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Exploring the triad of mathematical engagement: Perceived abilities, interests, and teacher-student dynamics

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Abstract

This study investigates the relationships between students' perceptions, interests, and engagement in mathematics within the cultural framework of K-12 education in Kazakhstan. A diverse sample of K-12 students representing various grade levels and community settings was included in the research. The analysis proceeded in three distinct phases: first, a Confirmatory Factor Analysis (CFA) was conducted to evaluate the reliability of the instrument; second, a Structural Equation Modeling (SEM) approach was applied to examine relationships between variables and assess the overall model fit; and finally, descriptive and inferential statistical methods were employed. Students perceived mathematical abilities and interests were identified as significant predictors of their attitudes toward mathematics teachers, as revealed through SEM. Due to the nature of the data, nonparametric tests were utilized to explore group differences. The findings indicated a consistent pattern of negative student perceptions regarding their mathematical abilities and interests, juxtaposed with positive attitudes toward their mathematics teachers. These positive attitudes were more closely associated with students' personal rapport with teachers rather than their instructional effectiveness. Further analyses examined variations in perceptions across different grade levels and community settings, revealing the influence of contextual factors. Notably, no significant gender differences were observed, challenging existing literature on gender disparities in education. The study underscores the importance of adopting holistic educational strategies that account for cultural contexts and promote teacher-student solid relationships.

Keywords: Math Engagement, Math Interests, Perceived Abilities, Teacher-Student Relationships

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Students' self-perception of their mathematical abilities plays a crucial role in determining their engagement with math and overall academic performance in the subject. When students view themselves as proficient and capable in mathematics, they tend to approach mathematical tasks with greater confidence, motivation, and a mindset oriented toward growth (Rodríguez et al., 2020). This self-perceived competence fosters a positive feedback loop, as students who trust their abilities are more likely to persist in problem-solving, embrace challenges, and demonstrate higher levels of achievement (Ross et al., 2002). In contrast, students questioning their mathematical competence may develop math anxiety, negatively affecting learning and performance (Karasel et al., 2010; Rada & Lucietto, 2022). Thus, cultivating positive self-perceptions in students regarding their mathematical abilities is critical for enhancing their engagement and academic success in mathematics (Bature et al., 2020).

Numerous studies have explored students' level of interest in mathematics. Christensen and Knezek (2020) demonstrated that students with a strong interest in mathematics tend to develop more positive attitudes toward the subject and engage more actively in math-related activities. Moreover, a heightened interest in mathematics has been associated with improved academic performance and long-term aspirations in STEM-related careers (Sellami et al., 2023). However, various factors, such as instructional methods, curriculum design, the perceived relevance of mathematical concepts to real-world applications, and individual differences in students' preferences and experiences, can significantly influence students' interest in mathematics (Pekrun et al., 2017). Therefore, educators should aim to create dynamic and stimulating learning environments that encourage curiosity, exploration, and connections to students' interests, ultimately fostering a sustained and positive interest in mathematics.

Interest in mathematics plays a pivotal role in maintaining sustained engagement and fostering academic achievement. Research indicates that students with a higher interest in mathematics demonstrate more positive attitudes, increased participation in math-related activities, and improved academic performance. Key factors influencing this interest include instructional strategies, the relevance of the curriculum, and the application of mathematics to real-world contexts (Christensen & Knezek, 2020; Pekrun et al., 2017; Sellami et al., 2023).

Moreover, students' perceptions of their relationships with math teachers are essential in shaping their approach to and experience of the subject. Positive teacher-student relationships significantly enhance students' engagement, motivation, and enjoyment of learning mathematics (Li et al., 2022). The quality of these relationships directly impacts students' attitudes and motivation in the math classroom (Admiraal et al., 2020). Teacher-student interactions characterized by warmth, support, and mutual respect are associated with higher levels of student engagement, motivation, and enjoyment of mathematics (McLure et al., 2022). When students feel appreciated, understood, and supported by their math teachers, they are more inclined to participate actively, ask questions, and take intellectual risks in their mathematical thinking (Kaya & Kükey, 2022; Turner & Patrick, 2004).

Students' perceptions of their teachers' competence, supportiveness, and ability to foster an inclusive and engaging learning environment are strongly linked to enhanced interest and achievement in mathematics (Gur et al., 2023; Istenic Starčič et al., 2016). On the other hand, negative interactions with teachers, such as perceived unfairness or lack of support, can lead to diminished motivation and disengagement from mathematics (Sakiz et al., 2012).

This study is grounded in Social Cognitive Theory (Bandura, 1978), which emphasizes the significance of observational learning, social experiences, and reciprocal determinism in shaping behavior. In the context of this research, the theory suggests that students' mathematical abilities and interests are shaped by their personal beliefs, as well as the actions and behaviors of their teachers and peers. As demonstrated in previous studies, positive teacher-student relationships are instrumental in enhancing students' self-efficacy in mathematics (Bandura, 1993; Zimmerman, 2000).

There are notable gender differences in students' perceptions of their mathematical abilities. Research by Anaya et al. (2022) indicates that female students tend to report lower levels of self-perceived mathematical competence compared to their male peers. Similarly, female students often display a reduced interest in mathematics and lower confidence in their mathematical skills. When confronted with challenges, girls typically exhibit significantly less confidence in their abilities than boys, even when their actual performance is comparable (Catsambis, 1994). Samuelsson and Samuelsson (2016) also found that boys and girls perceive their learning environments differently, with boys reporting more frequent group work, more significant influence over lesson content, higher engagement in lessons, and a more robust perception of the importance of mathematics than girls. Among academically gifted elementary school students, boys generally identified their strengths in mathematics and science. At the same time, girls perceived their strengths in verbal areas, with these self-perceptions aligning with their actual test performance (Olszewski-Kubilius & Turner, 2002).

