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Mathematics achievement emotions of high school students in Kazakhstan

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Abstract

Emotions such as anxiety, fear, and frustration can interfere with cognitive processing and hinder our ability to learn and perform well on tasks. Mathematics is a school subject that could generate various emotions in students. This study examined mathematics achievement emotions of students across gender, grade level, and academic performance. Data was collected from 246 students using a questionnaire measuring seven emotions: enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom. Results indicated that except for females' higher pride, we did not find differences between males' and females' emotions. Ninth-grade students demonstrated higher anxiety and shame than grade seven and eight students. Finally, students' mathematics exam grades are weakly correlated with all seven measured emotions. Our findings add to the literature by presenting that emotions are contextual. Except for pride, the results clearly indicated that math emotions in our sample are gender irrelevant and further imply that the socio-cultural context of Kazakhstan supports females to compete with their male friends.

Keywords: Emotions, Gender, Grade, High School, Mathematics Achievement, Students

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Emotions play a crucial role in shaping individuals' experiences, perceptions, and behaviors across various domains of life (Fredrickson, 2001; Lazarus, 2006). In the realm of education, emotions have garnered increasing attention as researchers recognize their profound influence on students' learning outcomes and academic achievement (Pekrun et al., 2011; Pekrun et al., 2014). Emotions experienced within the context of mathematics education have emerged as a significant area of investigation due to their potential impact on students' attitudes, engagement, and overall mathematics performance (Goetz et al., 2013). Understanding the nature and extent of mathematics emotions among high school students is essential for designing effective instructional strategies, creating supportive learning environments, and promoting students' mathematical success.

The primary objective of this study is to examine the degree of mathematics emotions among high school students. We aim to explore the range of emotions experienced by students in their mathematics classes, with a particular focus on enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom. By delving into these emotions, we seek to shed light on the intricate interplay between affective

experiences and mathematics learning, thereby enriching our understanding of the emotional landscape in high school mathematics education.

One key aspect that we will investigate is whether there are differences in the experience of these emotions among students. We will explore potential variations in emotional experiences across different demographic groups, including gender and grade level. Gender differences in emotions have been a topic of interest due to the potential role of sociocultural factors and societal expectations in shaping emotional experiences (Else-Quest et al., 2010; Hyde, 2014). Understanding how emotions differ across gender groups can provide valuable insights for educators and policymakers in fostering inclusive and equitable learning environments that cater to the diverse emotional needs of all students.

Moreover, this study aims to establish whether there is an association or correlation between students' mathematics emotions and their test marks in mathematics. By examining the relationship between emotional experiences and academic performance, we can identify potential factors contributing to students' success or difficulties in mathematics (Pekrun et al., 2007; Ramdass & Zimmerman, 2011). This information can guide educators in developing targeted interventions to enhance students' emotional well-being and academic achievement in mathematics.

The findings of this research have significant implications for both theory and practice. From a theoretical standpoint, this study contributes to the growing body of knowledge on mathematics emotions by providing empirical evidence on the prevalence and differentiation of specific emotions among high school students. By expanding our understanding of how emotions manifest in the mathematics classroom, we can refine existing theoretical frameworks and develop more comprehensive models of affective experiences in mathematics education (Pekrun et al., 2011; Schutz et al., 2007).

From a practical perspective, this study offers valuable insights for educators, policymakers, and curriculum designers. By identifying the emotional needs and challenges of high school students in mathematics, we can develop tailored interventions and instructional strategies that foster positive emotions, reduce negative emotional experiences, and ultimately promote students' motivation, engagement, and achievement in mathematics (Pekrun et al., 2014; Putwain et al., 2018). Furthermore, the investigation of gender differences in mathematics emotions can inform efforts to create inclusive educational environments that address the unique emotional experiences and needs of students across gender groups (Else-Quest et al., 2010; Hyde, 2014).

As said in previous paragraphs, this research aims to explore the degree of mathematics emotions among high school students and investigate potential differences across genders and grade levels. This study contributes to our understanding of the complex interplay between affective experiences and academic performance by examining the relationship between mathematics emotions and students' test marks. The outcomes of this research have far-reaching implications for educational practice, offering insights into the design of supportive learning environments that foster positive emotions and promote students' mathematics achievement.

Our broad and systematic literature review yielded no study on emotions and mathematics achievement in Kazakhstan. This makes our study quite significant. Moreover, few studies in Mathematics Education are focused on students' emotions beyond their emotions in problem-solving (Martínez-Sierra & García-González, 2017).

