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The Role of Test Anxiety and Working Memory in Predicting Students' Mathematics Performance

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A B S T R A C T

Purpose: This study aimed to investigate the role of test anxiety and working memory in predicting mathematics performance among female high school students.
Methods and Materials: This applied study employed a descriptive-correlational research design. The statistical population consisted of female students enrolled in the second cycle of secondary education in Kermanshah, Iran. A total of 300 students were selected through a multistage cluster sampling method. Data were collected using the Test Anxiety Inventory developed by Spielberger (1980), the Wechsler Working Memory assessment, and a researcher-developed Mathematics Performance Test comprising 15 items derived from the mathematics curriculum of the tenth and eleventh grades. Data were analyzed using descriptive statistics, Pearson correlation coefficients, and simultaneous multiple regression analysis in SPSS version 27.
Findings: The results revealed a significant negative relationship between test anxiety and working memory ($r = -0.551$, $p < .001$). Test anxiety was also negatively and significantly associated with mathematics performance ($r = -0.535$, $p < .001$), whereas working memory demonstrated a significant positive relationship with mathematics performance ($r = 0.489$, $p < .001$). Simultaneous multiple regression analysis indicated that test anxiety and working memory jointly predicted mathematics performance significantly. The multiple correlation coefficient was $R = 0.780$, and the coefficient of determination was $R^2 = 0.609$, indicating that the two predictors explained 60.9% of the variance in mathematics performance. The regression model was statistically significant ($p < .001$). Standardized regression coefficients showed that test anxiety ($\beta = -0.544$, $p < .001$) negatively predicted mathematics performance, while working memory ($\beta = 0.365$, $p < .001$) positively predicted mathematics performance. Furthermore, test anxiety contributed more strongly to the prediction of mathematics performance than working memory.
Conclusion: The findings suggest that mathematics performance is influenced not only by cognitive abilities such as working memory but also by emotional factors, particularly test anxiety. Reducing test anxiety and strengthening working memory may therefore serve as important targets for educational and counseling interventions aimed at enhancing students' academic achievement in mathematics.
Keywords: *Test Anxiety, Working Memory, Mathematics Performance, Academic Achievement, High School Students, Cognitive Factors, Educational Psychology.*

1. Introduction

Mathematics is widely recognized as one of the most fundamental academic disciplines and serves as a cornerstone for educational achievement, scientific advancement, technological innovation, and economic development. Competence in mathematics is not only essential for success in school but also plays a critical role in developing problem-solving abilities, logical reasoning, decision-making skills, and critical thinking. Contemporary educational systems increasingly emphasize mathematical literacy because it equips students with the cognitive tools necessary to navigate complex personal, social, and professional challenges. Recent evidence suggests that mathematical competencies are strongly associated with higher-order cognitive processes and critical thinking skills, highlighting the importance of identifying the factors that contribute to successful mathematics learning and performance (Alvarez-Tinajero et al., 2026). Despite the recognized importance of mathematics achievement, many students continue to experience considerable difficulties in learning mathematical concepts and performing effectively in mathematics-related tasks. Researchers have therefore sought to identify the cognitive, emotional, and motivational variables that influence mathematics performance and explain individual differences among learners (Fiedler et al., 2025; Ikeda et al., 2026).

Research in educational psychology has consistently demonstrated that mathematics achievement is influenced by a complex interaction of cognitive and affective factors. While traditional perspectives emphasized intelligence and cognitive abilities as the primary determinants of academic success, more recent approaches suggest that emotional and psychological variables play equally important roles in shaping learning outcomes. Cognitive factors such as working memory, executive functioning, information processing capacity, and reasoning skills are essential for solving mathematical problems and maintaining task-related information during learning activities. At the same time, affective variables including anxiety, motivation, self-efficacy, and emotional regulation can facilitate or hinder students' engagement with mathematical tasks. Contemporary theoretical models therefore emphasize that mathematics performance should be understood as the product of interactions among cognitive capacities and emotional experiences rather than the result of cognitive abilities alone (He et al., 2025; Ikeda et al., 2026). This multidimensional perspective has become increasingly important for understanding why some students succeed in mathematics whereas others experience persistent difficulties despite possessing adequate intellectual abilities.

