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Unpacking the Differential Effects of Growth Mindset on Mathematics Academic Achievement Between Competitive and Regular Students

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Article

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Abstract

Against the backdrop of the growing popularity of mathematics competitions and intensifying academic competition, exploring the impact of students' psychological constructs on academic achievement in different learning contexts has become an important topic in current research. Based on Social Cognitive Theory, this study examines the complex relationships among teacher support, growth mindset, mathematics anxiety, self-efficacy, learning attitude, and mathematics academic achievement, and compares the heterogeneity of these paths between competitive students (n = 320) and regular students (n = 478). The results of Multi-Group Structural Equation Modeling (MGSEM) show that teacher support can significantly and positively predict growth mindset in both groups of students; growth mindset can indirectly promote academic achievement through the paths of reducing mathematics anxiety, enhancing self-efficacy, and shaping learning attitude. In terms of group differences, growth mindset among regular students cannot directly predict mathematics scores, and its effect entirely relies on the mediation of psychological mechanisms; while growth mindset among competitive students not only exerts an indirect effect but also significantly and directly predicts mathematics academic achievement. Furthermore, the promoting effect of growth mindset on learning attitude is more pronounced among regular students, whereas the positive predictive effect of self-efficacy on mathematics scores is stronger among competitive students. These findings reveal the context-dependent nature of growth mindset and enrich its application in competitive environments.

Introduction

As a foundational discipline underpinning the cultivation of innovative talents in the 21st century and the construction of national core competitiveness, improving students' mathematics academic achievement has become a common core goal of educational reform and development across countries worldwide. To achieve this goal, while improving the conventional mathematics teaching system, national education systems are also actively exploring differentiated cultivation paths for top mathematics talents. Among them, Mathematical Olympiad competitions have transcended the mere category of academic competition and become an important avenue for measuring higher-order mathematical thinking abilities and selecting top intellectual talents. In recent years, extracurricular Mathematical Olympiad training programs have expanded rapidly on a global scale, forming a large-scale and well-structured out-of-school education ecosystem, which is particularly prominent in East Asian educational contexts such as China (Lv et al., 2024; Xu et al., 2024). Characterized by high-intensity, professional and systematic training, these programs aim to break through the knowledge boundaries of conventional teaching and cultivate students' creative problem-solving abilities and abstract logical thinking abilities. Students participating in such programs are commonly referred to as "competitive students", who must pass multiple rounds of rigorous selection to gain admission and constitute a unique subgroup of mathematics learners at the secondary school level (He et al., 2022).

The academic community generally agrees that competitive students possess superior mathematical and scientific intellectual potential and higher-order academic abilities, and participation in Mathematical Olympiad training has been repeatedly confirmed to be significantly and positively correlated with higher mathematics academic achievement and deeper learning engagement (Marushina, 2021). However, behind this facade of high achievement lies a long-overlooked psychological cost: a growing body of evidence shows that a highly competitive academic environment may simultaneously amplify students' psychological vulnerability and significantly exacerbate the risks of mathematics anxiety, fear of failure and academic burnout (Jiang, 2025; Lee et al., 2012). This paradoxical effect of "high achievement coexisting with high risk" precisely exposes the cognitive limitations of existing research on Mathematical Olympiad training. We neither understand how competition training simultaneously generates academic advantages and psychological dilemmas, nor comprehend the underlying cognitive and psychological reshaping mechanisms behind it. Characterized by intensive performance evaluation, excessive social expectations and continuous peer ability comparison, competition training may fundamentally reshape students' cognitive frameworks regarding the value of effort, the meaning of challenges and the attribution of failure, thereby altering the functional paths and forms of core psychological constructs.

Growth mindset, based on the construct of individual intellectual plasticity, has been widely recognized as an important predictor of academic achievement, especially in mathematics (Blackwell et al., 2007), and holds significant value for the competitive student group (Jiang, 2025). Students with a stronger growth mindset tend to view challenges as opportunities for self-improvement, demonstrate greater perseverance, experience lower levels of mathematics anxiety, and report higher academic self-efficacy (Yeager & Dweck, 2020). Nevertheless, the relationship between growth mindset and academic achievement has not been consistently supported across all studies (Li & Bates, 2019; Sisk et al., 2018). Recent research has found that the effects of growth

mindset are often context-dependent and may vary significantly across different cultural backgrounds, educational environments and student groups (Lou & Noels, 2019). Meanwhile, multiple studies have revealed that growth mindset does not directly predict academic achievement, but exerts indirect effects through psychological mechanisms such as self-efficacy, anxiety regulation and learning attitude. Furthermore, growth mindset does not develop in isolation; students' beliefs and learning behaviors are the result of the dynamic interaction between environmental influences and individual cognition. Among numerous environmental factors, teacher support is regarded as one of the most influential contextual resources for shaping students' motivational beliefs.

Despite the growing body of research literature on growth mindset, most previous studies have treated students as a relatively homogeneous group, which may mask important intergroup differences in the mechanisms through which growth mindset exerts its effects (Yeager & Dweck, 2020). In particular, competitive students and regular students exhibit significant differences in learning experiences, social expectations and psychological characteristics (Marushina, 2021). On the one hand, competitive students are more likely to internalize the identity of "genius" or "gifted", which may increase their sensitivity to failure and reinforce ability-based self-evaluation. On the other hand, they often receive stronger external support and higher academic expectations from teachers, parents and peers (Jiang, 2025). These differences suggest that the paths linking teacher support, growth mindset, psychological functioning and mathematics achievement may operate differently across student groups. Therefore, this study aims to examine the differences in the paths connecting teacher support, growth mindset, mathematics anxiety, self-efficacy, learning attitude and mathematics achievement between competitive and regular students, and further reveal whether Mathematical Olympiad training has reshaped the psychological paths between growth mindset and mathematics achievement. It primarily addresses the following research questions:

RQ1: What is the association between teacher support and the development of students' growth mindset?

RQ2: Through which psychological paths is growth mindset associated with mathematics achievement?

RQ3: Do these paths differ between competitive students and regular students?

Literature Review

Growth mindset and mathematics academic achievement

Growth mindset is essentially an ability belief that intelligence and abilities are not fixed, but can be continuously developed through effort and learning. Over the past few decades, numerous studies have documented its close association with academic achievement. Students with a growth mindset are more inclined to adopt adaptive learning strategies, demonstrate stronger achievement motivation, persist longer in the face of difficulties, and engage more deeply in academic tasks (Dong et al., 2023). In a longitudinal study, Blackwell et al. (2007) found that students' growth mindset positively predicted their subsequent mathematics academic achievement even after controlling for prior grades. Compared with students with a fixed mindset, those with a growth mindset tend to view challenges as opportunities for self-improvement, thus exhibiting greater academic resilience and perseverance. In particular, the role of growth mindset may be especially critical in mathematics learning, a domain universally associated with challenges, performance pressure, and fear of failure. Previous studies have shown that students with a stronger growth mindset report lower levels of mathematics anxiety, less academic burnout in mathematics, higher learning engagement, and greater self-efficacy (Samuel & Warner, 2019). These findings suggest that growth mindset may help students generate adaptive emotional and motivational responses in demanding learning contexts.