Societal stereotypes and gender biases significantly shape students' perceptions of their mathematical abilities, often leading girls to underestimate their skills, even when their actual performance is equal to or surpasses that of boys (Dweck, 2007). Math anxiety, which is more prevalent among females, plays a critical role in these gender differences, as higher levels of anxiety erode self-confidence and diminish girls' belief in their math competence (Hembree, 1990; Perez-Felkner et al., 2017). Teachers also exert considerable influence on students' perceptions of their abilities, with their attitudes and expectations often shaping how students assess their mathematical competence. Biased expectations and differential interactions in the classroom can contribute to gender disparities in math self-assessment (Beilock et al., 2010). For instance, boys tend to perform better in mathematics than girls (OECD, 2019), and girls frequently report lower self-assessed math proficiency, weaker interest, and reduced belief in the importance of mathematics in their lives (Crombie et al., 2005; Watt et al., 2012).

Additionally, there is a consistent decline in student interest in school subjects, particularly in mathematics, throughout elementary and secondary education (Frenzel et al., 2012). Chen's (2022) analysis of gender differences in math achievement and attitudes using data from the Trends in International Mathematics and Science Study (TIMSS) found that students perceived mathematical abilities decline as they advance to higher grade levels. This decrease may result from increasing academic rigor, higher expectations, and peer comparisons. Furthermore, as students' progress through grade levels, their perceptions of their mathematical competence, interest in mathematics, and positive feelings toward their math teachers tend to diminish (Frenzel et al., 2012). The decline in math motivation—evidenced by reduced perceptions of math ability, interest, and perceived value—suggests that as students grow older and move through their academic journey, their motivation for mathematics decreases (Fredricks & Eccles, 2002; Jacobs et al., 2002; Nagy et al., 2010; Watt et al., 2012).

Private schools often provide smaller class sizes, greater resources, and a focus on individualized instruction, which may contribute to students' heightened perceptions of their abilities and more positive attitudes toward their teachers. However, the impact of school type on students' perceptions can vary significantly across cultural contexts. For instance, public school students frequently outperform their private school peers on math assessments (Lubienski & Lubienski, 2005; Reardon et al., 2009). Data from the PISA 2012 math assessments further support the idea that private school students only hold a significant advantage in a few countries (Sakellariou, 2017). In most instances, public school students perform on par with those in privately subsidized schools and even surpass those in independent schools (Sakellariou, 2017).

Contrary to Sakellariou's (2017) findings, Bernardo et al. (2015) reported that private school students demonstrated higher achievement levels than their public-school counterparts. Private schools may create more supportive learning environments, which can positively influence students' attitudes toward mathematics (Hedges & Nowell, 1999). For example, research by Balta et al. (2023) showed that girls in private schools exhibited significantly more interest in technology and engineering careers than those in public schools, although no such difference was observed for science and mathematics careers between students from the two types of schools. This increased interest in technology and engineering careers is likely linked to higher engagement in mathematics learning.

Lee et al. (1998) found that students in private schools are more likely to enroll in advanced mathematics programs compared to their public-school peers. When accounting for student characteristics, a correlation emerges between attending private schools and higher achievement in both math and reading across all grade levels (Peterson & Llaudet, 2006). However, socioeconomic status (SES) often intersects with school type, as private school tuition is typically significantly higher than public school fees. As a result, a family's SES may have a greater influence on a student's math education experience than the type of school attended. Students from lower SES backgrounds, regardless of school type, often face limited access to high-quality math education resources, which can present additional challenges in their math learning (Reardon, 2011).

Furthermore, the geographical location of a school—whether urban, suburban, or rural—can influence students' perceptions of their mathematical abilities and attitudes toward math teachers. For instance, students in rural communities engage in cultural practices, economic systems, and ways of life that differ from those of students in urban and suburban areas (Howley et al., 2005). These lifestyle differences may shape how rural students perceive mathematics and its relevance to their future, potentially affecting their engagement and performance in math.

Urban schools, often characterized by larger student populations, higher population densities, and greater cultural diversity, provide access to both formal and informal educational resources. Students in these settings may benefit from a wider range of math-related learning opportunities, such as advanced courses and extracurricular activities (Lee & Burkam, 2002). Despite these advantages, urban schools may face challenges such as overcrowded classrooms and pronounced socioeconomic disparities, which can negatively impact students' mathematical learning experiences (Lee, 2000).

In contrast, suburban schools typically offer a more balanced educational environment, with access to additional learning resources and lower student-to-teacher ratios. These conditions often enable students to take advantage of diverse math courses and extracurricular activities, fostering positive educational experiences (Entwisle & Alexander, 1992; Planty et al., 2009). However, reports like the National Assessment of Educational Progress (NAEP) have consistently shown that students in urban schools underperform in math compared to their suburban and rural peers (Perie et al., 2005). Contributing factors to this disparity include larger class sizes, limited individualized instruction, and pervasive socioeconomic inequalities (Lubienski & Lubienski, 2006).

Hudson et al. (2020) examined the challenges faced by rural school students in math education, identifying several factors that hinder their learning experiences. These include limited access to advanced math courses, a shortage of qualified math teachers, and fewer opportunities for engaging in extracurricular math activities. Such contextual challenges can lead to negative feelings toward learning math and their math instructors, which may, in turn, influence how students in rural areas perceive their mathematical abilities.