Among the emotional factors associated with academic achievement, test anxiety has received considerable attention from researchers. Test anxiety refers to a set of cognitive, emotional, physiological, and behavioral responses that emerge in evaluative situations and interfere with an individual's ability to perform effectively. Students experiencing high levels of test anxiety often report excessive worry, intrusive thoughts, fear of failure, physiological arousal, and difficulties concentrating during examinations. These reactions may impair information processing, reduce attention to task-relevant cues, and ultimately diminish academic performance. Numerous studies have documented the detrimental effects of test anxiety on students' educational outcomes across different age groups and academic domains (Dortuo, 2020). In mathematics education, anxiety appears to be particularly influential because mathematical tasks frequently involve complex reasoning, sequential problem solving, and high levels of cognitive demand. Consequently, students who experience elevated anxiety may struggle to utilize their cognitive resources efficiently when solving mathematical problems (Yarkwah et al., 2024).

A closely related construct that has received extensive empirical attention is mathematics anxiety. Mathematics anxiety is generally defined as feelings of tension, apprehension, fear, or nervousness that interfere with mathematical activities and performance. Research conducted across diverse educational settings has consistently shown that mathematics anxiety is negatively associated with mathematics achievement. A comprehensive meta-analysis confirmed a robust negative relationship between mathematics anxiety and mathematics performance, indicating that students with higher anxiety levels tend to achieve lower mathematics scores than their less anxious peers (Barroso et al., 2021). Similarly, international investigations have demonstrated that the association between anxiety and mathematics performance is a global phenomenon observed across different cultures and educational systems (Foley et al., 2017). Further research has shown that anxiety negatively affects students' mathematical literacy, self-regulated learning, and academic engagement, thereby creating barriers to effective mathematics learning (Gabriel et al., 2020). These findings underscore the importance of understanding the mechanisms through which anxiety influences mathematics achievement.

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One of the most prominent explanations for the negative relationship between anxiety and academic performance involves the role of working memory. Working memory is a limited-capacity cognitive system responsible for temporarily storing and manipulating information necessary for complex cognitive activities such as reasoning, problem solving, comprehension, and learning. Mathematical tasks frequently require students to maintain numerical information, execute multiple mental operations, monitor intermediate solutions, and integrate new information with previously learned knowledge. Consequently, working memory is considered one of the most important cognitive predictors of mathematics achievement. Studies have repeatedly demonstrated that individuals with stronger working memory capacities tend to exhibit superior performance in mathematics and other cognitively demanding domains (Fiedler et al., 2025; Passolunghi et al., 2016). Moreover, working memory has been identified as a significant determinant of successful performance in a variety of educational and athletic contexts, reflecting its broad role in supporting complex cognitive functioning (Sadeghi, 2020).

Theoretical models suggest that anxiety may impair performance by consuming working memory resources that would otherwise be allocated to task completion. According to processing efficiency theory and attentional control theory, anxious individuals devote substantial cognitive resources to worry-related thoughts, leaving fewer resources available for task-relevant processing. As a result, performance on cognitively demanding tasks may deteriorate, particularly when substantial working memory capacity is required. Empirical evidence supports this perspective. Research has demonstrated that anxiety can hinder cognitive performance by reducing the efficiency of working memory processes, particularly under conditions of high cognitive load (Owens et al., 2014). In mathematics contexts, students experiencing elevated anxiety often exhibit reduced working memory effectiveness, which in turn negatively affects their mathematical performance. These findings suggest that working memory may serve as a critical mechanism linking anxiety and academic achievement.

Several studies have directly examined the interplay among anxiety, working memory, and mathematics performance. Research involving secondary school students found that mathematics anxiety, working memory, and mathematics achievement are closely interconnected, with working memory contributing significantly to students' mathematical success (Passolunghi et al., 2016). Similarly, studies of younger learners have demonstrated that the relationship between anxiety and mathematics achievement is particularly pronounced among students with high working memory capacity because anxiety consumes cognitive resources that would otherwise support performance (Ramirez et al., 2013). Investigations of children with mathematical learning difficulties have likewise revealed significant associations between mathematics anxiety and impairments in working memory processes (Mammarella et al., 2015). Collectively, these findings indicate that anxiety and working memory should not be considered independent predictors of mathematics achievement but rather interacting variables that jointly influence academic outcomes.