Mathematics is an important academic subject, and students might enjoy mathematics class, feel hopeless during a mathematics test, or worry that they will receive a bad grade (Frenzel, Pekrun, & Goetz, 2007). This research is significant, especially in the social-cultural context relevance for emotional research in mathematics education, provided the present paper intends to fill the gap of studies on Kazak

high school students' emotions in the mathematics classroom. Therefore, this study followed survey design and was guided by the following research questions:

1. What is the degree of mathematics emotions of high school students?
2. Are there differences between the emotions: enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom?
3. Do math emotions differ across gender groups?
4. Do math emotions differ across grade level groups?
5. Is there an association between students' math emotions and their test marks in mathematics?

Emotions in Mathematics Education

Research in mathematics education (ME) has been mainly focused on cognitive factors, while affective ones were ignored before the 70s of the XX century. There is a broader corpus of research since the 1980s on beliefs (Schoenfeld, 1983) or attitudes towards mathematics (Leder, 1987), reported in the revision of Byrd et al. (2022), while emotions started to be analyzed in ME a bit later, about the beginning of XXI century, when Hannula (2012) considers emotions together with attitude in mathematics education, and many evidenced a close relation to mathematical achievement and anxiety (Lipscomb & Lorenzen, 2023; Zan et al., 2006). It was with Mcleod (1992) and its model for an affective domain that emotions were set up on the scene in ME. He defined it as emotional (mood or feeling) responses to mathematics. This author considered beliefs, attitudes, and emotions as components for the affective domain, assigning them differences along intensity and temporal stability (beliefs the least intense and most stable; emotions the most intense and least stable; attitudes, intermediate regarding intensity and stability). In the field of educational psychology, emotions are considered a crucial aspect of education (Pekrun & Linnenbrink-Garcia, 2014) and have been widely studied.

The definitions of emotions consider multiple dimensions such as personal experiences with physiological, cognitive, and behavioral bases; an evaluative outcome; a reaction to a stimulus; and a feeling influenced by culture because of the interaction with others (Shuman & Scherer, 2014). In this paper, we assume emotions as a combination of all of them, emphasizing that the personal experience and the evaluative value towards mathematics can be different in different socio-cultural contexts, so in different countries. Some examples of country differences in emotions are reported by Rodrigues et al. (2017), focused on anxiety towards mathematics of Spanish and Portuguese preservice teachers, being more anxious towards mathematics the first ones, or the requirement of the scale adaptation suggested by Zakariya (2017) when studying the attitude towards mathematics with Nigerian students.

Emotions do have different characteristics, along with valence, temporal stability, situational specificity, and object. Valence refers to personal perceptions of pleasantness and can be positive or negative (McLeod, 1992). It is worth noting that not always positive emotions imply a better learning outcome (Di Martino & Zan, 2015). Temporal stability relates to the durability of the emotion (McLeod, 1992), underlined by affect psychological theories (Eysenck, 1987), which consider fewer stable emotions (i.e., traits) or more stable ones (i.e., states). Situational specificity accounts for the emotion caused in the individual derived from the interactions with others (i.e., agents, objects, tasks) in a specific sociocultural context (Hannula, 2012) where norms, morals, and other social factors are embedded and where the individual is embedded. The last characteristic, object, is what the emotion is focused on, i.e., a topic like mathematics, a situation like an exam, an outcome like succeeding or failing, etc.

One of the core subjects in schools is mathematics; many students indicate emotional experiences

with mathematics. Based on our observations, students may be proud of the high grades they receive in math; they may feel shame when they cannot answer a question or a math test, math concepts may be boring for them, etc. In ME, the object of emotion has to do with mathematics. In Schukajlow, Rakoczy, and Pekrun (2023) literature review, the authors reported that researchers had analyzed emotions respecting different objects such as mathematics topics (i.e., algebra, geometry, etc.), competencies (i.e. problems solving, modeling, etc.), and strategies (i.e., monitoring, drawing, etc.). Besides that, the work of Martínez-Sierra and García-González (2017) reported that a category emerging from the literature review is the analysis of emotions in the mathematics classroom. This is the scenario we are interested in in this study.

