Teacher Support and Students' Achievement in Mathematics—Discovery and Enlightenment Based on PISA 2022 East Asian Cultural Circle Data

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Abstract. To elucidate the mechanism through which teacher support influences students' academic achievement in mathematics, this study constructs a moderated mediation model. It focuses on the mediating role of the teacher-student relationship quality in this connection, as well as the moderating effect of math anxiety. Using the PISA 2022 data report officially released by the OECD, this study analyzes responses from 23,082 junior high school students across South Korea, Japan, Hong Kong (China), and Chinese Taipei within the East Asian Cultural Circle. The investigation examines teacher support, teacher-student relationship quality, and math anxiety, employing the within-structure matrix sampling method. The results reveal that: (1) Teacher support significantly positively predicts students' academic achievement in mathematics, even after controlling for economic, social, and cultural factors; (2) The quality of the teacher-student relationship mediates the relationship between teacher support and students' academic achievement in mathematics; (3) The direct predictive effect of teacher support on the quality of the teacher-student relationship is moderated by math anxiety. These findings not only enhance our understanding of the relationship between teacher support and mathematical academic achievement from the perspectives of attachment theory and control-value theory, but also offer practical insights for guiding junior high school students in managing their math anxiety, reinforcing the positive impact of teacher support, and improving the quality of teacher-student relationships.

Keywords: Teacher support, Student Academic Achievement in Mathematics, Teacher-student Quality Relationships, Math Anxiety, PISA.

1. Introduction

As the traditional teaching mode is gradually replaced by the concept of learning-oriented teaching, the role of teachers is gradually changing from knowledge transmitters to learning supporters, and teacher support thus becomes an important component of teacher competence [1]. Several researchers at home and abroad have found that teacher support plays a prominent role in education, especially in influencing students' academic achievement [2]. The mathematical proficiency of pupils in secondary school is an important issue of concern to countries all over the world, and the factors affecting the mathematical proficiency of pupils in secondary school not only include educational factors, but also involve psychological factors. Students in junior high school are in the psychological immaturity period, the psychological mechanism is immature, easy to produce anxiety, and due to the knowledge structure of junior high school mathematics and elementary school mathematics knowledge structure difference is large, resulting in students to appear fearful of psychology, or even produce mathematics anxiety [3]. Therefore, exploring the mechanisms of influence Associated with Teacher Support and student-generated math anxiety on the academic achievement of middle school students in mathematics has gained the attention of many scholars and even countries around the world.

As one of the core components under the social support theory, teacher support refers to “the range of support, such as advice, trust, and resources, that teachers provide to students” [4]. Research indicates that it cultivates students' academic skills and promotes positive mental states [5], sparking exploration into its role in students' math academic achievement. He Shengqing and Qi Chunxia (2023)

discovered that teacher support directly and indirectly contributes to achievement by enhancing psychological factors like self - efficacy. Since students' psychological factors vary across subjects, the impact of teacher support on academic achievement also differs [6]. Math's logical and abstract nature makes students more likely to experience math anxiety when facing task failure [7]. Teachers, as learning supporters, influence the development of math anxiety [8]. Teacher support is a crucial indicator of a good teacher - student relationship [6], which improves academic completion and achievement [9]. Zhou Wenye and Bian Guoxia's study revealed moderating mechanisms: a stronger relationship with higher socioeconomic status, a variable role of gender, and a weakening relationship with age [10]. Therefore, in order to further clarify the developmental mechanisms of teacher support, the mediating and regulating mechanics of the qualitative relationship between teachers and students, and the impact of mathematics anxiety on students' mathematics achievement, need to be examined from the perspective of the simultaneous integration of multiple factors from the perspective of integrating factors from multiple perspectives at the same time. Applying Bowlby's attachment theory to the teaching and learning scenario, the teacher-student relationship can be viewed as an affective relationship including closeness, warmth, and caring, and a good teacher-student relationship can be viewed as an affective foundation for students to gain security in the school environment, which enhances student achievement by facilitating the regulation of their emotions [9]. In view of this, investigating the mediating effect of the quality of teacher-student relationships in the connection between the two helps elucidate the cognitive mechanism of how teacher support influences student academic progress in mathematics. In addition, control value theory provides a theoretical foundation for the study of student academic achievement. The theory states that the external environment can elicit students' corresponding academic emotions by influencing their own control and value evaluations. And the control of the process and results of students' learning activities and their value assessment are the key factors determining academic emotions [4]. Accordingly, this theory provides important support for exploring how teacher support affects students' academic achievement in situations that produce math anxiety.

