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Girls and mathematics – A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics

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This study analyzed gender differences in achievement emotions in the domain of mathematics. Based on Pekrun's (2000, 2006) control-value theory of achievement emotions, we hypothesized that there are gender differences in mathematics emotions due to the students' different levels of control and value beliefs in mathematics, even when controlling for prior achievement. The structural relationships between prior achievement, control and value beliefs, and emotions were assumed to be invariant across girls and boys in spite of hypothesized mean level differences of beliefs and emotions across genders. The emotions and beliefs of 1,036 male and 1,017 female 5th grade students were assessed by self-report measures, and their prior mathematics achievement was assessed by academic grades. Even though girls and boys had received similar grades in mathematics, girls reported significantly less enjoyment and pride than boys, but more anxiety, hopelessness and shame. Findings suggested that the female emotional pattern was due to the girls' low competence beliefs and domain value of mathematics, combined with their high subjective values of achievement in mathematics. Multiple-group comparisons confirmed that the structural relationships between variables were largely invariant across the genders.

It is a widespread belief among students, teachers, and parents alike that girls and mathematics are a "bad fit". Researchers from a wide range of disciplines have long been

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concerned with the potential psychological, biological, and social reasons for gender differences in mathematics (e.g., Gallagher & Kaufman, 2005). Recent findings of gender differences display a striking pattern of small and declining differences in mathematics achievement, but consistent and considerable differences in the affective domain (e.g., Organisation for Economic Co-operation and Development (2004a). In the latter context, much research attention has been directed towards girls' and boys' judgments of competence, self-efficacy expectations, or expectations for their future performance in a given domain (e.g., Bandura, 1997; Covington, 1984; Eccles, Wigfield, & Schiefele, 1997; Nicholls, 1990).

Less attention has been paid to *emotional variables* in the context of learning and achievement. However, we can assume that emotions – our "hot" cognitions – are prevalent and influential in such situations. Recent research indicates that students experience a wide range of emotions in the context of learning and achievement. It is acknowledged that emotions are highly relevant and important in learning and achievement situations, as indicated by three recent special issues on emotions and learning in the *Educational Psychologist* (Schutz & Lanehart, 2002), in *Learning and Instruction* (Efklides & Volet, 2005), and in the *Educational Psychology Review* (Linnenbrink, 2006), and one edited volume (Schutz & Pekrun, 2007). In this context, the most extensively researched emotion has been anxiety (Hembree, 1988; Zeidner, 1998). The subject of mathematics in particular has been found to elicit anxiety in students (Ashcraft, 2002; Ma, 1999; Wigfield & Meece, 1988). Pekrun, Goetz, Titz, and Perry (2002) reported that emotions typically experienced by students include task- or activity-related feeling states such as task enjoyment, and emotions which relate to learning outcomes, such as pride, shame, anxiety, and hopelessness. However, emotions other than anxiety have received conspicuously little attention in research on learning and achievement, with the exception of research on the attributional antecedents of achievement emotions (Weiner, 1985, 1994).

We believe that there are at least three reasons why studying emotions in learning and achievement is important. *First*, emotions are important dependent variables in their own right, since they are key components of subjective well-being and psychological health (e.g., Diener, 2000). *Second*, emotions impact students' learning and achievement. High quality learning is time-consuming and effort-intensive. Learners are more willing to invest such effort if learning activities are affectively rewarding – that is, enjoyable and interesting rather than anxiety-laden or boredom-inducing. Moreover, emotions influence learning by changing dopamine levels in the brain, thereby affecting long-term memory (Ashby, Isen, & Turken, 1999); by directing attentional processes and the use of cognitive resources (Meinhardt & Pekrun, 2003); by inducing and sustaining student interest in learning material (Ainley, Corrigan, & Richardson, 2005; Krapp, 2005); by triggering different modes of information processing and problem solving (Isen, 1999); and by facilitating or impeding students' self-regulation of learning and performance (Pekrun et al., 2002). *Third*, while a student's cognitive competencies predict success at learning, affective variables better predict whether or not the student actually enrolls in courses or pursues a career in a given domain (Harackiewitz, Barron, Tauer, Carter, & Elliot, 2000; Wigfield, Battle, Keller, & Eccles, 2002). That is, if students are emotionally attracted by the content of a domain, they become keen to learn more about this domain, and decide to follow a career in this domain.

The importance of emotions for educational and occupational career choices makes emotion-related gender differences in mathematics particularly relevant. Significant progress has been made in reducing the gender gap in formal education, as indicated by gender equality in graduation rates in many of the OECD member countries (OECD, 2004b). This progress notwithstanding, gender differences in tertiary qualifications remain persistently high in mathematics and computer science. On average, in the OECD countries only 30% of the university graduates in mathematics and computer science are female (OECD, 2004b). Because of the importance of emotions for career goal choices, inquiry on gender differences in emotional experiences is of crucial relevance if one wants to design interventions aiming to increase the number of women entering careers in traditionally male, socially recognized and economically important job domains.

In the present study, we focused on gender differences in five distinct mathematics emotions, namely enjoyment, pride, anxiety, hopelessness, and shame. In doing so, we attempted to describe and explain girls' and boys' patterns of emotions in mathematics. Furthermore, we wanted to identify appraisal antecedents of mathematics emotions which might be responsible for gender differences in these emotions.

