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Mathematics Interest and Achievement: What Role Do Perceived Parent and Teacher Support Play? A Longitudinal Analysis

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ABSTRACT
This study investigated the effects, on their own mathematics interest and achievement, of girls' and boys' perceived teacher support behaviors, domain-specific gender stereotyping, and ability expectations. Furthermore, effects of perceived parents' valuing and school support on students' mathematics interest and achievement were analysed. Questionnaire data were collected at two measurement points, mid-year and three months later, from 361 students in grades 8, 9, and 10 (41.3% female) attending ten public schools located in Berlin, Germany. Results from structural equation modelling showed a positive effect of perceived parental school support on students' interest and a negative effect of perceived teacher support on students' grades. Multiple group analysis revealed that gender functioned as a moderator for these relationships.

KEYWORDS
Mathematics interest; motivation; gender; classroom; parents

Mathematics Interest and Achievement: What Role Do Perceived Parent and Teacher Support Play? A Longitudinal Analysis

INTRODUCTION

Subject-specific interest is an important determinant for successful learning and advanced achievement (Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012; Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Hidi & Renninger, 2006). Students who are interested in their learning activities are likely to report high competence beliefs (e.g., Marsh, Trautwein, Lüdtke, Koeller, & Baumert, 2005; Tracey, 2002), high achievement levels (e.g., Koeller, Baumert, & Schnabel, 2001) and choose high school courses that are related to their interests (e.g., Watt et al., 2012). Given this great importance of students' interest for their learning processes it is highly problematic that interest substantially declines during secondary school (e.g., Eccles et al., 1993; Gottfried, Fleming, & Gottfried, 2001). This decline occurs particularly in mathematics (e.g., Frenzel, Goetz, Pekrun, & Watt, 2010; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Nagy et al., 2010; Watt, 2004). Additionally, studies highlight gender differences in students' interests indicating lower interests of girls compared to boys in mathematics (e.g., Fredricks & Eccles, 2002; Watt, 2006) and science (e.g., Gardner, 1998; Miller, Slawinski Blessing, & Schwartz, 2006).

One way to inhibit the decline of interest and to narrow the gender gap is to identify aspects of socializers' beliefs and behaviors that are important for girls' and boys' mathematics learning (Hidi & Renninger, 2006; Krapp, 2007). A large amount of research has focused on the role of either teacher beliefs and support behaviors, or parental domain-specific and school-related attitudes and support, for the development of students' mathematics interests and achievement (e.g., Aunola, Viljaranta, Lehtinen, & Nurmi, 2013; Eccles, 1993; Frenzel, Goetz, Pekrun, & Watt, 2010; Ing, 2013). Only a small number of longitudinal studies have analyzed the joint influence of both sources of support (e.g., Daniels, 2008; Frenzel et al., 2010).

The present study contributes to that current state of research by examining the relationships between perceived teacher and parent beliefs, expectations, attitudes, and support behavior, in relation to girls' and boys' mathematics interest and grades. Empirical studies on the influence of perceived and actual features of the learning environment suggest that perceived classroom dimensions are more influential for students' domain-specific motivation than objectively observed dimensions (Spearman & Watt, 2013). Referring to the role of parental support, Jacobs and Bleeker (2004) concluded that only activities which students interpreted as supportive are relevant for their motivation and learning outcomes.

Theoretically, the Eccles and colleagues' expectancy-value model of achievement motivation (Eccles et al., 1983; Eccles, 2005, 2009) describes perceived socializers' beliefs, expectations, attitudes and behaviors to impact students' interest and thereby their achievement. Empirical studies reveal effects of perceived parent support behavior on students' interest (e.g., Wentzel, 1998) as well as the predictive role of student interest for later grades (Koeller et al., 2001). Based on these theoretical and empirical assumptions it was expected that perceived socializers' support would impact students' achievement via their interest. Additionally, empirical research reveals the importance of general support behaviors for secondary students' domain-specific learning (e.g., Gottfried, Marcoulides, Gottfried, & Oliver, 2009; Ing, 2013). Thus, in the present study, both domain-specific and general support dimensions were included as predictors.

The model analyzed in this study is based on this Eccles and colleagues' expectancy-value model of achievement motivation (Eccles, 2005, 2009) that proposes socializers' task- and domain-specific beliefs, expectations, attitudes and behaviors influence students' expectancies for success, task- and domain-specific values, achievement-related behaviors and performance (e.g., Eccles, 1993). Studies on the relationships between perceived socializers' school support and students' learning outcomes often examine gender-related mean differences (e.g., Eccles et al., 1993; Jacobs & Bleeker, 2004) or the development of such gender differences (e.g., Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002; Nagy, et al., 2010; Watt, 2004). Some studies have examined the role of gender for relationships between perceived socializers' beliefs, expectations, attitudes, behaviors, and secondary students' motivational and learning outcomes (e.g., Simpkins, Davis-Kean, & Eccles, 2005; Wang, 2012). Simpkins and colleagues (2005) for example revealed that parents' socializing behavior significantly predicted all reports of children's participation in math and science activities, except children's report of their science activities, in both gender-groups. Wang (2012) showed that teacher expectations were more strongly associated with expectancies and increasing support of collaboration was more strongly associated with value for girls than for boys.

Perceived Teacher Support Behaviour, Beliefs, Expectations and Students' Mathematics Interest and Achievement

Meta-analyses reveal that teachers' expectations, teaching styles and affective support are highly important influences on adolescents' learning development (Cornelius-White, 2007; Hattie, 2009). Brophy (2000) emphasized teachers' ability expectations as highly important for student achievement; Wentzel (2002) showed teachers' ability expectations of students predicted their levels of interest; and perceived teacher affective support has been shown to relate to student interest and achievement (e.g., Sakiz, Pape, & Hoy, 2012).