At this point, it is pertinent to introduce some theories on emotions. Emotions are feelings expressed with words by the individual, such as anxiety, anger, enjoyment, pride, etc. The different theories, such as the cognitive structure of emotions (OCC, Ortony, Clore & Collins, 1988), assign emotions to stimulus types: consequences of events, actions of agents, and aspects of objects. Besides the control value theory, CVT proposes that achievement emotions are connected to specific antecedents and outcomes (Pekrun, 2006), considering as such, for instance, students' appraisals and expectations about a mathematics task, activity or test (Putwain et al., 2018). These two theories have been used in the literature as a tool to measure emotions.

Measuring emotions with instruments based on OCC is mainly qualitative (Martínez-Sierra & García-González, 2017; García-González & Sierra, 2020). Provided the role played but contexts in emotions and the differences in students' emotions in different countries (Bieleke et al., 2022), it is relevant to perform studies where the provided data can be compared among cultures and countries, that is, that were measured with instruments whose psychometric properties make them reliable and confinable for different languages and cultures (Kim & Lee, 2014; Sanches et al., 2020). We took that into account in this paper to be able to analyze and contrast the student mathematics emotions in different cultural contexts, which requires quantitative methods obtained with a validated instrument.

Emotions in High School Students

The degree of mathematics emotions among high school students has been a topic of interest in educational research. A study by Bieleke et al. (2022) investigated the emotional experiences of high school students in mathematics and found that students exhibit a wide range of emotions, including enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom. This highlights the complex and multifaceted nature of emotions in mathematics education.

Several studies have examined the differences between various mathematics emotions experienced by high school students (Martínez-Sierra, 2017; Plenty & Heubeck, 2013). A study by Linnenbrink-Garcia and Pekrun (2011) explored the distinct emotions students experience in mathematics and identified differences in the intensity and frequency of emotions such as enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom. These findings suggest that emotions in mathematics are not uniform and can vary among students.

There are many studies about the effects of mathematics on preservice teachers or tertiary students, but not that many on high school students. In the literature review on the latter authored by Grootenboer and Mashman (2016), who analyzed studies of quantitative and qualitative nature with New Zealand and Australian students, it is reported that students' feelings towards mathematics are rather related to their success in the subject that the teaching of mathematics is focused on numbers and algorithms, and that girls feel that boys are more competent at mathematics. These authors also reported

that different factors generate students' emotions, most of them falling in the mathematics classroom; the emotions influence learning in both directions, improvement or worsening; and that negative emotions in the student promote the use of low order thinking strategies based in memorization and repetition and are leaning to make mistakes.

Peixoto et al. (2017) reported correlations between math achievement emotions (boredom, hopelessness, anger, anxiety, enjoyment, pride, and relief) experienced in two different settings: classroom and tests for 8th graders. Although they found associations between emotional experiences and math achievement, taken as the class grades, in the structural equations model, they created only anger in test situations, and hopelessness were significant negative predictors of students' math achievement.

Gender differences in mathematics emotions among high school students have also been investigated. A study by Gunderson et al. (2012) examined gender differences in mathematics achievement and emotions and found that female students tend to experience higher levels of anxiety and lower levels of enjoyment in mathematics compared to their male counterparts. These gender differences highlight the importance of considering the unique emotional experiences of both male and female students in mathematics education.

Considering gender, although some authors reported invariancy across gender in the instruments used to measure emotions (Kim & Lee, 2014; Sanches et al., 2020), differences between female and male students were reported in the sense that girls show more negative emotions towards mathematics (Frenzel, Thrash, Pekrun, & Goetz, 2007). Not only in the classroom but also in the homework related to mathematics, correlations are observed between emotions and achievement in Goetz et al. (2012). Although the sample was described by gender, the authors did not do any gender comparisons. In the study of Suparman, Juandi, and Herman (2021), where participants were exposed to a problem-solving experience, the observed effects were a small negative effect on joyful emotion and a small positive effect on depressed emotion. Gender is also a controlling factor in the study of Pekrun et al. (2017), who found that positive emotions (enjoyment and pride) predict high scores in achievement and vice versa, and those negative emotions (anger, anxiety, shame, boredom, hopelessness) predict low scores in achievement, and vice versa. These authors also reported that the low scores predicted negative emotions, while high scores predicted positive emotions, exhibiting loops in these relationships between achievement and emotions.

Several authors have reported that the sociocultural context influences achievement and emotions regarding high school students. In this regard, Tze et al. (2021) analyzed the TIMSS (Trends in International Mathematics and Science Study) data in different countries, finding differences in emotional relationships with achievement in mathematics, for instance, in Germany and the US or Canada. The authors found that enjoyment and boredom mediated these relationships in expected directions, while in other countries, they didn't mediate, and just in a few, the mediation was the opposite. In the work of Frenzel, Thrash, Pekrun, and Goetz (2007), the participants were German and Chinese eighth graders, and higher levels of anxiety, pride, enjoyment, shame, and lesser anger, were shown by Chinese students.