Gender differences in mathematics-related affect

Gender differences in affective variables relating to mathematics moved to the center of research interest since the Fennema-Sherman studies in the 1970s (Fennema & Sherman, 1977, 1978). Variables that have been extensively researched include confidence, perceived usefulness, math as a male domain, and attitude towards math success. All of these variables reflect a pattern of self-related cognitions and affect which is more favorable for boys in terms of learning and practicing mathematics. A meta-analysis by Hyde, Fennema, Ryan, Frost, and Hopp (1990) showed that gender-based discrepancies of affect in mathematics are prevalent and of considerable size.

In the literature on gender differences in mathematics, emotions are typically discussed rather generally in terms of the positive vs. negative valence of experiences related to learning mathematics. For example, Eccles, Adler, Futtermann, Goff, Kaczala, Meece, and Midgley (1983) emphasized the importance of "affective experiences in mathematics" (p. 96). Similarly, Brush (1985) spoke of a "feelings factor" in mathematics learning. She operationalized this factor as the combination of students' assessments of mathematics as being easy *vs.* difficult, enjoyable vs. anxiety-provoking, and creative vs. dull. According to Brush, this "feelings factor" was highly predictive of the level of students' course preferences. However, in her study, she did not separate different emotions. Consequently, it seems that emotions have so far been studied as constituents of more global factors in the context of gender differences in mathematics attitudes, but not as distinct constructs in their own right.

Concerning potential gender differences in discrete mathematics emotions, the only variable which has been researched extensively is mathematics anxiety. Various studies showed that girls tend to be more anxious than boys during mathematics tasks and in contexts involving mathematical thinking. In Hyde, Fennema, Ryan, et al.'s (1990) meta-analysis on gender differences in mathematics affect, the difference in math anxiety yielded an overall Cohen's *d* of .15.

One study that explicitly addresses mathematics-related emotions other than anxiety is Stipek and Gralinsky's (1991) study on gender differences in emotional responses to success and failure in mathematics. This study was conceptually based on Weiner's (1985) attributional theory which posits that discrete emotional experiences are elicited by the attributions for success and failure endorsed by the student. Stipek and Gralinsky's (1991) data indicated that girls showed a "female" attribution bias by attributing failure to low ability, and not attributing success to high ability. Girls were further found to report less pride after success and a stronger desire to hide their paper after failure, a behavior interpreted as representing feelings of shame. This study thus suggested that girls tend to experience a more negative emotional pattern in mathematics, beyond the well-researched emotion of anxiety.

The control-value theory of achievement emotions

Our theorizing on emotions is grounded in an appraisal theoretical approach which posits that interindividual differences in emotions are due to differences in the cognitive interpretations of situations and events (e.g., Scherer, Schorr, & Johnstone, 2001). Specifically, we base our assumptions on gender differences on Pekrun's control-value theory of achievement emotions (Pekrun, 2000, 2006; Pekrun et al., 2002). The theory postulates that appraisals pertaining to achievement activities and their outcomes are of primary importance for the instigation of achievement emotions. More specifically, control-related appraisals (such as, competence beliefs, causal expectations, and causal attributions) and value appraisals are held to be most

important. The theory integrates assumptions from expectancy-value (Pekrun, 1992; Turner & Schallert, 2001) and attributional approaches (Weiner, 1985) to achievement-related emotions.

In the present study, concerning control appraisals, we specifically concentrated on the students' subjective competence beliefs in mathematics, i.e., subjective generalized judgments concerning how competent one is at performing demanded tasks. Apart from causal expectations and attributions, such competence beliefs should be of high importance in academic contexts such as school mathematics.

In regard to value appraisals, we considered two categories addressed by the control-value theory: (1) beliefs regarding the intrinsic values of the domain under consideration; and (2) beliefs regarding the value of achievement outcomes in this domain (see also Eccles et al., 1983, for a conceptual discussion of subjective values of academic tasks). For example, a student may like the subject of mathematics because he or she appreciates the formal nature of mathematics and the action of dealing with figures. We label this the (intrinsic) *domain value* of mathematics. Another student may be more concerned with performing well in mathematics in order to increase career options, to meet parents' expectations, or to attain personal achievement standards. We call this *achievement value* of mathematics.

We consider these two core value dimensions to be conceptually orthogonal. That is, even though these two types of values may be closely connected in many individuals, there may also be students who have high values of a domain, but regard achievement in the same domain as less important, or vice versa.

Regarding the effects of these appraisals on achievement emotions, the control-value theory would generally predict that high competence beliefs will be associated with higher levels of the positive emotions enjoyment and pride. Conversely, the belief that one is incompetent should be related to the negative emotions anxiety, hopelessness, and shame. Concerning the effects of value beliefs on achievement emotions, the theory implies that domain values should be positively related to activity-related emotions such as task enjoyment. In contrast, achievement values should be positively related to any outcome emotion, positive or negative (such as, pride, anxiety, hopelessness or shame). That is, if achievement is important, both positive and negative feelings relating to success and failure are enhanced.