The nature of teachers' interactions with students significantly affects math achievement outcomes (Reyes et al., 2012). Rimm-Kaufman et al. (2015) found that teachers employing interactive and student-centered instructional strategies enhance students' competence and confidence in math. Moreover, Zhou et al. (2020) demonstrated a direct and positive relationship between teacher-student rapport and students' problem-solving proficiency in mathematics. Recent studies have highlighted strong connections between nurturing teacher-student relationships and academic success in both math and reading (Hajovsky et al., 2017; McCormick & O'Connor, 2015). Students who report more positive emotions towards their teachers tend to exhibit higher confidence levels in their mathematical skills. This underscores the importance of fostering positive teacher-student relationships and emotional support in the classroom, as they significantly influence students' perceptions of their mathematical capabilities.

While previous studies have examined the impact of perceived mathematical abilities, interests, and teacher-student relationships on student engagement and achievement, there remains a significant gap in comprehensive research that integrates these factors within the specific cultural context of Kazakhstan. Furthermore, the interaction between these variables across diverse student demographics—including gender, grade level, and school location—has not been adequately explored. This study aims to address these gaps by investigating how students' perceptions of their mathematical abilities, interests, and attitudes towards their mathematics teachers differ across these demographic categories, with a focus on the Kazakhstani education system.

In light of our literature review and our desire to gain a deeper understanding of the influences on student perceptions of their mathematical abilities, we propose the following research questions:

1. What are students perceived mathematical abilities, interest in math, and feelings toward their math classroom teachers?
2. How do students perceived mathematical abilities, interest in math, and feelings towards their math classroom teachers change across gender, school type, grade level, and school location?
3. What is the relationship between students' feelings towards their math classroom teachers, perceived mathematical abilities, and math interests?

METHODS

Sample and Context

We employed a convenience sampling strategy to recruit participants for our research, which included a sample of 285 secondary school students from Kazakhstan. The sample comprised 65.3% female students and 37.4% male students, with participants distributed across various grade levels: grade 5 (n = 29), grade 6 (n = 49), grade 7 (n = 35), grade 8 (n = 55), grade 9 (n = 31), grade 10 (n = 50), and grade 11 (n = 34). The mean age of the students was 13.9 years (SD = 1.99). The participants were drawn from two types of schools: public (n = 268) and private (n = 9) and were located in three distinct environments: rural (n = 59), suburban (n = 14), and urban (n = 205).

We collected data from students in grades 5 through 11 across five schools in Almaty, Kazakhstan. One of the participating institutions was School-gymnasium №202, situated in the center of Almaty, which serves approximately 970 students in grades 5 to 11. The school employs twelve mathematics teachers, comprised of three males and nine females.

For grades 5 and 6, students receive math instruction for five hours per week, supplemented by an additional two hours of math-related extracurricular activities, resulting in a total of seven hours of math exposure each week. In grades 7 to 9, the curriculum includes algebra classes for three hours per week and geometry classes for two hours per week, alongside two hours dedicated to supplementary math education, totaling seven hours of instruction per week.

For grades 10 and 11, the curriculum varies based on the educational direction. In the natural-mathematical track, algebra is taught for an average of four hours per week, geometry for two hours, and an additional two hours of supplementary math education, summing to eight hours per week. In contrast, the social-humanitarian track offers algebra classes for three hours per week and geometry classes for one hour per week, along with an additional two hours of math education, totaling six hours of instruction per week.

Another institution included in our study was the Specialized Lyceum named after Al-Farabi, located in the Karasai District of Almaty Region, approximately 30 kilometers from the city of Almaty. This school serves about 960 students across grades 5 to 11 and employs 20 mathematics teachers, comprised of seven males and thirteen females.

In grades 5 and 6, students participate in math classes for a total of seven hours each week. For grades 7 to 9, the curriculum consists of four hours of algebra instruction and three hours of geometry instruction per week, also totaling seven hours of math exposure weekly.

For grades 10 and 11, the curriculum differs based on the educational direction. In the natural-mathematical track, students receive an average of four hours of algebra and three hours of geometry each week, equating to a total of seven hours of math instruction. Conversely, in the social-humanitarian track, students attend algebra classes for three hours per week and geometry classes for two hours per week, resulting in five hours of math instruction weekly.

Data were collected from the Secondary School Kemertgan, located in the Karasai District of Almaty Region, approximately 15 kilometers from the city of Almaty. This school serves around 3,500 students across grades 5 to 11 and employs a total of sixteen mathematics teachers, comprising three males and thirteen females.

In grades 5 and 6, students receive five hours of math instruction each week. For grades 7 to 9, the curriculum includes three hours of algebra and two hours of geometry weekly, resulting in a total of five hours of math instruction. In the natural-mathematical track for grades 10 and 11, students attend four hours of algebra and two hours of geometry each week, totaling six hours of instruction. In the social-humanitarian track, students have three hours of algebra and one hour of geometry per week, equating to four hours of math instruction.

Data were also gathered from Secondary School Karatal, located in the Zaisan District of the East Kazakhstan Region, approximately 30 kilometers from the district center. This school has a student population of around 450 in grades 5 to 11 and employs six math teachers, including one male and five females. Similar to Kemertgan, students in grades 5 and 6 receive five hours of math instruction weekly. In grades 7 to 9, the math curriculum includes three hours of algebra and two hours of geometry, again totaling five hours per week. For the natural-mathematical direction in grades 10 and 11, students attend four hours of algebra and two hours of geometry, resulting in six hours of math instruction. In the social-humanitarian direction, students have three hours of algebra and one hour of geometry each week, totaling four hours of math instruction.