In summary, this study integrates attachment theory and control-value theory to investigate the correlation between educator assistance and students' academic performance in mathematics, focusing on the underlying mechanisms. Specifically, it investigates the mediating function of the quality of teacher-student relationships and the moderating effect of mathematics anxiety. By doing so, the study seeks to answer two key questions: how teacher support influences students' academic achievement in mathematics and when this effect becomes more pronounced. This method facilitates a comprehensive understanding of the cognitive and emotional mechanisms that influence the effect of teacher assistance on academic achievement. Furthermore, the findings provide valuable insights into how positive teacher-student relationships can enhance students' emotional regulation and academic outcomes, particularly in the context of mathematics. Ultimately, this study offers guidance on how teachers can strategically support students to enhance academic performance, particularly in subjects where students are prone to anxiety.

1.1. The relationship between teacher support and students' academic achievement in mathematics

Teacher support refers to the ability of teachers to provide care and attention to students, offering guidance and assistance when they face difficulties. Scholars define teacher support as encompassing a range of behaviors aimed at fostering students' emotional well-being and academic success. These behaviors include caring, understanding, encouragement, and expressing genuine concern for students’ progress [11]. Teacher support alleviates students' psychological stress, offers academic guidance for knowledge and skill acquisition, and creates a nurturing environment to boost learning motivation and engagement. Research shows it significantly enhances academic achievement across various cultural and economic settings. Studies indicate teacher support's positive impact on academic success is not notably influenced by socioeconomic factors, demonstrating its universal benefits. It positively affects students' academic performance across disciplines, including the liberal arts.

Moreover, it often has a significant indirect influence on students' achievements via factors like enhanced motivation, self - efficacy, and emotional well – being. In the field of language learning, Liu Xiaohong and colleagues discovered that teacher support cultivates a sense of comfort and confidence in pupils, empowering them to surmount learning challenges and pressures. This, in turn, boosts their academic performance [12]. Similarly, in physical education, teacher support not only enhances students' interest and motivation but also strengthens their self-confidence and initiative, encouraging active participation in sports activities, which ultimately leads to improved academic outcomes [13]. Furthermore, under the 3P (Person, Process, Product) teaching model, the role of teacher support is also significant. Students' attitudes toward language learning, for example, are heavily influenced by the degree of support they receive from their teachers. Positive teacher support encourages high-quality engagement in learning activities, which promotes students' academic development [14]. In a supportive learning environment, teachers' responsiveness to students' needs fosters positive emotional and cognitive growth, which leads to better academic achievement. Thus, teacher support is a critical component in creating an educational environment that enhances both the emotional and academic development of students. Therefore, how teacher support promotes students' scholarly success in maths deserves to be further verified through more empirical studies. This study hypothesizes that teacher support is a favorable predictor of academic progress in mathematics [15].