Recent research has further highlighted the moderating and mediating functions of working memory in the relationship between anxiety and mathematics performance. For example, evidence suggests that visuospatial working memory moderates the association between mathematics anxiety and mathematics achievement, such that students with stronger working memory resources may be better able to cope with the adverse effects of anxiety (Cuder et al., 2023). Likewise, studies have shown that working memory mediates the relationship between mathematics anxiety and achievement, indicating that anxiety influences performance partly through its impact on working memory functioning (Szczygieł, 2021). More recent investigations have reported that working memory significantly moderates the relationship between mathematics anxiety and mathematics achievement among middle school students, reinforcing the importance of considering cognitive resources when examining the effects of emotional variables on learning outcomes (Ma & Sun, 2025). Research exploring numerical cognition has similarly demonstrated that mathematical anxiety and working memory jointly influence children's mathematical processing and learning capacities (He et al., 2025).

Although the existing literature provides substantial evidence regarding the importance of anxiety and working memory in mathematics achievement, several gaps remain. First, much of the available research has focused specifically on mathematics anxiety rather than the broader construct of test anxiety, despite the fact that evaluative anxiety frequently occurs in school settings and may significantly influence academic performance. Second, most studies have been conducted in Western educational contexts, and comparatively less evidence is available from Middle

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Eastern populations. Cultural differences in educational expectations, assessment practices, and attitudes toward academic achievement may influence the relationships among anxiety, working memory, and mathematics performance. Third, although previous studies have examined the separate effects of anxiety and working memory, fewer investigations have evaluated their simultaneous predictive contributions within a single explanatory model. Given the growing recognition that academic achievement results from the interaction of cognitive and emotional processes, additional research is needed to clarify the relative importance of these variables in explaining mathematics performance among adolescents (Ikeda et al., 2026; Leder, 2019).

Considering the theoretical significance of working memory as a cognitive resource, the documented negative effects of anxiety on academic functioning, and the need for further evidence in adolescent educational settings, investigating the combined role of test anxiety and working memory may contribute to a more comprehensive understanding of students' mathematics achievement. Such knowledge may help educators, school psychologists, and counselors design interventions aimed at reducing anxiety and strengthening cognitive skills, thereby enhancing students' academic outcomes and educational success. Therefore, the present study aimed to investigate the role of test anxiety and working memory in predicting mathematics performance among secondary school students.

2. Methods and Materials

2.1. Study Design and Participants

The present study falls within the positivist research paradigm and was conducted using a quantitative approach and a descriptive-correlational design. The primary objective of this study was to explain and examine the role of two variables, test anxiety and working memory, in students' mathematics performance. Since the study sought to identify the relationships among the research variables and determine the predictive power of the independent variables in explaining the dependent variable, namely mathematics performance, without any intervention or experimental manipulation, a descriptive-correlational design was considered the most appropriate methodological approach. The statistical population consisted of all upper secondary school students in Kermanshah during the 2025–2026 academic year. From this population, 300 students were selected as the study sample using a multistage cluster sampling method. Initially, schools were considered the primary clusters, and a number of schools were randomly selected. Subsequently, eligible students from the selected schools were recruited for participation. This sampling method was deemed appropriate and efficient given the large population size, the distribution of students across different schools, and the ease of access to participants. Inclusion criteria consisted of enrollment in upper secondary education, regular school attendance, willingness to participate in the study, and provision of informed consent by both students and their parents. Exclusion criteria included incomplete questionnaires, invalid or unrealistic responses, withdrawal from participation at any stage of the study, and absence during data collection sessions. To collect data, appropriate instruments were employed to assess the main study variables. Test anxiety was measured using a standardized Test Anxiety Questionnaire, working memory was assessed using a valid working memory measure, and mathematics performance was evaluated using mathematics course grades or a mathematics achievement test.

2.2. Measures

In the present study, working memory was assessed using the Digit Span subtest derived from the Wechsler Intelligence Scale. This test is among the most commonly used instruments for evaluating working memory and was developed within the framework of the revised Wechsler intelligence scales. It has been widely employed in psychological research and assessment. Owing to their strong psychometric properties, including satisfactory validity and reliability, the Wechsler scales have consistently been regarded as reliable measures of cognitive abilities (Groth-Marnat, 2009). In this study, the fifth edition of the Wechsler scale was used to assess working memory. The Digit Span subtest consists of two components: Digit Span Forward and Digit Span Backward, each administered separately. In the forward condition, participants are required to repeat a sequence of numbers in the same order presented, whereas in the backward condition they must repeat the numbers in reverse order. This subtest follows the standardized Wechsler administration procedures and, due to the similarity of administration across child and adult versions, can be applied to different age groups.