METHODS

This research utilized a quantitative approach (Marzano et al., 2015) to investigate the mathematics achievement emotions of students across gender, grade level, and academic performance. Data was

collected from 246 students through a questionnaire designed to measure seven emotions: enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom. The mathematics teachers administered the questionnaire online through Google Forms during mathematics lessons to students from different grade levels, and their academic performance in mathematics was considered by examining their exam grades. Statistical analyses were conducted to explore differences in emotions across gender, grade level, and academic performance, as well as to examine any correlations between emotions and exam grades.

Participants and Context

We used a convenient sampling method (Farrokhi & Mahmoudi-Hamidabad, 2012) to compose our study group. The first author works as a mathematics teacher in one of the Bilim Innovation Schools (BIL), where we collected data (BIL, 2023). The sample comprises 176 girls and 70 boys in 7-11th grades who voluntarily accepted participation. The data used in this study were collected from students attending five BIL in Almaty-Kazakhstan.

While the schools aim to be open to all segments of the public, they accept students through entrance exams and go through a difficult application process. Entrance exams are held in Russian and Kazakh languages; students take the exam after the 6th grade and graduate from BIL in the 11th grade. Schools are spread across the country (18 different cities), many of which have boarding services. Most schools follow the regular school curriculum of Kazakhstan, while schools with international status follow the Cambridge AS Level and A Level curriculum. Teaching is carried out in four languages: English, Kazakh, Turkish, and Russian; the language of the science courses is English and starts from grade 7. Namely, after graduation, students speak Kazakh and Russian at a native level and speak English and Turkish fluently.

Instrument

The short version of the Achievement Emotions Questionnaire—Mathematics (AEQ-M) developed by Bieleke et al. (2022) was used to collect data. This version of AEQ-M includes 60 items across seven achievement emotion constructs (factors) in the domain of mathematics: enjoyment (10), pride (6), anger (9), anxiety (15), shame (8), hopelessness (6), and boredom (6). Each item is evaluated on a 5-point Likert-like scale where one is not true at all, two is hardly true, three is somewhat true, four is largely true, and five is exactly true. Since the participant already speaks English, at least at the B2 level, and the items are worded in a simple fashion, we did not translate them into Kazakh language. The questionnaire took about 15 min.

Questionnaire Validity

The internal consistency, Cronbach Alpha, of the whole questionnaire in our sample, was 0.970. For each factor of the AEQ-M, the internal consistency coefficient was 0.924, 0.918, 0.803, 0.903, 0.864, 0.848, and 0.837, respectively, for enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom, providing good to excellent values for social sciences.

Data Analysis

The independent variables are grade level and gender, while the dependent ones are the seven emotions (enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom). The score for each dependent variable was calculated by averaging the provided 1-5 responses for each factor, with those that have a negatively stated being reversed (for example, see Núñez et al., 2023).

Descriptive statistics (mean, standard deviation) were provided, and the data's normality for the

questionnaire's dimensions was checked through Shapiro-Wilk Test. Because of the lack of normality ($p<0.05$), non-parametric tests were used for the dependent variables (Montgomery & Runger, 2010).

A line graph was constructed to visualize differences in students' emotions across grade levels. Statistically significant changes between different emotions were determined through Kruskal-Wallis's test. Similarly, the differences in each emotion across grade levels were also tested with Kruskal-Wallis Test. Dwass-Steel-Critchlow-Fligner pairwise comparisons were conducted to identify the significant differences between pairs of grade levels; for the differences in the emotions across gender groups Mann-Whitney U Test was done. Finally, relationships between the seven emotions and students' math exam marks were tested with Spearman's rho. All the statistical analyses are done with Jamovi 2.2.28 version (The Jamovi project, 2022).

RESULTS AND DISCUSSION

Results of this study are organized according to the research questions.

RQ1: What is the degree of mathematics emotions of high school students?

Students' average scores on each dimension of the questionnaire are presented in Table 1. There were seven dimensions (each for a different psychological emotion). For the rest of the paper, we will use the word "emotions" for the dimensions of the questionnaire.

