Proximal: Jurnal Penelitian Matematika dan Pendidikan Matematika
ISSN 26158132 (cetak)
ISSN 26157667 (online)

EXPLORING STUDENTS' MINDSET IN LEARNING REAL ANALYSIS: CHALLENGES, RESPONSES, AND LEARNING EXPERIENCES

Eline Yanty Putri Nasution[1], Darmono[2], Siswantoyo[3]
Pendidikan Jarak Jauh Ilmu Pendidikan, Sekolah Pascasarjana, Universitas Negeri Yogyakarta [1,2,3]
Email: elineyanty.2026@student.uny.ac.id[1], darmono@uny.ac.id[2], siswantoyo@uny.ac.id[3]

Corresponding Author: Eline Yanty Putri Nasution Email: elineyanty.2026@student.uny.ac.id

Abstract. Students' beliefs about mathematical ability may shape how they interpret difficulty and respond to unsuccessful attempts, particularly in proof-oriented courses such as Real Analysis. Previous studies have documented that learning Real Analysis can involve substantial affective and cognitive challenges, including frustration, anxiety, and difficulties in constructing formal mathematical proofs. This study explored mathematics education students' mindsets in learning Real Analysis by examining their responses to a Likert-scale questionnaire and five open-ended questions. The participants were 16 fifth-semester students enrolled in the Real Analysis course in the Mathematics Education Program at IAIN Kerinci, Indonesia. Data were collected during the odd semester of the 2026/2027 academic year using a questionnaire consisting of 23 closed-ended items on a four-point Likert scale and five open-ended questions. The questionnaire used a four-point response scale and covered beliefs about mathematical ability, responses to challenges, effort and persistence, and feedback, learning, and improvement. Open-ended responses were examined thematically to identify students' perceived challenges, beliefs about their abilities, coping strategies, interpretations of feedback, and reported changes in perspective. Descriptive questionnaire patterns suggested an overall growth-oriented tendency. The quantitative findings showed mean scores of 2.78 for beliefs about mathematical ability, 2.55 for responses to challenges, 2.98 for effort, failure, and persistence, and 2.88 for feedback, learning, and improvement. These scores indicate varying degrees of growth-oriented responses across the four dimensions rather than a uniformly strong growth mindset. The qualitative analysis identified five themes: perceived challenges in understanding formal definitions and mathematical proofs; beliefs about mathematical abilities; strategies for coping with learning difficulties; interpretations of feedback and assessment; and perceived changes in learning perspectives. Students reported using strategies such as reviewing concepts, practicing problems, seeking assistance, and adjusting learning approaches, although some also experienced self-doubt, frustration, and difficulty sustaining their efforts. The findings suggest that growth-oriented beliefs can coexist with uncertainty and avoidance in demanding mathematical situations. These findings highlight the importance of instructional practices that provide structured scaffolding for mathematical proof construction, opportunities to revise unsuccessful attempts, and formative feedback that emphasizes students' learning processes.

Keywords: **Growth Mindset, Real Analysis, Students' Beliefs, Proof Learning, Mathematics Education**

A. Introduction

Students' beliefs about whether mathematical ability can develop are relevant to how they interpret academic difficulty, respond to errors, and decide whether to persist (Nasution & Rukiyati, 2026). In mindset theory, an incremental or growth-oriented belief refers to the view that abilities can develop through learning and effort, whereas an entity- or fixed-oriented belief treats ability as relatively stable (Dweck & Yeager, 2021). These beliefs are not simply labels for students' achievement or effort; they concern how individuals interpret their abilities and respond to academic challenges. Students who doubt their mathematical competence may experience uncertainty or anxiety when facing unfamiliar and demanding tasks (Tempelaar et al., 2026). In this context, mathematics anxiety refers to feelings of tension, apprehension, or worry associated with mathematical activities and problem-solving. Mindset beliefs may be relevant to how students interpret such experiences: students who view mathematical ability as

CC BY SA

developable may be more inclined to interpret difficulties as opportunities for learning, whereas those who perceive ability as relatively fixed may be more likely to interpret difficulties as indications of limited competence. However, these tendencies should not be assumed to apply uniformly to all students. Mathematics anxiety is also associated with students' motivation and learning experiences (Vrasetya & Nasution, 2026). Therefore, examining students' mindset-related beliefs alongside their reported learning experiences may provide insight into how they respond to the demands of Real Analysis.

The issue is particularly salient in Real Analysis, a university mathematics course that requires students to engage with formal definitions, mathematical quantifiers, theorems, and rigorous proof construction. Beyond students' difficulties in constructing and understanding mathematical proofs, several latest reasearcher also deserves attention. Melhuish et al. (2025) examined gendered language in textbooks on Abstract Algebra, Real Analysis, and Introduction to Proof, highlighting how linguistic features are represented in proof-oriented mathematical texts. Guo et al. (2026) introduced LeanSide that enables undergraduate students to formulate mathematical arguments in natural language while receiving feedback through a formal proof-verification backend. The transition from computational approaches to formal mathematical reasoning can be challenging because students must move beyond obtaining numerical answers toward constructing logically justified arguments (Bennett & Lai, 2025). These demands make Real Analysis an important context for examining how students interpret mathematical difficulties, evaluate their abilities, and respond to challenges during learning. The transition from computational procedures to abstract reasoning can require students to explain why a statement is true rather than merely obtain a numerical answer. Students may therefore experience difficulty not only because concepts are unfamiliar, but also because the standards of mathematical explanation and proof differ from those emphasized in earlier coursework. Mathematics difficulty occurs from a feeling of discomfort when facing mathematical problems (Vrasetya et al., 2024). When students struggle to construct a proof, their interpretations of that struggle may shape whether they revisit definitions, seek assistance, alter their strategy, or disengage.