In sum, we expected that enjoyment should result from a pattern of appraisals combining favorable judgments of competence with high domain values, whereas pride should result from a combination of favorable judgments of competence and high achievement values. Anxiety, hopelessness, and shame, on the other hand, should result from low competence beliefs, combined with high values of achievement (Abela & Seligman, 2000; Hembree, 1988; Pekrun, 1992).

Assumptions concerning the interplay of gender, prior achievement, beliefs, and emotions in mathematics

Gender differences in beliefs and emotions and a mediation assumption. There is cumulative evidence that girls tend to have lower competence-related beliefs in mathematics by the end of primary school (Hyde, Fennema, Ryan, et al., 1990). Therefore, we assumed that girls would be less confident in their competence judgments in mathematics in grade five, the age group under study here. Furthermore, in line with the findings of Hyde, Fennema, Ryan, et al., we expected girls to perceive the subject of mathematics as less valuable, that is, having a lower domain value. However, in recent years adolescent girls seem to have adopted similar perceptions as boys concerning the importance of performing well in mathematics (e.g. Meece, Wigfield, & Eccles, 1990; Mullis, Martin, Fierros, Goldberg, & Stemler, 2000; Wigfield et al., 1997). Thus, we expected that girls would have the same subjective value of achievement in mathematics as boys. In sum, girls were expected to judge their mathematics competence as being relatively low and the subject of mathematics as being unattractive, while being aware of the importance of attaining good grades in this subject.

Applying the control-value theory, we predicted that this female pattern of competence and value appraisals would lead to a debilitating emotional profile. This profile should be characterized by more anxiety, hopelessness and shame due to the girls' comparably lower

control beliefs, but equally high achievement values as compared to boys. Furthermore, the theory would also imply that girls would experience less enjoyment in mathematics, due to their low competence beliefs and low domain values. Finally, in spite of expected similar levels of achievement values which should be important for the formation of pride, we assumed that the lower competence beliefs in girls reduce their experienced pride in relation to mathematics. In other words, when they do not believe they are doing well in mathematics, girls should have less to be proud of in this subject as compared to boys.

Thus, the control-value theory suggests that gender differences in mathematics emotions are due to girls' and boys' differential patterns of appraisals relating to mathematics. By implication, we assumed that the effects of gender on mathematics emotions are mediated by these appraisals (see Figure 1a).

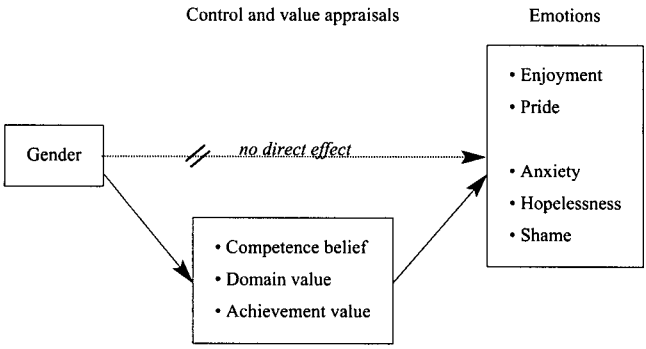

Figure 1a. Effects of gender on achievement emotions by control and value beliefs: Mediation.

Prior achievement as a covariate. Since gender differences in mathematics achievement have declined in recent years and tend to remain substantial only at the high school and university levels (for meta-analyses, see Hyde, Fennema, & Lamon, 1990; Leahey & Guo, 2001; Linn & Hyde, 1989), we did not expect any large differences in mathematics achievement in our target population (grade five). However, prior academic achievement can be considered as an important antecedent of individual competence beliefs, and, therefore, of students' emotional experiences. In order to ensure that gender differences in beliefs and emotions were not confounded by prior achievement, we considered it important to include this variable as a covariate.

Gender universality of relationships between variables. In the control-value theory, it is assumed that the functional relationships between emotions, appraisals, and achievement are universal across genders and cultures, with few exceptions (see Scherer, 1999). In the domain of mathematics, universality assumptions are supported by findings reported by Meece et al. (1990), as well as by Seegers and Boekaerts (1996). Using path analytical procedures, Meece et al. (1990) showed that the pattern of relationships between student attitudes (including expectancies for success, subjective values, and perceived ability), math anxiety, and achievement were very similar for boys and girls. Similarly, Seegers and Boekaerts (1996) found no gender differences in the relations between self-related cognitions, task-specific beliefs, and mathematics performance. In contrast, evidence suggesting that gender can function as a moderator of relations between cognitive-affective variables is limited (see Meyer & Koehler, 1990; Zeidner & Safir, 1989). Therefore, even though we did expect mean level differences in beliefs and emotions between girls and boys, we assumed that the relationships between prior achievement, students' beliefs, and their emotions would be universal, that is, they should function similarly across genders. By implication, we did not expect that gender would function as a moderator of these relationships (see Figure 1b).

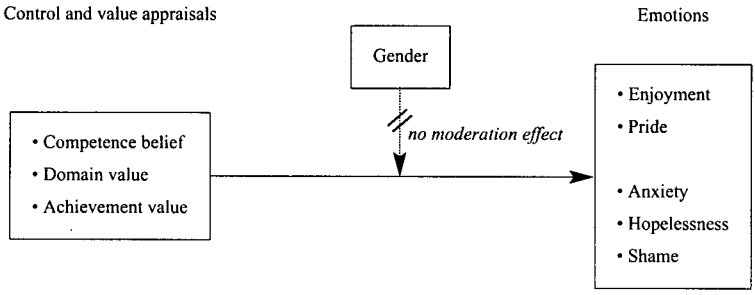

Figure 1b. Gender universality of the relationships between control and value beliefs and achievement emotions: No moderation.

