

The Effects of the Learning Pit Model and Active Learning on Mathematical Resilience: A Case Study of an Academically Competitive Secondary School in Thailand

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ABSTRACT

Background and Objectives: Grade 8 students at Chalermkwansatree School in Phitsanulok Province demonstrated low levels of mathematical resilience, characterized by fixed mindsets, low self-efficacy, emotional discomfort, and limited engagement with mathematical learning. These issues, likely stemming from competitive academic environments and high parental expectations, pose significant barriers to students' persistence and success in mathematics. As mathematical resilience is essential for overcoming challenges and fostering long-term learning, a pedagogical shift is necessary. Active Learning and the Learning Pit Model, both grounded in theories of cognitive development and productive struggle, offer a promising framework for addressing these issues by creating supportive, engaging, and intellectually stimulating learning environments. Therefore, this study aims to: (1) determine the average mathematical resilience scores of Grade 8 students following instruction integrating Active Learning with the Learning Pit Model; (2) identify the proportion of students demonstrating positive change in resilience after the intervention; and (3) explore how this integrated approach contributes to the development of mathematical resilience among students.

Methodology: This study adopted a sequential explanatory mixed-methods design (Creswell & Plano Clark, 2018), prioritizing quantitative data and supplementing it with qualitative insights to deepen understanding. Although a quasi-experimental control group design was ideal, ethical constraints required delivering the intervention to all students. To mitigate this limitation, the study employed several safeguards, including extended baseline measurement, separation of instructional and research roles, systematic fidelity monitoring, and triangulation through multi-source qualitative data.

Results: The integration of Active Learning with the Learning Pit Model led to a notable improvement in mathematical resilience for Grade 8 students. The average score increased from 85.04 to 103.96 out of a maximum of 115 points, representing an improvement of 18.92 points, equivalent to 16.45% of the maximum possible score, with all students individual

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improvement (range = 8–31 points). Qualitative findings further revealed that problem-based tasks, peer collaboration, teacher guidance, and effective learning materials significantly enhanced students' understanding, critical thinking, and engagement during mathematical challenges.

Discussion: The integration of Active Learning with the Learning Pit Model significantly enhanced Grade 8 students' mathematical resilience, particularly in polynomial factorization is supported by the theory of Zone of Proximal Development (ZPD; Vygotsky, 1978) and the role of productive struggle in conceptual development (Nottingham, 2017; Warshauer, 2015). Three mechanisms underpin this outcome: cognitive development through active engagement, socioemotional support via collaborative learning (Johnston-Wilder & Lee, 2013), and increased metacognitive awareness (Braithwaite & Sprague, 2021). While growth mindset and value recognition showed substantial gains, the struggle dimension improved modestly, suggesting the need for longer interventions (Aljarrah & Towers, 2021). Although the single-group design and limited duration constrain generalizability, the use of mixed methods and triangulated analysis strengthens the findings. Theoretically, the study reinforces the value of integrating pedagogical models to build resilience; practically, it offers a structured framework for fostering perseverance and adaptability in mathematics classrooms.

Conclusion: This study confirms that integrating active learning with the Learning Pit Model effectively enhances students' mathematical resilience, thereby offering a pedagogical approach that supports both cognitive growth and psychological adaptability within mathematics education.

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Introduction

Mathematics is fundamental for developing critical thinking, problem-solving abilities, and analytical reasoning skills that are essential across various scientific disciplines and real-world applications (National Research Council, 2001). Research has demonstrated that mathematical competency enhances cognitive functions and facilitates success across diverse fields, ranging from economics to engineering (Butterworth, 2018). While the inherent abstraction of mathematics causes many students to struggle, "mathematical resilience"—the capacity to persist through challenges despite obstacles and negative emotions—has emerged as a critical factor in students' long-term achievement (Johnston-Wilder & Lee, 2013; Kookan et al., 2016). This resilience, characterized by perseverance, patience, and positive attitudes, is

closely related to a growth mindset. Despite its importance, systematic approaches to developing mathematical resilience remain underexplored, particularly in Asian educational contexts where mathematical achievement is often emphasized over affective dimensions of learning.

Among Grade 8 students in large, academically competitive secondary schools—particularly those characterized by high parental involvement and performance-oriented learning cultures—a recurring pattern of mathematical resilience deficits has been observed, as evidenced by a case study conducted at Chalermkwansatree School in Phitsanulok Province, Thailand. Affected students demonstrated a fixed mindset regarding their mathematical ability, a tendency to disengage when confronting challenging problems, and difficulties in emotional self-regulation, which manifested as frustration, anxiety, and diminished confidence in class participation. Furthermore, these students exhibited limited recognition of the practical relevance of mathematics to daily life and a reluctance to seek assistance when encountering conceptual difficulties, deficits attributable to the cumulative pressures of highly competitive learning environments and elevated parental expectations, which collectively undermined the mathematical resilience essential for sustained and effective learning.

