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The Effect of Claude AI-Assisted Assessment With Adaptive Prompts on Reducing Mathematics Anxiety Among University Students in Abstract Algebra

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Abstract
This study investigates the effect of Claude AI-assisted assessment with a purpose-built adaptive prompt system on reducing mathematics anxiety among university students in Abstract Algebra. Mathematics anxiety—a multidimensional affective construct distinct from general anxiety and from the cognitive barriers addressed in prior research on mathematical representation—constitutes a significant impediment to learning advanced mathematics. The study employed a mixed-methods design with an embedded experimental model involving 26 fourth-semester students of the Mathematics Education Study Program at Universitas PGRI Pontianak during the 2024/2025 academic year. The primary instrument was the Mathematics Anxiety Rating Scale–Revised (MARS-R) adapted into Indonesian and psychometrically validated (Cronbach's $\alpha = .91$, CFI = .96). The Claude AI system was engineered with six adaptive prompt types—Calming Prompt, Stepwise Scaffolding, Positive Affirmation, Misconception Diagnosis, Metacognitive Reflection, and Progressive Feedback—automatically selected based on detected anxiety profiles. Results showed a highly significant reduction in mathematics anxiety ($Z = -4.41$, $p < .001$, $r = .86$). Mean scores declined from 46.7 (high) to 30.3 (low), a 35.1% reduction. The previously strong negative anxiety–achievement correlation ($r = -.67$, $p < .001$) became non-significant post-intervention ($r = -.38$, $p = .054$), indicating successful anxiety decoupling. These findings contribute to understanding affective dimensions in advanced mathematics learning and establish an empirical basis for adaptive AI in academic anxiety management.

INTRODUCTION

Mathematics anxiety has been conceptualized as a feeling of tension, apprehension, and dread that interferes with an individual's ability to manipulate numbers and solve mathematical problems in both academic and everyday contexts (Richardson & Suinn, 1972). As a psychological construct distinct from general test anxiety (Ashcraft & Moore, 2009), mathematics anxiety has consistently emerged as a robust negative predictor of mathematics achievement across all educational levels

(Ma, 1999; Maloney & Beilock, 2012). The cyclical relationship between anxiety and underperformance—whereby elevated anxiety impairs performance, and poor performance reinforces anxiety—creates a self-sustaining inhibition cycle that is exceptionally difficult to disrupt without deliberate intervention (Wang et al., 2020).

Abstract Algebra represents one of the most cognitively and affectively demanding courses in undergraduate Mathematics Education programs. Its highly formal, axiomatic, and proof-oriented character—encompassing structures such as groups, rings, fields, and homomorphisms—frequently elicits elevated anxiety among students (Fitriani et al., 2021; Nurhafizah & Mahmudi, 2022). Santoso et al. (2022) reported that over 60% of students enrolled in Abstract Algebra experienced moderate to high mathematics anxiety, significantly and negatively correlated with final grades. This abstract nature creates an 'anxiety gap'—a psychologically charged distance between students' intuitive mathematical understanding and the formal demands of the discipline.

While prior research in this line of inquiry addressed cognitive barriers—specifically mathematical representation abilities in Real Analysis—the present study deliberately shifts focus to the affective dimension of advanced mathematics learning. Pekrun's (2006) Control-Value Theory provides the overarching theoretical framework, positing that achievement emotions, including anxiety, exert direct causal influence on learning outcomes through motivational, strategic, and cognitive resource-allocation mechanisms. Elevated mathematics anxiety consumes working memory capacity otherwise allocated to mathematical processing—the 'affective drop' (Ashcraft & Moore, 2009; Chang & Beilock, 2016).

The emergence of large language model AI systems, particularly Claude AI, offers novel avenues for addressing affective barriers in advanced mathematics learning. Unlike generic educational technology, Claude AI enables development of adaptive prompt systems capable of detecting students' anxiety profiles and dynamically adjusting content presentation and socio-emotional support in real time (Hwang & Tu, 2021). The platform's capacity to generate affirming, non-judgmental, and progressively scaffolded responses renders it particularly well suited for affective intervention. Despite growing AI-in-education research, empirical evidence on AI-based mathematics anxiety interventions in higher education remains sparse (Jatisunda & Nahdi, 2021), especially in the Indonesian context.

