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Investigating the Causal Relationship Between Epistemological Beliefs and Mathematics Anxiety with the Mediating Role of Academic Self-Efficacy in Female Upper Secondary School Students in Fereydunkenar

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ABSTRACT

Purpose: The present study aimed to examine the causal relationship between epistemological beliefs and mathematics anxiety with the mediating role of academic self-efficacy among female upper secondary school students.

Methods and Materials: This study employed a descriptive–correlational design using structural equation modeling (SEM). The statistical population consisted of all female upper secondary school students in Fereydunkenar during the 2024–2025 academic year, from whom 354 students were selected through appropriate sampling procedures. Data were collected using Schommer's Epistemological Beliefs Questionnaire (1990), the Academic Self-Efficacy Scale developed by Jinks and Morgan (1999), and the Revised Mathematics Anxiety Rating Scale by Plake and Parker (1982). Prior to analysis, assumptions of normality and absence of multivariate outliers were examined and confirmed. Data were analyzed using SPSS version 27 and AMOS version 24. Direct and indirect effects were estimated within the proposed structural model, and statistical significance was evaluated at the .05 level.

Findings: Structural equation modeling indicated that epistemological beliefs had a significant direct positive effect on mathematics anxiety ($\beta = 0.56$, $p = .001$) and a significant direct negative effect on academic self-efficacy ($\beta = -0.58$, $p = .001$). Academic self-efficacy demonstrated a significant direct negative effect on mathematics anxiety ($\beta = -0.38$, $p = .001$). Moreover, the indirect effect of epistemological beliefs on mathematics anxiety through academic self-efficacy was statistically significant ($\beta = 0.22$, $p = .001$), confirming the mediating role of academic self-efficacy in the structural model.

Conclusion: The findings underscore the critical role of cognitive–motivational factors in explaining mathematics anxiety and suggest that naïve epistemological beliefs increase anxiety both directly and indirectly by diminishing students' academic self-efficacy, highlighting the importance of targeting epistemological beliefs and strengthening self-efficacy in educational interventions.

Keywords: *epistemological beliefs, mathematics anxiety, academic self-efficacy, female students, upper secondary school*

1. Introduction

Mathematics learning during adolescence constitutes a pivotal domain of academic development, as it not only shapes students' cognitive competencies but also influences their broader academic trajectories and career aspirations. Upper secondary school represents a critical developmental stage in which academic demands intensify and students' beliefs about knowledge, ability, and learning processes become increasingly consolidated. In this context, understanding the cognitive–motivational determinants of mathematics-related outcomes is essential. Contemporary educational psychology emphasizes that students' performance in mathematics cannot be adequately explained solely by cognitive ability; rather, it is deeply embedded within a network of epistemological beliefs, motivational orientations, self-evaluative processes, and contextual influences (Steinberg et al., 2024; Stoten, 2023). Therefore, examining how epistemological beliefs and academic self-efficacy interact to shape mathematics-related experiences provides an important avenue for both theoretical advancement and practical intervention.

Epistemological beliefs refer to individuals' beliefs about the nature of knowledge and the process of knowing. These beliefs encompass dimensions such as the simplicity or complexity of knowledge, the certainty or tentativeness of knowledge, the source of knowledge, and beliefs about the speed and controllability of learning. From an epistemic cognition perspective, such beliefs influence how learners interpret instructional information, respond to academic challenges, and regulate their learning behaviors (Stoten, 2023). Research has demonstrated that more sophisticated epistemological beliefs—characterized by viewing knowledge as complex, evolving, and constructed—are associated with deeper learning strategies and higher academic achievement, whereas naïve beliefs may lead to surface-level processing and maladaptive academic responses (Lodewyk, 2007). In secondary school students, epistemological beliefs have been found to be significantly related to academic performance and task engagement, particularly in cognitively demanding subjects such as mathematics (Lodewyk, 2007; Madadpour et al., 2016).