However, despite its theoretical appeal, the relationship between growth mindset and academic achievement has not been consistently supported across all empirical studies. A growing body of evidence indicates that the effect sizes of growth mindset are typically small and highly context-dependent (Li & Bates, 2019; Yeager & Dweck, 2020). Existing research has not reached a consensus on the predictive effect of growth mindset on mathematics academic achievement: some studies have confirmed a significant positive association between the two, while others have found no significant direct effect. For example, Dong et al. (2023) reported that growth mindset does not directly predict mathematics academic achievement among Chinese students, but exerts indirect effects through self-efficacy, intrinsic motivation, attributional styles, and mathematics anxiety. Similarly, Ba et al. (2025) found that the relationship between growth mindset and academic achievement is mediated by self-beliefs and effort regulation, rather than direct cognitive effects. Furthermore, there is significant heterogeneity across different cultural backgrounds and student groups. Sun et al. (2021) found that growth mindset is positively correlated with mathematics academic achievement

among American students, but the association is weaker or even slightly negative among Chinese students. Similarly, Claro et al. (2016) reported that the protective effect of growth mindset is stronger for students from socioeconomically disadvantaged backgrounds than for those from more affluent families. These findings collectively indicate that growth mindset is not a universally adaptive psychological resource, and its effectiveness may vary depending on educational environments, sociocultural expectations, and students' learning experiences. Therefore, identifying the contextual conditions under which growth mindset promotes academic achievement has become an increasingly important topic in contemporary educational research.

The mediating mechanism between growth mindset and mathematics academic achievement

The impact of growth mindset on academic achievement exhibits significant heterogeneity, and a compelling explanation is that growth mindset does not directly predict academic achievement through a single path; its effectiveness is highly dependent on specific mediating transmission mechanisms. Research has shown that growth mindset primarily influences academic achievement indirectly through emotion regulation, motivational beliefs, and learning attitude, and this effect is more pronounced in high-pressure educational environments (Dong et al., 2023). Self-efficacy, as an individual's belief in their ability to successfully complete learning tasks and overcome challenges (Bandura et al., 1997), has long been regarded as a core predictor of academic motivation, perseverance, and learning performance. Existing studies have demonstrated that self-efficacy plays an important mediating role between growth mindset and academic achievement (Su et al., 2021;He et al., 2024). Students with a growth mindset are more likely to attribute academic outcomes to controllable factors such as effort and strategy use rather than fixed ability, which enhances their self-efficacy in tackling challenging tasks and subsequently translates into higher academic achievement (Leondari et al., 2002).

mathematics anxiety refers to the feelings of tension, worry, and avoidance that individuals experience in mathematics-related contexts (Richardson & Suinn, 1972). High levels of mathematics anxiety impair attention, reduce working memory efficiency, and hinder students' participation in mathematical activities, ultimately undermining academic achievement (Geary et al., 2021). Studies have found that growth mindset can alleviate mathematics anxiety by reducing students' tendency to interpret failure as evidence of low ability (Smith et al., 2019). When students believe that abilities can be improved, academic setbacks pose less threat to their self-worth, which facilitates more adaptive emotional responses to challenges and ultimately affects academic achievement (Young et al., 2021). Learning attitude reflects students' cognitive evaluations, emotional experiences, and behavioral tendencies toward learning activities (Ajzen, 2001). A positive learning attitude is typically associated with stronger learning interest, higher perceived value of learning, and more active academic engagement. Existing research confirms that students with a stronger growth mindset tend to hold more positive attitudes toward mathematics learning (Blackwell et al., 2007). By emphasizing progress and effort rather than fixed ability, growth mindset may encourage students to approach mathematics learning with greater interest, enjoyment, and perseverance (Diseth et al., 2011). This adaptive attitude can in turn translate motivational beliefs into sustained learning behaviors and improved academic outcomes. Therefore, the above findings suggest that self-efficacy, mathematics anxiety, and learning attitude may be important psychological paths linking growth mindset to mathematics academic achievement.

Teacher Support and the Development of Growth Mindset

Growth mindset does not solely originate from stable internal traits of individuals, but is gradually constructed through ongoing social interactions and educational experiences. Based on Social Cognitive Theory, there is a dynamic interaction among students' cognition, behavior, and environment. A supportive external environment can further shape students' learning beliefs and developmental orientations by influencing their attributional styles, self-perception, and behavioral experiences. In school contexts, teacher support is widely regarded as one of the most critical environmental resources affecting students' motivational development and psychological adaptation (Vestad & Bru, 2024). Existing studies have pointed out that teachers not only fulfill the function of knowledge transmission but also continuously influence students' understanding of "whether abilities can be changed" through classroom feedback, emotional interactions, and evaluation methods (Lou & Noels, 2019). Teacher feedback that emphasizes effort, strategies, and the learning process is more likely to reinforce students' beliefs about the malleability of intelligence than ability-labeled evaluations (Yeager et al., 2022; Jakubiak & Tomlinson, 2020).

Cross-cultural studies have further strengthened the association between teacher support and growth mindset. Based on large-scale survey data from 32 OECD countries, Hu & Zhang (2024) found that students' perceived teacher process feedback and

autonomy support significantly and positively predict growth mindset in most countries, thus revealing the cross-cultural stability of the promoting effect of teacher support on growth mindset. Meanwhile, Sun et al. (2019) also noted that in East Asian educational contexts that emphasize academic competition, teacher emotional support is particularly crucial for buffering students' academic stress and promoting positive learning beliefs. Especially for adolescent junior high school students, teachers are often one of their most important sources of social support at school, and their evaluations and feedback profoundly influence students' understanding of the relationship between ability, effort, and success. Therefore, teacher support is not only an important external environmental resource for students' learning but also promotes the development of growth mindset by shaping their attributional styles, emotional experiences, and ability cognition. Supportive teacher-student interactions help students view challenges and failures from a developmental perspective, thereby enhancing learning engagement and self-efficacy, and ultimately positively predicting academic achievement.

The Operational Logic of Growth Mindset in Competitive Students

As research continues to deepen, the academic community has increasingly focused on the contextual conditions under which growth mindset exerts its effects. Academic contexts characterized by high peer competition and academic workload have significant cognitive shaping effects, which may fundamentally reshape students' cognitive frameworks for interpreting the nature of ability, the value of effort, and the meaning of failure (Jiang, 2025). Competitive students represent a unique educational subgroup characterized by high-intensity training, continuous performance evaluation, and excessive academic expectations. Compared with regular students, they are more likely to be labeled as "geniuses" or "gifted" due to their outstanding academic achievement (Mofield et al., 2018). While such labels may boost academic confidence, they can also increase students' vulnerability to failure and exacerbate their concerns about maintaining their gifted identity. Mueller and Dweck (1998) described this phenomenon as the "paradox of giftedness", whereby high-achieving students gradually come to view effort as evidence of insufficient ability and are more likely to avoid challenging situations that would threaten their self-worth.