To summarize, the following hypotheses were tested in the present study.

Hypothesis 1. There are gender differences in discrete emotions experienced by students in mathematics, with girls showing a more negative pattern of emotions than boys (less enjoyment and pride, and more anxiety, hopelessness and shame).

Hypothesis 2. Girls have lower competence beliefs and domain values in mathematics than boys, but there are no gender differences in the value of achievement in mathematics.

Hypothesis 3. The gender differences in mathematics emotions are mediated by gender differences in competence and value beliefs.

Hypothesis 4. The relationships between prior achievement as well as competence and value beliefs, on the one hand, and emotions, on the other, are structurally equivalent for girls and boys (i.e., gender does not function as a moderator of these relationships).

Method

Sample and procedures

The sample consisted of N=2,053 fifth grade students (1,036 male and 1,017 female) from 42 different schools in the state of Bavaria, Germany. It was representative for the Bavarian student population at this grade level, comprising a mix of socio-economic and cultural backgrounds. Sampling included all three school types of the German state school system ("Hauptschule", "Realschule", and "Gymnasium"). The average age was 11.7 years for both girls and boys (SD=.49 for girls, SD=.48 for boys).

Emotions, competence beliefs, and value beliefs were assessed by a questionnaire at the end of the school year. This assessment was administered by external, trained testing personnel. Students were informed that the questionnaires would not be seen by their teacher or other school personnel and that the questionnaire asked them for their personal opinion and judgments, having no "right" or "wrong" answers. Administration time for the entire questionnaire (which also included a set of scales not reported here) was approximately 50 minutes. We further obtained the students' mid-term mathematics grades through the school administration. It is important to note that these mid-term grades had been administered to the students about four months prior to the assessment of beliefs and emotions, implying that there was a clear temporal ordering of the assessment of prior achievement, on the one hand, and beliefs and emotions, on the other.

Measures

Competence belief. The competence belief scale asked students to rate their competence in mathematics (10 items with 5-point Likert scales from 1, "strongly disagree" to 5, "strongly agree"; α=.92; sample item: "I am a good student in mathematics").

Value beliefs. Both the domain value and the achievement value scales consisted of five items (5-point Likert scales from "strongly agree" to "strongly disagree"; α=.84/.80; sample item for domain value: "Mathematics is my favorite subject;" sample item for achievement value: "It is very important for me to get good grades in mathematics"). Exploratory factor analysis clearly indicated that domain value and achievement value constituted two separate factors which were moderately correlated (correlation of the factors r=.34, correlation of the sum scales r=.35).

Mathematics emotions. Five discrete emotions (enjoyment, pride, anxiety, hopelessness, and shame) were assessed in the present study. Based on the Achievement Emotions Questionnaire (AEQ; Pekrun, Goetz, & Perry, 2005), a shorter German version of the instrument was developed in which survey items referred specifically to the subject of mathematics (Achievement Emotions Questionnaire – Mathematics, AEQ-M; Pekrun, Goetz, & Frenzel, 2005). In this inventory, items are answered on the same 5-point Likert scale as described above. Sample items for the five scales and Cronbach's Alphas as obtained in the present sample are presented in Table 1.

Table 1

Sample items and alpha reliabilities for the emotion scales

Emotion	Sample item	Number of items	α
Enjoyment	I enjoy my math class.	9	.87
Pride	I am proud of my contributions to my math class.	8	.87
Anxiety	When taking the math test, I worry I will get a bad grade.	15	.90
Hopelessness	During the math test, I feel hopeless.	6	.86
Shame	I am ashamed that I cannot answer my math teacher's questions well.	6	.86

Mathematics grades. We obtained students' scholastic achievement in mathematics in terms of their mid-term grades through the school administration. These mid-term grades represent the teacher-based judgment of the students' oral and written mathematics performance in the first half of the year. German grades range from 1 (very good) to 6 (insufficient). For the present analyses, these grades were inverted so that higher values indicated higher achievement.

Analysis Procedures

First, we performed a multivariate analysis of variance (MANOVA) to analyze gender differences in the mean levels of mathematics emotions and competence and value beliefs (Hypotheses 1 and 2). To examine if the observed gender differences were due to differences in prior mathematics achievement, we additionally integrated mathematics achievement as a covariate and ran a MANCOVA.

Second, we applied regression analyses to test Hypothesis 3, which stated that gender differences in mathematics emotions were mediated by students' competence and value beliefs. In order to test mediation, we followed a stepwise rationale as suggested by Kenny and his colleagues (Baron & Kenny, 1986; Kenny, Kashy, & Bolger, 1998). Given that gender was systematically related both to the emotions and to the assumed mediators, mediation models were calculated including competence belief, domain value, and achievement value as well as gender as predictors. Mediation would be confirmed if the initial effect of gender on the emotions would disappear or be decreased in these mediation models. In these models, we integrated

mathematics achievement as a covariate. All regression analyses were computed with AMOS 5.0 (Arbuckle, 2003) using maximum likelihood estimation and full information maximization imputation of missing data.