Table 1. Mean, standard deviation, and p-value for the normality test of each emotion of the questionnaire

	Enjoyment	Pride	Angry	Anxiety	Shame	Hopelessness	Boredom
N	246	245	245	245	246	246	245
M	3.02	3.06	3.81	3.50	3.69	3.65	3.83
SD	0.981	1.04	0.935	0.979	1.05	1.08	1.06
Shapiro-Wilk p-value	0.005	< .001	< .001	< .001	< .001	< .001	< .001

Note: M= Mean, SD= Standard deviation, and p-value= significance of the statistical tests

Since the answer could go from 1 to 5, data in Table 1 indicate that students' enjoyment in math is the least emotion (M=3.02) while boredom in math is the highest (M=3.83). In other words, among the seven emotions, our sample showed boredom with the highest score. Since students have different mean scores on each emotion, further analysis is needed. Besides, the p-value in the normality test indicated that all the emotions follow a non-normal distribution, so non-parametric inferential statistics will be used for each emotion.

The fact that among all negative emotions, our sample indicated boredom the most can be attributed to the intensive math curriculum. In BIL schools, grades 7-9 study algebra for 3 hours a week and geometry for 1 hour, a total of 144 hours in a full academic year. As for the senior classes, grades 10-11 study algebra for 4 hours a week and geometry for 2 hours, a total of 216 hours in the academic year. Educators must

handle the high boredom because students who feel uncomfortable with their low grades on a test might not be interested in pursuing help when facing trouble in solving a problem in mathematics.

RQ2: Are there differences between the emotions: enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom?

Kruskal-Wallis test was used to find whether there is a statistically significant difference among the emotions (Table 2).

Table 2. Kruskal-Wallis test for the differences between the emotions in math

	χ^2	df	p	ε^2
Score	162	6	< .001	0.0944

There are statistically significant differences between the emotions in mathematics ($p<0.05$). To determine whether students' pairs of emotions are different, Dwass-Steel-Critchlow-Fligner pairwise comparisons were conducted (Table 3).

Table 3. Pairwise comparisons for the scores on the emotions

Pairs		W	p	Pairs		W	p
Enjoyment	Pride	0.706	0.999	Angry	Anxiety	-5.1	**0.006**
Enjoyment	Angry	12.249	**< .001**	Angry	Shame	-1.511	0.937
Enjoyment	Anxiety	7.557	**< .001**	Angry	Hopelessness	-1.818	0.859
Enjoyment	Shame	10.226	**< .001**	Angry	Boredom	1.313	0.968
Enjoyment	Hopelessness	9.655	**< .001**	Anxiety	Shame	3.468	0.177
Enjoyment	Boredom	12.354	**< .001**	Anxiety	Hopelessness	2.791	0.432
Pride	Angry	11.346	**< .001**	Anxiety	Boredom	5.827	**< .001**
Pride	Anxiety	6.749	**< .001**	Shame	Hopelessness	-0.459	1.000
Pride	Shame	9.503	**< .001**	Shame	Boredom	2.454	0.592
Pride	Hopelessness	8.889	**< .001**	Hopelessness	Boredom	2.91	0.378
Pride	Boredom	11.47	**< .001**				

Note: $p<0.05$ implies statistical significance for the differences and is highlighted in bold

The statistically significant differences in Table 3 indicate, on the one hand, that enjoyment is different from the other emotions, as well as pride. On the other hand, anxiety is different from anger and boredom. Therefore, it can be summarized as follows: (1) students' enjoyment (M=3.02) and pride (M=3.06) emotions are statistically lower than other emotions, or in other words, negative emotions are more intense than these two; (2) among negative emotions, students' anxiety (M=3.50) is lower than both angry and boredom. We then further analyzed if students' emotions against mathematics differ according to gender and grade level.

RQ3: Do math emotions differ across gender groups?

We first checked the change of emotions across gender groups through Mann-Whitney U Test (Table 4).

Table 4. Comparison of the emotions according to gender groups

		Statistic	p		Effect Size
Enjoyment	Mann-Whitney U	5487	0.627	Rank biserial correlation	0.04
Pride	Mann-Whitney U	4597	**0.029**	Rank biserial correlation	0.18
Angry	Mann-Whitney U	5334	0.531	Rank biserial correlation	0.05
Anxiety	Mann-Whitney U	5229	0.397	Rank biserial correlation	0.07
Shame	Mann-Whitney U	5698	0.963	Rank biserial correlation	0.004
Hopelessness	Mann-Whitney U	5498	0.644	Rank biserial correlation	0.04
Boredom	Mann-Whitney U	5387	0.605	Rank biserial correlation	0.04

Note: $p<0.05$ implies statistical difference in the means for gender and is highlighted in bold

Table 4 indicates that male and female students' emotions are statistically different only in pride ($p<0.05$). In other words, female students' pride in mathematics is higher than that of male students, with a small effect size close to 0.2.

