, by collecting data at different times and situations to examine the consistency of participants' responses and learning experiences. Data analysis referred to the interactive analysis model proposed by Miles & Huberman, (1994), consisting of data reduction, data display, and conclusion drawing. During the data reduction stage, interview transcripts, observation results, and documentation data were organized, coded, and categorized into thematic patterns related to learning barriers, mathematical resilience, and the role of Artificial Intelligence. The findings were then presented descriptively in narrative form, and conclusions were continuously verified throughout the analysis process to ensure consistency and validity of the research findings.

RESULTS

Learning Barriers Experienced by Students

The findings revealed that students experienced various learning barriers in mathematics learning, particularly affective and epistemological barriers. Students with low mathematical ability demonstrated dominant affective barriers, including mathematics anxiety, fear of making mistakes, low self-confidence, and emotional instability during problem-solving activities. Participant R1 explained:

> *"I usually panic when the mathematics problems are difficult because I am afraid that my answers will be wrong and I do not understand the formulas."*

Similarly, participant R2 admitted:

> *"When I do not know how to solve the problem, I sometimes stop because I am afraid of making mistakes repeatedly."*

The interview findings also indicated that students experienced epistemological barriers related to conceptual understanding and procedural difficulties. Participants S1 and S2 frequently encountered confusion when solving mathematical problems involving formulas, multistep procedures, and contextual questions. Participant S1 stated:

> "*I often get confused when the problems are long and require many solution steps*."

Meanwhile, participant S2 explained:

> *"Sometimes I know the formula, but I am confused about how to apply it in the problem."*

Observation findings further showed that students often hesitated when explaining mathematical reasoning and tended to seek external assistance from teachers, peers, or Artificial Intelligence platforms when experiencing difficulties.

Table 1. Types of Learning Barriers Experienced by Students

Participant	Dominant Learning Barriers	Observed Responses
R1	Mathematics anxiety, low confidence	Hesitant to answer, easily panicked
R2	Fear of making mistakes, emotional instability	Frequently stopped problem-solving
S1	Conceptual difficulty	Repeatedly reviewed formulas
S2	Procedural confusion	Sought additional explanations

Table 1 demonstrates that students experienced different forms of learning barriers depending on their mathematical abilities and emotional conditions. Low-ability students tended to experience affective barriers such as anxiety, fear, and lack of confidence during mathematics learning activities. In contrast, moderate-ability students more frequently experienced epistemological barriers related to conceptual understanding and procedural difficulties. The findings also indicate that emotional responses significantly influenced students' persistence and engagement in problem-solving activities. Students who experienced stronger anxiety were more likely to hesitate and discontinue mathematical tasks temporarily. Overall, the results suggest that mathematics learning barriers involve not only cognitive difficulties but also emotional and behavioral dimensions that influence students' learning experiences.

Students' Mathematical Resilience

The findings demonstrated that students showed varying levels of mathematical resilience during mathematics learning activities. Students generally attempted to regulate their emotions by remaining calm, retrying mathematical procedures, rereading questions, and seeking assistance when facing learning difficulties. Participant R1 stated:

> *"When I make mistakes, I try to solve the problem again slowly so that I can understand it better."*

Participant S1 also demonstrated persistence by independently reviewing incorrect answers and practicing repeatedly:

> *"Usually, I try to solve the problems again at home until I fully understand them."*

Students also demonstrated resilience through adaptive learning strategies and sustained learning engagement despite experiencing difficulties. Participant S2 explained:

> *"When I do not understand something, I look for another method or additional explanations."*

These findings indicate that mathematical resilience is closely associated with students' emotional regulation, self-confidence, conceptual understanding, and adaptive learning behavior.

Table 2. Indicators of Students' Mathematical Resilience

Indicator	Evidence from Participants
Emotional control	Students attempted to remain calm during difficulties
Persistence	Students retried incorrect answers repeatedly
Adaptive strategy	Students sought alternative explanations
Self-confidence	Confidence increased after understanding concepts

Table 2 indicates that students demonstrated mathematical resilience through various adaptive behaviors during mathematics learning activities. Emotional control appeared when students attempted to remain calm and continue solving problems despite experiencing difficulties. Persistence was reflected in students' willingness to retry incorrect answers and practice repeatedly until understanding was achieved. Students also showed adaptive strategies by seeking additional explanations from teachers, peers, and Artificial Intelligence platforms. Furthermore, self-confidence gradually improved after students understood mathematical concepts and successfully completed problem-solving tasks. These findings suggest that mathematical resilience develops through continuous interaction between emotional regulation, conceptual understanding, and adaptive learning experiences.