Active learning has emerged as a widely adopted pedagogical approach among contemporary educators, demonstrating efficacy in fostering 21st-century skills and promoting meaningful, sustainable learning outcomes (Freeman et al., 2014). Its structural emphasis on collaborative problem-solving, active participation, and contextually relevant applications renders it particularly well-suited to addressing multidimensional deficits in mathematical resilience. These deficits—encompassing a fixed mindset, mathematical anxiety, disengagement, and limited recognition of value—are commonly observed among students in academically competitive secondary schools. Through structured hands-on experiences, active learning methodologies expose students to iterative cycles of attempt, error, and revision. These experiential processes allow students to accumulate direct evidence of their capacity for mathematical improvement. Consequently, these processes progressively erode fixed beliefs regarding mathematical inadequacy and fosters a growth-oriented disposition toward learning (Dweck, 2006; Freeman et al., 2014). While collaborative activities reduce mathematical anxiety (Smith et al., 2009) and contextual applications highlight the subject's practical value, these Active Learning strategies alone may be insufficient for rebuilding mathematical resilience within Chalermkwansatree School's highly competitive environment (Lee & Johnston-Wilder, 2017). Given this cohort's demonstrated aptitude, educators must integrate cognitively challenging techniques to extend students' mathematical capabilities while concurrently fostering resilience.

The Learning Pit Model conceptualizes the learning process as a cognitive journey through which students must overcome challenges and confusing ideas to achieve deep understanding (Nottingham, 2017). In mathematics education, this process begins with students' prior mathematical knowledge and progresses through increasingly complex problem-solving scenarios. Navigating these scenarios requires sustained effort, iterative attempts, and strategic guidance from teachers and peers until conceptual connections emerge. Given its alignment with the characteristics of the sample group, the researcher integrated this pedagogical framework with active learning approaches to address the following research questions:

(1) What are the average mathematical resilience scores of Grade 8 students after receiving instruction integrated with the Learning Pit Model?

(2) What percentage of students demonstrated a significant improvement in their mathematical resilience after this intervention?

(3) How does integrating active learning with the Learning Pit Model contribute to the development of students' mathematical resilience?

Review of Literature

Integrating active learning strategies and conceptual models like the Learning Pit is of increasing interest in mathematics education research as educators seek more effective approaches to engaging students and developing deeper mathematical understanding. This review examines key concepts and research related to active learning, the Learning Pit model, and their potential applications for teaching the factoring of quadratic polynomials.

Active Learning and Mathematics Education: From Theory to Practice

Active learning encompasses a diverse array of instructional strategies that share a common emphasis on student engagement, collaboration, problem solving, and reflection. These approaches are grounded in constructivist learning theories that view knowledge as actively constructed by learners through interaction with their environment, peers, and instructors. In mathematics education specifically, active learning strategies aim to move beyond procedural fluency and develop conceptual understanding, mathematical reasoning, and the ability to apply mathematical knowledge to authentic problems (Freeman et al., 2014, Hazzan et al., 2011).

Numerous studies have demonstrated the advantages of active learning in mathematics education. For instance, Warinporn (2019) found that active learning strategies enhance students' critical thinking abilities and their sense of mathematical self-efficacy. Similarly, research by Mingmuangmoon and Jatnin (2022) indicates that active learning techniques improve secondary students' mathematical achievement and problem-solving skills.

The effective implementation of active learning involves several key components, including providing students with opportunities to engage in hands-on exploration and problem-solving, fostering group discussions, and promoting collaborative learning. Supnoon and Chonchaiya (2024) found that when active learning was combined with gamification, students demonstrated significant improvements in critical thinking skills, particularly in the areas of recognizing assumptions, evaluating arguments, and drawing conclusions. This is because gamification elements, such as challenges and feedback, create a stimulating learning environment that enhances engagement and motivation.

The transition from a teacher-directed to a facilitative instructional role in mathematics education is substantiated by a growing body of research examining effective questioning strategies, mathematical problem-posing, and the development of higher-order thinking skills. Collectively, this research demonstrates that strategic teacher questioning stimulates deeper cognitive engagement and promotes students' capacity for mathematical reasoning beyond procedural competency. In particular, active learning encourages students to challenge their knowledge and critique the reasoning of others, fostering a deeper conceptual understanding of mathematical principles (Leavy & Hourigan, 2020; Supnoon & Chonchaiya, 2024). By adopting these approaches, educators can more effectively guide students in exploring mathematical

concepts and developing higher-order thinking skills, which are essential for success in the 21st-century learning environment.

In this context, the study adopts the active learning framework proposed by Hazzan et al. (2011), which comprises four essential stages: engaging students through triggering questions, fostering exploration through guided activities, facilitating conceptual formalization through collaborative discussion, and applying knowledge through meaningful implementation tasks. This framework is particularly well-suited for integration with the Learning Pit Model and aligns with the nature of mathematics.

The Learning Pit Model

Nottingham (2017) developed a conceptual model termed the Learning Pit to illustrate the cognitive journey learners undergo when engaging with challenging subject matter. Before detailing its sequential stages, it is essential to understand that the Learning Pit is fundamentally a pedagogical framework designed to normalize cognitive struggle. Its core components consist of (1) establishing a psychologically safe environment for making mistakes, (2) explicitly teaching the value of a growth mindset, and (3) reframing confusion and cognitive dissonance as necessary catalysts for deep learning. Rather than avoiding difficulty, this model posits that experiencing a temporary decline in confidence when facing complex mathematical problems is an expected and valuable part of the educational process. The model characterizes this learning process as a progressive passage into and out of a metaphorical "pit" of uncertainty, comprising four sequential stages:

Stage 1: Concept introduces learners to a key idea about which they possess foundational but limited knowledge, establishing the entry point for intellectual inquiry.