Third, we used the multiple group option in AMOS 5.0 (Arbuckle, 2003) to test for gender universality of the relationships between prior achievement and competence and value beliefs, on the one hand, and emotions, on the other (Hypothesis 4). To this end, we set all of the predictors' regression weights to equality across the male and the female subgroups. Compared to the simple regression models which were just identified (zero degrees of freedom), the model which set the regression coefficients to equality had 4 degrees of freedom, making it possible to compute a χ^2-statistic. Therefore, we were able to test whether the constraint of equality of regression coefficients across the male and female subgroups resulted in a loss of fit which was statistically significant in terms of the likelihood ratio test.

Results

Gender differences in mean levels of mathematics emotions, beliefs, and achievement

Based on cumulative empirical evidence of gender differences in mathematics competence beliefs, values, and anxiety, and scattered findings concerning other mathematics emotions, our first two hypotheses considered gender level differences among these variables. Given the large size of the present sample, effect sizes (Cohen's *d*) of differences were calculated to analyze the relevance of gender differences in emotions, beliefs and achievement, in addition to *F*-values of the MANOVA (see Table 2). To obtain mean scores in the emotion and belief measures, mean scores were calculated for all items comprising a scale, resulting in a range of possible values from 1 to 5 for each of these scales.

Table 2

Results of multivariate analyses of variance and covariance with gender as predictor, mathematics grade as covariate and mathematics emotions and control value beliefs as dependent variables

	Results from MANOVA						Results from MANCOVA		
	Mean		*SD*				Estimated mean		
Variable	Girls	Boys	Girls	Boys	*F*-Value	Effect size d^{α}	Girls	Boys	*F*-Value
Enjoyment	3.23	3.42	.81	.87	23.81**	.23	3.25	3.46	21.23**
Pride	3.08	3.36	.91	.94	45.71**	.30	3.07	3.39	42.67**
Anxiety	2.38	2.14	.83	.79	37.35**	-.30	2.36	2.13	32.98**
Hopelessness	2.15	1.89	1.03	.90	31.69**	-.27	2.10	1.86	27.21**
Shame	1.94	1.81	.86	.85	14.65**	-.14	1.92	1.78	11.06**
Competence belief	3.31	3.70	.80	.78	99.02**	.49	3.34	3.72	98.78**
Domain value	3.19	3.52	1.04	1.03	39.03**	.31	3.22	3.55	36.01**
Achievement value	3.88	3.90	.83	.89	1.29	.02	3.87	3.92	1.39

Note. $^{\alpha}$Positive numbers indicate higher values for boys; **p<.01.

In line with Hypothesis 1, boys reported considerably more enjoyment and pride in mathematics, and less anxiety and hopelessness than girls (see Table 2, left part). These effects can be considered small to medium in size (Cohen, 1988). Boys also reported significantly less shame. However, this effect size was noticeably smaller and therefore, this gender difference cannot be regarded as substantial.

Our assumptions on gender differences in competence and value beliefs (Hypothesis 2) were supported as well. As expected, there were pronounced differences in students' perceptions of competence, with girls being considerably less confident than boys about their abilities in

mathematics. Furthermore, girls rated the domain value of mathematics as being significantly lower than their male peers. However, both girls and boys judged the importance of doing well in mathematics as being rather high (mean scores close to 4 on the 5-point scale), and did not significantly differ in their judgments of achievement value (see Table 2, left part).

Concerning mathematics achievement, girls obtained a mean score of 4.06 (SD=.91), and boys a mean score of 4.14 (SD=.94). This difference was not significant (t=1.92, p>.05). Nevertheless, in order to account even for non-significant differences, we ran a MANCOVA analyzing the gender differences in emotions and beliefs with mathematics achievement as a covariate. An inspection of the estimated means for emotions and beliefs when controlling for achievement revealed that there were slight shifts as compared to the uncorrected means for most of the variables. However, the gender differences virtually remained the same (see Table 2, right part).

Mediation and moderation effects in the interplay of gender, achievement, beliefs, and emotions

Based on the assumptions of the control-value theory, we had assumed that competence and value beliefs mediated the gender differences in emotions (Hypothesis 3), but that gender would not act as a moderator of the relationships between prior achievement, beliefs, and emotions (Hypothesis 4). To test these two hypotheses, we conducted multiple regression analyses, and we compared the regression weights for the prediction of the emotions across girls and boys by means of a multiple-group comparison.

Regression analyses. To test the mediation hypothesis, we systematically compared the regression weight of gender for the prediction of the emotions when gender and achievement were entered into the analyses alone (non-mediational analysis), with the regression weight of gender when the competence and value beliefs were additionally entered into the regression (mediational analysis). We conducted these analyses separately for each emotion. Given that gender was systematically related to both the criteria (the emotions) and the assumed mediators (competence and value beliefs), a decrease or a disappearance of the predictive power of gender for the emotions would indicate mediation (Kenny et al., 1998). As can be seen from Table 3, there were significant effects of gender on all of the emotions in the non-mediational analysis (left coefficients within emotions). After additionally introducing the belief variables, these effects became insignificant for pride, anxiety, hopelessness and shame (right coefficients), which is in line with our mediation hypothesis. For enjoyment, there still was a significant effect (now even inverted), however, this effect was irrelevant in terms of its effect size.