In this study, test anxiety was measured using the Spielberger Test Anxiety Inventory. The original version consisted of 32 items; however, following revision, 12 items

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were removed because of content overlap and limited diagnostic value, resulting in the final 20-item version used in this study. The questionnaire items are organized into two principal dimensions: nine items assess the worry or cognitive component, and eleven items assess the emotional or physiological component. Responses are scored on a four-point Likert scale ranging from 1 (Very Low) to 4 (Very High). Accordingly, in addition to an overall test anxiety score, separate scores are calculated for the cognitive and physiological dimensions (Spielberger, 1980). Psychometric evidence supports the reliability of this instrument. In a study by Abolghasemi (2003), reliability coefficients were reported as .92 using internal consistency, .92 using the split-half method, and .90 using the test–retest method.

The Mathematics Performance Test was developed based on the content of the Grade 10 and Grade 11 mathematics textbooks and consisted of 15 items. The content validity of the test was confirmed by experts in mathematics education. Furthermore, a Cronbach's alpha coefficient of .76 indicated acceptable reliability of the instrument.

2.3. Data Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 23. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were calculated to summarize participants' demographic and study variables. Inferential statistical analyses were conducted using regression analysis to examine the predictive contributions of health locus of control and self-efficacy to blood glucose control. Regression models were employed to determine the extent to which psychological factors could explain variations in glycemic outcomes among patients with type 2 diabetes. Statistical significance was evaluated using conventional probability levels, and the results were interpreted to identify the relative predictive strength of the independent variables in explaining blood glucose control among male and female patients.

3. Findings and Results

A total of 300 female upper secondary school students participated in this study. Participants ranged in age from 15 to 18 years, with a mean age of 17.41 years (SD = 0.89). Table 1 presents the means and standard deviations of the study variables.

Table 1

Means, Standard Deviations, Skewness, and Kurtosis of the Study Variables

Variable	Mean	SD	Skewness	Kurtosis
Test Anxiety	47.82	8.64	0.41	-0.36
Working Memory	10.53	2.71	-0.28	-0.44
Mathematics Performance	11.76	2.95	-0.19	-0.51

The descriptive statistics indicated that the mean score for test anxiety was 47.82 (SD = 8.64), the mean working memory score was 10.53 (SD = 2.71), and the mean mathematics performance score was 11.76 (SD = 2.95). Examination of skewness and kurtosis values for all three variables showed that score distributions were within acceptable limits of normality. Specifically, skewness and kurtosis values were 0.41 and −0.36 for test anxiety, −0.28 and −0.44 for working memory, and −0.19 and −0.51 for mathematics performance, respectively. These findings indicate that the distributions of the research variables were sufficiently normal to satisfy the assumptions required for subsequent inferential analyses.

Table 2

Correlation Matrix of the Study Variables

Variable	1	2	3
1. Test Anxiety	1		
2. Working Memory	-0.551*	1	
3. Mathematics Performance	-0.535**	0.489**	1

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The results presented in Table 2 indicate significant relationships among the study variables. Specifically, a significant negative correlation was observed between test anxiety and working memory (r = −.55), suggesting that higher levels of test anxiety are associated with lower working memory performance. Likewise, test anxiety was negatively and significantly correlated with mathematics performance (r = −.53), indicating that higher levels of anxiety are associated with poorer mathematics achievement. In contrast, a significant positive correlation was found between working memory and mathematics performance (r = .49), indicating that students with greater working memory capacity tend to demonstrate better mathematics performance.

Table 3

Summary of the Regression Model Predicting Mathematics Performance Based on Test Anxiety and Working Memory

Multiple Correlation (R)	R^2	Adjusted R^2	Standard Error of Estimate
0.780	0.609	0.606	15.38

The results shown in Table 3 indicate that the multiple regression model developed to predict mathematics performance from test anxiety and working memory demonstrated an acceptable fit. The multiple correlation coefficient (R = .780) indicates a relatively strong relationship between the set of predictor variables and mathematics performance. Furthermore, the coefficient of determination (R^2 = .609) indicates that 60.9% of the variance in students' mathematics performance is explained jointly by test anxiety and working memory. The close correspondence between the adjusted R^2 (.606) and R^2 values further suggests that the model possesses satisfactory stability and predictive power. Moreover, the standard error of estimate (15.38) indicates an acceptable level of prediction error. Overall, these findings demonstrate that test anxiety and working memory contribute substantially to the prediction of mathematics performance.