Stage 2: Conflict deliberately induces cognitive dissonance by presenting contradictions, exceptions, or anomalous situations that destabilize existing understanding and propel learners into the "pit" — a productive state of uncertainty that compels deeper reasoning.

Stage 3: Construct occurs as learners begin to resolve this conflict through systematic investigation, collaborative dialogue, and the identification of patterns and relationships, ultimately constructing a more precise and coherent conceptual understanding.

Stage 4: Consider engages learners in metacognitive reflection on their learning journey, evaluating the strategies employed, consolidating newly acquired knowledge, and transferring insights to novel contexts.

Collectively, these stages operationalize the model's central premise: that meaningful and enduring learning emerges not from the avoidance of confusion, but from deliberate navigation of productive cognitive struggle.

This model is related to mathematical resilience in that it helps learners to understand that feelings of confusion and frustration are normal parts of learning, not something to fear or avoid, but rather as essential steps toward genuine understanding (Johnston-Wilder & Lee, 2010; Nottingham, 2017). It is also related to ZPD by Vygotsky (1978) which is elaborated on in the following section.

The Zone of Proximal Development

The Zone of Proximal Development (ZPD), as defined by Vygotsky (1978), is the area between what a learner can accomplish on their own and what they can accomplish with assistance. The Learning Pit model is highly compatible with this idea. The Learning Pit

methodology seeks to move pupils into their ZPD to promote deeper learning through purposeful cognitive conflict. Although research on the Learning Pit's efficacy in teaching mathematics is still in its infancy, several relevant findings have emerged. For example, Russo et al. (2021) discovered that students' tenacity and attitudes toward mathematics tasks improved when the Learning Pit metaphor was freely discussed with them. Similarly, García et al. (2015), Braithwaite and Sprague's (2021), and Barrientos et al. (2022) showed that integrating the Learning Pit model into problem-solving tasks can enhance students' conceptual knowledge and metacognitive awareness. This is achieved through metacognitive reflections, deep learning approaches, and the interaction between conceptual and procedural knowledge. Additionally, emotional factors such as anxiety can modulate the relationship between metacognition and problem-solving, underscoring the intricate interplay between cognitive and emotional processes in learning.

Integrating Active Learning and the Learning Pit Model

Although the Learning Pit model and active learning have frequently been researched independently, there is interest in exploring how they could be effectively integrated. While the Learning Pit provides a framework for helping students through conceptual obstacles, the active learning method offers a framework for student-centered and engaging instruction.

This section also illustrates the correlation between active learning, as proposed by Hazzan et al. (2011), and the Learning Pit Model (Figure 1), as well as the Timeline of Classroom Learning Activities (Figure 2).

Figure 1

Correlation between Active Learning and The Learning Pit Model

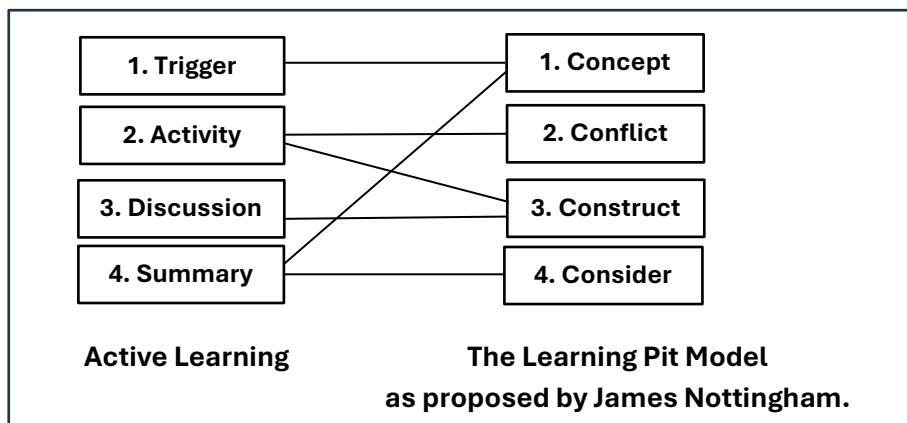
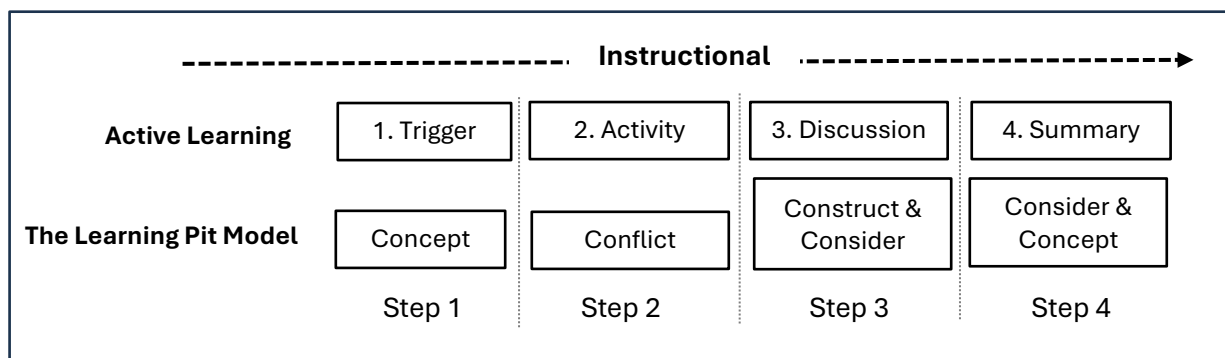