Lastly, data were collected from S. Kyrykbaeva Secondary School in the Koksu District of Zhetysu Region, located 15 kilometers from the Koksu district center. This smaller school accommodates approximately 81 students across grades 5 to 11 and employs two male math teachers. For grades 5 and 6, students have five hours of math classes each week. In grades 7 to 9, the curriculum includes three hours of algebra and two hours of geometry weekly, resulting in a total of five hours of instruction. In the natural-mathematical track for grades 10 and 11, students receive four hours of algebra and two hours of geometry per week, totaling six hours of instruction. In the social-humanitarian track, students have three hours of algebra and one hour of geometry weekly, amounting to four hours of math instruction.

Instrument

The survey employed in our study comprised nineteen items, along with several demographic questions aimed at gathering data on participants' age, gender, grade level, type of school, and location of the school. The primary objective of the survey was to assess various dimensions related to the students' mathematical abilities, their interests in mathematics, and their perceptions of their mathematics teachers. This comprehensive approach allowed for a nuanced understanding of the factors influencing students' experiences and attitudes toward mathematics education.

1. Perceived Abilities

   To evaluate students' perceived abilities in mathematics, we employed seven sets of items developed by Zhao and Perez-Felkner (2022). Sample survey items included statements such as "You see yourself as a math/science person" and "You are confident that you can do an excellent job on assignments in the math/science course." Participants indicated their level of agreement with these prompts on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The average scores for each of the seven item sets were calculated, resulting in average scale scores between one and five. The reliability coefficient for this dimension was determined to be .894, indicating high internal consistency.

2. Math Interests

   To measure students' interests in mathematics, we utilized three sets of items, which produced a reliability coefficient of .727, reflecting acceptable internal consistency. Example items in this dimension included statements such as "You are enjoying this math/science class very much" and "You think this math/science class is a waste of your time." Participants responded to these items on a five-point Likert scale, with 1 representing "strongly disagree" and 5 representing "strongly agree." Given that two items were negatively phrased, we reverse-coded the responses for consistency in the analysis.

3. Students' Feelings

   This dimension assessed students' affective responses toward their math and science teachers through nine items. The reliability coefficient for this dimension was found to be .849, indicating suitable internal consistency. Example Likert-type items included statements such as "Math/science teacher values and listens to students' ideas" and "Math/science teacher makes math easy to understand." Similar to the previous dimension, two items were reverse-coded due to their negative phrasing to ensure consistency in scoring.

The survey items were initially translated into Kazakh by the first author, who is fluent in both Kazakh and English. Two English language teachers reviewed the translated items for accuracy and cultural relevance, focusing on maintaining the original meaning while ensuring that the language and concepts were appropriate for Kazakh students. Additionally, we sought feedback from two students as they completed the survey, asking them to think aloud. Based on the insights from these students and the language teachers, we made slight revisions to the wording of certain items, resulting in the final version of the survey.

Data Collection

All participants completed the questionnaire anonymously during the final week of the spring semester in 2023. The survey took approximately eight minutes to complete. We discarded 12% of the surveys due to incomplete responses, identical answers across all items, and inappropriate submissions.

Data Analysis

We initiated our analysis by calculating both descriptive and inferential statistics to identify significant differences among demographic groups categorized by gender, grade level, school type, and school location. Given that our data did not conform to the assumptions required for parametric tests, we employed either the nonparametric Mann-Whitney U test or the Kruskal-Wallis test, depending on the number of group levels involved.

Our Structural Equation Modeling (SEM) analysis was conducted in three phases. In the first phase, we performed a first-order CFA using all selected dimensions to assess the reliability of our measurement instrument. Subsequently, we estimated a SEM to quantify the relationships between the constructs and to evaluate the model's fit to the data, as outlined by Boateng et al. (2018) and Hair et al. (2017). In this model, we utilized students perceived mathematical abilities and interests as predictors of their attitudes toward their mathematics teachers. We interpreted the results in accordance with standard SEM analytics, ensuring a comprehensive evaluation of the model's effectiveness.

RESULTS AND DISCUSSION

Students' Mathematical Abilities, Interests, and Teacher Feelings

Our first research question aimed to explore students perceived mathematical abilities, math interests, and feelings toward their math classroom teachers. To address this question, we conducted a thorough examination of various descriptive statistics (see Table 1). The results indicated that the data for each dimension did not meet the criteria for normality. Consequently, we opted to proceed with our analysis utilizing nonparametric statistical methods to ensure the validity of our findings.

Table 1. Descriptive statistics for perceived abilities, math interest, and feelings toward teachers

Statistic	Perceived Abilities	Math Interest	Feelings Toward Math Teachers
N	283	284	285
Mean	2.92	2.48	3.42
Median	2.86	2.33	3.44
Standard deviation	.86	.48	.60
Shapiro-Wilk W	.981	.92	.94
Shapiro-Wilk p	< .001	< .001	< .001

Table 1 presents the findings, indicating that students perceived their mathematical abilities (M = 2.92) and math interests (MMI = 2.48) with a slight negative bias. In contrast, their feelings toward their math classroom teachers were notably more positive (MFMT = 3.42). These results suggest that students generally tended to disagree or remain neutral regarding their perceptions of mathematical abilities and interest in mathematics. However, they displayed a tendency to lean toward agreement in their affective responses toward their teachers, reflecting moderately positive feelings about their educators.

Differences by Individual Variables

To address our second research question regarding how students perceived mathematical abilities, math interests, and feelings toward their math classroom teachers vary by gender, school type, grade level, and school location, we initially conducted a Mann-Whitney U Test. This analysis aimed to explore the effects of gender and school type on the students' perceptions of their abilities, interests in mathematics, and feelings toward their math teachers as presented in Table 2.