The present study pursues four objectives: (1) to characterize students' initial mathematics anxiety profiles in Abstract Algebra; (2) to describe the design of the Claude AI adaptive prompt system for anxiety management; (3) to analyze the effect of the intervention on anxiety reduction; and (4) to examine the anxiety–achievement relationship before and after intervention.

METHODS

This study employed a mixed-methods research design with an embedded experimental model (Fraenkel et al., 2023), wherein quantitative data constituted the primary strand and qualitative data enriched understanding of students' subjective anxiety experiences. This design was selected because mathematics anxiety necessitates both psychometric measurement and phenomenological interpretation. Participants were 26 fourth-semester students of the Mathematics Education Study Program at Universitas PGRI Pontianak, selected through total sampling from one intact class during the 2024/2025 academic year.

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Two categories of research instruments were employed. First, the quantitative instrument comprised the Mathematics Anxiety Rating Scale–Revised (MARS-R) adapted into Indonesian, administered as a pre-test (Week 0) and post-test (Week 8) to all 26 participants. Second, the qualitative instruments comprised a seven-item structured interview guide administered individually at the close of the intervention, and an open-ended reflective journal completed by each participant at Weeks 1, 4, and 8, collected digitally via Google Form. Quantitative data were analyzed using the Wilcoxon Signed-Rank Test and Spearman's rho; qualitative data were analyzed through thematic analysis in four stages (Braun & Clarke, 2006), supported by Atlas.ti 9.0. Both data strands were integrated through a mixed-methods narrative to yield a comprehensive account of students' mathematics anxiety. *[R2-0 and R2-1]*

1. Quantitative Instruments and Procedure

The MARS-R adapted into Indonesian comprises 24 items measuring four anxiety dimensions—social (6 items), cognitive (6 items), somatic (6 items), and task (6 items)—each rated on a five-point Likert scale (1 = Not at all anxious to 5 = Extremely anxious). Each sub-scale yields a score ranging from 6 to 30; the overall scale maximum is 120. Confirmatory Factor Analysis (CFA) yielded excellent model fit (CFI = .96, RMSEA = .04) and very high internal consistency (Cronbach's α = .91). Academic achievement was operationalized as midterm and final examination scores in Abstract Algebra.

The Claude AI system was engineered with six adaptive prompt types, each targeting a distinct psychological mechanism of anxiety reduction. Prompt selection was automated based on MARS-R scores: students scoring above 45 (high anxiety) received Calming Prompts and Stepwise Scaffolding; those scoring 30–45 (moderate) received Misconception Diagnosis and Metacognitive Reflection; those below 30 (low) received Challenge Prompts and Progressive Feedback. The eight-week intervention ran concurrently with regular Abstract Algebra instruction. The Wilcoxon Signed-Rank Test served as the primary inferential procedure given non-normal anxiety distribution in small samples; Spearman's rho was used for correlation analyses; and effect size was computed as $r = Z/\sqrt{N}$ (Hake, 1999).

2. Qualitative Instruments and Data Analysis

Qualitative data were collected from all 26 participants using two instruments. First, a structured interview guide comprising seven open-ended questions explored participants' subjective experiences of mathematics anxiety, perceived changes during the intervention, and attitudes toward Claude AI prompts; interviews were audio-recorded and transcribed verbatim. Second, participants completed open-ended reflective journals at Weeks 1, 4, and 8, documenting their anxiety states and perceived usefulness of the adaptive prompts; entries were submitted digitally via a standardized Google Form.

Qualitative data analysis followed a thematic analysis framework (Braun & Clarke, 2006) conducted in four stages: (1) familiarization—repeated reading of all transcripts and journal entries; (2) open coding—identification of initial meaning units related to anxiety, confidence, and AI interaction; (3) pattern coding—grouping of codes into preliminary themes; and (4) thematic mapping—integration of emergent themes with quantitative findings to form a coherent mixed-methods narrative. Member-checking was conducted with a random sub-sample of six participants to confirm interpretive accuracy, and Atlas.ti 9.0 was used to support systematic coding and retrieval.