In this competitive context, growth mindset may play a particularly complex role. On the one hand, growth mindset may help competitive students reframe challenges as opportunities for improvement rather than threats to their identity (Jiang, 2025). By reducing fear of failure and promoting adaptive perseverance, growth mindset can support emotional resilience under sustained academic pressure. Park et al. (2025) further found that growth mindset among competitive students is associated with stronger intrinsic motivation, mastery-oriented goals, and a high value placed on the learning process (rather than just academic achievement). On the other hand, there may be significant group differences in how competitive and regular students interpret environmental support. Teacher process feedback that emphasizes effort and progress may be perceived by some students as encouragement for growth, while others may interpret it from the perspective of performance comparison and ability evaluation. This difference in cognitive interpretation may alter the actual effectiveness of teacher support in fostering students' growth mindset. In addition, previous studies have shown that competitive students typically exhibit higher self-efficacy and lower mathematics anxiety than regular students (Frank, 1996), but they may also experience greater vulnerability when faced with tasks that challenge their sense of competence (Alabbasi et al., 2023). The above findings indicate that competitive students are not merely high-achieving learners but represent a unique academic context in which the psychological paths linking teacher support, growth mindset, and mathematics academic achievement may operate differently.

Current research

Despite previous studies having revealed the importance of growth mindset for mathematics academic achievement, the following research gaps remain. Firstly, most existing studies treat students as a homogeneous group and pay little attention to whether the psychological mechanisms through which growth mindset influences academic achievement vary across different educational contexts, particularly lacking a comparative investigation between competitive students and regular students. Secondly, although teacher support is widely recognized as an important environmental factor shaping students' motivational beliefs, few studies have further examined whether the mechanisms of action of teacher support differ across student groups and what these differences specifically entail. Finally, while existing research indicates that growth mindset generally does not directly affect academic outcomes but exerts indirect influences through psychological mechanisms such as emotion regulation and motivational beliefs, there is still a lack of systematic evidence regarding the specific paths linking growth mindset, emotion regulation, motivational mechanisms, and mathematics academic achievement across different student groups in the Chinese educational context.

To address these gaps, grounded in Social Cognitive Theory and Growth Mindset Theory, this study constructs a Multi-Group Structural Equation Model (MGSEM) to systematically examine the relational mechanisms among teacher support, growth mindset, mathematics anxiety, self-efficacy, learning attitude, and mathematics academic achievement. As shown in Fig. 1, this study conceptualizes teacher support as an external environmental antecedent, growth mindset as the core ability belief, mathematics anxiety, self-efficacy, and learning attitude as key psychological mechanisms, and mathematics academic achievement as the ultimate learning outcome variable. More importantly, this study views participation in Mathematical Olympiad training not merely as a demographic classification but as a unique competitive academic context that may reshape the psychological paths linking growth mindset to academic achievement. This study aims to further elucidate how growth mindset influences students' mathematics learning performance by affecting cognitive and psychological mechanisms in different academic environments, and whether a competitive educational context alters the operational modes of the aforementioned psychological mechanisms. The study proposes the following hypotheses:

H1: Teacher support can significantly and positively predict students' growth mindset.

H2: Growth mindset does not directly predict students' mathematics academic achievement.

H3: Growth mindset can indirectly predict students' mathematics academic achievement through the following psychological variables:

(a) mathematics anxiety; (b) self-efficacy; (c) learning attitude.

H4: Teacher support can predict students' mathematics academic achievement through the chain mediating path of "growth mindset - psychological variables".

H5: There are significant intergroup differences in the structural paths among teacher support, growth mindset, psychological variables, and mathematics academic achievement between competitive students and regular students.

Methods

Participants and procedure

This study adopted a combination of convenience sampling and random sampling for data collection. First, 322 eighth-grade students participating in extracurricular Mathematical Olympiad training programs were recruited as the competitive student group. These students came from 83 regular classes in 8 schools and participated in centralized mathematics competition training after school in addition to completing daily classroom learning. The selection for the competition training programs was primarily based on students' mathematics academic achievement, problem-solving abilities, and willingness to participate, aiming to support students in participating in the National Mathematical Olympiad through continuous high-level knowledge teaching and specialized training.

To construct a control group, 488 regular students were further randomly selected from the aforementioned 8 schools. Except for not participating in additional mathematics competition training, regular students had extremely high consistency with competitive students in terms of school backgrounds, curriculum standards, examination systems, and daily learning environments. All research subjects came from the same batch of schools, which helped to control potential confounding effects caused by school-level differences to a large extent, thereby improving the internal validity of the intergroup comparison.

Questionnaire data were administered uniformly during regular school teaching activities. The study strictly followed the principles of voluntary participation and anonymous completion, and clearly informed students that their responses would only be used for academic research and would not have any impact on academic evaluation or competition selection. Mathematics academic achievement data were derived from the city-wide unified mathematics final examination. This examination adopted unified proposition, unified examination arrangements, unified scoring standards, and unified marking procedures across all participating schools, so it could objectively reflect students' mathematics academic level and serve as a highly standardized indicator of academic achievement. In the data cleaning stage, 10 questionnaires with a large amount of missing information and 2 data samples lacking final examination scores were excluded. Finally, 798 valid samples were obtained, including 320 competitive

students and 478 regular students, with an effective response rate of 98.52%. In addition, the result of Little's Missing Completely at Random (MCAR) test did not reach a significant level (Zhang et al., 2019).

Measurements

All measurement tools were adaptively adjusted in conjunction with the mathematics learning context, and contextualized expressions such as "mathematics" or "mathematics learning" were explicitly included in the item statements to enhance the consistency between the measurement content and the research topic. Meanwhile, considering that the research subjects were in the dual contexts of daily mathematics learning and mathematics competition training, to avoid students confusing regular learning experience with competition training experience when answering, the study adopted relatively general and generic expressions to reduce the potential impact of contextual confusion on measurement results. To further improve the applicability, readability, and contextual fit of the scales for Chinese junior high school students, the study consulted several mathematics teachers with rich teaching experience during the scale adaptation process and made localized revisions to some expressions based on their suggestions.

The research subjects completed a questionnaire survey on teacher support, growth mindset, and key psychological variables (i.e., mathematics anxiety, self-efficacy, and learning attitude). All measurement items were scored on a 5-point Likert scale. Mathematics academic achievement was taken as the operational indicator based on students' actual scores in the standardized mathematics final examination. The specific reliability and validity indicators are presented in Table 1. In addition, the study also collected students' gender, family income level, and mid-term mathematics examination scores, which were included as control variables in subsequent analyses to reduce the impact of potential confounding factors on the research results. Harman's single-factor test was used to control common method variance (CMV) for the self-report scale items in this study. Five factors with eigenvalues > 1 were extracted, with a cumulative explained variance of 67.34%, and the explanation rate of the first factor was 29.78%, which was below the 40% critical value, indicating no significant CMV problem.