For example, for gender groups, except for pride, we did not find differences in other math emotions. Namely, we found that female students' pride in mathematics was higher than that of male students, but no differences were detected for enjoyment, anger, anxiety, shame, hopelessness, and boredom. This finding contradicts many other studies that indicated differences in mathematics-related emotions. For example, Plenty and Heubeck (2013) showed that females possess meaningfully more mathematics anxiety than males. In their meta-analysis comparing many nations, Else-Quest et al. (2010) indicated that females in about 95% of the OECD countries showed higher levels of mathematics anxiety than males. Frenzel, Pekrun, and Goetz (2007) showed that compared to males, female students have more hopelessness, anxiety, and shame and less enjoyment and pride in mathematics learning. Pekrun

et al. (2017) reported that even though females achieve as well as males in math, they indicate less enjoyment and more anxiety and shame.

The unique result we obtained from gender groups might stem from the nature of our sample. There is no coeducation in BIL schools; girls and boys are educated at different schools. This may affect students' emotions because girls alone and boys alone may feel better in their gender-free environments. For example, Zulkiflee and Nimehchisalem (2022) found that female students' speaking anxiety was significantly higher in co-educational schools. Moreover, why girls' pride is higher than that of boys can be attributed to gender characteristics. Studies indicate that males' math achievements are higher than that of females (Liu & Wilson, 2009). Thus, we hypothesize that females immediately take pride in their success once they achieve something in math. This finding can also be explained by Kazakh sociocultural aspects. According to the Kazakh tradition, boys are more responsible in the family, and girls are pampered more (Kuzhabekova et al., 2018). Therefore, when girls achieve something, they openly demonstrate it, and boys perceive it as normal.

RQ4: Do math emotions differ across grade-level groups?

Students' emotions across grade levels are analyzed through the visual presentation in Figure 1 and through Kruskal Wallis test in Table 5.

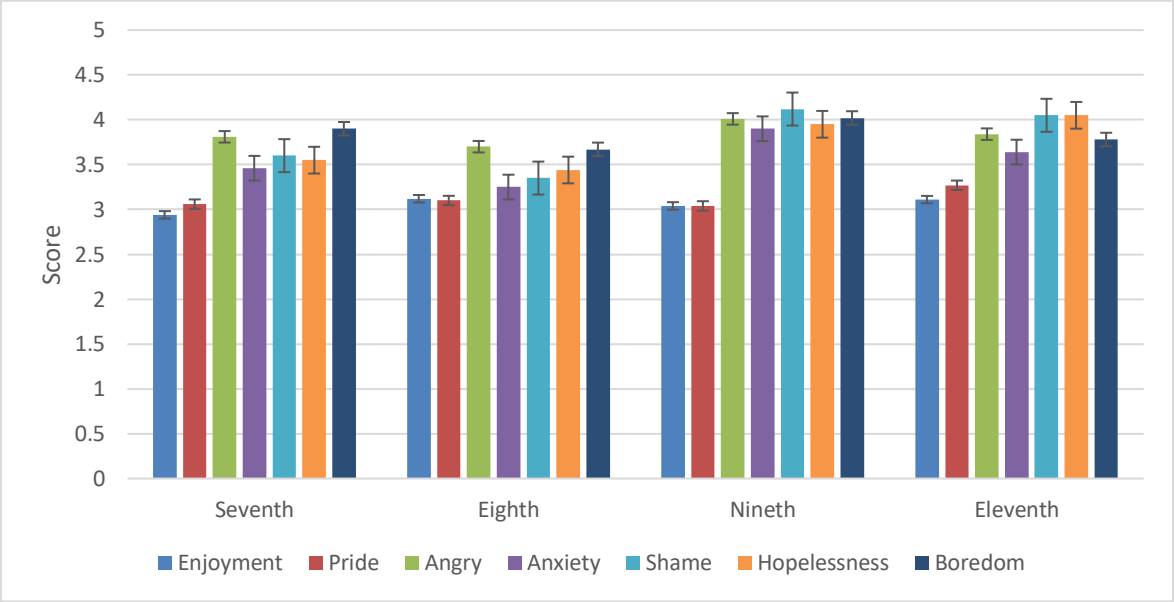

Figure 1. Emotions across grade levels

Figure 1 shows that students' enjoyment of math is the least in all grades, and anger and boredom are the emotions that score the highest for all grades. Moreover, there is an increase in negative emotions from lower grades toward upper grades. In other words, as students learn more math, the emotions of anxiety, hopelessness, shame, anger, and boredom increase. Finally, the variability is high in all the emotions, and the highest is a shame. Namely, shame scores across the grade levels differ greatly from other emotions.