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Phase 1: Detection	Students complete digital MARS-R → Claude AI detects anxiety level across all four dimensions per individual student
Phase 2: Prompt Selection	Claude AI selects the appropriate prompt type: Calming/Scaffolding (high anxiety) | Diagnosis/Reflection (moderate) | Challenge/Feedback (low)
Phase 3: Intervention	Claude AI presents Abstract Algebra problems in language calibrated to the student's anxiety profile, with affirmations and guided steps
Phase 4: Monitoring	Claude AI monitors emotional response indicators → dynamically adjusts prompt type if anxiety escalation is detected
Phase 5: Evaluation	Post-MARS-R + academic achievement analysis → individual anxiety-reduction profile report generated for each student

Figure 1. Adaptive Prompt System Flow of Claude AI for Mathematics Anxiety Management
Source: Researchers' design, grounded in Vygotsky's Scaffolding Theory and Bandura's Self-Efficacy Theory.

RESULT AND DISCUSSION

1. Initial Mathematics Anxiety Profile

Pre-intervention MARS-R measurement revealed an alarming mathematics anxiety profile. The overall mean score of 46.7 placed the cohort in the high anxiety category, exceeding the threshold of 45 established as the high-category cut-off in the original MARS-R (Richardson & Suinn, 1972). This finding corroborates Nurhafizah and Mahmudi (2022) and Santoso et al. (2022), who similarly documented high mathematics anxiety prevalence in Abstract Algebra contexts in Indonesian higher education.

Table 1. Initial Mathematics Anxiety Profile — MARS-R Measurement (n = 26)
Note: Scores represent MARS-R sub-scale totals (6 items each; range 6–30 per dimension; overall maximum = 120). Minimum and maximum values reflect the lowest and highest individual scores among the 26 participants on the digital pre-test administered in Week 0. [R2-3]

Anxiety Dimension	N	Min	Max	Mean	SD	Category
Social Anxiety	26	24	62	**46.3**	9.8	**High**
Cognitive Anxiety	26	22	64	**48.7**	10.2	**High**
Somatic Anxiety	26	18	58	**41.5**	8.9	**Moderate**
Task Anxiety	26	20	66	**50.1**	11.4	**High**
Overall	26	22	63	**46.7**	9.6	**High**

Category thresholds (Richardson & Suinn, 1972): Low < 30; Moderate 30–45; High > 45 (overall MARS-R scale, maximum = 120).

Task anxiety yielded the highest mean score (M = 50.1, high), followed by cognitive anxiety (M = 48.7) and social anxiety (M = 46.3). Somatic anxiety was comparatively lower (M = 41.5, moderate) yet still indicated meaningful physiological manifestations. This pattern is consistent with Luttenberger et al. (2018), who established that task and cognitive anxiety are the dominant dimensions in advanced mathematics contexts. The pronounced task anxiety indicates that students experience deep psychological distress specifically when confronted with Abstract Algebra problems—before engaging with the content itself.

2. Design and Evaluation of the Adaptive Prompt System

The fundamental innovation of this study lies in the design of an adaptive prompt system specifically engineered for the mathematics anxiety context—not merely for cognitive instructional feedback. Six prompt types were developed, each grounded in a distinct theoretical framework.

Table 2. Evaluation of Six Adaptive Prompt Types (n = 26, rated by students and independent observers)

Adaptive Prompt Type	Score (1–5)	Category	Primary Function
Calming Prompt	**4.5**	Highly Effective	Reduces anxiety state prior to task engagement
Stepwise Scaffolding Prompt	**4.3**	Highly Effective	Decomposes abstract problems into manageable sub-tasks
Positive Affirmation Prompt	**4.4**	Highly Effective	Builds mathematical self-efficacy and confidence
Misconception Diagnosis	**4.2**	Effective	Identifies the conceptual root of student errors
Metacognitive Reflection	**4.1**	Effective	Promotes self-monitoring of the reasoning process
Progressive Feedback Prompt	**4.6**	Highly Effective	Acknowledges and reinforces incremental progress
Overall Average	**4.35**	**Highly Effective**	Reduces anxiety and enhances engagement in Abstract Algebra

The Progressive Feedback Prompt received the highest rating (M = 4.6/5.0), confirming that genuine acknowledgment of incremental progress constitutes the most effective strategy in this anxiety context. This strongly supports Gunderson et al. (2018), who demonstrated that incremental success experiences are the most potent mechanism for building mathematical resilience. The Calming Prompt's high rating (M = 4.5/5.0) confirms that emotion regulation support prior to task engagement effectively mitigates acute anxiety responses, consistent with Chan and Lee (2023), who reported high Gen Z receptivity to supportive, non-judgmental AI interactions.