Teachers' ability expectations are influenced by their domain-specific stereotypes about gender (Chalabaev, Sarrazin, Trouilloud, & Jussim, 2009; Tiedemann, 2000). Teachers' expectations shape their supportive behavior (Eccles & Roeser, 2011; Simpkins, Fredricks, & Eccles, 2012) through which mechanism students' perceptions of their teacher's gender-related ability expectations influence their achievement (Dickhaeuser & Meyer, 2006). However, perceived teacher support can inhibit achievement of learners under certain circumstances.

Empirical studies document that girls perceive lower levels of teacher ability expectations in mathematics, even when their objective performance level does not differ from that of their male classmates (e.g., Dickhaeuser & Meyer, 2006). Other studies on teachers' own reported expectations suggest that teachers perceive girls as performing better than boys in mathematics, but at the same time to be less talented (Jussim & Eccles, 1992; Van Matre, Valentine, & Cooper, 2000). Girls frequently report higher levels of perceived teacher affective support (e.g., Reddy, Rhodes, & Mulhall, 2003), although some studies demonstrate that boys and girls perceive similar teacher support (De Wit, Karioja, & Rye, 2010; Malecki & Demaray, 2003), and might not differ in their levels of perceived teacher expectations for their academic engagement (e.g., Wentzel, Battle, Russell, & Looney, 2010).

Perceived Parent mathematics-related Support Behavior, Beliefs and Students' Interest and Achievement

In their socialization model of parental influences on achievement attitudes and beliefs, Eccles (Parsons), Adler, and Kaczala (1982) propose that parents' values and ability beliefs shape students' own values and performance. Based on these theoretical assumptions, Harackiewicz, Rozek, Hulleman, and Hyde (2012) conducted a theory-based intervention aiming to help parents convey the importance of mathematics and science to their secondary school children. Results showed that the intervention had an indirect effect on students' perceived value of mathematics and science through mothers' perceived utility value and conversations. Although longitudinal studies reveal relations between parents' value of mathematics and students' mathematics interest (Frenzel et al., 2010), it has been suggested that parents' domain-specific value motivates students mostly extrinsically (Wild & Lorenz, 2009). Self-Determination Theory suggests that intrinsic motivational aspects such as interest are facilitated by supportive behaviors that enhance students' internal needs for competence, autonomy, and relatedness in learning situations (Deci & Ryan, 1985).
In line with this theoretical framework, Ing (2013), for example, demonstrated that high levels of perceived parental practices such as encouragement and communication of positive ability expectations influenced students' mathematical achievement. Aunola and colleagues (2013) showed that high levels of actual maternal support of their children's needs for autonomy and relatedness predicted mathematics interest of their children. There are mixed findings concerning the role of student gender in perceptions of parental support: some studies suggest higher levels of perceived parental support for girls (e.g., Rice, Barth, Guadagno, Smith, & McCallum, 2012), whereas Malecki and Demaray (2003) did not find gender-related differences in perceived parental support of secondary students.

The Role of Gender as a Moderator

The studies that analyze the role of gender as a moderator of relations between perceived socializers' beliefs and behaviors and students' attitudes show heterogeneous results. Results of Goodenow (1993) indicated that perceived teacher support was more closely related to motivation for girls than for boys. Wang (2012) showed that perceiving support for collaboration in mathematics class was more important for girls' than boys' mathematics value. Other studies suggest similarities in the relations between socializers' support and students' interest and motivation. Skaalvik and Skaalvik (2013) showed that students' perceptions of their teachers as emotionally supportive were similarly related to intrinsic motivation for both girls and boys. Similar results were shown for the relations between actual supportive behavior of parents and motivation of their children (e.g., Gottfried et al., 2009; Simpkins et al., 2005).

On a theoretical level, socialization theorists suggest that emotional investment in interpersonal relationships may be more important for girls than boys, due to socialization experiences that encourage girls to show behaviors that enhance the formation of interpersonal relationships (e.g., Umberson, Chen, House, Hopkins, & Slaten, 1996). Based on these assumptions, it was shown previously that girls were more likely to seek social support as a coping strategy (Eschenbeck, Kohlmann, & Lohaus, 2007). Given lower academic self-concepts of girls in mathematics and higher domain-specific task anxiety (Eccles & Jacobs, 1986; Tiedemann, 2000) it may be that perceived social support is more important for girls than boys particularly in mathematics. However, since the quality of teacher-student relationships declines throughout high school (Eccles et al., 1993; Hamre & Pianta, 2001), other social agents than teachers might be important for girls' mathematics interest and achievement.

Hypotheses

Based on the presented theoretical state of research and previous empirical results, the present study addressed the following hypotheses:

(a) Students' mathematics interest and achievement are predicted by their perceptions of teachers' stereotype beliefs, ability expectations and affective support; and perceptions of parents' value and school support.

(b) Perceived social support relates indirectly to mathematics achievement through mathematics interest.

(c) Student gender moderates the relations between perceived teachers' gender stereotyping, ability expectations, affective support; perceived parents' value and school support; and students' mathematics motivation and learning outcomes.

METHOD

Sample

Student data were collected at two measurement points from ten secondary schools in Berlin, Germany (NT1 = 425; NT2 = 361; 21 classrooms). The questionnaire was first administered at mid-year and again three months later at the end of the school year. Analyzed data were from 361 students who participated at both measurement points (41.3% female). The majority of participants (53.5%, n = 193) reported that both they and their parents were born in Germany. The German school system is characterized by early selection to different secondary school types. In the present sample 13% of the students attended Hauptschule (lower track), 16.3% attended Gesamtschule (comprehensive school), and 60.1% attended Gymnasium (upper track) (10.5% missing). At Time 1, approximately 29% of the respondents were in grade 8, 37% in grade 9, and 24% in grade 10 (10% missing). The mean age of the respondents was 14.87 years (SD = 0.97) at Time 1, and 15.13 years (SD = 0.96) at Time 2.