The influence of epistemological beliefs extends beyond cognitive processing and directly intersects with motivational constructs. Chen and Pajares (2010) demonstrated that implicit theories of ability are closely linked to epistemological beliefs and academic motivation, suggesting that students who perceive knowledge as fixed and certain are more likely to adopt maladaptive motivational patterns (Chen & Pajares, 2010). In online and collaborative learning environments, domain-specific epistemic beliefs have also been shown to predict academic achievement, highlighting the pervasive role of epistemological orientations across diverse learning contexts (Liang et al., 2023). These findings underscore the need to consider epistemological beliefs as foundational determinants of students' academic experiences, including emotional and motivational outcomes in mathematics learning.

Within mathematics education, the interplay between epistemological beliefs and mathematics-specific constructs has attracted growing scholarly attention. Madadpour et al. (2016) reported that epistemological beliefs, motivational beliefs, and mathematical self-efficacy jointly predicted academic achievement in high school students, indicating that students' conceptions of knowledge are intertwined with their confidence in performing mathematical tasks (Madadpour et al., 2016). Furthermore, critical thinking interventions have been shown to modify students' epistemological beliefs, suggesting that these beliefs are not static but responsive to educational experiences (Elhamifar et al., 2019). Given that mathematics often involves abstract reasoning and problem-solving under evaluative pressure, students who hold simplistic or rigid beliefs about knowledge may be particularly vulnerable to maladaptive emotional responses such as anxiety.

Mathematics anxiety represents one of the most extensively studied negative emotional responses in academic settings. It refers to feelings of tension, apprehension, and fear that interfere with mathematics performance and engagement. Mathematics anxiety is not merely a transient emotional reaction; rather, it constitutes a stable pattern of affective responses that can impair working memory, reduce cognitive efficiency, and ultimately undermine achievement. Emotional experiences in academic contexts are closely related to students' motivational resources and coping capacities (Sadat & Setayeshiazhar, 2019). When students lack adaptive beliefs about learning and knowledge, their exposure to challenging mathematical tasks may trigger heightened anxiety, especially in evaluative situations.

Adolescence is a developmental period characterized by increased sensitivity to stress and self-evaluative concerns. Empirical evidence suggests that academic stress is closely linked to self-related constructs such as self-esteem and self-efficacy among school-going adolescents (Shalu et al., 2025). In mathematics contexts, students' beliefs about their competence play a central role in determining whether they interpret challenges as opportunities for growth or as threats to their self-worth. Therefore, investigating the cognitive antecedents of mathematics anxiety, particularly epistemological beliefs, is essential for clarifying the mechanisms through which emotional difficulties in mathematics emerge.

Academic self-efficacy, defined as students' beliefs in their capability to successfully perform academic tasks, constitutes a core motivational variable in educational psychology. A substantial body of research has documented a positive association between self-efficacy and academic performance across domains (Farid & Ashrafzade, 2020). In mathematics specifically, mathematical self-efficacy has been shown to predict both mathematics achievement and self-regulated learning strategies (Baseri, 2024; Charousaei, 2021). Interventions designed to enhance classroom-based self-efficacy strategies have yielded improvements in mathematical performance and academic outcomes among female students (Khayyat Qiyasi, 2020). These findings highlight the central role of efficacy beliefs in shaping students' engagement, persistence, and resilience in mathematics.

Recent studies have also emphasized the mediating function of academic self-efficacy in linking contextual and personal variables to mathematics achievement. For instance, Geng et al. (2024) found that academic self-efficacy mediated the relationship between teaching style and mathematics behavioral engagement among junior high school students (Geng et al., 2024). Similarly, research on academic buoyancy indicates that self-efficacy contributes to students' capacity to cope with everyday academic setbacks and is associated with mathematics achievement (Weißenfels et al., 2022, 2023). These findings suggest that academic self-efficacy may function as a psychological buffer, reducing the detrimental impact of adverse beliefs or stressors on mathematics outcomes.