Table 3

Multiple regression analyses for mathematics emotions: Standardized regression coefficients

	Regression weights without/with mediation									
Predictors	Enjoyment		Pride		Anxiety		Hopelessness		Shame	
Gender	.11	-.06	.14	*n.s.*	-.13	*n.s.*	-.12	*n.s.*	-.06	*n.s.*
Mathematics grade	.18	-.06	.17	-.06	-.34	-.16	-.35	-.18	-.31	-.19
Competence belief		.40		.49		-.39		-.40		-.31
Domain value		.54		.28		-.15		-.09		*n.s.*
Achievement value		*n.s.*		.10		.22		.15		.15

Note. Coefficients in left columns: Non-mediational analysis; Coefficients in right columns: Mediational analysis; p<.01 for all shown coefficients; Gender is coded female=1, male=2.

Furthermore, the regression analyses revealed that prior achievement also had significantly positive effects on enjoyment and pride, and negative effects on anxiety, hopelessness, and shame when beliefs were not taken into account (Table 3, left coefficients within emotions).

Although remaining significant, all of these effects were substantially reduced when beliefs were entered as additional predictors (right coefficients), thus indicating partial mediation of the effects of prior achievement by competence and value beliefs.

The regression effects of competence belief, domain value, and achievement value differed across emotions. In line with our assumptions, competence belief and domain value were positively related to enjoyment, whereas achievement value did not contribute significantly to the explanation of variance for this emotion. All three kinds of beliefs contributed positively to explaining pride. As for the negative emotions, they were all negatively related to mathematics achievement, and strongly negatively related to the competence belief, but positively related to achievement value. In addition, anxiety and hopelessness were also negatively related to the domain value of mathematics.

Multiple-group comparisons. In order to test for moderation of relationships between predictors and emotions by gender, the mediational regression analyses were repeated separately for girls and boys (Table 4). We then compared these unconstrained regression models with models that constrained all regression coefficients to be equal across genders. The constrained models had four degrees of freedom, and a likelihood ratio test based on the χ^2-statistic was performed to judge whether the assumption of gender universality was tenable. The results clearly showed that universality could be assumed for anxiety and shame, where the discrepancy between the unconstrained and the equality models could be considered negligible, and regression coefficients for girls and boys were indeed very similar. For pride, the discrepancy between the unconstrained and the equality models was only marginally significant ($p>.01$, but $<.05$), implying that the universality assumption could be regarded as tenable for this emotion as well. The slight discrepancy between models was caused by the fact that the regression coefficient for achievement value was higher for boys than for girls, thus suggesting that the value of achievement might be more important for boys' than for girls' pride in mathematics. In addition, prior achievement was not significantly related to pride in girls, whereas the regression coefficient for achievement was slightly negative for boys.

Table 4

Multiple regression analyses for mathematics emotions in girls and boys: Standardized regression coefficients and comparison of models across genders

	Enjoyment		Pride		Anxiety		Hopelessness		Shame	
Predictors	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Mathematics grade	-.07	-.06	-.09	*n.s.*	-.15	-.17	-.16	-.21	-.20	-.18
Competence belief	.37	.44	.48	.49	-.37	-.41	-.33	-.47	-.30	-.32
Domain value	.58	.48	.30	.26	-.14	-.16	-.09	-.09	*n.s.*	*n.s.*
Achievement value	*n.s.*	*n.s.*	.14	.06	.19	.26	.10	.19	.11	.21
$\Delta\chi^2$	17.59		11.98		4.93		22.35		4.92	
p	<.01		.02		.29		<.01		.29	

Note. All regression coefficients shown are significant, $p<.05$. $\Delta\chi^2$ indicates the fit of the model which constrained regression coefficients to equality across the genders ($df=4$) in comparison to the unconstrained model ($df=0$).

For enjoyment and hopelessness, the differences between regression coefficients for girls and boys also were rather small. Nevertheless, for these two emotions the likelihood ratio test indicated significant discrepancies between the regression models for girls and boys. Concerning enjoyment, the regression coefficient for competence belief was higher for girls than for boys, whereas the coefficient for domain value was lower for girls. Finally, the reason for the discrepancy between the male and the female hopelessness models was that all predictors except domain value were more closely related to hopelessness in girls than in boys.

However, given that the χ^2-statistic is dependent on sample size (e.g., Marsh, Balla, & McDonald, 1988), the likelihood ratio test tends to be very sensitive with a high N in detecting differences. The effect size of the observed discrepancies (differences between regression

weights for girls and boys) was very small for all of the predictors in each emotion, and none of these weights changed signs across genders (Table 4). Therefore, the significance of the differences between models for enjoyment and hopelessness notwithstanding, it can be concluded that the pattern of relationships was very similar across genders, thus corroborating universality assumptions.