Table 5. Kruskal-Wallis test for the grade level and emotions

	χ^2	df	p	ε^2
Enjoyment	2.59	4	0.628	0.01070
Pride	1.40	4	0.843	0.00583
Angry	2.55	4	0.637	0.01056
Anxiety	13.66	4	**0.008**	0.05667
Shame	20.12	4	**< .001**	0.08314
Hopelessness	9.87	4	**0.043**	0.04080
Boredom	3.76	4	0.439	0.01561

As seen in Table 5 for three emotions, anxiety, shame, and hopelessness, students' scores significantly change across grade levels. To reveal the significant differences between groups, we executed pairwise comparisons through the Dwass-Steel-Critchlow-Fligner test. The significant results from this test can be summarized as (1) ninth graders are more anxious than seventh and eighth graders in math classes, (2) ninth graders are shyer than seventh and eighth graders in math classes, (3) even though Kruskal Wallis test (Table 5) indicated a significant difference between at least two grade levels, pairwise comparisons did not indicate any differences for hopelessness.

We observed the highest variability across grade levels. Ninth-grade students indicated the highest amount of shame. This can be explained within the Kazakhstan context. Education in Kazakhstan switched to a system of criteria-based assessment on September 1, 2013. Until 2013, there was a 5-point grading system formed by the Soviet Union, and the training requirements were based on evaluation, not learning outcomes. Consequently, students and their parents agreed that the assessment indicates knowledge. Therefore, many parents still require a good assessment from their children to indicate knowledge. Hence, it is a "shame" to receive low grades; that is, the student believes that if he/she received a low grade, then he/she has no knowledge of a particular subject, and he/she did not justify the parents' hope. In many families still, knowledge is valued, not its application and necessity.

RQ5: Is there an association between students' math emotions and their test marks in mathematics?

Finally, we searched for the correlation among the seven emotions as well as the relationship between each of these emotions and students' math exam marks (Table 6). Because of the non-normal distribution of our data, we calculated Spearman's rho for the correlation coefficients, as indicated in the data analysis.

Significant correlations were detected between some variables of interest. The findings are organized by emotion, starting with the one with the most significant correlations. Boredom strongly correlated with anger (r=0.678) and hopelessness (0.633), moderately correlated with anxiety (0.531)

and shame (0.472), and weakly correlated with enjoyment (0.316) and pride (0.116). Hopelessness strongly correlated with shame (r=0.799) and anxiety (0.775), moderately correlated with anger (0.588), and weakly correlated with enjoyment (0.202). Shame strongly correlated with anxiety (r=0.787), moderately correlated with anger (0.509), and weakly correlated with enjoyment (0.152). Anxiety moderately correlated with anger (0.648). Angry weakly correlated with enjoyment (0.300). Pride strongly correlated with enjoyment (0.763). Finally, students' marks in mathematics are weakly correlated with all emotions. In other words, as students' exam marks increase, their positive emotions (enjoyment and pride) and their negative emotions (anger, anxiety, shame, hopelessness, and boredom) increase.

Table 6. Correlation between the seven emotions and the math exam marks

		Enjoyment	Pride	Angry	Anxiety	Shame	Hopelessness	Boredom
Pride	r	0.763	—					
	p	**< .001**	—					
Angry	r	0.300	0.116	—				
	p	**< .001**	0.07	—				
Anxiety	r	0.133	0.026	0.648	—			
	p	0.038	0.69	**< .001**	—			
Shame	r	0.152	0.086	0.509	0.787	—		
	p	**0.017**	0.18	**< .001**	**< .001**	—		
Hopelessness	r	0.202	0.08	0.588	0.775	0.799	—	
	p	**0.001**	0.213	**< .001**	**< .001**	**< .001**	—	
Boredom	r	0.316	0.141	0.678	0.531	0.472	0.633	—
	p	**< .001**	**0.028**	**< .001**	**< .001**	**< .001**	**< .001**	—
Mark	r	0.33	0.327	0.249	0.267	0.276	0.31	0.21
	p	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**0.002**