The Role of Artificial Intelligence in Supporting Mathematical Resilience

The findings revealed that Artificial Intelligence played an important role in supporting students' mathematical resilience during mathematics learning activities. Students utilized several AI platforms, including ChatGPT, Gemini, Meta AI, Cici, and Dola, primarily to verify answers, understand mathematical procedures, and obtain alternative explanations for difficult concepts. Participant S1 explained:

> *"When using AI, I can understand the material more easily because the explanations can be repeated."*

Participant S2 further stated:

> *"AI helps me become more confident because it provides step-by-step explanations."*

The use of Artificial Intelligence also positively influenced students' emotional conditions during mathematics learning. Participant R2 explained:

> *"When asking AI, I do not feel embarrassed, so I become more confident in trying to answer mathematics problems."*

Observation findings further showed that students became more active and engaged during mathematics learning activities after utilizing AI-based learning support. However, low-ability participants tended to use AI mainly for answer verification and task completion, whereas moderate-ability participants used AI more reflectively by comparing explanations and reviewing mathematical procedures independently.

Table 3. The Role of Artificial Intelligence in Mathematics Learning

AI Function	Student Experience
Immediate feedback	Reduced confusion during problem-solving
Alternative explanation	Helped students understand formulas
Emotional support	Reduced anxiety and fear of failure
Independent learning support	Increased motivation and persistence

Table 3 shows that Artificial Intelligence contributed to both cognitive and affective aspects of mathematics learning. AI-assisted learning provided immediate feedback and alternative explanations that helped students better understand mathematical concepts and procedures. Students also reported feeling more comfortable asking questions to AI systems because they did not fear negative judgment or embarrassment. In addition, AI-supported learning increased students' motivation and persistence when facing difficult mathematical tasks. Nevertheless, differences in AI utilization patterns were observed between low-ability and moderate-ability students. While some students used AI mainly for answer verification, others used it more reflectively to strengthen conceptual understanding and independent learning strategies.

DISCUSSION

Learning Barriers and Students' Emotional Experiences

The findings revealed that students experienced both affective and epistemological barriers during mathematics learning activities. Students with low mathematical ability demonstrated fear of making mistakes, emotional instability, and low self-confidence during classroom activities. According to Ashcraft & Krause, (2007), mathematics anxiety negatively affects students' working memory and interferes with mathematical problem-solving performance. Students who experienced stronger anxiety tended to hesitate, avoid answering questions, and temporarily discontinue problem-solving activities when facing difficult mathematical tasks. Students also showed reduced confidence when they could not understand mathematical formulas and procedures independently. Serin (2023) further explained that emotional tension and conceptual confusion are closely related to students' learning difficulties in mathematics. Therefore, the findings indicate that emotional pressure significantly influences students' mathematical engagement and learning persistence during mathematics learning processes.

The findings also showed that moderate-ability students experienced epistemological barriers related to conceptual understanding and procedural difficulties. Students frequently struggled to connect formulas with contextual mathematical problems and often experienced confusion during multistep problem-solving activities. Hiebert & Grouws (2007) argued that mathematics instruction emphasizing procedural achievement without conceptual understanding may intensify students' learning difficulties. This argument supports the present findings, where students demonstrated uncertainty when applying mathematical procedures in unfamiliar situations. Although moderate-ability students demonstrated stronger persistence than low-ability students, conceptual uncertainty still affected their confidence and emotional stability during mathematics learning. Students often needed repeated explanations before they fully understood mathematical concepts and procedures. Similar findings were also reported by Fitriani & Widjajanti (2024), who emphasized that learning obstacles in mathematics frequently emerge from weaknesses in conceptual understanding and instructional design. Consequently, mathematics learning barriers should not be viewed solely as cognitive limitations but also as emotional and metacognitive challenges influencing students' learning experiences.

The findings further indicate that students' emotional responses significantly influenced their adaptive learning behavior during mathematics learning activities. Students who experienced stronger anxiety and lower confidence tended to rely heavily on external assistance from teachers, peers, or Artificial Intelligence platforms when solving mathematical problems. Al-Sayed et al. (2024) emphasized that mathematics learning difficulties involve emotional, motivational, and self-regulation dimensions influencing students' learning engagement and persistence. This perspective aligns with the present findings, where emotionally insecure students showed lower independence and greater hesitation during problem-solving activities. However, students who received constructive learning support generally demonstrated greater willingness to continue learning and retry difficult mathematical tasks. Students also became more confident after receiving explanations and encouragement from teachers or learning technologies. Mayani (2024) similarly explained that mathematics anxiety often reduces students' confidence and participation during learning processes. Therefore, effective mathematics instruction should not only focus on academic achievement but also support students' emotional readiness, self-confidence, and adaptive learning capacity.