Figure 2

Timeline of Classroom Learning Activities



This integrated approach is consistent with the study by Mesa et al. (2014) and Demonty et al. (2018), which found that Thai secondary students' comprehension of algebraic concepts increased when active learning methodologies and organized conceptual growth were combined. For teaching factoring quadratic polynomials, the integrated approach can be described by the following steps.

Four Steps of Active Learning with the Learning Pit Model for Teaching Factoring Quadratic Polynomials:

Step 1: Trigger Presenting a summary of factoring principles using practical manipulatives or visual representations (active learning)

Step 2: Activity Introducing progressively intricate factoring tasks to generate cognitive tension (Learning Pit)

Step 3: Discussion Leading conversations in small groups as students work on factoring techniques (Active learning)

Step 4: Summary Directing class-wide thought on the relationship between various factoring techniques and the learning process (Learning Pit)

Mathematical Resilience: Conceptual Evolution and Components

Mathematical Resilience is a theoretical construct developed by Johnston-Wilder and Lee (2010) that describes the positive adaptive capability of students to overcome challenges and difficulties in mathematical learning. This concept encompasses learners' attitudes, beliefs, and behaviors that enable them to persist in developing mathematical understanding when encountering obstacles. Mathematical Resilience integrates several interconnected components: a growth mindset that believes in the development of mathematical abilities through effort, the recognition of mathematics's value and relevance in real-world applications, an understanding that mathematical learning requires sustained effort and practice, and the development of strategic approaches to manage learning difficulties. This construct emphasizes the importance of developing psychological resources and coping strategies that allow students to navigate the complexities of mathematical learning. Ultimately, this construct sustains their positive disposition toward the discipline.

Contemporary understanding of mathematical resilience encompasses four interrelated dimensions: (1) growth mindset regarding mathematical ability, (2) recognition of the value of mathematics, (3) strategic approaches to managing mathematical challenges, and (4) support-seeking behaviors when facing difficulties (Lee & Johnston-Wilder, 2017). This multidimensional conceptualization moves beyond simplistic notions of "persistence" to recognize the complex interplay of beliefs, behaviors, and environmental factors that enable students to engage productively with mathematical struggle.

In conjunction with this theoretical framework, active learning in Mathematics Education emerges as a complementary instructional approach that substantially enhances mathematical resilience. This pedagogical methodology emphasizes student engagement through structured problem-solving activities, collaborative discourse, and autonomous knowledge construction. Within this context, educators function as facilitators rather than transmitters of knowledge, and employ sophisticated questioning techniques designed to stimulate higher-order cognitive processes. Notably, the Learning Pit framework has demonstrated significant efficacy in

cultivating perseverance and resilience within mathematical contexts by deliberately immersing students in challenging problem scenarios while providing structured support mechanisms. This investigation examines the synergistic relationship between active learning methodologies and the Learning Pit approach in fostering mathematical resilience and developing transferable problem-solving competencies. Furthermore, the research underscores the critical importance of meticulously formulated questioning strategies, particularly emphasizing the integration of authentic contextual problems during the initial Trigger phase of the Active Learning sequence. To illustrate the practical implementation of this theoretical integration, the study presents a comprehensive case analysis involving quadratic functions and projectile motion applications. Additionally, the investigation critically analyzes the collaborative dynamics among peers and the strategic scaffolding provided by teachers during the Discussion and Activity phases. The empirical evidence suggests that when systematically implemented, active learning methodologies significantly contribute to students' mathematical development and enhance their problem-solving self-efficacy, thereby fostering substantial gains in mathematical resilience.

Research Methods

This study employed a sequential explanatory mixed-methods design (Creswell & Plano Clark, 2018) with a dominant quantitative phase followed by a qualitative phase to provide a deeper understanding of observed changes. While a quasi-experimental design with a control group would have strengthened causal inferences, ethical considerations within the school context necessitated providing the intervention to all students in the selected classroom. To address this limitation, the study incorporated several methodological safeguards:

1. Extended baseline period with multiple pre-intervention measures to establish stability of mathematical resilience scores.
2. Implementation of the intervention by a teacher not involved in data collection or analysis.
3. Collection of detailed field notes to monitor intervention fidelity.
4. Triangulation of quantitative findings with qualitative data from multiple sources.

Research Design

The study employed a one-group pretest–posttest design. The experimental phase was implemented through the teaching of factoring quadratic polynomials, using active learning strategies integrated with the Learning Pit model. The effectiveness of the integrated teaching approach was measured by comparing students' mathematical resilience before and after the intervention.