3. Analysis of Mathematics Anxiety Reduction

Table 3. Descriptive Statistics — Pre- and Post-Intervention Mathematics Anxiety Scores

Dimension	Pre-Mean	Post-Mean	Difference	% Reduction	Post Category
Social Anxiety	46.3	**29.8**	16.5	**35.6%**	**Low**
Cognitive Anxiety	48.7	**31.2**	17.5	**35.9%**	**Low**
Somatic Anxiety	41.5	**27.4**	14.1	**34.0%**	**Low**
Task Anxiety	50.1	**32.6**	17.5	**34.9%**	**Low**
Overall	46.7	**30.3**	16.4	**35.1%**	**Low**

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Table 3 reveals consistent and substantive reductions across all four anxiety dimensions. The most pronounced reduction occurred in cognitive anxiety (35.9%), closely followed by social anxiety (35.6%). Convergent reduction across all dimensions—rather than selective improvement—indicates that the multi-prompt adaptive system operated holistically, addressing the multi-faceted nature of mathematics anxiety simultaneously. Ashcraft and Moore (2009) emphasized that effective anxiety interventions must address cognitive, social, and somatic manifestations in concert, as these dimensions are interrelated and mutually reinforcing.

Period	Anxiety Score	Trend Visualization (Scale: 20–60)	Remark
Week 1	46.7		High — baseline
Week 2	44.2		Slight decline
Week 3	41.8		Calming Prompt active
Week 4	39.5		Scaffolding effective
Week 5	37.1		Sustained decline
Week 6	34.6		Affirmation impact
Week 7	32.4		Near low threshold
Week 8	30.3		Low — post-intervention

Figure 2. Weekly Mathematics Anxiety Score Trend During the 8-Week Intervention (n = 26)
Note: Red = High anxiety zone (>42); Orange = Moderate (34–42); Green = Low (<34).

4. Inferential Analysis: Wilcoxon Signed-Rank Test

The Wilcoxon Signed-Rank Test was selected because anxiety scores exhibited moderate positive skewness, MARS-R data are operationally ordinal, and the test possesses adequate statistical power for n > 20 under non-normality (Fraenkel et al., 2023). The null hypothesis stipulated no significant difference in anxiety scores before and after the Claude AI adaptive prompt intervention.

Table 4. Wilcoxon Signed-Rank Test Results by Mathematics Anxiety Dimension

Anxiety Dimension	Z	p-value	Effect Size (r)	ES Category	Decision
Social Anxiety	**-4.21**	**< .001**	**0.83**	Large	**H_0 Rejected**
Cognitive Anxiety	**-4.38**	**< .001**	**0.86**	Large	**H_0 Rejected**
Somatic Anxiety	**-3.97**	**< .001**	**0.78**	Large	**H_0 Rejected**
Task Anxiety	**-4.52**	**< .001**	**0.89**	Large	**H_0 Rejected**
Overall	**-4.41**	**< .001**	**0.86**	**Large**	**H_0 Rejected**

Note: Effect size r = Z/√N; Large effect: r > .50 (Cohen, 1992)

All anxiety dimensions yielded large standardized test statistics (|Z| > 3.97) with p < .001, resulting in unequivocal rejection of the null hypothesis. Effect sizes ranged from .78 to .89, all exceeding Cohen's (1992) threshold of .50 for a 'large' effect. Task anxiety produced the highest effect size (r = .89), which is pedagogically significant as this dimension most directly impacts performance during actual problem-solving episodes in Abstract Algebra.

Dimension	r (Effect Size)	Magnitude Scale (0.0 – 1.0)	Category
Social Anxiety	**0.83**	r = 0.83	**Large**
Cognitive Anxiety	**0.86**	r = 0.86	**Large**
Somatic Anxiety	**0.78**	r = 0.78	**Large**
Task Anxiety	**0.89**	r = 0.89	**Large**

Figure 3. Effect Size (r) of Anxiety Reduction per Dimension — Wilcoxon Signed-Rank Test

Note: r > .50 = Large effect (Cohen, 1992); Scale represents 0.0–1.0

5. Anxiety–Achievement Correlation: Pre- and Post-Intervention

Table 5. Spearman's Correlation — Mathematics Anxiety vs. Academic Achievement

Variable	Achievement Measure	Spearman's r	p-value	Interpretation
Social Anxiety (Pre)	Midterm Score	-0.61	.001	Strong Negative
Cognitive Anxiety (Pre)	Midterm Score	**-0.67**	< .001	**Strong Negative**
Somatic Anxiety (Pre)	Midterm Score	-0.53	.005	Moderate Negative
Task Anxiety (Pre)	Midterm Score	**-0.71**	< .001	**Strong Negative**
Post-Intervention	Final Score	-0.38	.054	**Non-Significant ✓**