Teacher Support. The teacher support dimension was assessed using 8 items from Chai and Gong's (2013) study on mathematics teachers' cognitive support (α = 0.925). For example: "My mathematics teacher always encourages us to explore different solutions to problems".

Growth Mindset. The growth mindset scale was derived from Dweck's (2006) measurement of implicit theories of intelligence, which included four statements about the growth mindset (α = 0.924). For example: "In mathematics learning, I can always significantly change my level of intelligence".

mathematics anxiety. The items in the mathematics anxiety scale were taken from 6 questions in the 2012 Programme for International Student Assessment (PISA) study (OECD, 2013), aiming to examine students' psychological states such as fear, worry, and avoidance of mathematics (α = 0.878). One sample item is: "I often worry about facing difficulties in learning mathematical knowledge".

Mathematics Self-Efficacy. The items on mathematics self-efficacy (8 items, α = 0.925) were adapted from Schwarzer and colleagues' (1999) study, used to examine students' subjective assessment of their own mathematics learning ability. For example: "I always believe that I have sufficient ability to solve various problems encountered in mathematics learning".

Mathematics Learning Attitude. The items on mathematics learning attitude (7 items, α = 0.916) were adapted from the 2019 Trends in International Mathematics and Science Study (TIMSS) assessment framework (Mullis & Martin, 2017), aiming to examine students' cognition of the importance and practicality of mathematics. One sample item is: "I think learning mathematics is very helpful for my daily life".

Mathematics Academic Achievement. Mathematics academic achievement was selected as the outcome variable based on the final examination with unified proposition, unified organization, and unified marking in the city where the students were located. This set of test papers included knowledge modules such as algebra and equations, geometry and figures, basically covering the core content of junior high school mathematics. The overall difficulty was 0.860, the discrimination was 0.57, and McDonald’s ω was 0.880.

Table 1
Composition of the Student Questionnaire and Reliability and Validity Tests.

Dimension	Number	Reliability	Confirmatory Factor Analysis					
		Cronbach's α	AVE	CR	CFI	TLI	SRMR	Factor loading
Teacher support	8	0.925	0.644	0.926	0.913	0.905	0.052	0.690–0.851
Growth mindset	4	0.924	0.761	0.927				0.764–0.925
mathematics anxiety	6	0.878	0.560	0.881				0.713–0.885
Self-efficacy	8	0.925	0.580	0.917				0.699–0.792
Learning attitude	7	0.916	0.551	0.895				0.644–0.833

Data Analysis

In this study, SPSS 26.0 was first used to test the reliability and validity of the questionnaire data. Specifically, Cronbach's α coefficient was adopted to evaluate the internal consistency reliability of the scales, and Confirmatory Factor Analysis (CFA) was performed to examine the construct validity of the scales. Subsequently, descriptive statistics, correlation analysis, and independent-samples t-tests were further conducted to explore the relationship between junior high school students' psychological traits and mathematics academic achievement, and to compare the differences in psychological traits and mathematics academic achievement between competitive students and regular students. Finally, Mplus 8.3 was utilized to construct a Multi-Group Structural Equation Model (MGSEM) to systematically investigate the mechanisms influencing mathematics academic achievement among regular and competitive students. To reduce the interference of potential confounding factors on the model results, students' gender, family income level, and mid-term mathematics examination scores were controlled for in the structural equation model analysis.

Results

Descriptive Statistics, Correlation Analysis and Difference Analysis

Grounded in Social Cognitive Theory, this study incorporated teacher support, growth mindset, learning attitude, mathematics anxiety, self-efficacy, and mathematics academic achievement to conduct descriptive statistics and correlation analysis. As shown in Table 2, the research subjects had the highest mean score for growth mindset and the lowest mean score for mathematics anxiety, while the mean scores of the remaining variables were all above 3.5, indicating an overall high level. The mean score of mathematics academic achievement was 76.729 with a large standard deviation, suggesting that the distribution of examination scores was relatively dispersed.

The correlation analysis revealed extremely significant correlations among all variables ($p < 0.001$). Among all variable pairs, growth mindset had the strongest correlation with self-efficacy ($r = 0.621^{***}$). With regard to mathematics academic achievement, self-efficacy showed the highest positive correlation with it ($r = 0.447^{***}$), while mathematics anxiety exhibited a significant negative correlation with it ($r = -0.381^{***}$). In addition, there were moderate to high positive correlations between each pair of teacher support, growth mindset, and learning attitude ($0.350 < r < 0.621$); in contrast, mathematics academic achievement exhibits a weak correlation with both teacher support and growth mindset ($r < 0.200$) (Rosnow et al., 2000). In summary, teacher support, growth mindset, learning attitude, mathematics anxiety, and self-efficacy jointly constitute the psychological correlation mechanism of mathematics academic achievement.

Table 2
Descriptive statistics and correlation analysis.

Dimension	Mean ± SD	Median	Kurtosis	Skewness	TS	GM	MAn	SE	LA	SC
Teacher support	3.610 ± 0.978	3.571	-0.407	-0.365	1					
Growth mindset	3.988 ± 1.021	4.000	0.203	-0.874	0.524***	1				
mathematics anxiety	2.580 ± 1.147	2.500	-0.939	0.283	-0.365***	-0.352***	1			
Self-efficacy	3.552 ± 0.980	3.625	-0.582	-0.342	0.495***	0.621***	-0.502***	1		
Learning attitude	3.716 ± 0.968	3.857	-0.512	-0.455	0.400***	0.541***	-0.350***	0.619***	1	
Academic achievement	76.729 ± 20.613	84.000	1.077	-1.314	0.168***	0.190***	-0.381***	0.447***	0.356***	1

Note:TS = teacher support; GM = growth mindset; MAn = mathematics anxiety; SE = self efficacy;LA = learning attitude; SC = academic achievement.*p < 0.05 **p < 0.01 ***p < 0.001*

The study further employed independent-samples t-tests to explore the differences between competitive students and regular students in perceived environmental support, cognitive construction, and mathematics academic achievement performance. As shown in Table 3, no statistically significant differences were found between the two groups of students in perceived teacher support, growth mindset, self-efficacy, and learning attitudes. However, extremely significant differences were detected in the dimensions of mathematics anxiety and academic achievement between the two groups, both with large effect sizes (Lowry, 1999).

Notably, the mathematics academic achievement of competitive students was significantly higher than that of regular students with an extremely large effect size, which was consistent with the research expectations. Since competitive students are selected based on their existing abilities, they generally have obvious advantages in mathematical competence and academic achievement, which is an important characteristic of this group and an objective reality in educational practice. Therefore, this study does not aim to eliminate the achievement gap between the two groups, but rather to further explore the potential differences in the formation mechanisms of their mathematics academic achievement on the basis of acknowledging this realistic difference.

Table 3
Independent-samples T test.