Procedure

Participation was voluntary and participants under 14 years of age required parental consent according to the research principles of the Senate Administration for Education, Science and Research in Berlin, Germany. Trained research assistants introduced the students to the questionnaire which they completed in approximately 45 minutes during their mathematics class.

Measures

Mathematics interest, Time 1 and Time 2. To measure mathematics interest, a nine-item scale, based on Berger's (2002) questionnaire on "Individual Interest in Physics", was used. The five-point Likert-type scale ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Example items are "I value mathematics class particularly because of the interesting topics", "I am really looking forward to mathematics class" and "I enjoy tasks and issues that are addressed in mathematics class".

Mathematics grades, Time 1 and Time 2. Students were asked to report their current grade average in mathematics at each timepoint. In Germany, grades are coded on a six-point scale ranging from 1 (*very good*) to 6 (*insufficient*). In our analyses, grades were reversed so that low scores represented poor grades, to increase ease of interpretation.

Perceived mathematics teacher affective support, Time 1. Perceived mathematics teacher affective support was assessed with a five-item scale based on the on the Learning Processes, Educational Careers, and Psychosocial Development in Adolescence and Young Adulthood (BIJU) study (Daniels, 2008). The four-point Likert-scale ranged from 1 (*strongly disagree*) to 4 (*strongly agree*). Items used as indicators of the latent construct were "Our mathematics teacher takes time for students if students want to talk to him/her", "Our mathematics teacher helps us as a friend" and "Our mathematics teacher cares about our problems".

Perceived mathematics teacher stereotypes, Time 1. Perceptions of teacher stereotypes regarding mathematics as a 'typical male domain' were assessed with a three-item scale based on Pohlmann (2005). The four-point Likert scale ranged from 1 (*strongly disagree*) to 4 (*strongly agree*). Items included "Our mathematics teacher thinks that boys are more talented in mathematics than girls", "Our mathematics teacher thinks that boys enjoy mathematics more than girls", and "Our mathematics teacher thinks that mathematics is a typical male domain".

Perceived mathematics teacher ability expectations, Time 1. Perceptions of mathematics teacher ability expectations were measured with a three-item scale based on Keller (1998). The four-point Likert scale ranged from 1 (*strongly disagree*) to 4 (*strongly agree*). Items included "In mathematics class our teacher expects me to understand what he explains", "In mathematics class my teacher expects me to be good at mathematics", and "In mathematics our teacher expects me to be interested".

Perceived parents` valuing of mathematics and science, Time 1. Perceived parents' valuing of mathematics was assessed with a six-item scale based on Wendland and Rheinberg (2004). The four-point Likert scale ranged from 1 (*strongly disagree*) to 4 (*strongly agree*). Example items are "We often speak about things related to mathematics and/or sciences at home" and "My parents enjoy watching programs related to mathematics and / or science".

Perceived parental school support, Time 1. Perceived parental school support was assessed with a five-item scale based on Bilz and Melzer (2005). The four-point Likert scale ranged from 1 (*strongly disagree*) to 4 (*strongly agree*). Example items included "My parents encourage me to do well in school" and "My parents are interested in my learning development".

Covariates. In the analyses we controlled for prior mathematics grades and interest, as well as for student gender (0 = male; 1 = female).

Statistical Analyses

The *Mplus* program version 6.0 was used for all analyses (Muthén & Muthén, 1998-2010). To specify an optimal measurement model, a series of Confirmatory Factor Analyses was first conducted. After establishing an adequate measurement model among the full sample, Longitudinal Structural Equation Modeling (LSEM) was then used to test the hypothesised effects in the model (Figure 1). Invariance testing was examined using multiple group analysis in line with Vandenberg and Lance (2000) and Muthén and Muthén (2009; 1998-2010). Chi-square difference tests incorporated the scaling correction factor indicated by Satorra and Bentler (2001).

Maximum likelihood with robust standard errors and chi-square (MLR) was the method of model estimation used in this study. This method is robust to non-normality and non-independence of observations when used with the TYPE=COMPLEX function of *Mplus* (Muthén & Muthén, 1998-2010). The current data set includes data nested within 21 classes. Standard errors were corrected using TYPE = COMPLEX, which is a function of *Mplus* that takes the nested structure of the data into account. Missing data were handled by using the full-information maximum likelihood (FIML) procedure. Based on Tanaka (1993), the following criteria were employed to evaluate the goodness of fit of the models: Yuan-Bentler scaled χ^2 (YB χ^2, mean-adjusted test-statistic robust to non-normality), Tucker and Lewis Index (TLI), Comparative Fit Index (CFI) and Root Mean Square of Approximation (RMSEA) with associated confidence intervals. Additionally Standardized Root Mean Residual (SRMR) values were reported. TLI and CFI values greater than .95 (Hu & Bentler, 1999), RMSEA values lower than .05 (Browne & Cudeck, 1993) and SRMR $\leq$ .08 (Hu & Bentler, 1999) were accepted as indicators of a good model fit.

RESULTS

Descriptive Statistics and Confirmatory Factor Analyses

The original measurement model for the 7 latent factors which included all 40 items showed deficits in fit indices (YB χ^2 = 1145.66, *df* = 719, CFI = .89, TLI = 0.88, RMSEA = .041, SRMR = .020). We created parcels, as indicated by Bandalos (2002), in order to improve model fit for the two parent constructs, which contained sufficient items for this approach. Parcels were created for Perceived parents' valuing of mathematics and science (6 items), and Perceived parental school support (5 items). Three parcels of 2 items each were created for Perceived parents' valuing, and 2 parcels for Perceived parental school support (one containing 2 items, the other including 3 items). Items were grouped based on their factor loadings by averaging the item with the highest loading with the item with the lowest loading as well as the items with the second highest loading with the item with the second lowest loading ("item to construct balance approach"; see Little, Cunningham, Shahar, & Widaman, 2002). By continuously following this approach parcels were created and used as indicators for the latent constructs.