1.2. The mediating role of the quality of teacher-student relationship

From a single-level perspective, the teacher-student relationship refers to the interpersonal bond and psychological connection formed between teachers and students through their daily interactions in study and life. However, from a multi-level perspective, this relationship encompasses not only the interpersonal connection but also the teaching relationship in the classroom, as well as the broader psychological interactions that transpire both within and beyond the classroom setting [16]. Teacher-student relationships are the most fundamental interpersonal connections in educational settings and play a crucial role in determining the dynamics between teachers and students. They also significantly influence the quality of teaching and learning [17], which, in turn, affects scholarly performance of students [18]. The quality of these relationships is shaped by numerous factors that do not exist in isolation but rather interact in complex ways [19]. One of the most influential factors is the affective components of the relationship, such as emotional support, empathy, and trust. Research has shown that teacher-student relationships are intricately linked to students' emotional and academic outcomes. A study that established a cross-lagged model of teacher-student relationships and math anxiety found that a positive teacher-student relationship leads to a higher level of students' ability to confront challenges in a constructive way. Consequently, students with better teacher relationships report lower levels of math anxiety. Additionally, the study confirmed that the quality of the teacher-student relationship indirectly impacts students' academic performance in mathematics by reducing math anxiety. Furthermore, teacher support plays a crucial role in shaping the quality of the teacher-student relationship. Higher levels of teacher support, particularly through support and constructive criticism, help students tackle academic challenges more effectively. This assistance cultivates a sense of proficiency in students, leading to stronger teacher-student relationships [20]. When students sense teachers' investment in their success, they are more likely to trust teachers, feel secure in learning, and have a stronger sense of school belonging. This strengthens the teacher - student bond and enriches the educational experience. Research shows that teacher support promotes trust and creates a safe emotional space for academic risk - taking and growth. Applying attachment theory to educational contexts, it is evident that a secure teacher-student relationship provides students with a sense of safety and confidence. These positive emotions, in turn, enhance students' motivation to engage with learning tasks [9]. When pupils perceive their relationships with teachers as secure, they are more likely to approach academic challenges with resilience and a growth mindset, which ultimately contributes to improved academic outcomes.

Based on these theoretical insights, this study hypothesizes that teacher support may indirectly influence individual procrastination behavior through the mediating effect of the caliber of the

teacher-student connection. Particularly, it is expected that a stronger teacher-student bond, fostered by supportive teaching practices, will reduce procrastination tendencies by enhancing students' emotional security and motivation.

1.3. Moderating effects of math anxiety

Math anxiety refers to the negative emotions such as fear, worry, and nervousness that students experience when solving mathematical problems or facing mathematical situations [21]. These emotions can significantly hinder students' ability to engage with mathematics, leading to poorer academic outcomes. Studies indicate that teacher support is essential in both preventing and mitigating arithmetic anxiety [22]. Teacher support influences students' attitudes toward mathematics, and through these attitudes, indirectly impacts the level of anxiety students experience in math-related tasks [23]. Continuous teacher support effectively reduces math anxiety by fostering a positive, supportive learning environment, making students feel more secure about their abilities. High - quality teacher support enhances students' classroom belonging, directly lowering math anxiety levels [24]. Li Pei's study found that the onset of math anxiety typically begins in the early elementary school years and intensifies during adolescence, particularly in junior high school [25]. As students transition into this stage, they often face increased pressure and complexity in mathematics, which exacerbates feelings of anxiety. Notably, math anxiety has been shown to negatively correlate with pupils' scholarly performance in mathematics, a finding supported by both national and international studies. According to the PISA 2022 data, a significant number of middle school students experience math learning anxiety, and this trend continues into high school, where it can severely affect students' attitudes and performance in mathematics [26]. The detrimental effect of mathematical anxiety on academic performance becomes even more pronounced at higher educational levels, where excessive anxiety impairs students' ability to complete math tasks and negatively affects their overall performance [27]. Studies have also shown that teacher support positively influences students' attitudes toward math, which in turn affects their level of anxiety [28]. According to control-value theory, students' academic emotions, including math anxiety, are shaped by how they perceive their control over the learning process and the value they assign to the subject. In this context, students with positive attitudes toward math are more likely to be engaged, confident, and interested in learning, which reduces their anxiety and improves their performance [29]. Based on this framework, the present study hypothesizes that math anxiety may moderate the relationship between teacher support and the quality of the teacher-student relationship. Specifically, it is proposed that the direct predictive effect of teacher support on the quality of teacher-student relationships will be moderated by the level of math anxiety. In other words, the more anxious students are about math, the weaker the impact of teacher support on fostering a positive and supportive teacher-student relationship.