From a broader motivational perspective, academic self-concept and goal orientations have been shown to interact with achievement across different learning environments (Steinberg et al., 2024). In this regard, academic self-efficacy can be conceptualized as a domain-specific component of students' academic self-system that directly influences their emotional responses to challenging tasks. Students who possess high academic self-efficacy are more likely to interpret mathematical difficulties as manageable, thereby reducing the likelihood of anxiety and avoidance behaviors. Conversely, low self-efficacy may amplify the negative impact of maladaptive epistemological beliefs, leading to increased mathematics anxiety.

The literature also indicates that psychological well-being and mental health are related to academic success (Tamnaifar et al., 2011). Students' beliefs about learning and their perceived competence may influence not only performance but also emotional stability in academic contexts. Educational interventions that target cognitive and motivational constructs, such as math skills training, have demonstrated broader cognitive benefits, including improvements in crystallized intelligence among secondary school students (Seadatee Shamir, 2024). These findings reinforce the importance of addressing underlying belief systems and efficacy perceptions in educational planning.

Although previous research has independently examined epistemological beliefs, academic self-efficacy, and mathematics-related outcomes, fewer studies have integrated these constructs within a unified causal framework. Existing evidence suggests that epistemological beliefs are associated with academic achievement and motivational processes (Lodewyk, 2007; Madadpour et al., 2016), while self-efficacy mediates the effects of instructional and personal factors on engagement and achievement (Geng et al., 2024; Weißenfels et al., 2022). However, the specific pathways through which epistemological beliefs influence mathematics anxiety, and the potential mediating role of academic self-efficacy in this relationship, remain underexplored—particularly among female upper secondary school students.

This gap is particularly salient given gender-specific patterns in mathematics-related beliefs and emotions. Female students often report higher levels of mathematics anxiety and lower mathematics self-efficacy compared to their male counterparts, even when achievement levels are comparable. Investigating these relationships within a female student population provides an opportunity to identify modifiable cognitive–motivational factors that may contribute to emotional difficulties in mathematics learning.

Furthermore, the integration of structural equation modeling allows for a comprehensive examination of both

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direct and indirect effects among epistemological beliefs, academic self-efficacy, and mathematics anxiety. Such an approach aligns with contemporary calls for multidimensional analyses of academic functioning that move beyond isolated bivariate associations (Steinberg et al., 2024; Stoten, 2023). By simultaneously modeling epistemological and motivational constructs, researchers can better elucidate the mechanisms underlying students' mathematics-related experiences.

In summary, theoretical and empirical evidence indicates that epistemological beliefs shape students' interpretations of knowledge and learning processes (Chen & Pajares, 2010; Liang et al., 2023), that academic self-efficacy plays a central role in promoting academic achievement and engagement (Baseri, 2024; Farid & Ashrafzade, 2020; Geng et al., 2024), and that emotional factors such as anxiety are closely intertwined with cognitive–motivational resources (Sadat & Setayeshiazhar, 2019; Shalu et al., 2025). Despite these advances, the integrated examination of these constructs within the mathematics domain—particularly focusing on the mediating role of academic self-efficacy in the relationship between epistemological beliefs and mathematics anxiety—remains limited in the context of female upper secondary students.

Therefore, the present study aimed to examine the causal relationship between epistemological beliefs and mathematics anxiety with the mediating role of academic self-efficacy among female upper secondary school students.

2. Methods and Materials

2.1. Study Design and Participants

The present study is classified as basic research in terms of its objective and was conducted using a cross-sectional design with respect to data collection. This investigation employed a descriptive–correlational methodology, and data analysis was performed based on structural equation modeling (SEM). Specifically, regression equations were estimated using an integrated approach combining path analysis and second-order factor analysis. The statistical population consisted of all female upper secondary school students in Fereydunkenar during the 2024–2025 academic year. According to statistics provided by the Information and Statistics Center of the Fereydunkenar Department of Education, the total number of students was 2,319. To determine the sample size, considering the number of observed variables and allocating a coefficient of 25 participants per variable, as well as accounting for the potential presence of incomplete questionnaires, a sample of 360 students was estimated and selected.