For the latent construct of interest, the 3 highest loading of the 9 items were retained (retained items: "I value mathematics class particularly because of the interesting topics", "I am really looking forward to mathematics class" and "I enjoy tasks and issues that are addressed in mathematics class"), at both Time 1 and Time 2. The deleted 6 items reflected perceived usefulness and importance for future plans ("What I learn in mathematics class is important for my future life", "Mathematics is important to me", "Thinking about mathematics is important for me", "In my spare time I keep on thinking about particular issues that we discussed in mathematics class", "I am sure that I learn a lot about myself in mathematics class", "Most topics that we discuss in mathematics do not mean anything to me") and relatedness to mathematics class ("In mathematics class tasks are discussed in a way I cannot relate to"). Items were deleted in order to improve model fit, indicated by low item reliabilities and high modification indices. The three retained items still tapped the value and affective aspects of interest, emphasised by Hidi and Harackiewicz (2000).

Concerning the teacher variables that were assessed at Time 1, the same approach was adopted to retain the 3 highest loading of the 5 items measuring Perceived mathematics teacher affective support (retained items: "Our mathematics teacher takes time for students if students want to talk to him/her", "Our mathematics teacher helps us as a friend" and "Our mathematics teacher cares about our problems"). Two items were excluded assessing teachers' willingness to attend to students' wishes, and to speak with them about things they do not like in class. No item deletions were made for either of the 3-item original scales, Perceived mathematics teacher stereotypes, and Perceived mathematics teacher ability expectations.

The final measurement model for the 5 latent factors included 14 indicators following item deletions and parcels, which showed good fit: YB $\chi^2 = 170.274$, *df* = 149, CFI = .99, TLI = 0.98, RMSEA = .020, SRMR = .040. Item loadings and composite reliabilities for the final measurement model including 14 indicators and 5 latent factors are presented in Table 1. To calculate composite reliabilities we used item loadings from this CFA model using the full sample. Table 1 further shows latent means and standard deviations for all latent factors for the full sample and for both gender groups.

Multigroup models were used to establish measurement invariance across time for the latent construct 'mathematics interest', and between gender groups for all variables, prior to estimating latent mean differences corrected for measurement error. In line with Vandenberg and Lance (2000), four steps were tested to establish measurement invariance in the full sample. Results of measurement invariance testing are reported in Table 2. After confirming measurement invariance of interest Time 1 and Time 2, equality of latent means of mathematics interest was tested in the full sample. Non-significant chi-square testing indicated that latent means of interest did not significantly differ across time in the full sample (see Table 2, I. step 5).

Keeping measurement invariance over time it was tested whether latent means of interest differed across the gender groups. Again measurement invariance was established. Restricting latent means of interest to be equal across gender groups revealed a significant decline of model fit (see Table 2, II. step 5). Further analyses showed that restricting only interest at Time 1 as well as restricting only interest at Time 2 led to a significant decline of model fit indicating that girls reported significantly lower mathematics interests at Time 1 and Time 2 (see Table 2, II. steps 5a-5b).

Table 1
Descriptive Statistics, Composite Reliability and CFA Factor Loadings for Latent Variables

	Full Sample			Boys	Girls	
	M (*SE*)	Composite Reliability	CFA standardized loadings range	*M* (*SE*)	*M* (*SE*)	*z*
Interest T1	2.68 (0.06)	.778	.701 - .781	2.82 (0.07)	2.53 (0.09)	-3.80*
Interest T2	2.60 (0.04)	.789	.729 - .769	2.70 (0.08)	2.42 (0.08)	-2.67*
Perceived teacher support T1	3.07 (0.08)	.794	.729 - .769	3.10 (0.08)	3.03 (0.15)	-0.47
Perceived teacher stereotype T1	2.00 (0.07)	.860	.694 - .914	1.96 (0.08)	2.07 (0.09)	1.47
Perceived teacher expectations T1	3.13 (0.04)	.678	.569 - .712	3.08 (0.07)	3.19 (0.04)	2.05*
Perceived parents' valuing T1	2.62 (0.08)	.856	.779 - .862	2.65 (0.10)	2.58 (0.10)	-0.89
Perceived parental support T1	3.31 (0.06)	.808	.825 - .850	3.25 (0.05)	3.38 (0.08)	2.04*

Note. $^*p < .05$.