	Mean ± SD		t	p	Cohen's d
	Regular students (n = 478)	Competitive students (n = 320)			
Teacher support	3.62 ± 0.99	3.59 ± 0.96	0.489	0.625	0.035
Growth mindset	4.01 ± 1.02	3.95 ± 1.03	0.834	0.405	0.060
mathematics anxiety	2.80 ± 1.19	2.25 ± 0.99	6.990	0.000***	0.486
Self-efficacy	3.50 ± 0.99	3.62 ± 0.95	-1.690	0.092	0.121
Learning attitude	3.73 ± 1.01	3.70 ± 0.90	0.493	0.622	0.035
Academic achievement	66.77 ± 21.13	91.60 ± 4.87	-24.727	0.000***	1.492
Note: *p < 0.05 **p < 0.01 ***p < 0.001					

Analysis of Influencing Mechanisms

Given that this study includes both psychological variables measured by 5-point Likert scales and percentage-based mathematics final examination scores, there are significant differences in the dimensionality and variance levels between the two types of variables. Direct inclusion in the Multi-Group Structural Equation Model (MGSEM) may lead to biased estimation of path coefficients,

unstable model convergence, and imbalanced model fitting weights, further compromising the accuracy of cross-group invariance tests and effect comparisons. Therefore, prior to constructing the structural equation model, all variables were subjected to Z-score standardization to eliminate potential interference caused by differences in dimensionality and variance, thereby enhancing the reliability and comparability of parameter estimation and multi-group analysis results.

Measurement Invariance Test

This study employed multi-group confirmatory factor analysis to examine the cross-group measurement equivalence of the measurement instruments between regular students and competitive students. As shown in Table 4, the configural invariance model exhibited good fit, indicating that the two groups of samples shared a consistent factor structure. After further constraining the factor loadings, the metric invariance model showed minimal changes in fit and met the criterion of $\Delta CFI \leq 0.01$, demonstrating loading equivalence of all measurement indicators across the two groups. Subsequently, with the measurement intercepts constrained, the scalar invariance model yielded a ΔCFI of 0.008, indicating that the two groups of samples maintained consistency in measurement scales, thus allowing for comparison of latent variable means. Finally, after further constraining the variances and covariances of the latent variables, the fit of the structural invariance model deteriorated significantly ($\Delta CFI = 0.016$; $\Delta\chi^2 = 172.07$, $\Delta df = 37$, $p < 0.001$), revealing significant differences in the structural relationships among latent variables between regular students and competitive students (Perez et al., 2024). In summary, the scales used in this study demonstrate satisfactory cross-group measurement invariance, ensuring the rationality of path coefficient comparisons. Meanwhile, the differences in the structural relationships of latent variables between the two groups of students justify the necessity of conducting multi-group structural analysis.

Table 4
Test of measurement invariance.

Model	χ^2	df	CFI	TLI	RMSEA	SRMR	$\Delta\chi^2$ (Δdf)	p	result
Configural Invariance	2689.45	908	0.924	0.915	0.060	0.049	/	/	✓
Metric Invariance	2761.37	935	0.921	0.915	0.060	0.051	66.86(27)	< 0.001***	✓
Scalar Invariance	2946.69	962	0.913	0.909	0.062	0.053	187.86(27)	< 0.001***	✓
Structural Invariance	3273.11	999	0.897	0.898	0.066	0.057	172.07(37)	< 0.001***	□
Note: *p < 0.05 **p < 0.01 ***p < 0.001									

Path Difference Test

On the premise that measurement invariance holds, the study further conducted a difference test of cross-group path coefficients. Based on the metric invariance model (i.e., weak invariance model) with all other parameter settings unchanged, the path-constrained model was fitted by simultaneously constraining factor loadings and path coefficients to be equal across groups. The Satorra-Bentler corrected chi-square difference test (2001) was employed to compare the fit differences between the metric invariance model with free paths and the path-constrained model, thereby examining whether there existed an overall cross-group difference in path coefficients.

Note

Values outside the parentheses represent the standardized path coefficients for competitive students, and values inside the parentheses represent those for regular students. Text in red indicates a statistically significant difference between the two groups.

As shown in Fig. 2, all paths were consistent with the hypotheses except that growth mindset among competitive students could positively predict mathematics academic achievement. Specifically, teacher support significantly and positively predicted students' growth mindset in both groups ($\beta_C = 0.635$***, $\beta_R = 0.534$***). Growth mindset also significantly promoted students' learning attitude ($\beta_C = 0.454$***, $\beta_R = 0.669$***) and mathematics self-efficacy ($\beta_C = 0.684$***, $\beta_R = 0.691$***), while significantly reducing the level of mathematics anxiety ($\beta_C = -0.566$***, $\beta_R = -0.416$***). At the outcome variable level, both learning attitude ($\beta_C = 0.233$***, $\beta_R = 0.210$***) and mathematics self-efficacy ($\beta_C = 0.538$***, $\beta_R = 0.384$***) significantly and positively predicted mathematics academic

achievement, whereas mathematics anxiety exerted a significant negative effect on mathematics academic achievement (β_C = -0.149***, β_R = -0.111***).

The results of the path difference test in Table 5 indicated that there were significant differences in the strength of effects of some psychological mechanisms between the two student groups. Specifically, the promoting effect of growth mindset on learning attitude was more pronounced among regular students (Wald χ^2 = 12.737***), while the positive predictive effect of self-efficacy on mathematics academic achievement was stronger among competitive students (Wald χ^2 = 16.167***). In contrast, the promoting effect of teacher support on growth mindset, the alleviating effect of growth mindset on mathematics anxiety, the promoting effect of growth mindset on mathematics self-efficacy, and the negative predictive effect of mathematics anxiety on mathematics academic achievement did not show significant differences between the two groups. Overall, although competitive students and regular students exhibited high consistency in their overall structural relationships, the strength of effects of some key psychological paths still showed obvious group heterogeneity.

Table 5
Path coefficients for different groups and their difference tests.

Path	Competitive	Regular	Competitive	Regular	Test of between-group differences			
	B_C	B_R	β_C	β_R	Δβ	Wald χ^2 (df)	p	Bonferroni correction
TS → GM	0.821***	0.674***	0.635***	0.534***	0.100	2.109(1)	0.146	✗
GM →LA	0.394***	0.659***	0.454***	0.669***	-0.215	12.737(1)	< 0.001***	✓
GM → MAn	-0.530***	-0.493***	-0.566***	-0.416***	-0.149	0.210(1)	0.647	✗
GM → SE	0.725***	0.752***	0.684***	0.691***	-0.007	0.140(1)	0.70	✗
LA → SC	0.047***	0.165***	0.233***	0.210***	0.022	6.166(1)	0.013*	✗
MAn → SC	-0.028***	-0.073***	-0.149***	-0.111***	-0.038	1.725(1)	0.189	✗
SE → SC	0.089***	0.273***	0.538***	0.384***	0.154	16.167(1)	< 0.001***	✓
GM→ SC	0.261***	0.023	0.346***	0.093	0.253	28.027(1)	< 0.001***	✓

Note:TS = teacher support; GM = growth mindset; MAn = mathematics anxiety; SE = self efficacy;LA = learning attitude; SC = academic achievement. **p < 0.05 **p < 0.01 ***p < 0.001*

Mediation Effect Test

This study employed the bias-corrected non-parametric Bootstrap method (5000 resamples) to conduct a robustness test of the mediation effects, in order to obtain the 95% confidence intervals (CI) for each indirect effect. Meanwhile, by introducing the MODEL CONSTRAINT command into the model, a significance test was performed on the difference in indirect effects (ΔEffect) between the two groups to evaluate the heterogeneity in structural path mechanisms across different student groups. As shown in Table 6, growth mindset in both student groups exerted significant independent mediating effects on mathematics academic achievement by influencing learning attitude, mathematics anxiety, and self-efficacy. In addition, the chain mediating paths of "teacher support → growth mindset → learning attitude/mathematics anxiety/self-efficacy → mathematics academic achievement" also reached statistical significance in both samples.