In summary, this study integrates attachment theory and control value theory to construct a moderated mediation model that explores the relationships between teacher support, the quality of the teacher-student relationship, math anxiety, and students' academic achievement in mathematics. The hypothesized model is shown in Figure 1. The primary aim of this research is to investigate both the mediating role of the teacher-student relationship quality and the moderating role of math anxiety in the process by which teacher support influences students' academic achievement. Specifically, it seeks to clarify how teacher support, through fostering a positive teacher-student relationship and by interacting with students' math anxiety, impacts students' performance in mathematics. By examining these mechanisms, this study hopes to provide empirical evidence and theoretical insights that can guide future educational practices, helping educators understand how their support can mitigate math anxiety and enhance student achievement in mathematics.

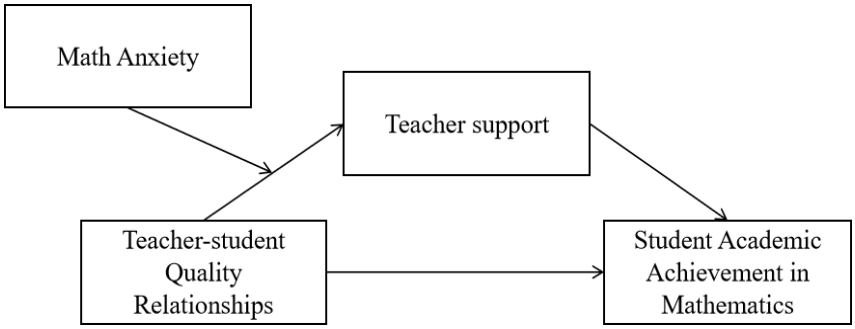

Figure 1. Hypothesized model of the mediating role of teacher-student relationship quality and the moderating role of math anxiety

2. Methodology

2.1. Subjects

Using the intra-structural matrix sampling method, the scope of this study focuses on the countries in the East Asian Cultural Circle. Vietnam and Macau (China) were excluded because they did not participate in all questionnaire sessions. The final subjects included in the study were South Korea, Japan, Hong Kong (China), and Chinese Taipei, from which a sample of 23,082 junior high school students was drawn. The average age of the subjects ranged from 15 to 17 (15.79±0.28), of which 11,688 (50.60%) were boys and 11,394 (49.40%) were girls; 5,471 (23.70%) were from Hong Kong (China) 5,722 (24.80%) were from Chinese Taipei, 5,602 (24.30%) were from Japan, and 6,287 (27.20%) were from South Korea. The basic information about the student sample is shown in Table 1.

Table 1. Basic information about the student sample

Variant	classification	N	Percentage%
Gender of students	male	11688	50.60%
	female	11394	49.40%
geography	Hong Kong (China)	5471	23.70%
	Chinese Taipei	5722	24.80%
	Japan	5602	24.30%
	Korea	6287	27.20%

2.2. Research tools

The data base of this study was obtained from the PISA2022 data report officially released on the official website of the Organization for Economic Co-operation and Development (OECD). In this case, the survey questions for teacher support were based on a 4-point scale (“Every class”, “Most classes”, “Some classes”, “Never or almost never ”), which was adapted from the TEACHSUP scale in PISA 2012; survey questions for math anxiety were on a 4-point scale (“Strongly agree,” “Agree,” “Disagree,” “Strongly Disagree”), which was adapted from the ANXMAT scale in PISA 2012; the survey questions on the quality of teacher-student relationships were also based on a 4-point scale (“Strongly Disagree ”, “Disagree”, “Agree”, and “Strongly Agree”), which utilized an within-construct matrix sampling design.

3. Results

3.1. Controls and tests for common method bias

For the existing data of PISA, this study utilized the Harman one-way test for common method bias. The results showed that there were four factors with eigenvalues greater than 1, and the amount

of variation explained by the first factor was 21.523%, which was less than the critical criterion of 40%, indicating that there was no common method bias.