2.2. Measures

Academic Self-Efficacy Scale (Jinks & Morgan, 1999): This instrument consists of 30 items and three subscales: Talent, Effort, and Context. The items are rated on a four-point Likert scale ranging from 1 to 4. Ten items are allocated to the Talent subscale, ten to the Effort subscale, and ten to the Context subscale. The scoring procedure is as follows: for Items 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 21, 24, 25, 26, 28, 29, and 30, a response of "strongly agree" receives a score of 4, "somewhat disagree" receives a score of 2, and "strongly disagree" receives a score of 1. Items 4, 5, 15, 16, 19, 20, 22, and 23 are reverse scored, such that "strongly disagree" receives a score of 4, "somewhat disagree" receives a score of 3, and "somewhat agree" receives a score of 1. The developers of the instrument reported a reliability coefficient of .82 for the total scale, and reliability coefficients of .78, .66, and .70 for the Talent, Effort, and Context subscales, respectively (Jinks & Morgan, 1999). In the present study, the reliability coefficient of the scale was .71.

Revised Mathematics Anxiety Rating Scale: Mathematics anxiety was assessed using the Revised Mathematics Anxiety Rating Scale developed by Plake and Parker (1982) to evaluate anxiety associated with participation in mathematics and statistics classes. This instrument is a revised version of the 98-item Mathematics Anxiety Rating Scale originally developed by Richardson and Suinn (1972). The revised version places greater emphasis on situation-specific (state) anxiety, general (trait) anxiety, and test anxiety. The Revised Mathematics Anxiety Rating Scale is a self-report instrument consisting of 24 items and two subscales: Mathematics Learning Anxiety (16 items), which pertains to anxiety experienced during the process of learning mathematics and working with numbers, and Mathematics Evaluation Anxiety (8 items), which assesses anxiety in mathematics-related evaluative situations. Respondents indicate their level of agreement with each statement on a five-point Likert scale ranging from 1 (very low anxiety) to 5 (high anxiety). This instrument is appropriate for high school students and university students. Plake and Parker (1999) standardized the revised scale on a sample of 170 college students enrolled in three mathematics and statistics courses. The total test reliability, estimated via

Cronbach's alpha, was .98, indicating excellent internal consistency. To assess test–retest reliability, the instrument was re-administered after 4 to 6 weeks to 91 male and 90 female participants from the initial sample. The test–retest reliability coefficient was reported as .88. In a study by Momeni et al. (2013), the reliability of the scale, estimated using Cronbach's alpha, was .78.