The cross-group difference analysis revealed that only the mediating mechanisms involving self-efficacy showed significant differences between the two student groups. The indirect effect of the path "growth mindset → self-efficacy → mathematics academic achievement" was stronger among competitive students, and the cross-group difference reached statistical significance (GM→SE→SC, ΔEffect = 0.103, 95% CI [0.024, 0.191]). Similarly, the chain mediating path of teacher support through growth

mindset and self-efficacy demonstrated a stronger indirect effect advantage among competitive students (TS→GM→SE→SC, ΔEffect = 0.092, 95% CI [0.021, 0.171]). In contrast, the confidence intervals for the cross-group differences of all mediating paths involving learning attitude and mathematics anxiety all contained zero, failing to reach statistical significance.

Table 6
Mediation effect test and its difference test.

Mediating path	Competitive β_C	Effect [95% CI]	Regular β_R	Effect [95% CI]	ΔEffect [95% CI]	Difference test result
GM →LA → SC	0.106***	[0.061, 0.158]	0.140***	[0.091, 0.198]	-0.034 [-0.086, 0.012]	×
GM → MA → SC	0.084**	[0.031, 0.139]	0.046**	[0.014, 0.083]	0.038 [-0.014, 0.087]	×
GM → SE → SC	0.368***	[0.281, 0.471]	0.265***	[0.187, 0.361]	0.103 [0.024, 0.191]	✓
TS → GM →LA → SC	0.067***	[0.039, 0.104]	0.075***	[0.049, 0.116]	-0.008 [-0.043, 0.021]	×
TS → GM → MA → SC	0.054**	[0.019, 0.091]	0.025**	[0.007, 0.049]	0.029 [-0.011, 0.064]	×
TS → GM → SE → SC	0.234***	[0.166, 0.326]	0.142***	[0.096, 0.212]	0.092 [0.021, 0.171]	✓

Note: **p < 0.05 **p < 0.01 ***p < 0.001*

Discussion

Grounded in Social Cognitive Theory and Growth Mindset Theory, this study constructed a Multi-Group Structural Equation Model (MGSEM) to systematically investigate the differential mechanisms of action among external support, ability beliefs, psychological variables, and mathematics academic achievement between junior high school competitive students and regular students.

Psychological Characteristics of Competitive and Regular Students Exhibit Both Commonality and Structural Differences

No significant differences were found between the two groups in perceived teacher support and growth mindset. This suggests that participation in mathematics competition training neither enhances students' perception of teacher support nor fosters stronger beliefs about the malleability of mathematical ability. The result further suggests that growth mindset, as a relatively enduring yet context-sensitive ability belief, is not solely determined by competition participation experience; instead, its formation is more likely shaped by the combined effects of socialized learning experiences and educational environments (Yeager et al., 2022).

Similarly, no statistically significant differences were observed between competitive and regular students in mathematics self-efficacy and learning attitudes. Even with the gap in academic achievement, regular students can also maintain relatively positive perceptions of their mathematical abilities and attitudes toward mathematics learning. The two groups of students are generally at similar levels in terms of recognition of the value of mathematics learning and self-evaluations. Mathematics self-efficacy and learning attitudes are not solely determined by the level of academic achievement, but are jointly influenced by multiple factors such as social comparison, learning context, and individual cognitive evaluation. Although competitive students generally have higher mathematics academic achievement, they have long been in a competitive environment with a high concentration of outstanding peers, and their self-evaluations are often based on comparisons with these excellent peers (He et al., 2022).

Consistent with existing research, regular students exhibited significantly higher mathematics anxiety than competitive students. Competitive students typically possess more solid mathematical knowledge, richer experience with high-difficulty tasks, and stronger problem-solving abilities, resulting in relatively lower emotional threats and uncertainty in mathematics learning. In contrast, regular students are more prone to failure concerns and task avoidance tendencies, thus manifesting higher levels of mathematics anxiety. In summary, the differences between the two student groups are not comprehensive in terms of ability beliefs

and positive psychological characteristics; rather, they are mainly concentrated at the emotional level, particularly in mathematics anxiety. Group differences in growth mindset, teacher support, self-efficacy, and learning attitude are relatively limited.

Teacher Support, as an Important Antecedent to the Formation of Growth Mindset, Demonstrates Strong Cross-Group Stability

Teacher support significantly and positively predicted growth mindset in both competitive and regular students, with no significant intergroup difference in path coefficients. This result is highly consistent with the principle of triadic reciprocal determinism in Social Cognitive Theory, revealing that the theoretical path from external support and ability beliefs to psychological variables and academic outcomes has strong stability across different student groups (Vestad & Bru, 2024). This indicates that teachers' process feedback, emotional encouragement, and autonomy support are consistently associated with students' adaptive beliefs about the malleability of mathematical ability. Meanwhile, it reveals that the formation of growth mindset not only depends on students' own learning experiences but is also deeply influenced by the interpersonal interaction atmosphere and supportive classroom environment created by teachers (Lou & Noels, 2019).

Notably, for competitive students who have long been exposed to high-intensity learning pressure and evaluation contexts, the positive association between teacher support and growth mindset remained stable. This suggests that although a competitive learning environment may shape the functioning of some learning psychological mechanisms, it does not weaken the foundational role of teacher support in shaping students' motivational beliefs. This finding further highlights the educational value of teachers' supportive teaching behaviors and offers empirical support for future teacher intervention strategies. Furthermore, this finding is deeply aligned with Social Cognitive Theory, revealing the contextual nature of growth mindset: students' thinking patterns are essentially constructed gradually through ongoing social interactions and environmental feedback (Yeager et al., 2022).

Significant Heterogeneity Exists in the Mechanisms Linking Growth Mindset to Mathematics Academic Achievement Between the Two Groups of Students

There is a substantial difference in the direct effect of growth mindset on mathematics academic achievement between the two groups. Growth mindset among regular students did not directly predict mathematics academic achievement, and its effect is realized through three parallel mediating paths: learning attitude, mathematics anxiety, and self-efficacy. However, growth mindset among competitive students not only exerts effects through the aforementioned mediating paths but also directly predicted mathematics academic achievement. One possible explanation is that participation in mathematics competition may be associated with a stronger link between growth mindset and students' perseverance in adversity, engagement in complex tasks, and participation in advanced training. In this context, students who believe that mathematical ability can be continuously developed are more willing to proactively face high cognitive load tasks and sustain long-term high-intensity training, thereby contributing more directly to mathematics academic achievement (Jiang, 2025; Mofield et al., 2018).