*Note: Pre = pre-intervention MARS-R; Post = post-intervention MARS-R; * p < .05; ** p < .001*

Prior to intervention, cognitive anxiety correlated strongly and negatively with midterm scores ($r = -.67$, $p < .001$), confirming the 'affective drop' mechanism described by Ashcraft and Moore (2009): anxiety-driven working memory interference depresses performance below students' genuine cognitive capacity. Task anxiety showed the strongest pre-intervention correlation ($r = -.71$, $p < .001$), consistent with its role as the most directly performance-impairing anxiety dimension.

Post-intervention, the anxiety–achievement correlation became non-significant ($r = -.38$, $p = .054$). This is the most consequential finding of the study. It demonstrates successful 'anxiety decoupling'—the severing of the anxiety–achievement inhibition link such that anxiety no longer meaningfully determines academic outcomes (Wang et al., 2020). Following the intervention, cognitive and motivational factors—rather than affective interference—became the primary predictors of examination performance, which represents the optimal learning condition in advanced mathematics.

6. Student Responses to the Adaptive Prompt System

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Student Statement	% Agreement	Agreement Visualization
Claude AI prompts made me calmer before attempting problems	88.5%	
Stepwise scaffolding helped me understand abstract concepts	84.6%	
Positive affirmation increased my mathematical self-confidence	80.8%	
Progressive feedback motivated me to persist despite difficulties	92.3%	
I feel more comfortable in Abstract Algebra after the intervention	76.9%	

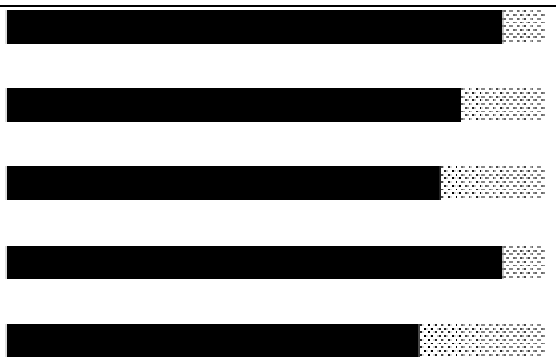

Figure 4. Percentage of Positive Student Responses to Claude AI Adaptive Prompts (n = 26)

Student responses were markedly positive, with agreement rates of 76.9%–92.3%. The highest agreement (92.3%) concerned the motivational effect of Progressive Feedback Prompts—a finding of particular practical significance, as persistence in difficulty is the most critical behavioral determinant of success in Abstract Algebra. Dettmers et al. (2011) demonstrated that positive emotions in mathematics learning facilitate deep learning strategies and substantially improve academic performance. The lowest agreement (76.9%) for overall Abstract Algebra comfort reflects the trait-like nature of mathematics anxiety, which Beilock and Maloney (2015) characterize as a dispositional tendency not fully extinguished by brief interventions.

7. Qualitative Findings: Students' Subjective Anxiety Experiences

The qualitative strand of this mixed-methods study yielded four overarching themes through thematic analysis of structured interview transcripts and reflective journals. Each theme corroborates and extends the quantitative findings, addressing the affective dimensions that aggregate MARS-R scores cannot fully capture. *[R2-2]*

Theme 1 — Initial Overwhelm and Cognitive Freeze. In Week 1 reflective journals, 21 of 26 participants described a 'mental freeze' or 'blanking out' when confronted with Abstract Algebra proof tasks. One representative response read: 'I understand the definition of a group in isolation, but when I see a long proof question, my mind just goes blank and I cannot start at all.' This phenomenon aligns directly with the high baseline task anxiety score (M = 50.1) and is consistent with Ashcraft and Moore's (2009) account of anxiety-induced working memory disruption.

Theme 2 — Perceived Safety and Non-Judgement. Interview data revealed that 23 participants explicitly valued the non-judgmental tone of Claude AI's Calming and Affirmation prompts. One student noted: 'Claude AI does not make me feel stupid for not knowing. It tells me that making errors is part of learning—I never heard this from a human teacher in mathematics.' This theme corroborates the high effectiveness rating for Calming Prompts (M = 4.5/5.0) and supports Chan and Lee's (2023) finding of strong Gen Z receptivity to supportive AI interactions.