Epistemological Beliefs Questionnaire (Schommer, 1990): Schommer (1990) developed a 63-item questionnaire to assess five proposed dimensions of epistemological beliefs. Of these five dimensions, three pertain to the nature of knowledge (Structure, Certainty, and Source of Knowledge), and two relate to the acquisition of knowledge (Control and Speed of Learning). Schommer constructed a set of items for each dimension, which were grouped into 12 subscales. Some epistemological dimensions are represented by a single subscale, whereas others are represented by two or three subscales. For example, the dimension "Simplicity of Knowledge" is operationalized through the subscales "Seeking a Single Answer" and "Avoidance of Integrating Information." In Schommer's (1990) study, factor analysis of the subscales yielded five factors: Simplicity of Knowledge, Certainty of Knowledge, Fixed Ability to Learn, Quick Learning, and Omniscient Authority. All items are rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The components of the questionnaire are as follows: Simplicity of Knowledge (Items 2, 3, 11, 14, 16, 17, 18, 19, 22, 23, 33, 35, 37, 38, 54, 63); Certainty of Knowledge (Items 1, 5, 6, 7, 13, 31, 36, 40, 45, 46); Fixed Ability to Learn (Items 4, 8, 15, 25, 26, 28, 32, 43, 47, 49, 55, 57, 62); Quick Learning (Items 10, 20, 24, 25, 29, 39, 50, 51, 53, 60); and Omniscient Authority (Items 9, 12, 21, 27, 30, 34, 41, 42, 44, 48, 61). In a study conducted by Rezaei (2009), construct validity was examined using factor analysis to obtain an appropriate factor structure. Prior to factor analysis, internal consistency was calculated for all 63 items. Eleven items were removed due to negative correlations with the total test score, and 16 items were eliminated due to item–total correlations below .10, resulting in the exclusion of 27 items from subsequent analyses. Principal component analysis was conducted on the remaining 36 items. Examination of the scree plot suggested a two-factor solution. To achieve this structure, principal component analysis with Promax rotation was performed. Twenty additional items were removed due to factor loadings below .35 or significant cross-loadings on more than one factor. The final analysis demonstrated that the remaining 16 items loaded on two factors, labeled "Simple/Certain Knowledge" and "Quick/Fixed Learning." The reliability of the questionnaire, estimated using Cronbach's alpha, ranged from .54 to .71. In a study by Kadivar et al. (2012), the reliability coefficients of the subscales, estimated using Cronbach's alpha, ranged from .65 to .75. Predictive validity of the instrument was demonstrated by Schommer (1993), who reported that three of the four beliefs within the Control dimension predicted general intelligence ability and various aspects of learning, such as reading comprehension. Test–retest reliability was reported as .74 (Kadivar et al., 2012).

2.3. *Data Analysis*

The collected data were analyzed using both descriptive and inferential statistical methods. In the descriptive statistics section, indices such as mean, standard deviation, and frequency distribution tables were calculated to describe demographic characteristics and research variables. To test the research hypotheses and examine the causal relationships among variables, structural equation modeling was employed. Data analysis was conducted using SPSS version 27 and AMOS version 24. In all statistical tests, a significance level of .05 was considered the criterion for statistical decision-making.

3. Findings and Results

The participants in the present study consisted of 354 female upper secondary school students. The distribution of the sample according to grade level and field of study is presented below.

Table 1

Demographic Distribution of the Sample

Indicator	Group	Frequency	Percentage
Grade Level	10th Grade	56	15.8
	11th Grade	124	35.0
	12th Grade	174	49.2
Field of Study	Humanities	171	48.3

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Experimental Sciences	76	21.5
Mathematics and Physics	107	30.2

The table above indicates that 15.8% of the students were enrolled in the 10th grade, 35% in the 11th grade, and 49.2% in the 12th grade. Additionally, 48.3% of the students were studying in the Humanities track, 21.5% in Experimental Sciences, and 30.2% in Mathematics and Physics.

Prior to conducting the statistical analyses, data screening procedures were performed. No missing data were detected. Subsequently, univariate outliers were examined using boxplots, and the results indicated no univariate outliers. Multivariate outliers were assessed by calculating Mahalanobis distances. The obtained distances were then adjusted based on the degrees of freedom (i.e., the number of predictor variables in the model) using the chi-square (χ^2) criterion (Mirza et al., 2017). The results indicated the absence of multivariate outliers. Accordingly, the analyses proceeded with data from 354 participants. The descriptive statistics of the research variables are presented below.