Discussion

The present study had three major goals. First, we aimed at examining girls' and boys' emotional experiences in mathematics, including the emotions enjoyment, pride, anxiety, hopelessness and shame. Pronounced gender differences were found among the 5th graders in our sample, with girls having a considerably more negative emotional pattern than boys. Our second aim was to test the assumption derived from control-value theory (Pekrun, 2000, 2006) that these differences are mediated by girls' and boys' appraisals of competence and values in mathematics. Our data largely confirmed this mediational hypothesis. Third, we had hypothesized that there would be gender universality of the relations between prior mathematics achievement, competence and value appraisals, and emotions. The pattern of relations between these variables proved to be very similar across the genders, thus supporting universality assumptions.

Gender differences in mean levels of experienced emotions

Concerning the gender differences observed in discrete emotions in mathematics, we found that girls experienced significantly less enjoyment and less pride than boys. At the same time, they experienced more anxiety and more hopelessness related to mathematics. Further, girls reported slightly more shame than boys.

Confirming earlier findings (e.g., OECD, 2004a), these gender discrepancies in emotional experiences were found even though girls and boys had achieved at similar levels in mathematics, as evidenced by their mid-term grades. This suggests that there are factors other than achievement that bolster boys' emotional experiences in mathematics, or harm girls' feelings concerning this domain. Gender-linked stereotypes of domain-related abilities are a plausible candidate for explaining the discrepancy between gender differences found for achievement and those for emotions. It might be that domain-related beliefs and stereotypes directly influence girls' and boys' academic self-perceptions in mathematics, over and above the information provided by formal feedback of achievement in terms of grades (e.g., Davies & Spencer, 2005; Forgasz, Leder, & Kloosterman, 2004; see also Goetz, Frenzel, Hall, & Pekrun, in press, for a similar argumentation). For example, females often think they have to work harder than boys to achieve good results in mathematics (Lupart, Cannon, & Telfer, 2004).

However, regarding gender differences in mean levels of mathematics emotions, two limitations of the present study should be considered. First, women are often found to experience emotions more intensely than men (Barrett, Robin, Pietromonaco, & Eyssell, 1998; Larsen & Diener, 1987). This is especially true for negative emotions, such as anxiety (e.g., Blier & Blier-Wilson, 1989; Brody, 1985), sadness (e.g., Grossman & Wood, 1993), shame, and guilt (Tangney, 1990). Thus, the higher levels of negative emotions reported by girls in our study with respect to mathematics may in fact have been due to higher levels of self-reported negative affectivity generally found in females.

Second, our study used self-report scales to measure emotions. Instead of actually *experiencing* different levels of emotions, female and male students may in fact have only differed in their capability and willingness to *report* their emotions (Bryant, Yarnold, & Grimm, 1996). Capability and willingness for emotional expression, in turn, may be influenced by social desirability and stereotyping (Eisenberg & Fabes, 1995; Grossman & Wood, 1993). The context of mathematics, which is stereotypically perceived as a male domain, may have enhanced this effect.

Nevertheless, it would likely be misleading to interpret the gender differences found in this study as being due to no more than the fact that "females are just more emotional", or to differences in response behavior when dealing with self-report emotion items. Both of these explanations would imply that girls should score higher on any kind of emotion. For positive mathematics emotions, however, girls scored lower than boys in the present study.

Mediation of gender differences in emotions by competence and value beliefs

The control-value theory of achievement emotions (Pekrun, 2000, 2006) implies that competence-related beliefs, as well as subjective domain-related and achievement-related values in mathematics, function as mediators of students' emotional experiences. Therefore, we expected that gender differences in mathematics emotions should be mediated by gender differences in students' competence and value beliefs. The findings of the present study are in line with this assumption.

Regression analyses confirmed that the degree to which a student experiences achievement emotions in some domain is largely dependent on his or her competence beliefs in that domain, perceptions of the domain as being intrinsically valuable, and perceptions of the importance of achievement in the domain. As expected, the different emotions assessed in this study proved to be differentially related to these beliefs. Activity-related enjoyment seems to occur if competence beliefs and domain values are high. While we had hypothesized that high values of achievement, along with competence beliefs, would be important for outome-related pride to occur, our data suggested that both domain and achievement value are positively related to pride. Domain value even proved to be more strongly related to pride than achievement value. For the negative, outcome-related emotions of hopelessness, anxiety and shame, we had predicted that these emotions would result from a pattern of low control paired with high achievement values. This prediction was confirmed. Anxiety and hopelessness additionally proved to be negatively related to the students' domain values in mathematics.

As for gender differences, girls perceived their competence to be considerably lower in mathematics, and judged the subject as intrinsically less valuable than boys. However, girls reported similar levels of the value of achievement in mathematics as their male counterparts. The results of regression analysis implied that these gender differences in beliefs can explain the gender differences in mean levels of mathematics emotions. That is, the girls' lack of competence beliefs and domain value pertaining to mathematics, paired with the need to do well in mathematics, seems to be responsible for their higher levels of negative emotions in this domain. The lack of competence perceptions, paired with a lack of domain value of the subject, also keeps girls from experiencing positive mathematics emotions such as enjoyment or pride.