Note: p<0.05 implies significance in correlation factors (bold)

For instance, consistent with Pekrun et al.'s (2017) study, the findings of this research showed evidence for the relationship between students' exam marks and their both positive (enjoyment and pride) and negative (anger, anxiety, shame, hopelessness, and boredom) emotions. Our findings are also in line with several other studies; Kim et al. (2014) indicated a positive relationship between anger and math performance, Goetz et al. (2008) indicated a similar relationship between enjoyment and exam marks; Luo et al. (2014) reported the positive relationship between pride/anxiety and math achievement; Tee, Leong, and Rahim (2018) found that low-performing group of students were less confident and motivated, high anxious, and less engaged in self-reflection as compared to the high-performing counterparts.

However, our results contradict the finding of Wu et al. (2014), who reported no significant relationship between anxiety and mathematics performance in a sample from the USA. Similarly, Holm et al. (2017) disclosed that students who perceived their mathematics performance as ineffective indicated fewer positive emotions and more negative emotions than students who thought their skills in math as successful, but our findings are different. Moreover, Peixoto et al. (2017) found a relationship between feelings of anger in test situations and hopelessness in both tests and classes.

We found that anxiety, hopelessness, shame, anger, and boredom increase as students learn more math. This needs explanation. In Kazakhstan, mathematics is taught in accordance with the unified mandatory curriculum of education. According to the curriculum, mathematics is taught 5 hours a week. Starting from the 7th grade, mathematics is divided into algebra and geometry - two separate subjects. The content of the curriculum is extensive, trying to cover all the topics specified in the standard fully. Therefore, more attention is paid to theoretical material. The tasks in the textbook are mainly devoted to the reproductive method, i.e., solving problems according to a certain algorithm (mechanically). There are few tasks requiring a creative approach or applied tasks. All of these result in an increase in negative emotions in math class.

We found that for three emotions, anxiety, shame, and hopelessness, students' scores significantly change across some grade levels. For example, ninth graders are more anxious than seventh and eighth graders in math lessons. This is probably because, in ninth grade, students prepare for a national exam requiring intense math preparation. In ninth grade, they learn new and relatively difficult topics such as trigonometry, binomial expansion, arithmetic, geometric series, etc. (Balta et al., 2021).

CONCLUSION

Our study examined different math emotions, positive or negative, of high school students in Kazakh in a sample of 246 high school students, whether emotions differ among them, and whether emotions change with gender and grade. Regarding question 1, enjoyment in math is the least emotion, while boredom in math is the highest. Regarding differences in emotions (question 2), students' enjoyment and pride emotions are statistically lower than the other emotions, or in other words, negative emotions are more intense than positive ones, and, among negative emotions, students' anxiety is lower than anger and boredom. Regarding question 3, for gender groups, except for pride, we did not find differences in the other math emotions. Moving on, the level of each emotion varies across grade levels, rising with grades both positive and negative emotions (regarding question 4), and with respect to question 5, students' marks in mathematics are weakly correlated with all emotions in such a way that when exam marks increase two positive emotions (enjoyment and pride), and the negative emotions (angry, anxiety, shame, hopelessness, and boredom) increase too, showing a positive correlation.

This study has several limitations that should be considered when interpreting the results. First, our sample consists of students from a group of private schools in Kazakhstan, so other samples in Kazakhstan may indicate different math emotions. Second, it is open to question whether the present findings would be valid for other school levels, such as primary or university students.

Future research may consider the origins of students' emotions. New research could discover how math emotions are related to student's academic success and skills. Furthermore, future research can discover if these findings generalize to emotions in subjects other than mathematics. To discuss emotions, it is not enough to only use quantitative data in the form of numbers, as emotions involve many factors and variables that influence them. We suggest future qualitative studies with interviews to support quantitative results.

Three significant messages follow from this study. First, the results clearly indicate that math emotions are gender irrelevant and further imply that the socio-cultural context of Kazakhstan supports females to compete with their male friends. Second, the results imply that the ninth-grade curriculum should be examined in terms of intensity and content to reveal why ninth-graders are more anxious and shyer when compared to seventh or eighth-graders. Third, the finding that students' negative emotions are stronger than positive emotions implies that teacher attitudes, course content, tasks assigned to students, teaching method, assessment types, and school environment should be reevaluated by educational leaders because negative feelings can lead to a failure which is something that should be avoided at all costs in educational settings.

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