Table 2. Mann-Whitney U test for gender and school type

	Gender		School type	
	Statistic	**p**	**Statistic**	**P**
Perceived Abilities	8674	.599	1204	.995
Math Interest	8700	.521	978	.312
Students' Feelings	8729	.515	1177	.873

Note. H_a: $\mu_{Female} \neq \mu_{Male}$, H_a: $\mu_{Public} \neq \mu_{Private}$

The analysis of the findings presented in Table 2 revealed no significant differences among groups concerning gender and school type. This indicates that students' perceptions of their abilities, interests in mathematics, and feelings toward their teachers were relatively uniform across these demographic variables.

However, a deeper examination of the item-level responses uncovered a statistically significant difference regarding the item stem "Others see you as a math person" within the perceived abilities dimension. Specifically, male students perceived themselves as being viewed as more math-oriented individuals (M = 2.81) compared to female students (M = 2.39). Despite this finding, no significant differences emerged across any of the survey items when analyzing the school type variable.

To further investigate the second research question, we conducted a Kruskal-Wallis Test to assess the effects of grade level (categorized into six groups) and school location (divided into three categories). The results of these analyses are detailed in Table 3.

Table 3. Kruskal-Wallis test by school location and grade level

	School Location			Grade Level		
	χ^2	**df**	**p**	χ^2	**df**	**p**
Perceived Abilities	5.108	2	.078	8.23	6	.222
Math Interest	.233	2	.89	10.55	6	.103
Students' Feelings	9.339	2	.009**	9.18	6	.164

* p < .05, ** p < .01

The results presented in Table 3 indicate that the only statistically significant difference observed pertained to students' feelings towards their math teachers, specifically across different school locations. To ascertain which school locations influenced this difference, we employed a Dwass-Steel-Critchlow-Fligner (DSCF) pairwise comparison. This analysis revealed a significant disparity between students attending rural and urban schools (p = .016). Notably, urban students reported more positive feelings toward their math teachers (M = 3.48) compared to their rural counterparts (M = 3.20).

In contrast, no significant differences were identified among the grade level groups in relation to perceived abilities, math interest, or students' feelings toward their teachers. To gain a more nuanced understanding of these dynamics, we further investigated differences at the item level. This involved conducting the Kruskal-Wallis Test followed by DSCF pairwise comparisons for individual survey items, as detailed in Table 4.

Table 4. Kruskal-Wallis test by grade level groups by survey item

Dimension	Item	χ^2	df	p	Grade Groups	p	Mean$_1$	Mean$_2$
Perceived Abilities	Others see you as a math person.	15.6	6	.016*	5th-7th	.03*	3	2.11
Math Interest	You think this math class is a waste of your time.	14.5	6	.025*	5th-10th	.032*	4.45	3.92
Students' Feelings	Math teacher treats every student fairly.	13.3	6	.038*	5th-6th	.023*	3.41	4.08
					5th-10th	.014*	3.41	4.10
	Math teacher thinks mistakes are okay as long as all students learn.	27.3	6	< .001**	5th-10th	.006**	3.18	4.02
					6th-8th	.042*	3.06	3.72
					6th-10th	<.01**	3.06	4.02
					7th-10th	.043*	3.14	4.02

* $p < .05$, ** $p < .01$

The results summarized in Table 4 reveal notable differences in students' perceptions across various grade levels. Specifically, fifth-grade students reported significantly more positive responses regarding being perceived as math-oriented individuals compared to seventh-grade students. Conversely, fifth-grade students expressed a stronger belief that math class was a waste of their time than their tenth-grade peers.

Additionally, sixth and tenth-grade students were more likely to believe that their math teacher treated every student fairly compared to fifth-grade students. Furthermore, tenth-grade students exhibited a more positive perception regarding their math teachers, specifically in their belief that mistakes are acceptable as long as all students are learning. However, it is important to note that the responses from tenth graders were not significantly different from those of eighth graders. This analysis underscores the varying perceptions of math instruction and teacher interactions across different grade levels, highlighting specific trends among students as they progress through their education.

Relationship among Students' Mathematical Abilities, Interest, and Teacher Feelings

To address our third research question—regarding the relationship among students' feelings towards their math classroom teachers, their perceived mathematical abilities, and their math interests—we conducted a SEM analysis. This analysis aimed to quantify the connections between students' perceptions of their math teachers, their self-reported mathematical abilities, and their interests in math.

The SEM approach allowed us to examine how perceived mathematical abilities and math interests influenced students' feelings towards their math teachers. By modeling these relationships, we sought to uncover the extent to which students' perceptions of their abilities and interests could predict their emotional responses to their teachers in the math classroom. The results of this analysis will provide insights into the dynamics of student-teacher interactions and contribute to our understanding of how these factors collectively impact students' attitudes toward mathematics education.

Model Fit Analysis

We conducted SEM to examine the relationships among the students' perceived abilities and math interest, and their feelings towards math teachers.