Although students' experiences in Real Analysis have been widely examined in relation to mathematical understanding, proof construction, and learning experiences, the relationship between students' mindsets and their engagement with this advanced mathematical course remains an area that deserves further investigation. Bennett and Lai (2025) explored students' experiences in a Real Analysis course and identified three themes: the perceived discontinuity of Real Analysis from other mathematics courses, its role as a gatekeeping or gateway experience for mathematics majors, and the influence of students' responsibilities outside the classroom on their engagement. Similarly, Krupnik et al. (2018) showed that students' epistemological perspectives shaped how they interpreted and engaged with the same Real Analysis lectures. Although these studies provide insights into students' experiences and engagement, further investigation is needed to understand how students' mindset-related beliefs are reflected in their responses to mathematical challenges, persistence, and learning strategies.

More recently, Bennett and Lai (2025) highlighted how the real analysis course could be perceived as either a gatekeeper or a gateway in students' academic journeys. Beyond the context of Real Analysis, Bui et al. (2023), through a systematic review of mindset interventions in mathematics classrooms, emphasized the relevance of mindset in understanding students' mathematical learning experiences and the potential of mindset-oriented approaches in mathematics education. Taken together, these studies suggest that students' beliefs, affective experiences, and responses to academic challenges are important aspects of learning advanced mathematics. However, affective experiences and epistemological beliefs should not be treated as equivalent to mathematical mindsets. Furthermore, the specific ways in which students' mindsets are reflected in their beliefs about mathematical ability, responses to challenges,

persistence in the face of difficulties, and receptiveness to feedback in Real Analysis learning warrant further investigation. Despite these contributions, the literature reviewed for this study has not yet established how mindset-related beliefs concerning mathematical ability, responses to challenges, effort and persistence, and receptiveness to feedback are manifested among Indonesian mathematics education students learning Real Analysis. Addressing this gap, the present study examines students' mindsets across these four dimensions to provide a more comprehensive understanding of how they perceive and respond to the challenges of learning Real Analysis.

Research on mindset has encouraged educators to consider how beliefs about ability relate to responses to challenge and feedback. However, mindset should not be interpreted as a simple guarantee of persistence or achievement. Evidence about mindset interventions and academic outcomes has been mixed, and effects can depend on context and implementation (Sisk et al., 2018; Yeager & Dweck, 2020). This makes context-sensitive investigation important. In proof-based mathematics, students' stated beliefs may coexist with anxiety, comparison with peers, and difficulty sustaining effort when progress is slow. Ahn and Sheu (2026) found that growth-mindset messages could increase blame for intellectual difficulties because individuals were perceived as having greater control over their performance. Their findings suggest that learning difficulties should not automatically be interpreted as a lack of effort or personal commitment.

The present study examines students' mindset in learning Real Analysis through questionnaire responses and open-ended written accounts. Rather than classifying each student as having a fixed or growth mindset, it considers the patterns and tensions expressed across four dimensions: beliefs about mathematical ability; responses to challenges; effort, failure, and persistence; and feedback, learning, and improvement. The open-ended questions provide additional context about students' first encounters with the course, their self-evaluations when they cannot complete proofs, their responses to unsuccessful attempts, their interpretations of grades and feedback, and whether they perceive changes in their views.

The novelty of this study lies in its individual-level integration of students' mindset-related questionnaire responses and their written accounts of learning Real Analysis. Unlike previous studies that have primarily examined students' epistemological perspectives, affective experiences, or broader experiences of participating in Real Analysis courses (Weber, 2023; Krupnik et al., 2018; Bennett & Lai, 2025), this study examines four interconnected dimensions of mindset-related beliefs: beliefs about mathematical ability, responses to challenges, effort, failure and persistence, and feedback, learning and improvement. By linking individual questionnaire scores with corresponding open-ended responses, the study illustrates how growth-oriented beliefs may coexist with self-doubt, avoidance, and adaptive learning strategies within the same learning context.

The study addresses two research questions: (1) What patterns of mindset-related beliefs are reflected in students' questionnaire responses while learning Real Analysis? (2) How do students describe challenges, responses to difficulty, feedback, and perceived changes in their ability to learn Real Analysis? The contribution is a context-specific description of how growth-oriented beliefs and self-doubt can coexist in a proof-oriented university mathematics course. This integrated perspective provides a context-specific account of the complexity of students' mindset-related beliefs and responses when engaging with proof-oriented mathematical content.

B. Research Methods

1. Research design and participants

This study employed a descriptive mixed-methods design, combining descriptive analysis of a four-point Likert questionnaire with thematic analysis of open-ended written responses.

CC BY SA

The qualitative component was used to interpret students' reported experiences and contextualize the quantitative questionnaire patterns.

The participants were 16 fifth-semester students enrolled in the Real Analysis course in the Mathematics Education Program at IAIN Kerinci, Indonesia, during the odd semester of the 2026/2027 academic year. The study involved students who completed a questionnaire consisting of 23 closed-ended items and five open-ended questions. Data were collected online using Google Forms. Each participant was assigned a response code to maintain confidentiality while allowing the researchers to organize the responses systematically. Participation was voluntary, and oral informed consent was obtained before data collection.