Table 2
Measurement Invariance Testing

	SY χ² (*df*)	CFI	TLI	RMSEA	SRMR	Δχ² (*df*), *p*
I. Measurement Invariance Testing of Interest over Time						
Step 1	9.03 (8)	0.99	0.99	.019	.020	
Step 2	10.09 (10)	1.00	1.00	.005	.026	0.83 (2), .66
Step 3	10.75 (12)	1.00	1.00	.000	.028	0.52 (2), .77
Step 4	11.45 (15)	1.00	1.01	.000	.045	1.16 (3), .76
Step 5	14.44 (16)	1.00	1.00	.000	.048	2.73 (1), .09
II. Measurement Invariance Testing of Interest (T1, T2) across Gender Groups						
Step 1	32.45 (30)	0.93	0.93	.021	.065	
Step 2	35.33 (32)	0.99	0.99	.024	.069	2.86 (2), .24
Step 3	37.47 (34)	0.99	0.99	.024	.068	2.15 (2), .34
Step 4	37.37 (37)	0.99	0.99	.007	.073	1.04 (3), .79
Step 5	50.96 (39)	0.97	0.98	.041	.104	19.41 (2), .000
Step 5a	48.92 (38)	0.97	0.98	.039	.096	18.65 (1), .000
Step 5b	46.52 (38)	0.97	0.98	.035	.095	10.84 (1), .000
III. Measurement Invariance Testing of Parent and Teacher Latent Constructs (T1) across Gender Groups						
Step 1	173.72 (134)	0.98	0.97	.043	.047	
Step 2	180.56 (143)	0.98	0.97	.040	.051	6.45 (9), .69
Step 3	201.38 (152)	0.97	0.96	.045	.056	19.19 (9), .02
Step 3b	190.13 (151)	0.98	0.97	.040	.053	9.66 (8), .29
Step 4	230.21 (165)	0.96	0.95	.050	.091	40.32 (14), .000
Step 4b	202.92 (163)	0.98	0.97	.039	.056	12.88 (12), .38
Step 5a	207.14 (164)	0.97	0.97	.040	.058	4.37 (1), .03
Step 5b	203.63 (164)	0.98	0.97	.039	.056	3.50 (1), .06
Step 5c	205.76 (164)	0.97	0.97	.040	.059	0.71 (1), .40

Table 3
Intercorrelations among Variables (n boys=212; n girls = 149)

	1	2	3	4	5	6	7	8	9
1. Grades T1	--	.399**	.424***	-.029	-.222**	.311***	.077	.031	.933***
2. Interest T1	.330***	--	.892***	.421***	-.235*	.091	.135	.056	.399**
3. Interest T2	.244**	.704***	--	.348***	-.245	.018	.302**	.150	.501***
4. Perceived teacher support T1	.052	.465***	.422***	--	-.165	-.065	.072	.018	-.043
5. Perceived teacher stereotyping T1	.128	.119	.022	.027	--	.208	-.165	-.097	-.190*
6. Perceived teacher expectations T1	.183	.238	.177	.335*	-.019	--	-.097	-.133	.290**
7. Perceived parents' valuing T1	.084	.181	.067	-.016	-.071	.091	--	.424***	.062
8. Perceived parent support T1	.055	.153	.251**	.247	-.110	.114	.499***	--	.037
9. Grades T2	.790***	.272***	.293***	-.096	.143*	.101	.110	.115	--

Note. The correlation coefficients of final latent constructs below the diagonal refer to boys; the correlation coefficients above the diagonal refer to girls.

*n.s. = not significant. ***p < .001. ** p <.01. * p <.05.*

In order to test whether latent means of parent and teacher variables differed across the gender groups we established partial measurement invariance across gender groups for these variables (see Table 2, III. step 3b). Significant chi-square difference testing using correction factor indicated that intercepts of latent factors varied between the gender groups. One intercept of an item assessing teacher expectations varied across the gender groups ("In mathematics class my teacher expects me to be good"; see Table 2, III. step3b). Further residual variances of one teacher stereotyping item and one teacher expectation item varied across gender-groups (see Table 2, III. step 4b). After establishing partial measurement invariance we tested the model for differences in latent means. Results showed that girls scored significantly higher than boys on perceived mathematics teacher expectations (see Table 2, III. step 5a). Parents' valuing (see Table 2, III. step 5b) and perceived parental school support (see Table 2, III. step 5c) did not differ significantly across the groups.

Independent t-tests tested whether mathematics grades varied for girls and boys. Boys (M = 3.98, SD = 0.91) reported significantly higher mathematics grades at Time 2 than girls (M = 3.75, SD = 1.06; t (245.03) = 2.00, p = .05, d = .23). There were no significant mean differences for mathematics grades at T1 (boys: M = 3.87, SD = 1.03; girls: M = 3.75, SD = 1.07; t (298) = .931, p = .353, d = .11). Intercorrelations of the latent factors for each of girls and boys are presented in Table 3.

Results demonstrated that at Time 1, perceived teacher support was significantly correlated with interest in the subsamples for boys and girls. However, Time 1 perceived teacher support was not significantly correlated with Time 1 grades for either gender. Perceived teacher stereotyping at Time 1 did not significantly correlate with interest at Time 1 for boys, but was significantly negatively correlated for girls. Similarly, perceived teacher stereotyping at Time 1 was not significantly correlated with grades at Time 1 for boys, but was significantly negatively correlated for girls. Perceived teacher ability expectations at Time 1 did not relate to interest in either subsample, nor to grades at Time 1 for boys, but was significantly correlated with grades at Time 1 for girls. Neither perceived parents' valuing nor parental support at Time 1, related to either students' mathematics interest or grades at Time 1.

Concerning Time 2 constructs, perceived teacher support at Time 1 and perceived parental support at Time 1 were significantly correlated with interest at Time 2 only for boys. For girls, interest at Time 2 was significantly correlated with perceived parents' valuing of mathematics and science at Time 1. Mathematics grades at Time 2 were significantly correlated with perceived mathematics-related teacher stereotyping at Time 1 for boys and girls. For girls, grades at Time 2 were further significantly correlated with perceived teacher expectations at Time 1 (see Table 3).

Longitudinal Structural Equation Modeling

Preliminary modeling. In preliminary longitudinal structural equation models, all Time 1 latent variables in the model as well as student gender, age, and school types (dummy-coded) were specified as predictors of the Time 2 outcome variables mathematics interest and grades. We tested three dummy-coded variables referring to the three school types in our sample. For each dummy-coded variable all other school types were set as reference category and coded with zero. Dummy-coded variable 1 referred to lower track schools, variable 2 to upper track schools, and variable 3 to comprehensive schools. No school type (variable 1: r = .17, SE = 0.11, z = 1.60; variable 2: r = -.12, SE = 0.07, z = -1.74; variable 3: r = .02, SE = 0.05, z = 0.33) nor age (r = .02, SE = 0.06, z = 0.40) was significantly correlated with mathematics interest at Time 2. Gender was significantly correlated with mathematics interest at Time 2 (r = -.27, SE = 0.09, z = -2.99) and accordingly was included in the final model as a control variable.