Table 5. EFA loadings

Factors	Item	Factor1	Factor2	Factor3	% of variance	Cumulative %
Perceived Abilities	PA1	.449			23.05	23.05
	PA2	.472				
	PA3	.795				
	PA4	.848				
	PA5	.819				
	PA6	.778				
	PA7	.805				
Math and science interests	MI1	.302	.369	.311	22.48	45.53
	MI2		.713			
	MI3		.664			
Students' Feelings	SF1			.799	8.72	54.26
	SF2			.850		
	SF3			.845		
	SF4			.758		
	SF5			.390		
	SF7			.663		
	SF8			.314		
	SF9			.733		

Exploratory Factor Analysis: We conducted (Exploratory Factor Analysis) EFA with Jamovi software, Version 2.3.21, using minimum residual factoring and oblimin rotation to enhance opportunity to detect the correlation among factors (see Table 5). Based on the fixed factor numbering technique, we classified items with loadings higher than .30 as significant (Boateng et al., 2018; Hair et al., 2017). We retained the items with two or more loadings greater than .30 hence the number of items in a factor had to be at least three. The other loadings were only displayed for items on their expected factors. An item (SF6) loading less than .30 was removed so that 18 items did load at the .30 level on any factor as a result of EFA. The new model we tested was based on the first order EFA results and our three correlated factors: perceived math ability, math interests, and students` feelings toward their math teachers.

Confirmatory Factor Analysis: We calculated the confirmatory factor analysis (CFA) using the 18 items in Table 5 that we retained. We tested theory-based models similar to those we tested in our EFA calculations. According to first-order CFA measurement statistics, the indices indicated a poor model fit (see Table 6).

Fitting Model Analysis with Structural Equation Model: We conducted an SEM model fitting analysis using Jamovi software, Version 2.3.21, using the SEMLj interactive module (Gallucci & Jentschke, 2021). We applied the SEM to assess the model fit with our three factors represented by the 18 items we retained through our EFA and CFA calculations. In SEM, the goodness of fit is the appropriate statistic to evaluate the validity of the models (Hair et al., 2017; Harrington, 2008; Rosseel, 2012).

Table 6. Goodness-of-Fit indices

	x^2/DF= CMIN/ DF	SRMR	RMSEA	GFI	AGFI	NFI	IFI	TLI NNFI	CFI	Outcome
Confirmatory Test	362/132= 2.742	.059	.078	-	-	-	-	.901	.915	Poor
SEM initial Test	352/132= 2.666	.060	.080	.976	.966	.867	.913	.898	.912	Poor
SEM Second Test	167/74= 2.256	.047	.069	.987	.979	.927	.958	.948	.957	Accept-able
SEM Final Test	105/72= 1.458	.037	.041	.991	.986	.954	.985	.981	.985	Perfect

CFI = comparative fit index; NFI = Normed fit index, NNFI = Non-normed fit index = TLI = Tucker–Lewis index; IFI = Incremental fit index; GFI = Goodness of fit index; AGFI = Adjusted goodness of fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual

Our initial SEM indices indicated that our model fit poorly with the data (see Table 6). We removed four items from our second SEM test due to their low correlations: SF5, SF8, PA1, and PA2. Our second model met the thresholds for CFI, TLI, IFI, GFI, and AGFI, and other indices were in the acceptable range with the CMIN\DF and NFI slightly below the recommended cutoff values. We conducted our final SEM test with modifications to our model. In our final model, the pair error variances of MI2--MI3 and SF7--SF9 had larger modification indices and, thus, were exposed as being associated with the same factor. The indices from our final analysis indicated that the measurement model fit the data (see Table 6 and Figure 1).

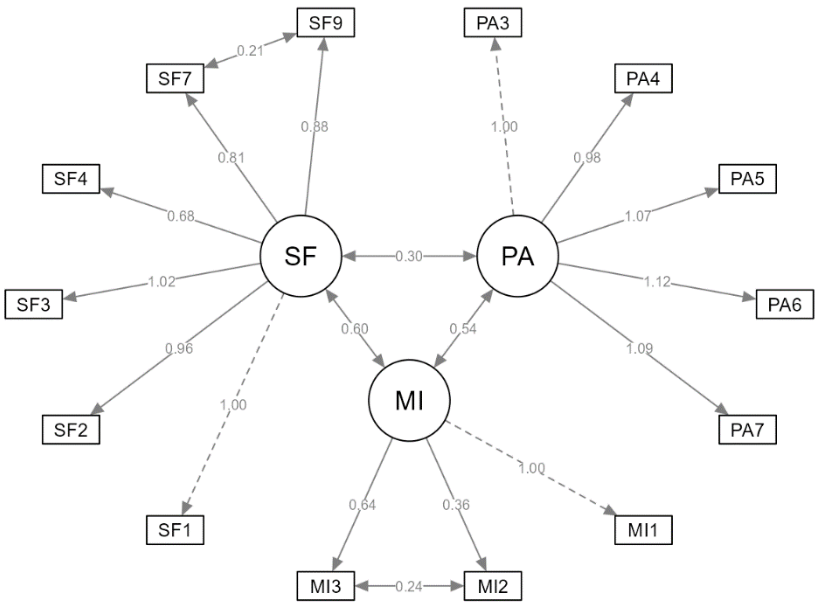

Figure 1. The measurement model (SF = Students Feeling toward Math Teachers, MI – Math Interest, PA – Perceived Math Ability)

Model Validation: We calculated the reliability (composite) and validity (convergent and discriminate) measurements in CFA to meet the structural model's good fitting indexes. Composite reliability is more appropriate than Cronbach's alpha reliability (Hair et al., 2017). The external loads should exceed .708 so that the AVE > .50 indicates good convergent validity (Hair et al., 2017). All reliability and validity values were determined (Jorgensen et al., 2022) and represented in Table 7. According to the reliability indices (see Table 7), the Composite and Cronbach alpha reliability values greater than .7 indicated good reliability. Our analysis produced a greater CR than .7 and a greater AVE than .5 (50%) for each factor, indicating acceptable values for convergent validity (Awang, 2015; Hair et al., 2017). However, for Factor 2 (Math Interest), the reliability value was close to the acceptable value.