The researcher was also the lecturer responsible for teaching the Real Analysis course. This dual role was acknowledged as a potential source of social desirability bias, as students might have felt inclined to provide responses they perceived as favorable to their lecturer. To address this concern, participation was voluntary, oral informed consent was obtained, and responses were recorded using participant codes rather than names. The findings were interpreted as students' self-reported perceptions and experiences, with consideration of the researcher's positionality in the research process.

2. Instruments and data collection

The questionnaire consisted of 23 closed-ended items organized into four dimensions: (1) beliefs about mathematical ability (six items), (2) responses to challenges (six items), (3) effort, failure, and persistence (six items), and (4) feedback, learning, and improvement (five items). Responses were recorded on a four-point Likert scale: strongly agree (4), agree (3), disagree (2), and strongly disagree (1). Items reflecting a fixed-mindset orientation were reverse-scored so that higher scores consistently indicated a more growth-oriented response. Specifically, items 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, and 22 were reverse-scored.

The questionnaire was developed by the researchers based on the conceptual dimensions of mathematical mindset and was reviewed through expert judgment before administration. The expert review was intended to assess the relevance and clarity of the questionnaire items in relation to the research dimensions. The fourth dimension comprised five items, while the first three dimensions comprised six items each. The complete questionnaire grid is provided in Table 1 below:

Table 1 The Questionnaire Grid

Dimension	Growth Oriented	Fixed Oriented	Number of items
Beliefs about Mathematical Ability	1, 3, 5	2, 4, 6	6
Responses to Challenges	7, 9, 11	8, 10, 12	6
Effort, Failure, and Persistence	13, 15, 17	14, 16, 18	6
Feedback, Learning, and Improvement	19, 21, 23	20, 22	5
Total	1-23		23

The questionnaire was developed by the researchers based on the conceptual dimensions of mathematical mindset and was used to describe students' self-reported beliefs and learning experiences. As formal psychometric validation and reliability testing were not conducted, the questionnaire scores are interpreted descriptively and are not used to establish validated psychological classifications of students' mindsets. The questionnaire underwent expert review to assess the content relevance and clarity of its items. However, internal consistency reliability and broader psychometric properties were not statistically established in this study. Therefore, the questionnaire scores were interpreted descriptively as indicators of students' self-reported mindset tendencies rather than as validated measures for individual psychological classification.

CC BY SA

The five open-ended questions asked students to describe: (1) when they first recognized Real Analysis as challenging; (2) what they thought about their abilities when they could not understand a concept or complete a proof; (3) what they did after trying unsuccessfully to solve a problem; (4) how grades, corrections, or feedback influenced their view of their abilities; and (5) whether their view of their ability to learn Real Analysis changed during the course. Responses were written in Indonesian. Quotations selected for the manuscript are retained in the original language or translated into English for reporting. The open-ended responses were collected in Indonesian. Selected quotations were translated into English by the author for reporting purposes. The translated quotations were checked against the original Indonesian responses to preserve the intended meanings and contextual nuances of the participants' statements. The original responses were retained during the analysis to minimize the risk of misinterpretation.

3. Data analysis

Questionnaire responses were summarized descriptively by item and dimension. Reverse-scored items were recoded before interpretation. The mathematical midpoint of the four-point scale was not treated as a validated cutoff for assigning students to mindset categories. The questionnaire results were interpreted as group-level response tendencies, not as evidence that individual students belonged to fixed categories.

Open-ended responses were analyzed using an inductive, semantic thematic approach informed by the six phases described by Braun and Clarke (2022): familiarization, initial coding, theme development, theme review, theme definition, and reporting. The initial coding was conducted by the first author, who repeatedly read the responses and assigned codes to meaningful segments of text. The coding process focused on students' explicitly reported experiences rather than inferring meanings beyond their statements. Initial codes included abstraction and proof, formal symbols and language, transition from calculation to proof, self-doubt, belief in improvement, self-regulated learning, help-seeking, persistence, stopping, emotional responses, feedback, and reported change. Responses could receive more than one code. The codes were subsequently reviewed and grouped into broader thematic categories based on conceptual similarities and their relevance to the research questions. Brief or non-substantive answers were retained in the dataset but were not interpreted beyond their stated content.

The dataset did not provide verified respondent identifiers consistently linked across all questions in a way that could support individual-level trajectories. Consequently, the analysis does not claim that a particular student's initial doubt was followed by a later increase in confidence unless that connection can be established from the original dataset. The coding matrix was used to organize the qualitative responses and identify the number of participants contributing to each theme. However, because respondent identifiers could not be consistently verified across all five open-ended questions, the analysis focused on theme patterns within the responses rather than individual-level trajectories across questions. Accordingly, no claims were made about changes in a particular student's mindset over time based on unlinked responses.

C. Results and Discussion

1. Questionnaire Patterns

The descriptive questionnaire analysis indicated an overall growth-oriented tendency, particularly in the dimension concerning effort, failure, and persistence. Students generally endorsed statements consistent with learning through effort and improvement. Responses concerning reactions to challenges were more mixed: alongside willingness to try or learn, some responses suggested avoidance of difficult tasks or concern about failure. The feedback,

learning, and improvement dimension also showed generally favorable responses to learning and feedback, but responses were less uniform when items concerned how students interpreted unsuccessful strategies.