Table 4

ANOVA Summary for the Significance of the Regression Model Predicting Mathematics Performance

Source	Sum of Squares	df	Mean Square	F	p
Regression	109,267.756	2	54,633.878	230.847	.001
Residual	70,290.041	297	236.667		
Total	179,557.797	299			

The results reported in Table 4 indicate that the multiple regression model predicting mathematics performance based on test anxiety and working memory was statistically significant. Specifically, the obtained F value was 230.847, which was significant at p < .001. Therefore, it can be concluded that the predictor variables included in the model significantly explain students' mathematics performance. In other words, the proposed regression model possesses substantially greater explanatory power than a model without predictor variables. Furthermore, the regression sum of squares relative to the residual sum of squares indicates that a considerable proportion of the variance in mathematics performance is explained by test anxiety and working memory.

Table 5

Regression Coefficients for Predicting Mathematics Performance from Test Anxiety and Working Memory

Variables	B	SE	β	t	p
Constant	49.958	10.253	—	4.872	.001
Test Anxiety	-1.252	0.093	-0.544	-13.391	.001
Working Memory	0.544	0.060	0.365	8.987	.001

The results presented in Table 5 indicate that both test anxiety and working memory made significant contributions to the prediction of mathematics performance. According to the regression coefficients, the intercept was 49.958 and was

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statistically significant at $p < .001$. Test anxiety demonstrated an unstandardized coefficient of $B = -1.252$ and a standardized coefficient of $\beta = -.544$, with a t value of -13.391, which was statistically significant at $p < .001$. This finding indicates that test anxiety is a significant predictor of mathematics performance. Similarly, working memory demonstrated an unstandardized coefficient of $B = 0.544$ and a standardized coefficient of $\beta = .365$, with a t value of 8.987, which was also statistically significant at $p < .001$. Therefore, working memory significantly predicts mathematics performance. Based on the standardized coefficients, test anxiety had a stronger predictive contribution than working memory because its beta coefficient was larger in magnitude. Overall, these findings indicate that variations in students' mathematics performance are significantly influenced by their levels of test anxiety and working memory capacity.

4. Discussion and Conclusion

The present study aimed to investigate the role of test anxiety and working memory in predicting mathematics performance among secondary school students. The findings revealed a significant negative relationship between test anxiety and working memory, a significant negative relationship between test anxiety and mathematics performance, and a significant positive relationship between working memory and mathematics performance. Furthermore, the results of the multiple regression analysis demonstrated that test anxiety and working memory jointly accounted for a substantial proportion of the variance in mathematics performance, with test anxiety emerging as the stronger predictor. These findings highlight the importance of considering both emotional and cognitive factors when explaining students' achievement in mathematics and provide further evidence that mathematics performance is influenced by a dynamic interaction between affective experiences and cognitive capacities.

One of the primary findings of the study was the significant negative association between test anxiety and mathematics performance. This finding suggests that students who experience higher levels of anxiety in evaluative situations tend to demonstrate poorer performance in mathematics. This result is consistent with a substantial body of literature indicating that anxiety interferes with academic functioning and reduces performance in cognitively demanding tasks. Previous studies have shown that test anxiety negatively affects students' academic achievement by impairing concentration, reducing confidence, increasing cognitive interference, and disrupting effective problem-solving processes (Dortuo, 2020; Yarkwah et al., 2024). The present findings also align with evidence demonstrating that mathematics-related anxiety is associated with lower mathematics achievement across educational levels and cultural contexts (Barroso et al., 2021; Foley et al., 2017). The consistency of these findings suggests that anxiety represents a pervasive obstacle to successful mathematics learning.

The negative impact of test anxiety on mathematics performance can be understood through several theoretical perspectives. Cognitive interference theory proposes that anxiety generates intrusive thoughts related to failure, negative evaluation, and self-doubt, which occupy attentional resources that would otherwise be allocated to task completion. As a result, students become less capable of processing information efficiently and solving mathematical problems accurately. Similarly, attentional control theory suggests that anxiety disrupts the balance between goal-directed and stimulus-driven attentional systems, making it more difficult for students to maintain focus on mathematical tasks. Mathematics often requires sustained attention, sequential reasoning, and the manipulation of numerical information; therefore, disruptions in attentional control can have particularly harmful consequences for performance. These mechanisms may explain why students with elevated anxiety scores in the present study exhibited lower levels of mathematics achievement.