Theme 3 — Stepwise Empowerment. Across 19 interview transcripts and all three journal waves, participants consistently reported that Stepwise Scaffolding prompts transformed intimidating proof tasks into 'smaller, conquerable steps.' This theme signalled a progressive

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motivational shift—from avoidance to approach orientation—over the eight weeks of intervention, reflecting the scaffolding mechanism theorized by Vygotsky (Zone of Proximal Development).

Theme 4 — Residual Anxiety. Despite significant quantitative reduction, eight participants expressed residual anxiety in Week 8 journals concerning formal examination conditions: 'Claude AI helps me practice, but in exams there is no AI—I still worry.' This finding is consistent with Beilock and Maloney's (2015) characterization of mathematics anxiety as a partially trait-like disposition and provides a qualitative explanation for the post-intervention correlation remaining non-zero ($r = -.38$, $p = .054$), even though it was no longer statistically significant.

8. Instrument Quality Summary

Table 6. Assessment Instrument Quality Summary

Quality Aspect	Measurement Indicator	Value	Category
Validity	Content Validity — Adapted MARS-R	3.9 / 4.0	**Highly Valid**
	Construct Validity — CFA (CFI)	CFI = .96	**Excellent Fit**
	Concurrent Validity — Corr. with GPA	r = .69**	**High**
Reliability	Cronbach's Alpha — MARS-R	.91	**Very High**
	Inter-rater (Claude AI vs Lecturer)	.87	**Very Good**
	Test-retest (2-week interval)	.84	**Good**
Practicality	Ease of Use — Lecturer	3.8 / 4.0	**Highly Practical**
	Ease of Use — Students	3.6 / 4.0	**Practical**
Average	Combined Practicality Score	3.77 / 4.0	**Highly Practical**

*Note: ** p < .001*

The instrument demonstrated robust psychometric properties. The inter-rater reliability between Claude AI and the course instructor (.87) marginally exceeded values from comparable studies, suggesting that theoretically grounded prompt engineering enhances AI assessment consistency—an important observation for the field. The overall practicality rating of 3.77/4.0 confirms that the system is deployable in regular Abstract Algebra instruction without imposing undue burden on instructors or students.

CONCLUSIONS

This study yields four principal conclusions. First, Abstract Algebra students exhibited high initial mathematics anxiety (MARS-R M = 46.7), with task anxiety and cognitive anxiety as the dominant dimensions. Second, the Claude AI adaptive prompt system comprising six theoretically grounded types was evaluated as highly effective (M = 4.35/5.0), with Progressive Feedback identified as the most impactful component. Third, the eight-week intervention produced a highly significant and practically substantial anxiety reduction ($Z = -4.41$, $p < .001$, $r = .86$), with mean scores declining from high (46.7) to low (30.3)—a 35.1% reduction maintained across all four dimensions. Fourth, the strong pre-intervention anxiety–achievement correlation ($r = -.67$, $p < .001$) became non-significant post-intervention ($r = -.38$, $p = .054$), providing the first AI-facilitated empirical demonstration of anxiety decoupling in advanced mathematics.

Based on these conclusions, the following recommendations are offered. Instructors of Abstract Algebra and analogous advanced mathematics courses should administer a validated anxiety instrument at semester outset as a diagnostic tool for emotionally responsive pedagogical design. Program administrators should systematically provide affective support structures—including adaptive AI interventions—for students in proof-intensive mathematics courses. Future research should employ randomized controlled designs, larger diverse samples, objective physiological anxiety indices, and longitudinal follow-up assessments to establish the causal efficacy and sustainability of AI-based affective interventions in mathematics education.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest regarding the publication of this article. The research was conducted in the authors' own institution (Universitas PGRI Pontianak) purely for academic purposes, and no funding or sponsorship from any commercial entity — including Anthropic (developer of Claude AI) — was received that could influence the study's design, data collection, analysis, interpretation, or reporting of results.

AUTHOR CONTRIBUTIONS

M: Conceptualization, methodology design, development of the adaptive prompt system, data collection, formal analysis, writing – original draft, and correspondence. **B:** Validation, review of psychometric instruments, data curation, writing – review & editing, and supervision.

All authors have read and approved the final version of the manuscript.

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