These patterns should be interpreted cautiously. The sample consisted of 16 students, the instrument's reliability and validity evidence was not available for this analysis, and the midpoint of the response scale was not a validated classification threshold. Accordingly, the results indicate tendencies in this group rather than the prevalence of fixed or growth mindsets in a broader student population.

Table 2 Summary of Students' Mindset Questionnaire Results

Mindset Dimension	Main Findings	Interpretation
Beliefs about Mathematical Ability	Students generally expressed a belief that mathematical understanding can develop, although some responses reflected doubts about their abilities.	A tendency toward a growth mindset, accompanied by some self-doubt.
Responses to Challenges	Students showed mixed responses regarding difficult tasks. Some were willing to engage with challenges, while others tended to avoid difficult tasks or feared failure.	A mixed mindset orientation, particularly when students encounter challenging mathematical problems.
Effort, Failure, and Persistence	Responses generally emphasized effort, learning from mistakes, and continued practice as important aspects of learning mathematics.	A relatively strong growth-oriented tendency in beliefs about effort and improvement.
Feedback, Learning, and Improvement	Students generally showed openness to feedback and learning improvement, although responses varied regarding how unsuccessful strategies were interpreted.	A growth-oriented tendency with some variation in responses to feedback and failure.
Overall Mindset Tendency	Across the four dimensions, students' responses indicated a generally positive orientation toward effort and improvement, alongside uncertainty when facing difficult mathematical tasks.	An overall growth-oriented tendency, but not a uniformly consistent growth mindset.

The questionnaire results indicated an overall growth-oriented tendency among students learning Real Analysis, particularly in the dimensions of effort, failure, and persistence. Students generally recognized the importance of effort, practice, and learning from mistakes. However, responses to challenges were more mixed, suggesting that positive beliefs about the possibility of improvement did not always correspond to a consistent willingness to engage with difficult mathematical tasks. Responses concerning feedback and improvement also showed some variation. Overall, the findings suggest that students tended to endorse growth-oriented beliefs, while self-doubt and avoidance of challenging tasks remained evident in some responses.

a. Theme 1: Real Analysis as a shift toward abstraction and formal proof

Students repeatedly described Real Analysis as different from mathematics courses centered on computation and formula application. They identified formal definitions, theorems, proof construction, symbols, and logical precision as challenging features. One student explained that the course required "tidak hanya menghitung, tetapi juga harus berpikir logis dan teliti dalam setiap langkahnya" [not only calculating, but also thinking logically and carefully at every step]. Another highlighted the difficulty of remembering mathematical symbols, while a further response emphasized that confusing expressions such as "untuk setiap" (for every) and "terdapat" (there exists) could change the meaning of a proof.

Some students reported surprise when they encountered a course in which mathematical work did not always involve numerical operations. Others described initially manageable material becoming more difficult when the course moved to theorems and proofs. These accounts suggest that the challenge was not merely the amount of content but the shift in what counted as a successful mathematical response: students had to justify claims and connect definitions with logical steps.

b. Theme 2: Self-doubt coexisted with beliefs in improvement

Students' accounts revealed varied self-evaluations when they could not understand a concept or complete a proof. Some expressed doubt about their ability, described themselves as less capable, or compared their pace with that of peers. One student wrote that they felt "lambat dan kurang cerdas dibandingkan teman lain" [slower and less intelligent than other classmates]. Another described feeling that their ability was insufficient. These responses indicate that difficulty could be interpreted as information about the self, not only about the task.

At the same time, other students resisted a global conclusion that they were incapable. One participant stated, "Saya berusaha untuk tidak langsung menganggap diri saya tidak mampu" [I try not to immediately assume that I am incapable]. Another described trying again after mistakes and maintaining the belief that continued effort could help. Thus, self-doubt and growth-oriented beliefs were not mutually exclusive in the accounts. Students could experience uncertainty while still recognizing the possibility of learning.

c. Theme 3: Students used varied strategies after unsuccessful attempts

The reported responses to difficulty included rereading definitions and theorems, checking proof steps, reviewing similar examples, seeking explanations from peers or lecturers, discussing problems in groups, and consulting additional learning resources. Some students described returning to a problem independently after receiving help. These strategies reflect attempts to regulate learning and identify gaps in understanding.

However, not all students reported sustained persistence. Some said that they stopped working on a problem when repeated attempts were unsuccessful. Emotional responses such as stress, tiredness, disappointment, frustration, and feeling overwhelmed also appeared in the accounts. One student summarized a direct response as "Berhenti mengerjakannya" [Stop working on it]. This contrast is important: the questionnaire's generally growth-oriented tendency did not mean that all students consistently persisted when faced with difficult proof tasks. Responses varied with the experience described.

d. Theme 4: Grades and feedback were interpreted in different ways

Several students described corrections and feedback as useful for identifying errors, recognizing weaknesses, and deciding what to study next. One student explained that an incorrect answer showed the need to be more careful and understand concepts rather than merely memorize solution procedures. Others reported that feedback motivated them to study harder or change their learning strategies.

Grades also influenced some students' confidence. Good grades could increase enthusiasm and confidence, whereas lower grades could reinforce doubts about ability. In contrast, one participant reported that grades did not affect their view of personal ability, emphasizing that each person has strengths in different areas. Some responses were brief or uncertain, including "Tidak ada" [None] and "Tidak tau" [Do not know]. These divergent accounts suggest that feedback does not have a single meaning for all students; its interpretation may depend on how students understand the relationship between performance, effort, and ability.