The findings are also consistent with research demonstrating that anxiety affects not only direct academic performance but also broader learning processes. For example, previous investigations have shown that mathematics anxiety negatively influences self-regulated learning, persistence, and mathematical literacy, thereby creating cumulative disadvantages in educational achievement (Gabriel et al., 2020). Students who frequently experience anxiety may avoid mathematics-related activities, engage less actively in classroom learning, and develop negative beliefs about their own mathematical competence. Over time, these experiences can contribute to lower achievement levels and reinforce cycles of academic underperformance. Consequently, the negative relationship observed in the present study likely reflects both immediate cognitive disruptions during testing and longer-term influences on learning and engagement.

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Another important finding was the significant negative relationship between test anxiety and working memory. Students with higher levels of anxiety demonstrated lower levels of working memory functioning. This finding is highly consistent with theoretical and empirical research emphasizing the close connection between anxiety and working memory processes. According to processing efficiency theory, anxious thoughts consume a portion of an individual's limited cognitive resources, leaving fewer resources available for task-relevant processing. As worry and physiological arousal increase, the effective capacity of working memory decreases, reducing an individual's ability to store, manipulate, and retrieve information efficiently. Previous research has repeatedly demonstrated that anxiety interferes with working memory performance, particularly in situations requiring complex cognitive processing (Owens et al., 2014).

The present finding is also consistent with studies conducted in mathematics education contexts. Research has shown that students experiencing mathematics anxiety often exhibit deficits in working memory performance because anxiety-related cognitions occupy resources that would otherwise support mathematical reasoning (Ramirez et al., 2013). Likewise, investigations involving students with mathematical difficulties have reported significant associations between anxiety and impairments in working memory functioning (Mammarella et al., 2015). More recent evidence has confirmed that mathematical anxiety and working memory jointly influence numerical processing and cognitive performance among children and adolescents (He et al., 2025). Therefore, the observed negative relationship between test anxiety and working memory in the present study supports the proposition that anxiety undermines cognitive efficiency by reducing the resources available for information processing.

The study also found a significant positive relationship between working memory and mathematics performance. Students with higher working memory capacity demonstrated superior mathematics achievement. This finding is consistent with extensive research identifying working memory as one of the strongest cognitive predictors of mathematical success. Mathematical tasks often require students to maintain information temporarily, perform mental calculations, monitor intermediate steps, inhibit irrelevant information, and integrate multiple sources of information simultaneously. Such processes place substantial demands on working memory resources. Consequently, students with stronger working memory capacities are generally better equipped to manage the cognitive requirements of mathematics learning and problem solving (Passolunghi et al., 2016).

The positive association between working memory and mathematics performance found in the present study supports previous empirical findings. Longitudinal research has shown that cognitive abilities, including working memory, play a critical role in the development of mathematics achievement over time (Fiedler et al., 2025). Similarly, studies examining the relationship between cognitive and emotional factors in academic performance have emphasized the importance of cognitive resources in explaining individual differences in mathematics achievement (Ikeda et al., 2026). Research conducted across various educational settings has consistently demonstrated that students with greater working memory capacity tend to perform better on mathematical tasks requiring reasoning, problem solving, and numerical manipulation (Passolunghi et al., 2016; Sadeghi, 2020). Therefore, the current findings further reinforce the central role of working memory in successful mathematics learning.

The regression analyses provided additional insight into the relative contributions of test anxiety and working memory. Together, these variables explained approximately 61% of the variance in mathematics performance, indicating substantial predictive power. This finding supports contemporary theoretical models proposing that mathematics achievement results from the interaction of cognitive and affective factors rather than from either domain alone (Ikeda et al., 2026). The large proportion of explained variance suggests that students' mathematics performance can be understood more accurately when both emotional experiences and cognitive capacities are considered simultaneously. This finding also supports recent systematic reviews emphasizing that successful mathematical performance depends upon multiple interrelated competencies rather than a single determinant (Alvarez-Tinajero et al., 2026).