Table 7. Composite reliability and validity values

Variable	Cronbach α	CR	AVE
Factor1- Perceived Ability	.906	.906	.660
Factor2- Math Interests	.732	.661	.495
Factor3- Students' Feelings	.898	.881	.592

AVE- Average Variance Extracted; CR-Composite Reliability

Evaluated on the measurement scale level, discriminant validity is commonly evaluated by checking if factor pair correlations are sufficiently below one (in absolute value) that the latent variables likely represent two distinct constructs (Rönkkö & Cho, 2022). Rönkkö and Cho (2022) presented the rule of achievement discriminant validity that the AVEs of the two factors are greater than the square of the HTMT ratio of correlations for every factor pair. Therefore, according to the findings in Table 8, we achieved acceptable discriminate validity.

Table 8. Heterotrait-Monotrait ratio of correlations (HTMT)

Comparison Pairs	Correlations	Square of Ratio
Factor1 ←→ Factor2	.599	.359
Factor1 ←→ Factor3	.409	.167
Factor2 ←→ Factor3	.625	.390

In discussion, the limited diversity of cultural perspectives in the research on the relationships among students' perceptions, interests, and engagement in math motivated us to explore the phenomenon among K-12 students in Kazakhstan. Thus, our research fills a gap in understanding how students think about math based on their cultures (Matabane & Machaba, 2024).

Students' Mathematical Abilities, Interests, and Teacher Feelings

Our findings indicate that students generally held negative perceptions regarding their mathematical abilities and interests, while simultaneously expressing more positive views of their math teachers. Notably, variations in students' feelings towards their teachers were evident based on grade levels and community locations. This trend aligns with previous research conducted by Frenzel et al. (2012) and Chen (2022), which documented a decline in students' interest and perceived abilities in mathematics as they advanced through their educational journey. The positive sentiments towards teachers identified in our study echo findings from other contexts, such as those by Li et al. (2022), which revealed that strong student-teacher relationships significantly enhance students' engagement and performance in mathematics.

We suggest that the respectful and supportive nature of students' interactions with their teachers contributed to these positive perceptions. Moreover, it appears that students' positive feelings were directed more toward the teachers as individuals rather than as instructors of mathematics. This separation implies a potential disconnect between students' perceptions of their teachers and the subject matter they teach, likely influenced by their somewhat negative feelings toward their mathematical abilities and interests. A promising avenue for future research would involve further exploring students' perceptions of their math teachers in comparison to their perceptions of teachers in other subject areas.

Differences by Individual Variables

Our analysis revealed few differences among the demographic factors of students. While we did identify specific differences in students' feelings toward their math teachers, perceived mathematical abilities, and interest in math across certain grade level groupings, these differences lacked a discernible or predictable pattern. Notably, we found no significant differences by gender, suggesting that male and female students in Kazakhstan perceive their mathematical abilities and interests equally (Anaya et al., 2022; Catsambis, 1994; Dweck, 2007). This observation reinforces our hypothesis that students tend to view their feelings toward their teachers as relating to the teachers as individuals rather than solely as math instructors.

This finding is consistent with Bandura's (1993) social cognitive theory, which underscores the importance of social interactions in shaping students' self-efficacy and academic outcomes, as further examined by Zimmerman (2000). It is also plausible that students in lower grades utilize different criteria for assessing their feelings toward their teachers compared to those in higher grades. The observed grade level differences may stem more from developmental variations and shifts in expectations rather than being specific to mathematics instruction.

Consequently, a critical direction for future research should explore whether these differences are unique to mathematics or if similar relationships exist across other disciplines. Understanding these dynamics could yield valuable insights into how students' perceptions of their teachers influence their attitudes toward learning in various subjects.

Relationship among Students' Mathematical Abilities, Interests, and Teacher Feelings

Our findings confirmed that our measurement effectively assessed the three anticipated factors: students perceived mathematical abilities, interests, and feelings toward their math teachers. The refined measurement model demonstrated a good fit with our data, validating the relationships among these three constructs. Importantly, the relationship between these factors appears to be reciprocal; while teacher attitudes can significantly influence student outcomes, students' abilities and interests can also shape teachers' perceptions and attitudes. For instance, a classroom filled with high-achieving, motivated students may enhance a teacher's confidence and enjoyment in teaching mathematics, thereby creating a positive feedback loop (Wentzel, 1998). Conversely, teaching a class characterized by low engagement and poor performance may contribute to teacher burnout and foster negative feelings toward the subject matter (Skaalvik & Skaalvik, 2014).

We speculate that the relationships among the three examined variables align with findings in prior research (Rimm-Kaufman et al., 2015; Zhou et al., 2020). This suggests that these interconnections are not unique to mathematics and could likely be observed in studies of other disciplines as well. The association between interest, ability, and feelings toward teachers is strongly related to student learning outcomes and developmental levels, indicating that similar dynamics may be present across various subject areas. Thus, an important direction for future research involves exploring whether these relationships are observable in different educational contexts and disciplines.

Moreover, our analysis highlights that students with higher mathematical abilities tend to exhibit greater interest in the subject. This correlation can be attributed to the self-reinforcing nature of success and enjoyment; as students experience success in mathematics, their confidence and interest increase, leading to further engagement and enhanced abilities (Ma & Kishor, 1997). Additionally, teachers' feelings and attitudes toward mathematics significantly influence their students' mathematical abilities and interests. Teachers who display enthusiasm and confidence in their mathematics instruction are more likely to inspire similar attitudes in their students, contributing to a more positive learning environment (Hattie, 2009).