3.2. Mean, standard deviation and correlation matrix of each variable

The results of the descriptive and correlation analyses (Table 2) reveal the following key findings: Teacher support is significantly and positively correlated with both the quality of the teacher-student relationship and students' academic achievement in mathematics. Additionally, teacher support shows a significant and positive correlation with students' math anxiety. The quality of the teacher-student relationship is significantly and negatively correlated with students' math anxiety, while also being significantly and positively correlated with students' mathematics achievement. Finally, students' math anxiety is significantly and negatively correlated with their academic achievement in mathematics.

Table 2. Results of descriptive statistics, correlation analysis

	M	SD	Teacher support	Teacher-student Quality Relationships	Math Anxiety	Student Academic Achievement in Mathematics
Teacher support	0.175	1.029	1			
Teacher-student Quality Relationships	0.223	1.021	0.357**	1		
Math Anxiety	0.196	1.157	-0.099**	-0.113**	1	
Student Academic Achievement in Mathematics	538.573	99.634	0.078**	0.080**	-0.207**	1

Note: **p<0.01

3.3. The Relationship between Teacher Support and Students' Academic Achievement in Mathematics: Moderated Mediation Model Tests

First, Model4 (Model4 is a simple mediation model) in the SPSS macro developed by Hayes (2012), was used to test the mediating effect of the quality of the teacher-student relationship in the relationship between mathematics teacher support and students' academic achievement in mathematics, controlling for economic, social, and cultural status. The results (Tables 3 and 4) indicated that teacher support was a significant predictor of students' academic achievement in mathematics (B=7.510, t=11.814, p<0.001) and that when the mediating variable was put in, the direct predictive effect of teacher support on students' academic achievement in mathematics remained significant (B=6.551, t=10.147, p<0.001). Teacher support was a significant positive predictor of teacher-student relationship quality (B=0.355, t=58.254, p<0.001) and teacher-student relationship quality was a significant positive predictor of student academic achievement in mathematics (B=6.551, t=10.147, p<0.001). In addition, the upper and lower bounds of the Bootstrap 95% confidence intervals for the direct effect of teacher support on students' academic achievement in mathematics and the mediating effect of the quality of teacher-student relationships did not contain zero (Table 4), indicating that teacher support not only directly predicted students' academic achievement in mathematics, but also predicted students' academic achievement in mathematics through the mediating effect of the quality of teacher-student relationships. This direct effect (6.551) and mediating effect (1.153) accounted for 85.03% and 14.97% of the total effect (7.704), respectively.

Table 3. Mediation model test of teacher-student relationship quality

		model fit indicators		significant value of the coefficient	
outcome variable	predictor variables	R-sq	F	efficiency value	t
quality of teacher-student relationships	ESCS	0.1329	1760.967***	0.081	11.602***
	teacher support			0.355	58.254***
Student Academic Achievement in Mathematics	ESCS	0.111	957.114***	35.272	51.327***
	quality of teacher-student relationships			3.245	4.978***
	teacher support			6.551	10.147***

Table 4. Decomposition of mediating effects, direct effects, total effects

	effect value	Boot SE	Boot LLCI	Boot ULCI	relative effect values
mediating effects of the quality of teacher-student relationships	1.153	0.244	0.682	1.639	14.97%
direct effect	6.551	0.646	5.285	7.816	85.03%
total effect	7.704	0.603	6.522	8.886	

Note: Boot SE, Boot LLCI and Boot ULCI refer to the standard error of the indirect effect estimated by the bias-corrected percentile Bootstrap method, the lower and upper bounds of the 95% confidence intervals, respectively; all values are retained to three decimals by rounding, the same below.