An especially noteworthy finding was that test anxiety demonstrated a stronger predictive effect than working memory. Although working memory contributed positively and significantly to mathematics performance, the magnitude of the standardized regression coefficient indicated that test anxiety exerted a greater influence. This finding highlights the powerful role of emotional factors in academic achievement and suggests that even students with adequate cognitive abilities may experience diminished performance if they are unable to manage anxiety

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effectively. Similar conclusions have been reported in previous research demonstrating that anxiety can substantially impair academic functioning by reducing the efficiency with which cognitive resources are utilized (Barroso et al., 2021; Gabriel et al., 2020). In practical terms, this finding indicates that interventions aimed solely at strengthening cognitive skills may be insufficient if emotional barriers remain unaddressed.

The findings also provide indirect support for research suggesting that working memory may function as a mediator or moderator in the relationship between anxiety and mathematics performance. Previous studies have shown that the relationship between mathematics anxiety and achievement is partially explained through working memory processes (Szczygieł, 2021). Other investigations have demonstrated that working memory moderates the effects of anxiety, allowing some students to maintain relatively high levels of performance despite experiencing anxiety (Cuder et al., 2023; Ma & Sun, 2025). Although mediation and moderation were not directly examined in the present study, the observed pattern of relationships is consistent with these theoretical perspectives. Specifically, the negative association between anxiety and working memory, combined with the positive association between working memory and mathematics performance, suggests that working memory may represent an important mechanism through which anxiety influences academic outcomes.

Another important implication of the findings concerns the educational experiences of adolescents. Secondary school students often encounter increasing academic demands, high-stakes examinations, and growing social expectations regarding educational success. These pressures may elevate anxiety levels and simultaneously increase reliance on working memory resources during learning and assessment activities. Gender-related factors may also be relevant because previous research has highlighted the importance of considering gender differences in mathematics education and mathematics-related emotional experiences (Leder, 2019). Although the present study focused on female students, the findings suggest that addressing anxiety and strengthening cognitive skills may be particularly important during adolescence, when academic demands become increasingly complex.

Overall, the results of this study support contemporary perspectives emphasizing that mathematics achievement is shaped by both emotional and cognitive determinants. Test anxiety appears to undermine performance directly and indirectly through its negative influence on working memory, whereas working memory serves as an important cognitive resource that facilitates successful mathematical reasoning and problem solving. The substantial predictive power of these variables underscores their importance in understanding individual differences in mathematics achievement and highlights the need for educational strategies that simultaneously address emotional well-being and cognitive development.

Several limitations should be considered when interpreting the findings of this study. First, the correlational design prevents causal conclusions regarding the relationships among test anxiety, working memory, and mathematics performance. Second, the study was conducted exclusively among female secondary school students from a single city, which may limit the generalizability of the findings to other populations, age groups, or educational settings. Third, self-report measures were used to assess test anxiety, making the results susceptible to response biases such as social desirability and inaccurate self-perceptions. Fourth, additional variables that may influence mathematics performance, including motivation, self-efficacy, socioeconomic status, teaching quality, and family support, were not examined. Finally, the cross-sectional nature of the data limits understanding of how these relationships may evolve over time.

Future studies should employ longitudinal and experimental designs to clarify the causal relationships among test anxiety, working memory, and mathematics performance. Researchers may also investigate potential mediating and moderating mechanisms, particularly the role of working memory in explaining how anxiety affects academic achievement. Replication studies involving male students, different age groups, and diverse cultural contexts would enhance the generalizability of findings. Future investigations could additionally examine the influence of related psychological variables such as academic self-efficacy, resilience, achievement motivation, emotional regulation, and executive functioning. The effectiveness of interventions designed to reduce anxiety or strengthen working memory should also be evaluated using controlled experimental methodologies.

Educational practitioners should consider implementing school-based programs aimed at reducing test anxiety through stress-management training, relaxation techniques, cognitive restructuring, and counseling services. Teachers may benefit from professional development programs that help them identify anxiety-related difficulties and create supportive classroom environments. Instructional strategies

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that strengthen working memory, such as structured problem-solving exercises, cognitive training activities, and scaffolded learning experiences, should be incorporated into mathematics instruction. School counselors and psychologists should collaborate with educators to identify students at risk for high anxiety and provide targeted interventions. Finally, educational policies should recognize the importance of both cognitive and emotional factors in academic achievement and promote comprehensive support systems that foster students' psychological well-being alongside their academic development.

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 interview and participated in the research with informed consent.

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