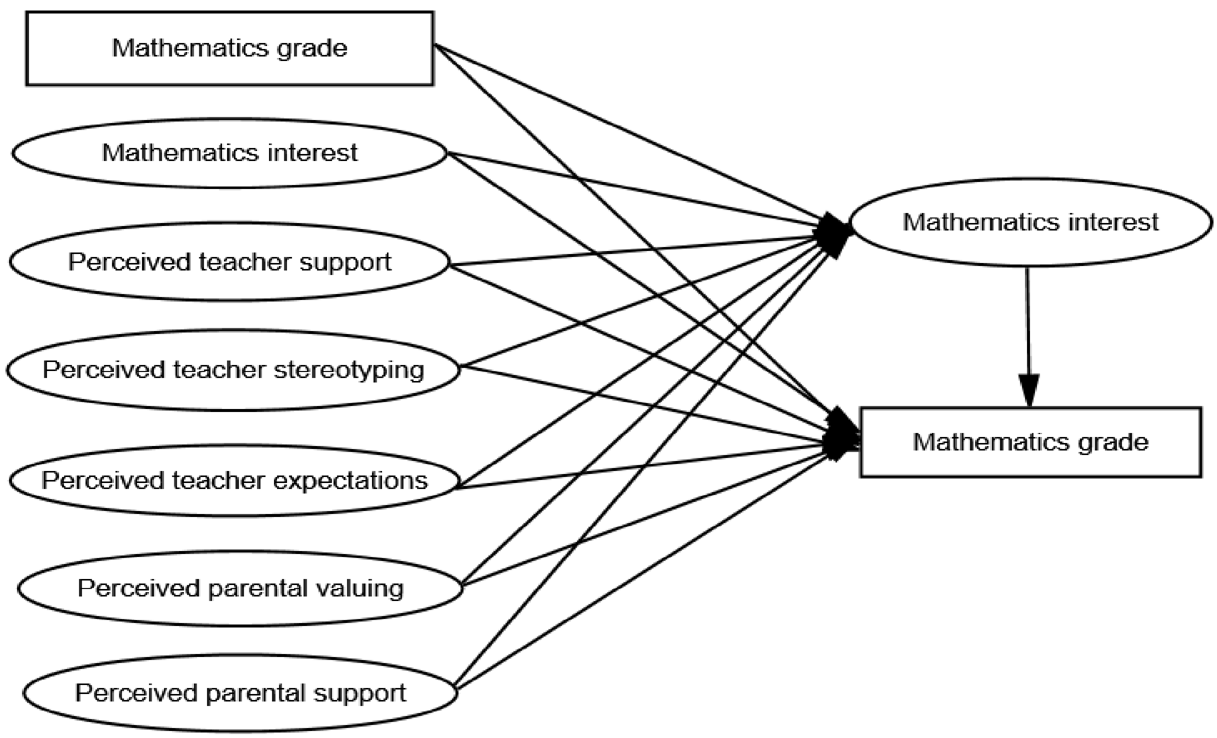

Figure 1***.*** *Hypothesized structural model*.

The initially hypothesized model is illustrated in Figure 1, and was tested in the full sample keeping interest time invariant. The model showed a good fit to the data, YB χ^2 = 313.59, df = 207, CFI = .95, TLI = .94; RMSEA = .041, SRMR = .072, explaining 63.3% of variance in Time 2 mathematics interest and 76.3% of variance in Time 2 mathematics grades. In line with our hypotheses, across the sample as a whole, Time 2 mathematics interest was significantly influenced by perceived parental school support (β = .12, p = .006, z = 2.73) when controlling for gender (β = -.12, p > .05, z = -2.73), previous mathematics grades (β = .01, p = .06, z = 0.34) and interest (β = .76, p < .001, z = 8.12). Mathematics grades at Time 2 were significantly impacted by perceived mathematics teacher support at Time 1 (β = -.12, p = .03, z = -2.24) when controlling for gender (β = -.02, p = .53, z = -0.68), previous mathematics grades (β = .85, p < .001, z = 20.84) and previous mathematics interest (β = -.07, p = .52, z = -0.64). In contrast to our hypotheses, the path between mathematics interest at Time 2 and mathematics grades at Time 2 was not significant (β = .21, p = .07, z = 1.84); therefore no indirect effect from perceived socializers' support, beliefs and expectations on mathematics achievement through mathematics interest could be tested.