Table 5. Mediation model test with moderation

		model fit indicators		significant value of the coefficient	
outcome variable	predictor variables	R-sq	F	effect value	t
quality of teacher-student relationships	ESCS	0.139	924.497***	0.073	10.495***
	math teacher support			0.348	56.914***
	math anxiety			-0.065	-11.827***
	Teacher Support x Math Anxiety			-0.017	-3.553***
Student Academic Achievement in Mathematics	ESCS	0.111	957.114***	35.272	51.327***
	teacher support			6.551	10.147***
	teacher-student relationships			3.245	4.978***

Second, Model 7 in the SPSS macro developed by Hayes (2012) (Model 7 assumes that the first half of the mediator model is moderated, consistent with the theoretical model of this study) was used to test the moderated mediator model while controlling for economic, social, and cultural status. The results (Tables 5 and 6) indicated that after placing math anxiety into the model, the product term of teacher support and math anxiety was a significant predictor of the quality of the teacher-student relationship (quality of teacher-student relationship: B=-0.017, t=3.553, p<0.001), suggesting that math anxiety moderated the prediction of the quality of the teacher-student relationship by math teacher support. Subsequent simple slope analysis indicated (Fig. 2) that teacher support exerted a strong positive predictive influence on the quality of teacher-student relationships for subjects with

lower levels of math anxiety (M-1SD); whereas, for subjects with higher levels of math anxiety (M+1SD), math anxiety, although it also exerted a positive predictive effect, it was less predictive, indicating that, as the level of control for math anxiety increased, the predictive effect of teacher support on the quality of the teacher-student relationship tended to decrease gradually (Table 6).

Table 6. Mediating effects in math anxiety at different levels of regulation

math anxiety	effect value	Boot SE	Boot LLCI	Boot ULCI
-1.1569	1.1903	0.2574	0.6823	1.6919
0.0000	1.1285	0.2411	0.6507	1.5972
1.1569	1.0667	0.2273	0.619	1.5112

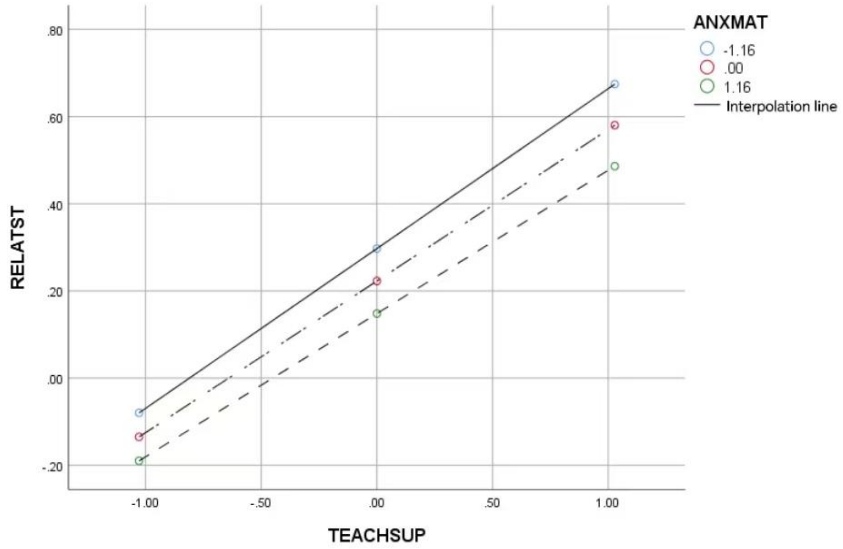

Figure 2. Moderating Role of Math Anxiety in the Relationship Between Math Teacher Support and Teacher-Student Relationship Quality

4. Discussion

Based on previous research and the frameworks of attachment and control value theories, this study developed a moderated mediation model with the quality of the teacher-student relationship as the mediating variable and math anxiety as the moderating variable. This model not only addresses the question of "how" teacher support influences students' academic achievement in mathematics (through the mediating effect of teacher-student relationship quality), but also explores the conditions under which this effect is more pronounced (via the moderating effect of math anxiety). Specifically, the model provides insight into the ways teacher support can enhance students' academic performance by fostering stronger teacher-student relationships and, at the same time, examines how math anxiety might influence the strength of this relationship. The findings of this study offer important theoretical and practical implications. They contribute to understanding the mechanisms behind the impact of teacher support on students' mathematical achievement, guiding educators in enhancing the quality of teacher-student relationships. Furthermore, the study emphasizes the need for strategies to mitigate math anxiety, offering a pathway to improve students' academic outcomes in mathematics by addressing both emotional and relational factors.