Instruments

Lesson Plans

A total of six lesson plans encompassing eight 50-minute intervals were developed, integrating the Learning Pit Model with Hazzan et al.'s (2011) active learning framework. Each lesson followed four steps, namely: Trigger, Activity, Discussion, and Summary.

Examples of Learning Activities

Step 1: Trigger Students reviewed prior knowledge of area and multiplication by engaging with a real-world scenario in which the teacher presented rectangular garden plots whose areas were expressed as polynomial expressions (e.g., *"If a garden plot has an area of $x^2 + 5x + 6$ square meters, what are its possible dimensions?"*). Using algebra tiles and visual area models, students connected their existing understanding to the concept of polynomial factoring, recognizing mathematics as a meaningful tool for solving practical, everyday problems — activating value recognition as a foundational dimension of mathematical resilience before transitioning to new algebraic content.

Step 2: Activity Students were presented with intentionally ill-formed quadratic expressions designed to induce cognitive dissonance. In the first expression,

$$x^2 + 6x + ? = (x + 3)(x + 2),$$

students initially applied their familiar factoring heuristic — identifying two integers whose product equals the constant term and whose sum equals the coefficient of the linear term. However, upon expanding the right-hand side, students obtained $x^2 + 5x + 6$, revealing that the given factored form was structurally inconsistent with the left-hand expression, rendering it irresolvable through routine procedures. The teacher deliberately withheld immediate correction, instead posing probing questions such as "Is this expression factorable as written? What condition must hold for factoring to be valid?" — redirecting students from procedural execution toward structural analysis, and positioning them within Nottingham's (2017) Learning Pit. Similarly, $4x^2 - 12x + ? = (2x - 2)(2x - ?)$ presented an analogous structural inconsistency, reinforcing the same cognitive conflict and compelling students to interrogate the underlying conditions that govern valid polynomial factorization rather than relying on procedural schema alone.

Step 3: Discussion Building on the cognitive conflict from Step 2, students collaboratively examined why their factoring attempts had failed, identifying and addressing the misconception that all quadratic expressions admit valid factorization over the integers. Through structured small-group and whole-class discourse facilitated by the teacher's probing questions, students verified coefficient relationships through systematic expansion, identified patterns in perfect square trinomials, and formalized generalized factoring criteria, transitioning from procedural errors toward coherent conceptual understanding and beginning to emerge from the Learning Pit through peer-supported knowledge reconstruction.

Step 4: Summary Students synthesized their learning by formalizing the algebraic conditions established through Steps 2 and 3 into explicit mathematical principles — articulating that a quadratic trinomial $ax^2 + bx + c$ is factorable over the integers only when its coefficients satisfy specific structural relationships, and that the validity of any proposed factored form must be verified through expansion. Returning to the real-world context introduced in Step 1, students applied these formalized principles to practical scenarios such as determining the dimensions of rectangular garden plots and optimizing product-packaging dimensions expressed as quadratic expressions, thereby consolidating value recognition alongside conceptual mastery. This metacognitive synthesis — moving from productive struggle and collaborative reconstruction to formal generalization and contextual application — directly targeted the mathematical resilience deficits observed in the sample group, particularly students' limited capacity to persist through algebraic challenges, recover from procedural setbacks, and recognize the practical relevance of mathematical knowledge.

Mathematical Resilience Questionnaire

Mathematical resilience was assessed using a 23-item questionnaire adapted from the Mathematical Resilience Scale (MRS) developed by Kookien et al. (2016), employing a five-point Likert scale. The instrument encompasses three psychometrically validated dimensions: Growth Mindset (7 items), Struggle (8 items), and Value (8 items), each capturing distinct aspects of students' self-beliefs regarding mathematical learning.

Notably, the Support dimension, though theoretically integral to Johnston-Wilder and Lee's (2010) original conceptualization of mathematical resilience, was absent from the MRS, as items related to help-seeking behaviors were eliminated during the scale's statistical development process due to insufficient psychometric fit. Given the theoretical significance of peer and teacher support in fostering resilience, particularly within the collaborative active learning environment employed in this study, the Support dimension was therefore assessed through qualitative focus group interviews, enabling a more contextually sensitive and nuanced examination of students' perceived support structures than a quantitative instrument alone could provide.

Validity and Reliability

Using the Index of Item-Objective Congruence (IOC), five subject matter experts evaluated the validity of the lesson plans and instructional tools. The assessment of the active learning lesson plans integrated with the Learning Pit model demonstrated a high level of appropriateness with an overall mean score of 4.60 (SD = 0.49). This robust validation score substantiates the pedagogical soundness and implementation feasibility of the developed instructional plans, confirming their alignment with the intended educational objectives and curricular standards.

Thirty students who were not in the sample group participated in pilot research that established the reliability of the Mathematical Resilience Questionnaire, yielding a Cronbach's alpha coefficient of 0.87, demonstrating robust internal consistency. Content validity was confirmed through expert evaluation (IOC: 0.60–1.00).

The use of a mixed-methods approach allowed for a comprehensive analysis of both the quantitative findings and the qualitative student experiences, resulting in a profound understanding of the effects of the intervention on students' mathematical resilience.