Mathematical Resilience as Adaptive Learning Capacity

The findings demonstrated that students showed varying levels of mathematical resilience through emotional regulation, persistence, adaptive strategies, and self-confidence during mathematics learning activities. Students attempted to remain calm, retry incorrect answers, reread mathematical questions, and seek additional support when facing learning difficulties. Oszwa (2022) described mathematical resilience as students' capacity to persist and adapt positively when facing academic challenges. This concept was reflected in the participants' behaviors, where students who demonstrated stronger resilience were more willing to continue solving mathematical problems despite experiencing confusion and conceptual difficulties. Students also attempted to regulate emotional pressure while maintaining engagement during mathematics learning activities. Joe et al. (2023) further emphasized that resilience supports students' persistence, optimism, and willingness to engage in challenging mathematics learning situations. Therefore, the findings suggest that mathematical resilience plays an important role in maintaining students' learning engagement during mathematics learning activities.

The findings also revealed that mathematical resilience developed through reflective and adaptive learning behaviors. Students with stronger resilience reviewed incorrect answers, practiced independently, and searched for alternative explanations to improve conceptual understanding. Meilani & Meiliasari (2024) explained that mathematical resilience involves cognitive, affective, and metacognitive dimensions collectively influencing students' adaptive learning behavior. This perspective supports the findings of the present study, where students demonstrated reflective learning awareness by evaluating mistakes and comparing different problem-solving strategies. In addition, students attempted to improve their understanding by practicing repeatedly and independently reviewing mathematics materials outside classroom activities. These findings indicate that mathematical resilience is not merely an emotional characteristic but also an adaptive learning process enabling students to respond constructively to academic difficulties. Kayes et al. (2022) similarly emphasized that resilience develops through students' ability to overcome unpleasant emotional experiences during learning processes. Consequently, resilience development requires learning experiences encouraging emotional regulation, persistence, and reflective thinking during mathematics learning.

Furthermore, the findings indicate that mathematical resilience was highly influenced by students' conceptual understanding and emotional conditions during mathematics learning. Students tended to demonstrate higher confidence and persistence after successfully understanding mathematical concepts or receiving constructive support during learning activities. Positive learning experiences contributed significantly to students' willingness to retry difficult mathematical tasks and maintain learning motivation. In contrast, unresolved conceptual confusion often weakened students' confidence and increased emotional pressure during mathematics learning. Students who successfully understood mathematical concepts generally demonstrated more optimism and persistence when facing subsequent mathematical challenges. Joe et al. (2023) explained that resilience in mathematics learning is closely associated with students' confidence and adaptive learning behavior. Similarly, Kyianovskyi & Pozdniakova (202b) argued that psychological resilience develops through supportive learning experiences and emotional adaptation processes. Therefore, strengthening mathematical resilience requires supportive learning environments encouraging emotional safety, conceptual understanding, adaptive learning strategies, and positive learning experiences.

Artificial Intelligence as Cognitive and Affective Learning Support

The findings revealed that Artificial Intelligence functioned not only as a cognitive learning support tool but also as an affective support system during mathematics learning activities. Students utilized AI platforms such as ChatGPT, Gemini, Meta AI, Cici, and Dola to obtain immediate feedback, alternative explanations, and procedural guidance for solving mathematical problems. Kanvaria & Srivastava, (2025) argued that Artificial Intelligence has transformative potential in mathematics education through adaptive and personalized learning support. This perspective was reflected in the findings, where AI-assisted learning enabled students to access explanations repeatedly according to their individual learning needs and learning pace. Students also perceived AI platforms as flexible learning tools that could be accessed independently without direct social pressure from teachers or classmates. AI-assisted learning further encouraged students to explore mathematical problems more actively and independently during classroom and home learning activities. Yoshida et al. (2025) similarly found that AI-supported learning environments can improve students' engagement and interaction during digital learning processes. Consequently, the findings indicate that AI-assisted learning environments may facilitate more student-centered and responsive mathematics learning experiences.