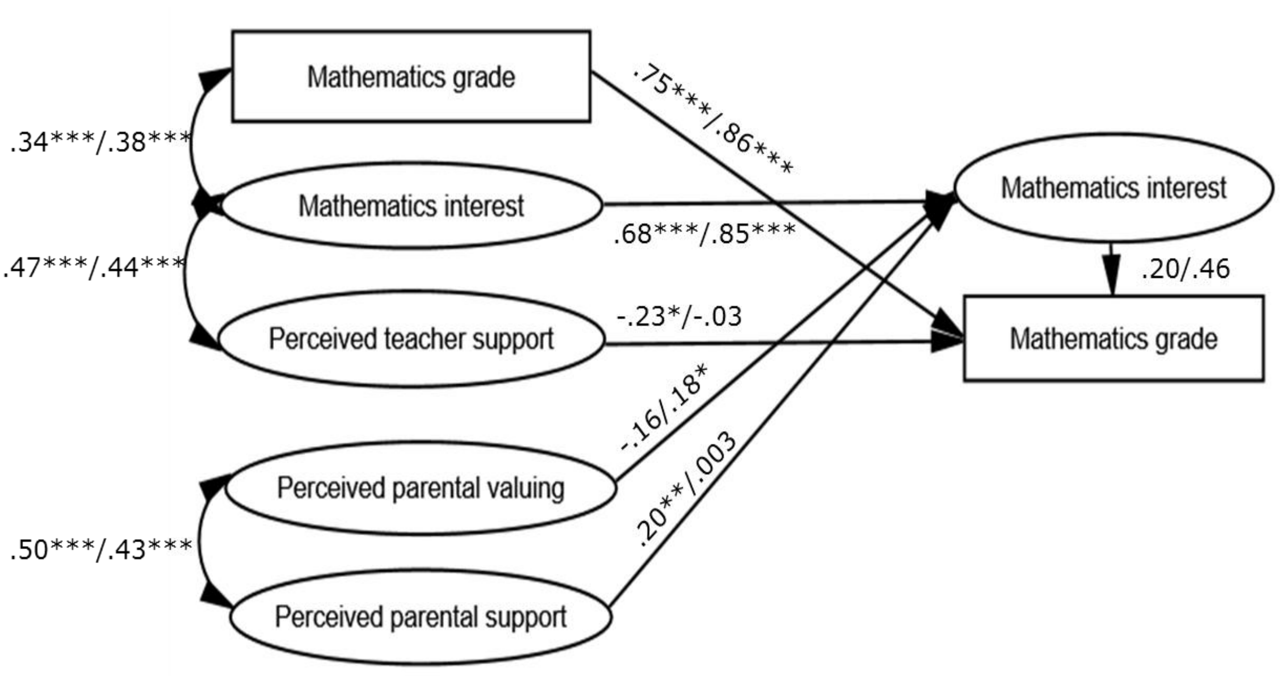

Figure 2. *Multiple Group Structural Model with time and group invariant measurement parameters and freely estimated regression weights (standardized coefficients; Boys / Girls). Only significant paths are presented.*
*Note. *** p < .001; **p < .01, *p < .05.*

Final model. Subsequently multiple group analyses were conducted. In a first step, configural invariance was tested with time and gender group invariant measurement parameters and freely estimated regression coefficients. Results revealed a good fit to the data (YB χ^2 = 470.57, df = 389, CFI = .97, TLI = .96; RMSEA = .034, SRMR = .062). Significant paths for that model are shown in Figure 2. Following establishment of measurement invariance (uniqueness invariance), fixing each regression coefficient sequentially to be equal across gender groups in that model revealed that the path between perceived parents' valuing at Time 1 and mathematics interest at Time 2 was significantly moderated by gender (YB χ^2 = 476.72, df = 390, CFI = .97, TLI = 0.96; RMSEA = .035, SRMR = .063; Δ χ^2corr (1) = 10.01, p = .001). Only for girls, higher levels of perceived parents' valuing of mathematics and science at Time 1 was significantly related with higher levels of mathematics interest at Time 2. The path between perceived teacher support and mathematics grades at Time 2 was also significantly moderated by gender (YB χ^2 = 530.69, *df* = 390, CFI= .97, TLI = 0.96; RMSEA = .035, SRMR = .063; Δ χ^2corr (1) = 4.70, *p* = .03). High levels of perceived mathematics teacher support were related to low mathematics grades at Time 2 for boys only.

DISCUSSION

Perceived Teacher and Parental Support, Beliefs, Expectations and Mathematics Interest and Achievement of Secondary Students.

The present study aimed to investigate the relationships between perceived teacher support, stereotyping, expectations, parents' mathematics valuing, parental school support and students' mathematics interest and achievement. The role of gender as a moderator of these relations was further taken into account. Surprisingly, high perceived teacher support was associated with low mathematics grades. A possible interpretation of this negative relationship is a reciprocal effect from student achievement to teacher beliefs and behaviors: Low-achieving students might receive higher levels of teacher support. An unexpected result was that parents' valuing of mathematics and science did not relate to either Time 1 or Time 2 mathematics interest, counter to previous research (e.g., Eccles & Jacobs, 1986; Frenzel et al., 2010). Referring to results of Simpkins and colleagues (2012) a possible explanation for this non-significant relationship might be that parents' valuing functions as a distal predictor of students' attitudes and interests. Simpkins and colleagues show that mothers' valuing of math is indirectly related to students' valuing via their parents' support behaviors. Another unexpected finding that might be due to the short time period between Time 1 and Time 2 and the high stability of student interest, was the non-significant relation between mathematics interest at Time 2 and achievement at Time 2. Future research should examine these relations during a longer time span with several measurement points.

Role of Gender

As expected for this age group (Eccles et al., 1993; Gottfried et al., 2001; Jacobs et al., 2002) compared to boys, girls reported significantly lower mathematics interest at both time points (e.g., Watt, 2006). Girls also reported significantly lower mathematics grades at Time 2. In their meta-analysis, Else-Quest and colleagues (2010) demonstrated considerable cross-national variability in the gender gap of 14-16 year old students' mathematics achievement. Thus, gender differences in the present study could be related to the nationality of the students. Results of the Programme of International Student Assessment (PISA) studies 2000-2009 reveal that in Germany gender-related differences in mathematics competencies exist with girls achieving lower scores than boys (Frey, Heinze, Mildner, Hochweber, & Asseburg, 2010).

In this study, girls reported higher levels of parental support and teacher ability expectations than boys. Higher teacher ability expectations for girls are in line with previous empirical results (e.g., Jussim & Eccles, 1992), which also suggested that girls tend to report generally higher levels of support from adults (e.g., Goodenow, 1993). The associated question whether or not these differences in perceived levels of social support were more influential for girls' motivation and achievement was addressed in subsequent moderation analyses. The results revealed gendered relationships between perceived socializers' beliefs, expectations, attitudes and behaviours and students' motivational and cognitive learning outcomes.