Procedures

This research employed a systematic methodological approach encompassing five primary phases: initial ethical clearance and preparation, pre-intervention assessment, intervention implementation, post-intervention evaluation, and comprehensive data analysis. The study commenced with obtaining ethical approval from King Mongkut's University of Technology Thonburi and establishing research protocols at Chalermkwansatree School. A pre-intervention mathematical resilience assessment was conducted to establish baseline resilience levels. This was followed by an eight-session intervention that implemented active learning strategies integrated with the Learning Pit Model. Post-intervention evaluation included both quantitative assessments through mathematical resilience questionnaires and qualitative data collection through focus group interviews with strategically selected participants demonstrating varying levels of mathematical resilience. The research concluded with rigorous

data analysis integrating both quantitative and qualitative findings to evaluate the intervention's effectiveness in developing students' mathematical resilience.

Data Analysis

Quantitative Analysis

The quantitative data analysis in this study comprised two main components. The first component involved analyzing individual mathematical resilience levels using basic statistics, including percentages, means, and standard deviations. Mathematical resilience was measured through a five-point Likert-scale questionnaire consisting of 23 items designed to assess students' perceptions of mathematical resilience, comprising 16 positively worded items (e.g., *"Good mathematicians experience difficulties when solving problems"*) and 7 negatively worded items (e.g., *"Everyone's mathematical ability is determined at birth"*), with response options ranging from Strongly Agree (5 points) to Strongly Disagree (1 point). The resulting mean scores were subsequently interpreted using established criteria categorized into five levels: Very High (4.50–5.00), High (3.50–4.49), Moderate (2.50–3.49), Low (1.50–2.49), and Very Low (1.00–1.49).

The second component focused on analyzing classroom-level mathematical resilience by comparing average progress scores. This comprehensive analytical framework facilitated a systematic evaluation of both individual and collective mathematical resilience development, as well as specific mathematical communication skills, following the implementation of active learning strategies integrated with the Learning Pit Model.

Qualitative Analysis

The qualitative data analysis of mathematical resilience in the support dimension was conducted through focus group discussions with eight eighth-grade students, comprising four students with the highest levels of mathematical resilience and four with high levels. The 50-minute discussion encompassed four key domains: emotional responses and attitudes toward learning, such as feelings before and after studying quadratic polynomial factorization; instructional methodology and learning materials, investigating the effectiveness of educational resources and peer support; learning motivation, focusing on students' autonomous problem-solving inclinations; and the learning environment that facilitates student engagement. The analysis followed a four-stage process: data organization, content categorization according to specified themes, coded data grouping, and methodological triangulation. The latter involved cross-referencing data from mathematical resilience questionnaires with focus group discussion transcripts to validate data reliability and ensure research consistency. Through this comprehensive approach, the study aimed to examine how students perceived and received support in enhancing their understanding and learning capabilities within the mathematical context.

Findings

1) Individual Mathematical Resilience Levels of Eighth-Grade Students Before and After Implementing Active Learning Integrated with the Learning Pit Model

Table 1

Distribution of Students by Mathematical Resilience Levels: A Pre-test and Post-test Comparison

Assessment	Mathematical Resilience Levels									
	Very High		High		Moderate		Low		Very Low	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Pre-Test	1	4	24	96	-	-	-	-	-	-
Post-Test	14	56	11	44	-	-	-	-	-	-

Table 2

A Comparative Analysis of Mathematical Resilience Questionnaire Scores: Pre-test and Post-test Assessment

Assessment	Minimum Score	Maximum Score	Mean Score	S.D.	Interpretation
Pre-Test	3.17	4.57	3.70	0.31	High Mathematical Resilience
Post-Test	4.13	5.00	4.52	0.21	Very High Mathematical Resilience

Based on Tables 1 and 2, before implementing active learning combined with the Learning Pit Model, most students ($n = 24$, 96%) demonstrated mathematical resilience at the 'high' level with a mean score of 3.70. Following the intervention, the majority ($n = 14$, 56%) exhibited mathematical resilience at the 'very high' level, with the mean score increasing to 4.52. This indicates an overall enhancement in students' mathematical resilience.

2) Percentage of Progress of Mathematical Resilience Among Eighth-Grade Students Through Active Learning Combined with the Learning Pit Model

Overall, the mean Mathematical Resilience score increased from 85.04 to 103.96 out of a maximum possible score of 115, representing a gain of 18.92 points. This improvement corresponds to 16.45% of the maximum possible score, reflecting a meaningful upward shift across the sample. Individual analysis confirmed that all 25 students demonstrated improvement in mathematical resilience, with progress scores ranging from 8 to 31 points, indicating that the intervention benefited students across varying initial resilience levels. This indicates that students who participated in active learning combined with the Learning Pit model enhanced their mathematical resilience.

3) Qualitative Findings on Mathematical Resilience Among Eighth-Grade Students After Implementing Active Learning Combined with the Learning Pit Model

The findings revealed that after experiencing active learning integrated with the Learning Pit model, students perceived that encountering problem-based tasks or situational problems enhanced their learning process, comprehension, and cognitive stimulation. These served as effective tools for facilitating group discussions and fostering critical thinking. When students faced mathematical challenges that they could not solve independently, they reported receiving valuable guidance and explanations from their instructors and peers during learning activities, which improved their understanding and problem-solving capabilities. Additionally, effective instructional materials facilitated their better comprehension of mathematical concepts.