The promoting effect of growth mindset on learning attitude is significantly stronger among regular students. Since competitive students are in a learning environment characterized by high-standard evaluation, frequent ability comparisons, and strong result orientation, their learning attitudes may be more influenced by grade rankings, competition selection, and external performance requirements (Park et al. 2025). In contrast, when regular students believe that mathematical ability can be continuously improved through effort, they are more likely to reduce negative attributions of failure, thereby further enhancing their positive cognition of the value and significance of mathematics learning. Therefore, growth mindset among regular students primarily influences mathematics academic achievement by affecting learning attitude.

Although no significant group differences were observed in the level of mathematics self-efficacy, its functional role in predicting mathematics academic achievement differed substantially across groups. The predictive effect of self-efficacy on mathematics academic achievement was significantly stronger among competitive students; meanwhile, the effects of all mediating paths of growth mindset through self-efficacy were also significantly higher than those among regular students. This indicates that in the high-intensity mathematics competition environment, students' confidence in their own mathematical abilities has become a core psychological resource affecting academic achievement. Since competitive students are long exposed to contexts of high-difficulty problem-solving, continuous grade comparisons, and high evaluation pressure, merely believing that "abilities can be developed" is insufficient to maintain high-level academic achievement; students' cognitive judgment of whether they have the ability to solve complex mathematical problems becomes more critical (Alabbasi et al., 2023).These findings suggest that a competitive academic environment may reinforce the bridging role of self-efficacy between growth mindset and mathematics academic achievement.

Therefore, growth mindset should not be simply regarded as a unified psychological resource applicable to all student groups, but should be understood contextually in combination with specific educational environments (Yeager et al., 2022).

Implications

The findings of this study have important implications for mathematics education practice and growth mindset interventions. First, teacher support was found to be a stable positive predictor of growth mindset across different student groups. Therefore, in the process of mathematics teaching, teachers should attach greater importance to process feedback, emotional support, and autonomy support, reduce evaluation methods based solely on ability labels, and guide students to view mistakes and challenges as opportunities for learning and growth, thereby fostering the development of growth mindset. Second, this study found that growth mindset influences mathematics academic achievement primarily through psychological mechanisms such as learning attitude, mathematics anxiety, and self-efficacy. This means that growth mindset interventions should not be limited to the indoctrination of the idea that "abilities can be developed", but should further integrate emotion regulation, learning motivation, and ability confidence cultivation. Teachers may help reduce mathematics anxiety and enhance learning engagement by providing progressive tasks, strengthening successful experiences, and optimizing failure feedback.

More importantly, this study suggests that a competitive learning environment may shape the mechanisms through which growth mindset relates to mathematics academic achievement. In high-competitive mathematics training contexts, self-efficacy has become the core psychological resource linking growth mindset to academic achievement. Therefore, for competitive students, merely emphasizing that "effort can improve ability" may not be sufficient; it is even more necessary to help students build stable confidence in their own mathematical abilities. Teachers and parents should avoid overemphasizing grade rankings and ability comparisons, and instead focus more on students' problem-solving processes, phased progress, and successful experiences in complex tasks to enhance their self-efficacy and academic resilience. Finally, this study also suggests that educational interventions related to growth mindset should avoid a "one-size-fits-all" implementation approach. Students in different learning contexts may have significant differences in their psychological needs and the paths through which growth mindset exerts its effects. When carrying out growth mindset education in the future, schools should implement more contextualized and differentiated educational support strategies in combination with students' learning ecology and the level of competitive pressure they face.

Conclusions

Grounded in Social Cognitive Theory and Growth Mindset Theory, this study constructed a Multi-Group Structural Equation Model (MGSEM) to systematically investigate the differential mechanisms of action among teacher support, growth mindset, psychological factors, and mathematics academic achievement between competitive and regular student groups. The results show that teacher support is a stable positive predictor of growth mindset in both groups of students, highlighting the important role of a supportive classroom environment in shaping adaptive ability beliefs. Meanwhile, growth mindset indirectly influences mathematics academic achievement through learning attitude, mathematics anxiety, and self-efficacy in both groups, verifying the critical mediating role of psychological mechanisms in the formation of academic achievement. More importantly, this study found that mathematics competition participation may serve as an important contextual factor associated with differences in the mechanisms through which growth mindset relates to mathematics academic achievement. Compared with regular students, growth mindset among competitive students has a stronger direct predictive effect on mathematics academic achievement, and self-efficacy also plays a more central mediating role. This suggests that highly competitive, performance-oriented learning environments may shape the psychological function of growth mindset, making it more closely associated with students' sustained engagement, perseverance, and confidence in dealing with challenging mathematical tasks. Overall, this study reveals the contextual heterogeneity of the paths through which growth mindset exerts its effects, demonstrating that growth mindset is not a universally applicable and constant psychological resource, but a contextual belief system influenced by the educational ecology. At the practical level, growth mindset interventions should be designed in combination with specific learning environments, and particular attention should be paid to the cultivation of students' self-efficacy in highly competitive academic contexts.

Limitations

Although this study has certain theoretical and practical value, it still has the following limitations. First, this study adopted a cross-sectional design, which cannot make rigorous causal inferences about the relationships between variables; future research needs to further verify these relationships through longitudinal or experimental studies. Second, competitive students were not randomly

assigned but selected based on their existing mathematical abilities and willingness to participate. Therefore, the observed differences between competitive and regular students should be interpreted as group-based associations rather than causal effects of competition training. Third, all psychological variables in this study were measured using self-report questionnaires, which may be affected by social desirability bias; future research can improve measurement validity by combining multi-source data such as teacher evaluations and classroom observations. Finally, this study was conducted in the Chinese educational context, and its results may be influenced by the highly competitive educational culture; future cross-cultural studies are still needed to further test the generalizability of the research conclusions.

Declarations

Ethical Approval

All procedures performed in studies involving human participants were approved by the Institutional Review Board of East China Normal University (IRB). This study was conducted in strict accordance with the ethical standards of the aforementioned institutional review board and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent

Written informed consent was obtained from all individual participants and their legal guardians (as participants were minors under 18 years of age) prior to data collection. All participants were fully informed that their responses would remain anonymous, participation was entirely voluntary, and the collected data would only be used for academic research purposes, with no impact on their academic evaluation or competition selection.

Conflict of Interest

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets and research materials generated or analyzed during the current study are fully available to editors and peer reviewers for the purpose of manuscript evaluation. The following materials have been shared:

- Raw dataset containing all original participant responses
- Processed dataset with cleaned variables and derived analytical indicators
- Detailed documentation of data processing procedures, including complete variable definitions, coding schemes, and descriptions of all data transformation operations
- Full versions of the psychological variable assessment questionnaires used in the study
- Complete item bank of the mathematics academic achievement test

All the aforementioned materials are provided as supplementary files accompanying the manuscript. Notably, in strict compliance with the personal information protection laws and regulations of the People's Republic of China regarding the privacy of minor students, the individual final scores of students' mathematics academic achievement in both the raw and processed datasets have been redacted. This redaction is a mandatory requirement to protect the confidentiality and privacy of underage participants. This limited redaction does not compromise the validity, reliability, or reproducibility of any results or conclusions reported in the manuscript.