CC BY SA

e. Theme 5: Reported changes in confidence were not uniform

Some students reported becoming more confident after practicing proof construction, reviewing concepts, discussing problems, and receiving corrections. They described a shift from believing that Real Analysis was beyond their ability toward seeing improvement as possible through consistent effort. One participant stated that they had become more confident and recognized that ability could develop through practice.

Other students reported no change or continued difficulty with particular problems. Some described leaving problems they could not understand, while a few gave minimal answers such as "tidak" or "tidak berubah." These responses were retained rather than treated as exceptions to be ignored. Because the responses were collected as written accounts and verified respondent-level links across questions were unavailable, the findings support a description of reported change among participants, not a claim that individual mindsets changed over time as a result of the course.

2. Integration of Quantitative and Qualitative Findings

The integration of the questionnaire findings revealed a generally growth-oriented tendency in students' mindsets toward learning Real Analysis, although this tendency was not consistent across all dimensions. The quantitative results showed that *Effort, Failure, and Persistence* had the highest mean score ($\bar{x}$ = 2.98), followed by *Feedback, Learning, and Improvement* ($\bar{x}$ = 2.88), *Beliefs about Mathematical Ability* ($\bar{x}$ = 2.78), and *Responses to Challenges* ($\bar{x}$ = 2.55).

Table 3 Integration of Quantitative and Qualitative Findings on Students' Mindset in Learning Real Analysis

Mindset Dimension	Quantitative Results (Mean = $\bar{x}$)	Qualitative Findings	Integrated Interpretation
Beliefs about Mathematical Ability	2.78	Students expressed both self-doubt and the belief that mathematical ability could improve through effort and practice. Some students felt less capable than their peers, while others tried not to immediately conclude that they lacked ability.	Students generally showed a growth-oriented tendency, although confidence in their mathematical ability was not consistent across experiences.
Responses to Challenges	2.55	Students described Real Analysis as challenging because of abstract concepts, formal symbols, logical reasoning, and proof construction. Some sought alternative explanations, while others avoided or stopped working on difficult problems.	Students showed a mixed response to challenges. Their willingness to seek help coexisted with hesitation and avoidance when difficulties became overwhelming.
Effort, Failure, and Persistence	2.98	Students reported rereading concepts, reviewing examples, practicing, and asking peers or lecturers for assistance. However, some also described frustration, exhaustion, or discontinuing their attempts.	This dimension showed the strongest growth-oriented tendency among the four dimensions. Nevertheless, persistence varied, particularly when students encountered demanding proofs.
Feedback, Learning, and Improvement	2.88	Students generally recognized grades, corrections, and feedback as opportunities to identify weaknesses and adjust learning strategies. However, some responses indicated uncertainty or limited reflection on how feedback influenced subsequent learning.	Students tended to view feedback as useful for improvement, although the extent to which they translated feedback into changes in learning strategies varied.

CC BY SA

The integration of quantitative and qualitative findings was extended to the individual level by linking each participant's questionnaire scores with their corresponding open-ended responses. The mean score for the Responses to Challenges dimension was 2.55 (SD = 0.33), indicating variation in students' responses to challenging mathematical tasks. An examination of the five participants with the lowest individual scores (ranging from 2.00 to 2.33) revealed different patterns of engagement.

Table 4 The Lowest Individual-Level Integration of Quantitative and Qualitative Findings for Responses to Challenges Dimension

Participant	Mean score	Evidence from open-ended responses	Integrated interpretation
P16	2.00	Reported confusion when unable to understand a concept, sought help from a friend, and indicated no perceived change in learning perspective.	Lower scores were accompanied by limited confidence and little reported change, although help-seeking was evident.
P07	2.17	Reported stopping work when unable to solve a problem and leaving some difficult questions unanswered.	The written responses were consistent with difficulty sustaining engagement when facing challenging tasks.
P11	2.17	Expressed self-doubt but described rereading definitions and theorems, reviewing similar proofs, and seeking help from peers or the lecturer.	Despite a relatively low score, the student reported several adaptive strategies for dealing with difficulties.
P13	2.17	Acknowledged difficulties with mathematical symbols and proofs but described reviewing concepts, finding examples, and asking for assistance.	The relatively low score coexisted with active help-seeking and efforts to improve understanding.
P06	2.33	Reported confusion and uncertainty but described reviewing material, examining proof examples, and consulting peers or the lecturer.	The student demonstrated a combination of self-doubt and persistence through alternative learning strategies.

Table 4 shows the five cases representing the participants with the lowest individual mean scores on the Responses to Challenges dimension. English translations of the original Indonesian responses are summarized by the author. These cases are illustrative rather than representative of all participants with similar scores. For example, P07 reported stopping work when unable to solve a problem and leaving some difficult questions unanswered. This account was consistent with the participant's relatively low score, suggesting difficulty sustaining engagement with challenging tasks. Similarly, P16 expressed confusion and reported no perceived change in their approach to learning Real Analysis. However, the other lower-scoring participants demonstrated more adaptive responses. P11, despite expressing self-doubt, described rereading definitions and theorems, examining similar proofs, and seeking assistance from peers or the lecturer. P13 and P06 also reported reviewing concepts, consulting examples, and asking for help when they encountered difficulties.