Cross-gender universality in the interplay of achievement, beliefs, and emotions

The pattern of relationships between prior achievement, beliefs, and emotions in mathematics was very similar for girls and boys in the present study. This is in line with findings on the cross-gender universality of relations between attitudes and performance in mathematics (Meece et al., 1990; Seegers & Boekaerts, 1996). A test of invariance between the regression models for the two genders corroborated the universality assumption for pride, anxiety, and shame, and detected minor discrepancies for enjoyment and hopelessness. Whereas domain value was the most important predictor of mathematics enjoyment in both genders, it seemed to play a more pronounced role in boys than in girls. In contrast, the competence belief that one can do well in mathematics was a stronger predictor for enjoyment in girls than in boys. For hopelessness, all predictors except domain value had more predictive power in girls than in boys. This may in part have been due to the reduced variance of the hopelessness scores in boys (SD=.90), as compared to the variance in girls (SD=1.03). Consequently, the predictive power of any variable may have been rendered lower in the male as compared to the female subsample in the case of hopelessness.

In conclusion, we argue that the gender differences in emotions found in this study were likely due to differences in competence and value beliefs as discussed above, rather than to gender differences in the relationships between beliefs and emotions. Therefore, if girls and boys had similar self-related beliefs in mathematics, they would probably experience similar levels of positive and negative emotions in this subject.

The pattern of findings is thus an endorsement of a nomothetic, universal nature of the cognitive antecedents of girls' and boys' achievement emotions. Consequently, we do not see the need to construct gender-specific models in order to describe these antecedents or to develop related intervention strategies.

Summary and implications for future research

Research on mathematics emotions has focused on students' anxiety in mathematics, but has largely neglected emotions other than anxiety. Consequently, there is also a lack of knowledge concerning gender differences in students' mathematics emotions other than anxiety, and concerning the reasons for such differences. The findings of the present study support the assumption that girls, as opposed to boys, are characterized by a debilitating pattern of mathematics-related emotions, and of underlying competence beliefs and value beliefs which can be observed as early as at the age of eleven. In line with assumptions of Pekrun's (2000, 2006) control-value theory of achievement emotions, our findings contribute to the understanding that maladaptive competence and value beliefs do not only influence behavior (e.g., Eccles, 1987), but also lead to the development of negative emotions related to mathematics.

Considerable progress seems to have been made towards gender equity in terms of cognitive performance. However, the gender gap still remains substantial in terms of attitudes and affect relating to mathematics. The findings of the present study support calls for more efforts to promote positive affect, and to prevent anxiety, hopelessness, and shame experienced by female students in mathematics (e.g., through the organization of schooling and instructional delivery; OECD, 2004a). The development of negative affective patterns already evident in early adolescence suggests that interventions designed to improve girls' attitudes towards mathematics should be administered no later than in the early elementary school years. In designing such interventions, students' social environments (parents, teachers, and peers) affecting students' domain-related competence and value beliefs should also be taken into account (Pekrun, 2000).

In conclusion, the findings of this study demonstrate the utility of social-cognitive approaches addressing students' appraisals, such as the control-value theory of achievement emotions, to better understand girls' and boys' emotions in academic settings. Future research should assess the generalizability of these findings to age groups beyond early adolescence, to high-ability students and students with special needs, to subject domains other than mathematics, and to different cultures. Finally, the potential effectiveness of classroom intervention techniques, and the role of social environments in shaping girls' and boys' emotions in mathematics other than just anxiety should be a primary target of future research.

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Cette étude porte sur les différences de genre en ce qui a trait aux "émotions mathématiques". S'appuyant sur la théorie émotionnelle des buts d'accomplissement ("control-value theory of achievement emotions") de Pekrun (2000, 2006), nous postulons la présence d'une différence de genre en ce qui a trait aux émotions mathématiques qui serait expliquée par les différents niveaux de perception de contrôle et de perception de valeur, spécifiques au domaine des mathématiques, présentés par les élèves. Nous avons posé comme hypothèse la présence de cette différence même une fois l'accomplissement antérieur pris en considération. En dépit des différences de moyennes de niveaux anticipées à travers des genres en ce qui a trait aux perception de

contrôle et de valeur ainsi qu'aux émotions, nous avons présupposé que les rapports structuraux entre l'accomplissement antérieur, les perception de contrôle et de valeur et les émotions demeureraient invariants à travers des garçons et des filles. 1036 garçons et 1017 filles de cinquième année ont participé à l'étude. Leurs émotions, leurs perceptions de contrôle et leurs sentiments de valeur furent évalués à l'aide de questionnaires d'auto-évaluation et leur accomplissement antérieur en mathématiques fut mesuré à partir de leurs résultats académiques. Malgré le fait que les écolières et les écoliers avaient reçu des résultats équivalents en mathématiques, les filles ont affirmé ressentir de manière significative moins de joie et de fierté que les garçons, ainsi que plus d'anxiété, de désespérance et de honte. Les résultats suggèrent que le pattern émotionnel féminin s'explique par les niveaux peu élevés du perception de contrôle et du perception d'importance accordé au domaine, ceci associé au haut niveau du perception d'accomplissement. Les comparaisons multigroupes confirment en grande partie l'invariance, à travers des genres, des rapports structuraux entre les variables.

Key words: Achievement emotions, Anxiety, Control-value theory, Gender differences, Mathematics.

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Current theme of research:

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Current theme of research:

Domain specificity of academic emotions. Boredom at school.

Most relevant publications in the field of Psychology of Education:

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