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Figures

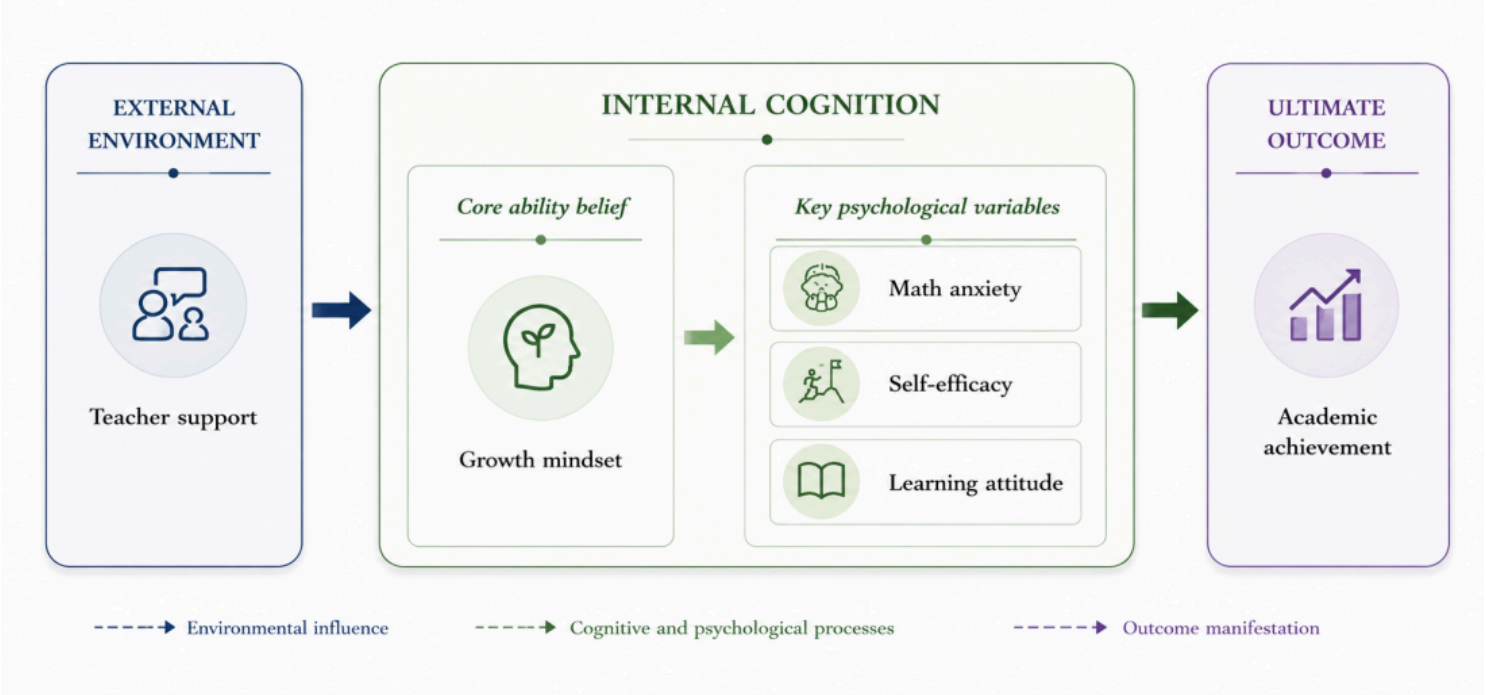


Figure 1

The Influencing Mechanisms Between Students' Growth Mindset and Academic Achievement from the Social Cognitive Perspective

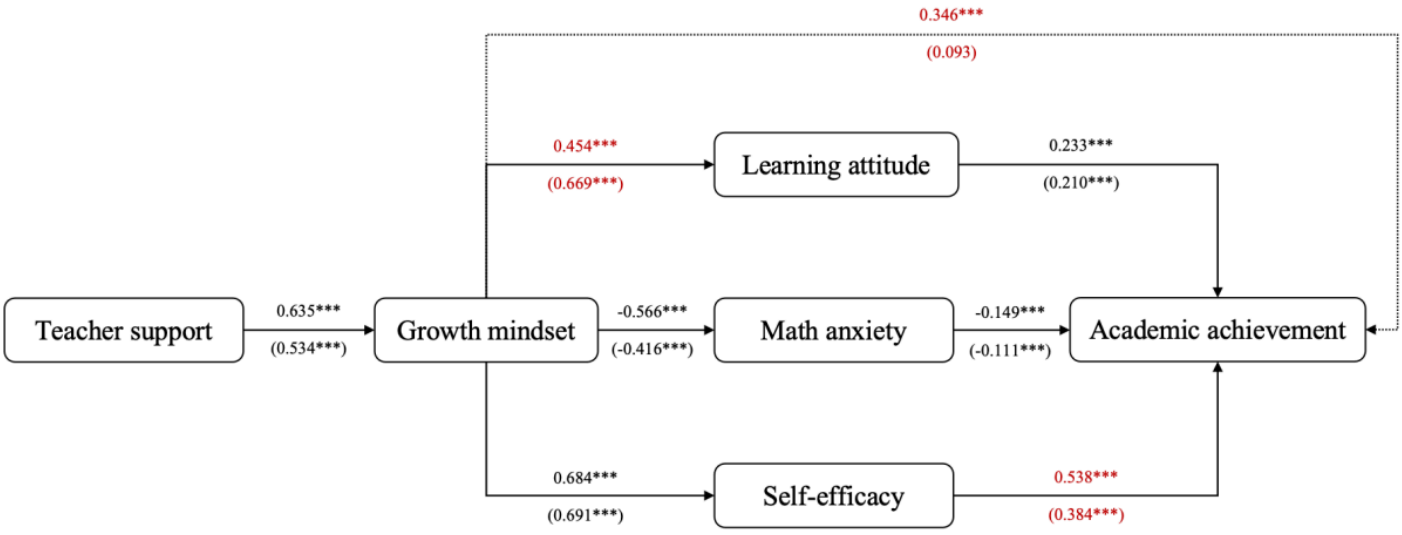


Figure 2

The Influencing Mechanism of Growth Mindset on Mathematics Academic Achievement Among Different Student Groups (The controlled variables are: gender, family income, and mid-term examination scores).

Note: Values outside the parentheses represent the standardized path coefficients for competitive students, and values inside the parentheses represent those for regular students. Text in red indicates a statistically significant difference between the two groups.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- InfluencingFactorsAssessmentQuestionnaire6.3.docx
- Poststandardizationdata.xlsx
- Prestandardizationdata.xlsx
- Rawdata.xlsx
- MathematicalAcademicAchievementAssessment6.3.pdf
- Dataanalysisprocess6.3.docx