Sample Interview Data on Mathematical Resilience

This study examines the role of peers and teachers in fostering mathematical resilience among students, as evidenced by their discussions of collaborative learning experiences. The analysis of the conversation highlights four key dimensions: *Value*, *Growth*, *Struggle*, and *Support*.

Value: While students did not explicitly mention the intrinsic value of mathematics, their emphasis on collaborative problem-solving suggests an appreciation for the learning process. Student 2, for instance, highlighted the importance of group discussions in tackling mathematical problems, demonstrating a commitment to active engagement.

Growth: Several students exhibited a growth-oriented mindset. Student 6 expressed a willingness to seek clarification from peers to ensure mutual understanding, while Student 8 emphasized the importance of asking for help when struggling with new concepts. These behaviors indicate a proactive approach to learning and self-improvement.

Struggle: Students acknowledged the challenges inherent in mathematical problem-solving. Student 5 and Student 8 discussed difficulties in comprehending certain problems, and Student 7 specifically mentioned the complexity of some tasks, reinforcing the notion that struggle is an integral part of learning.

Support: Peer collaboration emerged as a significant factor in overcoming learning obstacles. Students highlighted how group dynamics facilitated their progress; for instance, Student 2 described the value of collective problem-solving, while Students 3 and 4 noted the broad benefits of peer assistance. Reinforcing this view, Student 7 emphasized that teamwork is essential for tackling complex mathematical problems, underscoring the vital role of a supportive peer environment.

Overall, the conversation illustrates the essential role of *peer interactions in fostering mathematical resilience*. While the students did not explicitly address the broader value of mathematics, their engagement in problem-solving, willingness to seek help, and collaborative efforts reflect perseverance and adaptability—key attributes of mathematical resilience. These findings suggest that structured peer support mechanisms can be instrumental in promoting deeper learning and enhancing students' confidence in mathematics.

Discussion

This finding indicates that integrating active learning with the Learning Pit Model was associated with notable improvements in mathematical resilience among Grade 8 students learning polynomial factorization. The mean score rose from 3.70 to 4.52, transitioning from the "high" to the "very high" classification, with 56% of students reaching the highest resilience level compared to only 4% at baseline. This progression suggests that resilience functions not as a fixed trait but as a learnable capability that can be cultivated through appropriate instructional environments.

However, several interpretive considerations are necessary. Most notably, 96% of students were already classified at the "High" resilience level before the intervention, indicating a substantially elevated baseline. This ceiling proximity may reflect the sample's characteristics as students enrolled in a large, academically competitive institution where sustained engagement is typically expected. Two implications follow: First, the observed gains, while consistent, may not be fully representative of broader Grade 8 populations with lower baseline

resilience. Second, the possibility of a practice effect or increased test familiarity contributing to score gains cannot be entirely excluded, given the single-group design. Future studies employing control groups or longitudinal measurement would help disentangle genuine resilience development from these confounding factors. Nonetheless, the intervention's capacity to elevate resilience even among already capable learners carries practical significance within the Thai educational context: the collaborative structures of active learning appear to have reduced affective barriers—including help-seeking reluctance and fear of failure—while the Learning Pit Model explicitly reframed productive confusion as an expected and constructive dimension of mathematical learning, rather than a source of shame deeply embedded in Thai academic culture.

The substantial improvement in mathematical resilience can be explained through several theoretical lenses. First, the integration of active learning and the Learning Pit Model effectively creates what Vygotsky (1978) termed the Zone of Proximal Development, where students encountered productive challenges while receiving appropriate support. This finding aligns with Russo et al.'s (2021) research, which found that explicit discussion of learning struggles enhanced mathematical resilience.

The Success of this Integrated Approach Can Be Attributed to Three Key Mechanisms:

a) Cognitive Development: Active engagement and structured cognitive conflict helped students develop a deeper conceptual understanding, supporting Nottingham's (2017) assertion that meaningful learning occurs through productive struggle. Students' improved ability to navigate mathematical challenges reflects Warshauer's (2015) findings on the importance of productive struggle in mathematics education.

b) Social-Emotional Support: The collaboration of students in active learning, integrated with the Learning Pit model's framework for managing challenges, created a supportive learning environment. This aligns with Johnston-Wilder and Lee's (2013) emphasis on the social aspects of mathematical resilience development.

c) Metacognitive Awareness: Students' enhanced mathematical resilience was particularly evident in their improved self-regulation and problem-solving strategies, supporting Braithwaite and Sprague's (2021) findings on the role of metacognition in mathematical learning.

An unexpected finding was the varying impact across different dimensions of mathematical resilience. While the growth mindset and value recognition showed substantial improvement, the struggle dimension demonstrated more modest gains. This pattern suggests that developing comfort with mathematical challenges may require longer intervention periods, consistent with Aljarrah and Towers' (2021) observations.