4.1. The impact of teacher support on students' mathematics attainment: the mediating role of the quality of the teacher-student relationship

Teacher-student interactions refer to the interpersonal and psychological connections formed between teachers and students both within and beyond the classroom environment. This study investigated the mediating influence of the quality of teacher-student relationships in the association between teacher support and students' academic achievement in mathematics. The results showed that

a good teacher-student relationship not only makes students feel valued and recognized, which prompts them to express their opinions bravely, stimulates motivation to learn, and to face learning with a more positive attitude, but also helps to reduce students' stress and nervousness, which in turn enables them to face learning problems in a positive way [30]. This study found that teacher support predicts students' academic achievement in mathematics through the mediating role of teacher-student relationship quality in the East Asian Cultural Circle region. The results support previous research that teacher-student relationship is the most fundamental interpersonal relationship in schools that affects students' motivation to learn, and that good quality of teacher-student relationship is caused by a combination of factors. Good quality of teacher-student relationship induced by teacher support will further enhance students' academic achievement in mathematics.

Among the many components of a social support system, teacher support plays an important role. In the development of middle school students, emotional support from significant others is a key factor influencing their self-efficacy, among which teacher support is a key factor. A great deal of research and practice has shown that teacher support can provide strong support for students' development and play a broad and positive role in students' growth process [31]. The positive influence of teacher support on the quality of teacher - student relationships is manifested in two aspects. Firstly, teachers' concern and understanding can evoke emotional resonance in students, fostering trust, which is fundamental for a high - quality relationship. Students are then more likely to communicate with teachers, thus strengthening their bond. Secondly, teachers' effective academic support, such as personalized learning advice based on students' abilities and progress, can promote students' academic development. This targeted support elicits students' appreciation for teachers, further enhancing the connection between them. Previous research also validates the positive predictive effect of teacher support on the quality of teacher - student relationships. Sun Wenmei's research verified a significant positive correlation between students' perceived teacher emotional support and their academic well - being. The more emotional support students' sense, the greater their learning well - being grows, and a strong emotional bond is formed between teachers and students. Moreover, teachers' increased autonomy support significantly boosts students' learning engagement. This enhanced engagement optimizes the learning experience, promotes academic performance, and improves academic achievement [32]. In light of attachment theory, a positive teacher-student relationship can create a secure emotional atmosphere for students in a teaching situation and can further enhance their self-confidence. This positive emotional experience can effectively stimulate students' intrinsic learning motivation, prompting them to devote themselves to learning activities with more enthusiasm and firm beliefs, thus having a positive and far-reaching impact on students' learning and growth. Therefore, teacher support will exert a beneficial influence on students' academic performance in mathematics by improving the quality of the teacher-student relationship.

4.2. Moderating role of math anxiety

This study established a moderated mediation model grounded in control value theory to investigate the moderating effect of math anxiety on the relationship between teacher support and the quality of teacher-student relationships. The results indicated that math anxiety substantially influences the correlation between teacher support and the quality of teacher-student relationships.

Specifically, teacher support had a more significant direct predictive effect on the teacher - student relationship quality for students with low math anxiety than for those with high math anxiety; that is, this predictive effect tended to gradually decrease as math anxiety levels rose. East Asian cultural - circle education is highly competitive, and math scores are highly valued in college entrance exams. For example, in China's college entrance exams [33], Japan's university entrance exams, and Korea's proficiency exams [34], math as a major subject occupies a large portion of the exams, and its performance affects whether or not students can enter their desired schools. The high importance of this examination system makes students and parents attach great importance to mathematics learning, and students are prone to anxiety when they encounter difficulties in mathematics learning. The moderation of math anxiety in the relationship between teacher support and the quality of the teacher-