These individual-level findings indicate that relatively lower questionnaire scores did not necessarily correspond to a complete absence of persistence or adaptive learning strategies. Rather, students' responses reflected varying combinations of self-doubt, difficulty sustaining effort, help-seeking, and attempts to improve understanding. This integration provides a more nuanced interpretation of the quantitative findings and suggests that students' responses to challenges in Real Analysis cannot be adequately characterized by questionnaire scores alone.

The open-ended responses helped explain these patterns. Students described engaging in various learning strategies, including reviewing concepts and worked examples, practicing problems, consulting peers, and seeking explanations from lecturers or online resources. These

accounts were consistent with the relatively higher score for effort and persistence. However, persistence was not universal. Some students reported stopping their attempts or experiencing frustration and emotional exhaustion when they could not understand a concept or complete a proof.

A similar pattern emerged in students' responses to challenges. Difficulties with abstraction, formal mathematical language, symbols, and proof construction appeared to make Real Analysis particularly demanding. While some students responded by seeking help or changing their learning strategies, others expressed self-doubt or avoided difficult tasks. These qualitative findings help contextualize the comparatively lower mean for Responses to Challenges.

Regarding feedback, students generally recognized that grades and corrections could reveal gaps in their understanding and inform subsequent learning. Nevertheless, their responses varied in the extent to which they described using feedback to improve their learning strategies. Taken together, the findings suggest that students' mindsets are better understood as a combination of growth-oriented beliefs, self-doubt, adaptive learning responses, and occasional avoidance rather than as a uniform fixed or growth mindset.

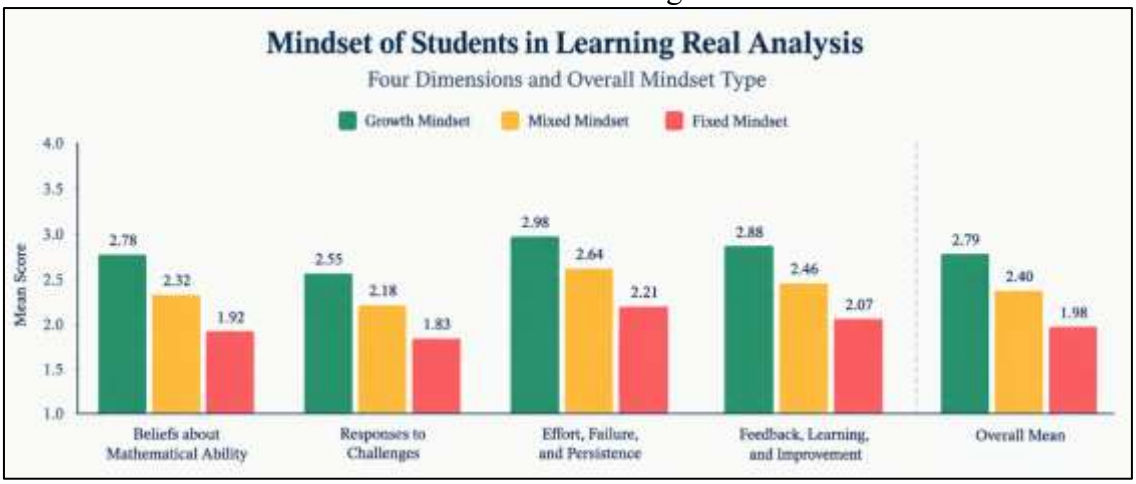


Figure 1: Students' Mindset in Learning Real Analysis.

The bar chart illustrates students' mean mindset scores across four dimensions: beliefs about mathematical ability; responses to challenges; effort, failure, and persistence; and feedback, learning, and improvement. The scores were measured using a four-point Likert scale, with higher scores indicating a stronger growth-oriented tendency after reverse-scoring the fixed-mindset items. The scores were measured on a four-point Likert scale, with higher scores indicating a stronger growth-oriented tendency after reverse-scoring the fixed-mindset items.

The highest mean score was found in Effort, Failure, and Persistence ($\bar{x}$ = 2.98, SD = 0.30), followed by Feedback, Learning, and Improvement ($\bar{x}$ = 2.88, SD = 0.28) and Beliefs about Mathematical Ability ($\bar{x}$ = 2.78, SD = 0.32). These findings suggest that students generally recognize the importance of effort, practice, and learning from feedback in developing their mathematical abilities. The relatively high score for effort and persistence also aligns with students' open-ended responses describing strategies such as reviewing concepts, practicing problems, and seeking assistance from peers or lecturers when they encounter difficulties.

In contrast, Responses to Challenges obtained the lowest mean score ($\bar{x}$ = 2.55, SD = 0.33). Although this score is slightly above the numerical midpoint of 2.50, it indicates that students' responses to challenging mathematical tasks may be less consistent than their beliefs about effort and improvement. The qualitative responses provide further context: some students tried alternative learning strategies or sought help, while others reported self-doubt, frustration, or stopping when they struggled with abstract concepts and formal proofs.

CC BY SA

The response distributions provided further insight into these patterns. Growth-oriented responses (agree and strongly agree after reverse-scoring) accounted for 83.3% of responses in Effort, Failure, and Persistence, 80.0% in Feedback, Learning, and Improvement, 68.8% in Beliefs about Mathematical Ability, and 58.3% in Responses to Challenges. These findings indicate that students expressed relatively more favorable beliefs about effort, persistence, and the use of feedback, whereas their responses to challenging mathematical tasks were more varied. Therefore, the findings suggest different degrees of growth-oriented responses across the four dimensions rather than a uniformly strong growth mindset among the participants.