The findings further demonstrated that Artificial Intelligence positively influenced students' emotional conditions during mathematics learning activities. Students reported reduced anxiety, increased confidence, and greater willingness to retry mathematical tasks after interacting with AI systems. Karroum et al., (2024) explained that Artificial Intelligence can support both cognitive and affective dimensions of learning when integrated appropriately into educational practices. This argument aligns with the present findings, where AI-assisted explanations helped students better understand formulas, procedures, and problem-solving steps, thereby reducing confusion during mathematics learning processes. Dembitska et al., (2024) also found that AI tutors contribute positively to students' motivation and learning effectiveness through adaptive and responsive learning interactions. Furthermore, students felt more comfortable asking questions to AI systems because they did not fear negative judgment or embarrassment when making mistakes. Yan & Singh (2026) similarly reported that AI-mediated learning environments may reduce learning anxiety and increase emotional engagement among students. Therefore, Artificial Intelligence can function as both an instructional tool and an emotional learning support system during mathematics learning activities.

However, the findings also revealed differences in students' patterns of AI utilization during mathematics learning activities. Low-ability students tended to use AI primarily for answer verification and rapid task completion without deeply exploring conceptual understanding. Yu (2024) (2024) emphasized that the effectiveness of AI-assisted learning depends significantly on students' adaptive learning behavior and self-regulation abilities. This perspective supports the findings showing that reflective students gained greater conceptual benefits from AI-assisted learning compared to students who relied solely on answer verification. Moderate-ability students used AI more reflectively by comparing explanations, reviewing procedures, and strengthening conceptual understanding independently. In contrast, some low-ability students became more dependent on AI-generated answers without fully understanding the mathematical reasoning behind the solutions. Yeribatuah & Boateng (202b) similarly explained that students' perceptions and learning engagement significantly influence the effectiveness of Artificial Intelligence in mathematics education. Therefore, the educational effectiveness of Artificial Intelligence depends not only on technological availability but also on students' critical engagement, reflective thinking, and learning awareness during mathematics learning processes.

Overall, this study contributes theoretically to understanding mathematical resilience within AI-assisted mathematics learning contexts. The findings indicate that Artificial Intelligence can function as both cognitive and emotional learning support that helps students overcome learning barriers, regulate emotional responses, and maintain persistence during mathematics learning activities. Trejo-Macotela et al. (2026) argued that Artificial Intelligence has the potential to strengthen students' academic resilience when implemented ethically and adaptively within educational systems. This argument supports the findings of the present study, where AI-assisted learning contributed positively to students' confidence, emotional regulation, and learning persistence. The study also demonstrates that resilience develops through the interaction between emotional regulation, conceptual understanding, adaptive learning strategies, and technology-supported learning experiences. Practically, the findings suggest that teachers should integrate AI-based learning tools pedagogically and critically to support adaptive, student-centered, and emotionally responsive mathematics instruction. Hau et al. (2026) similarly emphasized that AI integration in mathematics learning can strengthen students' engagement and conceptual understanding when implemented contextually and interactively.

CONCLUSION

This study explored students' mathematical resilience in overcoming mathematics learning barriers through AI-assisted mathematics learning. The findings revealed that students experienced affective barriers such as mathematics anxiety, fear of making mistakes, low self-confidence, and emotional instability, as well as epistemological barriers related to conceptual understanding and procedural difficulties. Students also demonstrated varying levels of mathematical resilience through persistence, emotional regulation, adaptive learning strategies, and self-confidence during mathematics learning activities. In addition, Artificial Intelligence helped students by providing immediate feedback, alternative explanations, and emotionally supportive learning environments that reduced anxiety and increased learning confidence.

This study demonstrates that Artificial Intelligence can function not only as a cognitive learning tool but also as an affective support system that strengthens students' mathematical resilience during mathematics learning processes. The findings contribute to understanding the interaction between emotional regulation, adaptive learning behavior, and AI-assisted mathematics learning in junior high school contexts. However, this study was limited to a small number of participants and focused only on one school using a qualitative approach. Therefore, future studies are recommended to involve broader participants, different educational levels, and mixed-method approaches. In addition, teachers are encouraged to integrate Artificial Intelligence critically and pedagogically to support adaptive, student-centered, and emotionally responsive mathematics learning.

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AUTHOR CONTRIBUTION STATEMENT

ME: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft.
SU: Data curation, Investigation, Validation, Writing – review & editing.
AH: Supervision, Methodology, Validation, Writing – review & editing.

AI DISCLOSURE STATEMENT

The authors declare that this research was prepared, conducted, and written without the use of artificial intelligence (AI) tools.

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