Table 2

Descriptive Statistics of the Research Variables

Construct	Variable	Minimum	Maximum	Mean	SD	Skewness	Kurtosis
Epistemological Beliefs	Simplicity of Knowledge	32	64	51.21	7.23	-0.15	-0.74
	Certainty of Knowledge	11	29	21.50	4.62	-0.18	-0.69
	Fixed Ability to Learn	18	36	29.31	4.46	-0.45	-0.39
	Quick Learning	15	34	24.62	4.76	-0.18	-0.68
	Omniscient Authority	16	32	25.18	3.69	-0.34	-0.86
Cognitive Flexibility	Perception of Alternatives	12	60	29.67	14.23	0.65	-0.55
	Perception of Controllability	10	35	19.48	6.33	0.91	-0.12
	Perception of Behavioral Justification	3	15	7.54	2.71	0.59	-0.10
	Total Score	28	107	56.69	19.67	0.59	-0.57
Mathematics Anxiety	Learning Anxiety	17	30	24.63	3.13	-0.67	-0.28
	Evaluation Anxiety	8	38	26.33	6.75	-0.48	-0.25
	Total Score	30	67	50.96	8.49	-0.49	-0.21

The table above indicates that among the epistemological belief dimensions, Simplicity of Knowledge had the highest mean, whereas Certainty of Knowledge had the lowest mean (51.21 vs. 21.50). In academic self-efficacy, the Context dimension had the highest mean (23.53), while the Effort dimension had the lowest mean (22.00). Finally, among the dimensions of mathematics anxiety, Evaluation Anxiety had a higher mean than Learning Anxiety (26.33 vs. 24.63).

Structural equation modeling requires the examination of several fundamental assumptions. These include univariate and multivariate normality of variable distributions, absence of multicollinearity, and independence of errors (Mirza et al., 2017). As shown in Table 4-2, considering acceptable skewness within ±2 (Schumacher & Lomax, 2012) and kurtosis within ±7 (West et al., 1995), the skewness and kurtosis values for all variables were within acceptable ranges, indicating that the assumption of univariate normality was met.

To examine multivariate normality, standardized residual values were calculated, and the distribution of residuals was assessed using the one-sample Kolmogorov–Smirnov test. The results indicated that the distribution of residuals was normal ($p > .05$, $df = 354$, $Z = 0.04$).

Table 3

Direct and Indirect Effects of Epistemological Beliefs and Academic Self-Efficacy on Mathematics Anxiety

Path	b	β	p	95% CI Lower	95% CI Upper
Epistemological Beliefs → Mathematics Anxiety	0.46	0.56	.001	0.40	0.74
Academic Self-Efficacy → Mathematics Anxiety	-0.19	-0.38	.001	-0.54	-0.20
Epistemological Beliefs → Academic Self-Efficacy	-0.91	-0.58	.001	-0.68	-0.46
Epistemological Beliefs → Academic Self-Efficacy → Mathematics Anxiety (Indirect)	0.18	0.22	.001	0.12	0.34

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As presented in Table 3, epistemological beliefs had a significant direct positive effect on mathematics anxiety (b = 0.46, β = 0.56, p = .001, 95% CI [0.40, 0.74]). Academic self-efficacy demonstrated a significant direct negative effect on mathematics anxiety (b = -0.19, β = -0.38, p = .001, 95% CI [-0.54, -0.20]). Additionally, epistemological beliefs had a significant direct negative effect on academic self-efficacy (b = -0.91, β = -0.58, p = .001, 95% CI [-0.68, -0.46]). The indirect effect analysis further indicated that epistemological beliefs exerted a significant positive indirect effect on mathematics anxiety through academic self-efficacy (b = 0.18, β = 0.22, p = .001, 95% CI [0.12, 0.34]), confirming the mediating role of academic self-efficacy in the proposed structural model.

4. Discussion and Conclusion

The present study examined the causal relationships among epistemological beliefs, academic self-efficacy, and mathematics anxiety in female upper secondary school students using structural equation modeling. The findings revealed that epistemological beliefs had a significant direct positive effect on mathematics anxiety. Specifically, more naïve epistemological beliefs—such as viewing knowledge as simple, certain, and quickly acquired—were associated with higher levels of mathematics anxiety. In addition, epistemological beliefs demonstrated a significant direct negative effect on academic self-efficacy. Academic self-efficacy, in turn, showed a significant direct negative effect on mathematics anxiety. Finally, the indirect path from epistemological beliefs to mathematics anxiety through academic self-efficacy was significant, indicating that academic self-efficacy played a mediating role in this relationship.