Limitations and Delimitations

Our first limitation pertains to the possibility that students may have interpreted the questions through perspectives or lenses that differ from our original intent. Although we assumed that students would understand the questions and prompts as we designed them, it is plausible that their responses were influenced by factors unrelated to the study's context. Future research could benefit from incorporating think-aloud protocols, allowing multiple students to verbalize their thought processes and explain their reasoning behind their responses. This approach would provide a clearer understanding of the contexts participants draw upon when answering survey items.

The second limitation involves the considerable variation in teacher personality and student interactions, which may have influenced students' responses. For instance, in smaller, rural elementary schools, students may have developed personal connections with their teachers, leading them to assess their feelings toward their instructors more personally rather than solely in terms of their role as math teachers. This phenomenon may also manifest in earlier grade levels, where math teachers often adopt more nurturing approaches.

A third limitation is the lack of direct knowledge regarding the students' actual mathematical learning experiences, instructional practices, and the nature of their relationships with teachers. Future research could gain insights by including direct observations of teaching practices, focusing on how teachers engage students in mathematics and assess their learning outcomes. Such observations would provide an opportunity to document how teachers form and nurture learning relationships with their students.

On the other hand, the first delimitation involves the potential wide variation in students' perceptions based on their age. We acknowledge that as students mature, their understanding may deepen. However, we did not account for the possibility that increased exposure to school and mathematical instruction could influence students' perceptions over time, leading them to develop different viewpoints. Future research may need to incorporate scaffolded scales that contextualize the potential impact of time and exposure on student responses.

The second delimitation concerns the absence of direct knowledge regarding the teaching styles and personalities of the instructors likely to influence students' perceptions of mathematics and their teachers (Turner & Patrick, 2004). Although we chose not to include observational data in our study design, we recognize, in retrospect, the potential advantages of such observations. Direct observations could enhance our understanding of the relationship between students' perceptions and feelings about mathematics and their teachers and their actual classroom experiences.

CONCLUSION

The established link between students' perceptions and feelings towards mathematics and their teachers has significant implications for their career choices, as well as their academic and professional success (Watt & Goos, 2017). A more nuanced understanding of this phenomenon may serve as a foundation for reforming mathematics education, ultimately enhancing student learning outcomes and attitudes towards mathematics and other STEM-related disciplines. For instance, it is crucial for policymakers and curriculum developers to take into account students' negative feelings towards mathematics, as highlighted in our research. Our findings indicate that certain aspects of this phenomenon are likely influenced by cultural factors, such as gender differences, thus warranting further investigation. We encourage subsequent researchers to expand upon our study by examining the variables associated with student attitudes and feelings towards mathematics and their teachers within various cultural contexts. Such cultural comparisons could be instrumental in comprehensively understanding how students perceive and succeed in mathematics.

The implications of this study are particularly salient for improving mathematics education in Kazakhstan. By underscoring the significant impact of students' self-perceptions, interest in mathematics, and the quality of teacher-student relationships, our research highlights the necessity for targeted interventions aimed at fostering positive self-concepts, cultivating sustained interest, and strengthening supportive classroom environments. Educators should be equipped with strategies to foster strong relationships with their students, design engaging and culturally relevant learning experiences, and promote a growth mindset that enhances students' confidence in their mathematical abilities. Furthermore, educational policies must be attuned to cultural contexts, ensuring that teaching practices are tailored to meet the unique needs of students. Collectively, these findings contribute to ongoing efforts to enhance mathematics education in Kazakhstan and lay the groundwork for future research exploring these dynamics across different cultural and educational landscapes.

Declarations

Author Contribution	:	NZ: Conceptualizing the research, collecting data, and writing methodology. NB: Carrying out statistical analyses and supervising the study. LZ: Writing literature review and contributing methodology. SY: Data analysis results, creation of model, and its fitting analysis. LSN: Formal analysis, visualization, and writing both original and editing.

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Appendix: Survey

A. Demographics

1. What is your age?

2. What is your gender?
   ❍ Male (1)
   ❍ Female (2)
   ❍ N/A (3)

3. What is your grade level?
   ❍ 6th
   ❍ 7th
   ❍ 8th
   ❍ 9th
   ❍ 10th
   ❍ 11th
   ❍ 12th

4. The school that I study in is:
   ❍ Rural
   ❍ Suburban
   ❍ Urban

5. The type of school that I study in is:
   ❍ Private
   ❍ public

B. Survey

1. Perceived mathematical/scientific abilities
   a. You see yourself as a math/science person
   b. Others see you as a math/science person
   c. You really understand math/science assignment
   d. You are confident to do an excellent job on math/science test
   e. You are certain that you can understand the most difficult material presented in the textbook in the math/science course
   f. You are certain that you can master the skills being taught in the math/science course
   g. You are confident that you can do an excellent job on assignments in the math/science course

2. Math and science interests
   a. You are enjoying this math/science class very much
   b. You think this math/science class is a waste of your time
   c. You think this math/science class is boring

3. Students' feelings towards their math and science classroom teachers
   a. Math/science teacher values and listens to students' ideas
   b. Math/science teacher treats students with respect
   c. Math/science teacher treats every student fairly
   d. Math/science teacher thinks every student can be successful
   e. Math/science teacher thinks mistakes are okay as long as all students learn
   f. Math/science teacher treats some kids better than other kids
   g. Math/science teacher makes math/science interesting
   h. Math/science teacher treats males and females differently
   i. Math/science teacher makes math easy to understand