Overall, the results indicate a general growth-oriented tendency accompanied by variation in how students respond to mathematical challenges. Students appear to value effort and improvement, but these beliefs do not always translate into persistent engagement when learning becomes difficult. This distinction is important in Real Analysis, where understanding formal definitions, constructing logical arguments, and developing mathematical proofs require sustained cognitive effort. Nevertheless, because the findings are descriptive, they should not be interpreted as evidence that students possess a uniformly growth-oriented mindset or that their mindsets have changed over time.

3. Discussion

The central finding is an overall growth-oriented tendency accompanied by inconsistency in responses to challenge. Students generally recognized effort, practice, and feedback as relevant to learning, yet some also expressed self-doubt or stopped working when proofs remained difficult. This pattern supports a nuanced interpretation of mindset: beliefs about the possibility of improvement should not be equated with uninterrupted persistence or the absence of negative emotions.

The nature of Real Analysis provides an important context for interpreting these responses. Formal proof requires students to coordinate definitions, logical implications, quantifiers, and previously learned concepts. A student who cannot initiate a proof may therefore experience a specific conceptual or representational obstacle, but may also interpret the obstacle as evidence of low ability. The responses in this study include both interpretations. Some students treated difficulty as a cue to revisit definitions or seek help, whereas others described global self-doubt or disengagement.

The findings are consistent with mindset theory's distinction between beliefs that abilities can develop and beliefs that abilities are relatively fixed (Dweck & Yeager, 2021). However, they also caution against assigning students a single mindset label from a small set of questionnaire responses. Students' accounts suggest situational variation: a student may believe that effort helps learning and still feel incapable during a demanding proof task. This interpretation is also compatible with the broader literature, which cautions that the relationship between mindset, intervention, and academic outcomes is not simple or uniform (Sisk et al., 2018; Yeager & Dweck, 2020).

Students' reported difficulties in understanding mathematical proofs highlight the importance of instructional support that helps them examine the logical structure and validity of mathematical arguments. Previous research has shown that undergraduate students may experience difficulties in constructing proofs because they lack strategic knowledge for selecting and applying relevant mathematical facts and theorems (Weber, 2015). Students also face challenges in comprehending and validating mathematical arguments, particularly in determining whether the logical steps constitute a valid proof (Mejía-Ramos et al., 2017). Furthermore, structured proof-validation activities have been reported to support students' proof-writing performance (Powers et al., 2010). In this context, opportunities to compare proof strategies, explain the validity of individual steps, receive formative feedback, and revise incomplete proofs may help students develop a deeper understanding of mathematical

CC BY SA

reasoning. These suggestions represent pedagogical implications drawn from the students' accounts and previous research, rather than instructional effects directly tested in the present study.

The reported use of peers, lecturers, examples, and additional resources indicates that help-seeking formed part of students' responses to difficulty. In a course where a single logical gap can prevent progress, accessible explanations and opportunities to discuss proof construction may support students in diagnosing their difficulties. At the same time, the accounts of stopping and emotional strain indicate that encouraging effort alone may be insufficient. Students may also need structured support for breaking proofs into manageable steps, interpreting definitions, and evaluating alternative strategies (Weber, 2015). To this end, educators need to take action to transform students' anxiety into enthusiasm for learning mathematics (Vrasetya et al., 2025), especially in real analysis.

The study's contribution lies in documenting the coexistence of growth-oriented beliefs and difficulty-related self-doubt in a specific university mathematics context. Rather than concluding that students either possess or lack a growth mindset, the results describe how their beliefs, emotions, and learning responses vary across situations. This contextual view is useful for mathematics educators because it directs attention to the interaction between students' interpretations of ability and the demands of formal proof.

4. Limitations

Several limitations should be considered. First, the sample comprised only 16 students from one course context, limiting transferability. Second, the questionnaire's validity and reliability evidence was not available, and the results are therefore descriptive rather than psychometrically established. Third, open-ended written responses vary in length and detail; brief answers provide less evidence for interpretation than extended accounts. Fourth, verified respondent identifiers were not available to support analysis of individual trajectories across the five questions. Finally, the study relies on self-reported perceptions and does not directly observe students' proof-solving behavior or measure changes through repeated assessment. Future studies could combine validated mindset measures, interviews, classroom observations, proof-task analysis, and longitudinal data.

D. Conclusion

This study found an overall growth-oriented tendency in students' mindset-related responses while learning Real Analysis, particularly in relation to effort and the possibility of improvement. Nevertheless, this tendency was not consistent across all responses to challenge. Students described formal definitions, abstraction, mathematical symbols, and proof construction as major difficulties. Their responses included reviewing concepts, practicing, seeking assistance, and changing strategies, but also self-doubt, emotional strain, and stopping work on difficult problems. Feedback could support improvement, while grades sometimes influenced confidence. Some students reported becoming more confident, whereas others reported little change or persistent difficulty.

These findings suggest that students' mindsets in Real Analysis are better understood as context-dependent beliefs and responses than as fixed categories. Instruction may benefit from explicit support for proof construction, constructive feedback, opportunities to revise errors, and accessible help-seeking. Given the small sample and descriptive design, the findings should be interpreted cautiously and not as evidence of causal change or population-level prevalence.