The direct positive association between epistemological beliefs and mathematics anxiety suggests that students who hold simplistic and rigid beliefs about knowledge and learning are more vulnerable to experiencing anxiety in mathematics contexts. This finding aligns with prior research indicating that epistemological beliefs influence students' interpretations of academic tasks and challenges (Lodewyk, 2007). Students who believe that knowledge is fixed and that learning should occur quickly may interpret temporary difficulties in mathematics as evidence of incompetence, thereby intensifying anxiety. Chen and Pajares (2010) reported that implicit theories of ability and epistemological beliefs are closely related to academic motivation and achievement, supporting the notion that maladaptive beliefs can undermine students' emotional and motivational functioning (Chen & Pajares, 2010). Similarly, Madadpour et al. (2016) found that epistemological beliefs were significantly related to mathematical self-efficacy and academic achievement, highlighting the central role of epistemic orientations in mathematics learning (Madadpour et al., 2016). The present findings extend this line of research by demonstrating that epistemological beliefs not only influence achievement but are also directly linked to mathematics-related emotional experiences.

The negative direct effect of epistemological beliefs on academic self-efficacy further underscores the importance of students' conceptions of knowledge. Students who perceive knowledge as complex, evolving, and requiring effortful construction are more likely to attribute success to controllable factors and persist in the face of difficulty. Conversely, students with naïve beliefs may perceive ability as fixed and learning as an all-or-nothing process, which can erode their confidence in their academic capabilities. This interpretation is consistent with research demonstrating that epistemological beliefs are associated with motivational beliefs and self-regulatory processes (Madadpour et al., 2016). Liang et al. (2023) also showed that domain-specific epistemic beliefs predict academic achievement in collaborative learning contexts, suggesting that adaptive epistemological beliefs foster more effective engagement and confidence in learning environments (Liang et al., 2023). Moreover, interventions aimed at enhancing critical thinking have been shown to modify epistemological beliefs among high school students (Elhamifar et al., 2019), implying that such beliefs are malleable and may be targeted to strengthen academic self-efficacy.

The finding that academic self-efficacy had a significant negative effect on mathematics anxiety is consistent with a robust body of literature identifying self-efficacy as a protective factor against negative academic emotions. Farid and Ashrafzade (2020), in a meta-analysis, reported a strong positive relationship between self-efficacy and academic performance, underscoring the motivational power of efficacy beliefs (Farid & Ashrafzade, 2020). In mathematics contexts, higher levels of mathematical self-efficacy have been associated with better mathematical performance and more positive attitudes toward mathematics (Baseri, 2024; Charousaei, 2021). Students who believe in their competence are more likely to approach challenging mathematical tasks with confidence, reducing the likelihood of anxiety and avoidance. Weißenfels et al. (2022, 2023) demonstrated that academic self-efficacy plays a key role in

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linking academic buoyancy to mathematics achievement, suggesting that efficacy beliefs enable students to cope effectively with everyday academic setbacks (Weißenfels et al., 2022, 2023). The present results align with these findings by showing that academic self-efficacy directly mitigates mathematics anxiety.

The mediating role of academic self-efficacy in the relationship between epistemological beliefs and mathematics anxiety represents a central contribution of this study. The indirect effect indicates that naïve epistemological beliefs increase mathematics anxiety partly by reducing students' academic self-efficacy. This finding is theoretically coherent within social-cognitive frameworks, which posit that beliefs about knowledge and learning shape efficacy perceptions, which in turn influence emotional and behavioral outcomes. Geng et al. (2024) reported that academic self-efficacy mediated the relationship between teaching style and mathematics engagement (Geng et al., 2024). Similarly, research on academic self-concept and achievement across different learning environments has emphasized the centrality of self-related beliefs in academic functioning (Steinberg et al., 2024). By demonstrating a mediational pathway, the present study integrates epistemological and motivational constructs within a unified explanatory model.