However, it is necessary to differentiate between outcomes when examining the relative importance of perceived social support from parents and teachers for girls and boys. Girls' grades were not impacted by perceived social support of parents and teachers, but perceived parents' valuing of mathematics and science was significantly associated with their mathematics interest. Thus, perceived social support was particularly important for girls' motivational, but not for their cognitive, learning outcomes. Considering the developmental phase of the participating girls might shed light on the weak effects of perceived parent and teacher support on girls' grades. In early adolescence, the influence of parents and teachers on students' development seems to decrease and peer-related support appears to play a more significant role (Wentzel, 1998). Conformity to the peer group is highly important (Goodenow, 1993) and particularly for adolescent girls, peers are an important source of social support (Malecki & Demaray, 2003).

The present study suggests that this might be particularly true for girls' achievement. Peers are important communicators of sex-role norms and particularly among girls counter-stereotypical achievement profiles lead to feelings of social exclusion and unpopularity (Kessels, 2005). Kessels revealed that students assumed girls who excelled in physics to be disliked by their male classmates and that these high-achieving girls in fact also reported to feel rather unpopular with boys; however, boys with gender-atypical achievement profiles did not perceive themselves as unpopular. Our findings underscore the importance of differentiating sources of perceived support, and motivational vs. cognitive outcomes, when considering which supports may be more important to what outcomes, for girls and boys.

Theoretically our results did confirm the assumption that perceived social support and interpersonal relationships are generally more important for girls than for boys due to socialization mechanisms (Umberson et al., 1996). However, findings differ depending on the source of social support and the analyzed outcome. A possible interpretation of why perceived teacher support was unimportant for girls' mathematics achievement might be the decline in teacher-student relationship quality after the transition to high school (Eccles et al., 1993; Reddy et al., 2003). Consequently, peer pressure for girls' gender-typical interests and role behavior may become more influential, coupled with the generally greater importance of social support for girls' learning, and parents as extracurricular role-models. To further examine this interpretation studies should analyze the role of perceived social support of multiple social agents in different domains. The greater importance of perceived teacher support for learning processes of boys is in line with other empirical results (e.g., Furrer & Skinner, 2003).

Limitations and Future Research

Some limitations of the present study merit taking into account. The present study did not take reciprocal effects into account. Other analyses however point to such effects by identifying subgroups within the class who perceive characteristics of their learning environment differently depending on their mathematics interest (Lazarides & Ittel, 2012). Although the reduced items approach to the measurement model improved model fit, by retaining only highest loading items for interest at Time 1 and Time 2 and perceived teacher support at Time 1, it is important to note that the examined factors consequently do not fully reflect the original constructs according to the selected instruments. The significant relationship between perceived parents' valuing and mathematics interest for girls indicates that perceived parents' value – at least for girls – is relevant for their interest development, operationalized as enjoyment. Omitted perceived teacher support items meant that this construct reflected perceived belongingness rather than perceived autonomy-support that has been found to positively relate to students' interest (Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Although empirical studies revealed significant relations between students' interest and perceived teacher emotional support (e.g., Wentzel et al., 2010) literature based on Self-Determination Theory describes relatedness or belonging as a more distal influence to students' intrinsic motivation or interest development (Deci & Ryan, 2000).

The present study did not take into account migration background of the students. Although it is well known that student achievement of natives and immigrants differs significantly in Germany, it was also shown that this effect strongly depends on students' immigrant group (Stanat, Rauch, & Segeritz, 2010). Due to this current state of research and due to the small sample size, students' different migration background was not assessed but should be addressed in further research.

This study assessed student ratings of support, beliefs and expectations of adult socializers. It is unclear whether stereotyping and expectations of teachers are projections of students' own beliefs. Future research could measure direct reports from parents and teachers, and explore student stereotyped expectations. Further, parallel measures were not used to assess students' perceptions of parental and teacher support, beliefs and attitudes in this study. For future research, the parallel assessment of parental and teacher support would be an important step to compare both influences more clearly.

Results showed high construct stability in the tested model, likely due to the short time-lag between measurement occasions. The short time period was intended, as the aim was to assess students' interest first at mid-year, when they already knew their teacher and classmates and could evaluate their domain-specific interest independently from the classroom context. However, future studies should utilize a more long-term design to avoid such high autoregressive effects and allow detailed analyses of longitudinal relations between perceived social support and motivational and cognitive learning outcomes. At the bivariate level, higher levels of perceived teacher support did significantly relate to higher levels of student interest at both time points for boys and girls. Because of the short time gap between Time 1 and Time 2, and the high stability of interest, the path between Time 1 perceived teacher support and students' mathematics interest at Time 2 was non-significant.

This is because the longitudinal estimate measures the extent to which perceived teacher support affected change in interest over time, which in fact does not occur.

CONCLUSION

The results of this study highlight the importance of perceived parental and teacher support for secondary students' motivational and cognitive learning outcomes, and point to the importance of taking into account the role of gender for these relations. Results revealed that particularly for boys, perceived teacher support plays an important role for mathematics achievement, and that perceived parental school support facilitates their mathematics interest. For girls' achievement in mathematics it was further discussed whether peers might play a more important role than adult socializers. In terms of educational practice the findings of the present study suggest that intervention programs which aim to facilitate girls' and boys' interest and achievement should be tailored to include the involvement of different social agents. More research is needed concerning socializers' behaviours and beliefs that are important for the enhancement of girls' mathematics interest and achievement, to enable educators and families to develop gender-sensitive teaching strategies.

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