Several limitations warrant consideration. The single-group design, practical for classroom research, limits causal inferences. Additionally, the relatively short intervention period (eight sessions) may not fully capture long-term resilience development. These limitations were partially addressed through mixed-methods data collection and rigorous analysis procedures.

Implications of the Findings for Mathematics Education

The results of this study have significant implications for mathematics education, encompassing theoretical, practical, and policy dimensions. These implications contribute to the advancement of both pedagogical practice and curriculum development, with a particular focus on fostering mathematical resilience among students (Hunter et al., 2020).

Theoretical Implications

This study extends understanding of the interplay between various pedagogical approaches and their role in cultivating mathematical resilience. By providing empirical evidence supporting the integration of active learning methodologies with the Learning Pit Model, the findings reinforce the theoretical foundations for resilience-building strategies in mathematics education. This integration further enhances the conceptual framework by elucidating the mechanisms through which students develop perseverance and adaptability in mathematical problem solving (Castle, 2023; Lee & Johnston-Wilder, 2017; Xenofontos & Mouroutsou, 2022).

Practical Implications

From a pedagogical perspective, the findings offer a structured framework for educators to systematically nurture mathematical resilience among students. The study outlines specific strategies that teachers can employ to support learners as they navigate mathematical challenges. These strategies include scaffolding techniques, metacognitive interventions, and the promotion of a growth mindset, all of which are instrumental in developing students' ability to persist in the face of difficulties. By implementing these approaches, educators can create a learning environment that fosters confidence and resilience in mathematical problem-solving (Ekayanti et al., 2023; Xenofontos & Mouroutsou, 2022).

Policy Implications

At the policy level, the findings underscore the necessity for professional development programs that focus on resilience-building pedagogies. Given the increasing emphasis on equipping students with problem-solving and critical thinking skills, there is a clear imperative to incorporate resilience development into mathematics curriculum design. Educational policymakers should prioritize the integration of resilience-focused instructional strategies within teacher training programs to ensure that educators are well-equipped to support students effectively. Furthermore, curriculum designers should consider embedding resilience-building components within mathematics instruction to enhance students' long-term engagement and success in the subject.

In conclusion, this study provides valuable insights into the theoretical, practical, and policy-related aspects of mathematics education. By reinforcing the importance of resilience-building pedagogies, these findings contribute to the ongoing discourse on effective teaching practices and curriculum innovation. Future research should continue to explore the broader implications of these approaches to further enhance mathematics education on a global scale.

Implications and Future Directions

The success of this integrated approach has significant implications for mathematics education. The study highlights the need for establishing an encouraging learning environment,

where students are motivated to engage in productive mathematical struggle. Subsequent investigations may examine the enduring impacts of this methodology on pupils' arithmetic performance and perspectives on mathematics. Further research into this model's application to other mathematical topics and grade levels may yield insightful information for curriculum development. In summary, active learning combined with the Learning Pit model is a potential strategy for improving mathematical resilience. Teachers have the power to change students' attitudes about mathematics by establishing an atmosphere that values constructive struggle. This approach will help students become more competent and confident in the subject.

Conclusions

This study contributes to the growing body of research on mathematical resilience by demonstrating the effectiveness of an integrated pedagogical approach. The successful combination of active learning and the Learning Pit model suggests a promising direction for mathematics education that supports both cognitive development and psychological resilience.

Recommendations for Implementation

1. Provide professional development seminars to support teachers in effectively implementing this integrated strategy.
2. Design challenging problem scenarios and use error analysis to stimulate critical thinking and cognitive conflict.
3. Allocate sufficient time for reflection and discussion, with teachers facilitating deeper thinking through probing questions.
4. Encourage students to apply newly acquired knowledge to initial challenges and reflect on their learning experiences.

Recommendations for Further Research

1. Develop more precise evaluation instruments to assess all aspects of the dependent variables.
 2. Explore additional active learning strategies to enhance mathematical resilience and reasoning.
 3. Expand the study to different grade levels to increase its applicability.
 4. Investigate the impact of this approach on problem-solving and creative thinking skills.
- These suggestions seek to broaden the field of study in mathematics education as well as enhance the application of the Learning Pit model and integrated active learning strategies.

Author Contributions

KS: Conceptualization, Methodology, Investigation, Data Curation, and Writing – Original Draft Preparation. TT: Software, Validation, and Supervision. RC: Resources, Writing – Review and Editing, Visualization, Supervision, Project Administration, and Funding Acquisition.

Declaration of the Use of Generative AI

During the preparation of this manuscript, the authors used Gemini 3 to assist with language editing and polishing the draft. The tool was used solely to improve clarity, grammar, and overall

readability. The authors reviewed and revised the output as necessary and take full responsibility for the content of the manuscript.

Ethics

This study received ethical approval from the KMUTT's Institutional Review Board (Approval Letter No. KMUTT-IRB-COA-2024-026). All participants provided voluntary informed consent after receiving detailed explanations of the study's purpose and procedures. Consent was also obtained from school principals to involve students in the study in accordance with established ethical guidelines. Participants were assured that all data collected would be kept confidential and used exclusively for research purposes. To maintain anonymity, participants were assigned identification codes in the study's reporting.

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