The results may also be interpreted in light of research on academic emotions and engagement. Sadat and Setayeshiazhar (2019) found that psychological resources such as academic buoyancy play mediating roles between academic emotions and engagement (Sadat & Setayeshiazhar, 2019). Academic self-efficacy may function in a similar manner, serving as a psychological resource that buffers the negative impact of maladaptive epistemological beliefs on mathematics anxiety. Moreover, given that adolescence is a period marked by heightened academic stress and self-evaluative concerns, the role of self-efficacy in regulating emotional responses becomes particularly salient. Shalu et al. (2025) reported significant associations between academic stress and self-related constructs among adolescents, reinforcing the importance of efficacy beliefs in emotional well-being (Shalu et al., 2025). The present findings suggest that strengthening academic self-efficacy may attenuate the anxiety-provoking effects of rigid epistemological beliefs.

Furthermore, educational interventions targeting mathematics skills and cognitive development have demonstrated broader benefits, such as improvements in crystallized intelligence (Seadatee Shamir, 2024). Such interventions may also indirectly influence students' epistemological beliefs and self-efficacy, thereby reducing mathematics anxiety. From an epistemic cognition perspective, fostering more sophisticated beliefs about knowledge—such as recognizing that mathematical understanding develops gradually through effort—may encourage adaptive attributions and resilience in the face of difficulty (Stoten, 2023). The present study supports this perspective by empirically demonstrating the interconnectedness of epistemological beliefs, self-efficacy, and anxiety within the mathematics domain.

Overall, the findings highlight the importance of cognitive–motivational factors in explaining mathematics anxiety among female upper secondary school students. By integrating epistemological and efficacy beliefs within a structural model, this study provides a more comprehensive understanding of the mechanisms underlying mathematics-related emotional experiences. The results corroborate previous research linking epistemological beliefs to academic outcomes (Lodewyk, 2007; Madadpour et al., 2016), self-efficacy to achievement and engagement (Farid & Ashrafzade, 2020; Geng et al., 2024), and self-efficacy to mathematics performance and buoyancy (Weißenfels et al., 2022, 2023), while extending these findings to the domain of mathematics anxiety.

Despite its contributions, the present study has several limitations. First, the cross-sectional design precludes definitive causal inferences, even though structural equation modeling was employed. Longitudinal data would provide stronger evidence regarding the temporal ordering of epistemological beliefs, academic self-efficacy, and mathematics anxiety. Second, the use of self-report questionnaires may introduce response biases such as social desirability or shared method variance. Third, the sample was limited to female upper secondary school students in a single geographical region, which may restrict the generalizability of the findings to other populations, including male students or students from different educational contexts.

Future research should adopt longitudinal or experimental designs to examine how changes in epistemological beliefs influence academic self-efficacy and mathematics anxiety over time. Investigating these relationships across different genders, cultural contexts, and educational systems would enhance the external validity of the findings. Researchers may also explore additional mediators or moderators, such as goal orientations, classroom climate, parental beliefs, or teacher feedback, to

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develop a more comprehensive model of mathematics anxiety. Incorporating qualitative methods could further illuminate how students interpret their beliefs about knowledge and competence in mathematics learning.

From a practical standpoint, educational programs should incorporate strategies aimed at fostering more sophisticated epistemological beliefs, such as emphasizing the constructive and evolving nature of mathematical knowledge. Teachers can design instructional practices that normalize struggle as part of the learning process, thereby counteracting rigid beliefs about quick and effortless learning. Additionally, interventions focused on enhancing academic self-efficacy—through mastery experiences, constructive feedback, and modeling—may help reduce mathematics anxiety. School counselors and educators should also provide supportive environments that address students' emotional experiences in mathematics, promoting resilience, confidence, and adaptive coping strategies.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent.

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