CC BY SA

REFERENCES

Ahn, W. K., & Sheu, C. K. (2026). Calibrating Growth Mindset About Intelligence: Increased Blame, Effort Misperception, And A Genes-And-Growth Solution For Blame. *Journal of Experimental Psychology: General*. https://doi.org/10.1037/xge0001944

Bennett, A. B., & Lai, Y. (2025). Gatekeeper Or Gateway? Lessons Learned From Students In A Real Analysis Course. *PRIMUS*, 35(3), 287–307. https://doi.org/10.1080/10511970.2025.2476674

Braun, V., & Clarke, V. (2022). Conceptual And Design Thinking For Thematic Analysis. *Qualitative psychology*, 9(1), 3. https://psycnet.apa.org/doi/10.1037/qup0000196

Bui, P., Pongsakdi, N., McMullen, J., Lehtinen, E., & Hannula-Sormunen, M. M. (2023). A Systematic Review Of Mindset Interventions In Mathematics Classrooms: What Works And What Does Not? *Educational Research Review*, 40, 100554. https://doi.org/10.1016/j.edurev.2023.100554

Dweck, C. S., & Yeager, D. S. (2021). *A Growth Mindset About Intelligence. In G. M. Walton & A. J. Crum (Eds.), Handbook Of Wise Interventions: How Social Psychology Can Help People Change* (pp. 9–35). The Guilford Press. https://psycnet.apa.org/record/2020-23031-001

Guo, C., Patel, M., Mehta, A., Kothari, K., Lu, T., Voss, N., ... & Ranade, G. (2026). *LeanSide: A Formally Verified Co-Reasoning System for Natural-language Proofs*. arXiv preprint arXiv:2610.00760. https://doi.org/10.48550/arXiv.2610.00760

Krupnik, V., Fukawa-Connelly, T., & Weber, K. (2018). Students' Epistemological Frames And Their Interpretation Of Lectures In Advanced Mathematics. *The Journal of Mathematical Behavior*, 49, 174–183. https://doi.org/10.1016/j.jmathb.2017.12.001

Mejía-Ramos, J. P., Lew, K., de la Torre, J., & Weber, K. (2017). Developing And Validating Proof Comprehension Tests In Undergraduate Mathematics. *Research in Mathematics Education*, 19(2), 130–146. https://doi.org/10.1080/14794802.2017.1325776

Melhuish, K. M., Wrightsman, E. M., Guajardo, L. R., Lew, K. M., & Weber, K. (2025). A gendered-language analysis of abstract algebra, real analysis, and introduction to proof textbooks. In *Proceedings of the 27th Annual Conference on Research in Undergraduate Mathematics Education*.

Powers, R. A., Craviotto, C., & Grassl, R. M. (2010). Impact Of Proof Validation On Proof Writing In Abstract Algebra. I*nternational Journal of Mathematical Education in Science and Technology*, 41(4), 501–514. https://doi.org/10.1080/00207390903564603

Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To What Extent And Under Which Circumstances Are Growth Mind-Sets Important to Academic Achievement? Two Meta-Analyses. *Psychological Science*, 29(4), 549–571. https://doi.org/10.1177/0956797617739704

Tempelaar, D., Giesbers, B., Rienties, B., Bátori, A., & Mihai, A. (2026). Combining Dispositional And Behavioural Facets of SRL, And The Role of Students' Growth Orientation. *Educational Psychology*, 46(3), 350-371. https://doi.org/10.1080/01443410.2025.2592750

Vrasetya, A., & Nasution, E. Y. P. (2026). Analisis Mathematics Anxiety Ditinjau Dari Tipe Kepribadian Sensing Dan Intuiting. *Proximal: Jurnal Penelitian Matematika Dan Pendidikan Matematika*, 9(1), 139-147. https://doi.org/10.30605/proximal.v9i1.7750

Vrasetya, A., Nasution, E. Y. P., & Sari, M. (2025). Transformasi Kecemasan Menjadi Antusiasme: Bimbingan Belajar Matematika Interaktif Berbasis Komunitas Untuk Siswa SD. *ABDI KARSA: Jurnal Pengabdian Masyarakat*, 2(2), 51-61. https://ejournal.unitaspalembang.ac.id/index.php/abdikarsa/article/view/604

Vrasetya, A., Nasution, E. Y. P., & Handican, R. (2024). Response Of Prospective Mathematics Teacher Students To Learning Difficulties In Calculus Course. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, 9(3), 645-660. https://doi.org/10.31943/mathline.v9i3.602

Walton, G. M., & Crum, A. J. (Eds.). (2020). *Handbook Of Wise Interventions*. Guilford Publications.

Weber, K. (2023). Instructions And Constructions In Set Theory Proofs. *Synthese*, 202(2), 34. https://doi.org/10.1007/s11229-023-04239-7

Weber, K. (2015). Effective Proof Reading Strategies For Comprehending Mathematical Proofs. *International Journal of Research in Undergraduate Mathematics Education*, 1(3), 289-314. https://doi.org/10.1007/s40753-015-0011-0

Yeager, D. S., & Dweck, C. S. (2020). What Can Be Learned From Growth Mindset Controversies?. *American psychologist*, 75(9), 1269. https://dx.doi.org/10.1037/amp0000794