student relationship can be understood in two ways. First, math anxiety, as a negative emotion, weakens students' motivation to learn math. The development of negative emotions will further affect their interest in learning mathematics, which in turn affects students' academic achievement in mathematics. In her study, Ping Zhang found that there is a significant negative predictive relationship between mathematics anxiety and mathematics academic achievement, i.e., the higher the level of mathematics learning anxiety, the more likely it is to adversely affect students' mathematics academic achievement, which in turn hinders their development in mathematics learning. Second, a positive teacher - student relationship enhances students' self - efficacy in math learning and reduces math anxiety as they face tasks more confidently. Research affirms a significant negative correlation between the two: a better relationship leads to less anxiety in math learning, and vice versa. Teachers should create opportunities for students' positive affective experiences and boost self - efficacy by countering negative factors. Effective teacher support can enhance the teacher - student relationship, alleviating students' learning - related anxiety and negative emotions [35]. Based on the control value theory, emotions play a mediating role between motivation and behavior, which is also true in mathematics learning. When students are in a state of math anxiety for a long time, they may gradually reduce their assessment of their ability to learn math, i.e., their sense of control decreases. At the same time, interest in mathematics learning may also be negatively affected by anxiety, adversely affecting academic achievement in mathematics. Therefore, teacher support is more likely to promote the quality of teacher-student relationship at students' low math anxiety level, which in turn improves math academic achievement.

4.3. Significance and shortcomings of the study

The moderated mediation model reveals not only the mechanism of teacher support's influence in promoting students' academic achievement in mathematics (the mediating role of the quality of teacher-student relationships), but also the level of significance of the effect of this mechanism of influence (the moderating role of math anxiety). The moderated mediation model responds to both the question of how teacher support affects students' academic achievement in mathematics and the question of under what conditions the direct predictive effect of teacher support on students' academic achievement in mathematics and the mediating effect of the quality of teacher-student relationships are more significant, which is important for the study of the relationship between emotional factors and the improvement of the quality of teacher-student relationships and students' academic achievement in mathematics. The study's findings indicate that teacher support can directly and positively predict students' academic achievement in mathematics, as well as indirectly influence this achievement and the underlying mechanisms at varying levels of mathematics anxiety through the quality of the teacher-student relationship, which effectively integrates the attachment theory and the control value theory, and contributes to the construction of a more perfect mechanism of influencing students' mathematics academic achievement.

In addition, the moderated mediation model has implications for guiding junior high school students to rationally control their math anxiety, reinforcing the positive effects of teachers' support for students and improving the quality of teacher-student relationships: first, in East Asian cultures, teacher-student relationships emphasize respect for the teacher and students are required to perform specific courtesies to the teacher to show their respect. For example, in China, students show respect to their teachers by bowing and initiating greetings. In Korea, when students encounter a teacher on campus, they bow and use honorific greetings, a ritualistic behavior that shows respect for the teacher's status and knowledge. Teachers' emotional support enables students to feel valued and cared for in the teacher-student relationship. Teachers need to listen attentively to students' ideas and problems in teaching and take the initiative to communicate with students to understand their confusion and worries in learning mathematics. By establishing a good relationship of trust with students, i.e., a good teacher-student relationship, teachers can make students feel cared for and supported by their teachers, thus reducing their resistance and anxiety towards learning mathematics [36]. Secondly, the East Asian Cultural Circle is deeply influenced by Confucian culture, which

attaches great importance to education and regards academic achievement as an important way for personal development and social status enhancement, and attaches particular importance to the learning of basic subjects such as mathematics. Teachers focus on discovering students' progress and merits in math learning, and give timely encouragement and affirmation. At the same time, to help students learn to self-regulate learning emotions and learning behavior, to reduce the junior high school students' mathematics anxiety.

This study has certain limitations that require enhancement in subsequent research. First of all, this study focuses on the East Asian Cultural Circle as an organic whole. Instead of analyzing different countries within the circle one by one, the study focuses on analyzing related phenomena and problems from a holistic perspective. Secondly, there are some limitations in this study. Due to the constraints of research methodology, variable control and other factors, it is difficult to conclusively reveal a causal relationship in the strict sense. Therefore, it is important to further explore the intrinsic mechanism of math anxiety in the quality of teacher support and teacher-student relationship in influencing students' academic achievement in mathematics in the future.

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