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CAN TEACHER PRACTICES REDUCE THE GENDER GAP IN MATHEMATICS INTEREST FOR STUDENTS WITH DIFFERENT ACHIEVEMENTS?

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CAN TEACHER PRACTICES REDUCE THE GENDER GAP IN MATHEMATICS INTEREST FOR STUDENTS WITH DIFFERENT ACHIEVEMENTS?[2]

Researchers have postulated that there is a positive effect of autonomy-supportive teacher practices on academic interest. Few studies, however, investigate how these practices can reduce the gender gap in mathematics interest. The goal of our study is to examine how autonomy-supportive practices effect on attitudes toward mathematics for girls and boys with different level of mathematics achievements.

We used data from the Russian longitudinal study “Trajectories in Education and Career” (TrEC) to identify teacher practices which can reduce the gender gap in mathematics interest. Using hierarchical linear regression analysis we focused on two types of teacher practices: autonomy-supportive and controlling. We conducted analysis for boys and girls separately and evaluated how the effect of teacher practices on mathematics interest varies for boys and girls in general and according to their level of mathematics achievements.

Our analysis demonstrates that girls are more sensitive to different teacher practices and some autonomy-supportive practices have a positive effect on mathematics interest for girls only and no effect on boys’ interest. We also identified that some teacher practices have different effects on students’ interest according to the level of their prior achievements. Autonomy-supportive practices are more important for students with high achievements.

Keywords: mathematics interest, intrinsic motivation to learn mathematics, gender differences, autonomy-supportive practices, controlling practices

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Introduction

Policymakers and researchers in many countries try to encourage their students to participate and succeed in science, technology, engineering and mathematics (STEM) related fields. Many policymakers believe that increasing the number of graduates from STEM fields significantly contributes into national development and global competitiveness (NAS, 2007).

Striving to increase the participation and success of students in STEM fields, policymakers and researchers are particularly concerned about female students. Both in developed and developing countries female students tend to be less active in STEM fields (Beede et al., 2011). Less interest in mathematics is an important factor in the lower participation of girls in mathematics and their choice of advanced mathematics courses (e.g. Beede et al., 2011; Riegle-Crumb, Moore, & Ramos-Wada, 2011; Jacobs, 2005). Some studies show that gender gap in mathematics interest (in favour of boys) is a possible factor in the gender disproportion in STEM areas (e.g. Heilbronner, 2011).

Like the most researchers, we use terms "mathematics interest" and "intrinsic motivation to learn mathematics" as interchangeable concepts. Ryan and Deci (2000: 55) in their core paper about two types of motivation describe intrinsic motivation as the intention of "doing something because it is inherently interesting or enjoyable". Intrinsic motivation to learn mathematics means that students like mathematics and enjoy studying it.

Academic intrinsic motivation has a positive correlation with wide range of educational outcomes. The most supported hypothesis postulates that academic interest has a positive correlation with academic achievement (e.g. Ginsburg & Bronstein, 1993; Gottfried, 1990; Singh et al., 2002). Academic intrinsic motivation also has a positive correlation with engagement in classroom activities (Green et al., 2012), course selection (Marsh & Yeung, 1997; Marsh et al., 2005), and attitudes toward school (Green et al., 2012).

The school environment is an important factor in the development of intrinsic motivation (e.g. Stipek, Salmon, Givvin, & Kazemi, 1998; Ludtke et al., 2005; Parsons, Kaczala, & Meece, 1982). Some findings suggest that teachers may have a greater effect on students' academic interest than parents (Chirkov & Ryan, 2001). In particular, autonomy-supportive practices when teachers encourage students' independence, provide positive feedback and promote different problem solving activities, have a positive effect on intrinsic motivation (e.g. Ryan & Deci, 2000; Niemiec & Ryan, 2009). However, sometimes autonomy-supportive practices have no positive effect on achievements and motivation (e.g. Furtak & Kunter, 2012).

Although researchers agree on the importance of autonomy-supportive practices to develop intrinsic motivation it is not well established how the effect of these practices may vary for different student attributes, particularly, gender and prior achievements.

To the best of our knowledge most studies on the effect of teacher practices use cross-sectional data and measure motivation and teacher practices at the same time. We use longitudinal data where mathematics interest was measured twice. Thus we can estimate how teacher practices effect mathematics interest taking into account prior level of mathematics achievement and mathematics interest.

The aims of our study are:

1) to estimate the effect of autonomy-supportive and controlling teacher practices on mathematics interest depending on student gender, prior interest and achievements;
2) to identify the teacher practices which can reduce the gender gap in mathematics interest.

This will provide information about teacher practices which can reduce the gender gap in interest in mathematics and support girls' participation in STEM.

Literature review

Gender differences in attitudes toward mathematics

Girls have a lower level of mathematics interest and mathematics self-confidence than equally able boys (Skaalvik & Skaalvik, 2004; Eccles, Wigfield, & Schiefele, 1998; Koller et al., 2001). Superiority in mathematics interest and math self-concept for boys also has been verified in twin studies (Kovas et al., 2015). Even among students with high abilities, girls tend to have a lower level of mathematics self-concept and mathematics interest (Reis & Park, 2001; Hong & Aqui, 2004). Some studies find that among high-ability students the gender difference in attitudes toward mathematics in favour of boys is larger than for average-ability students (Preckel, Goetz, Pekrun, & Kleine, 2008).

International comparative educational studies also confirm gender differences in attitudes toward mathematics in every country participating in these studies (e.g. OECD, 2013; Else-Quest, Hyde & Linn, 2010). Even if there are no gender differences in mathematics achievements within some countries, boys reported higher mathematics self-assessment and more positive attitudes toward mathematics (Else-Quest, Hyde & Linn, 2010).

Gender differences in attitudes toward mathematics can be manifested in different attributional styles in mathematics for boys and girls. Girls are less likely than boys to attribute their success in mathematics to ability. Instead, girls attribute their success to effort and hard work (Parsons, Meece & Adler, 1982). Also girls are more likely to suffer from learned helplessness in mathematic—they give up easily when confronted with failure and more often attribute their failure to lack of ability than boys (Dweck, 1986; Stipek & Gralinski, 1991; Middleton & Spanias, 1999). Even in groups of high-achieving students, girls are less likely than boys to attribute their success in mathematics to ability and are more likely to explain their success by hard work, whereas boys tend to explain their success by ability or luck (Reis & Park, 2001; Assouline, Colangelo, Ihrig, & Forstadt, 2006). Girls with high mathematics achievements are likely to react more negatively than boys when they receive scores which are lower than they expect (Reis & Callahan, 1989).

There are a plenty of explanations for gender differences in attitudes toward mathematics including the stereotype threat hypothesis (e.g. Schmader, 2002), the gender stratification hypothesis (Baker&Jones, 1993), social structural theory (Eagly&Wood, 1999). Despite some differences most sociological and psychological theories emphasis the importance of gender stereotypes about mathematics abilities and the values of mathematics for the gender gap in attitudes toward mathematics (e.g. Reilly,2012; Else-Quest, Hyde & Linn, 2010; Hirnstein, Andrews, & Hausmann, 2014). Parents and teachers both contribute to developing gender stereotyping behaviour encouraging different activities for boys and girls, transmitting different expectations and goals, applying different standards for estimations (e.g. Jacobs, 1991; Tiedemann, 2000; Gunderson et al., 2012).

Teacher practices and attitudes as factors of the gender gap in attitudes toward mathematics

A slight gender difference in attitudes toward mathematics appears in early elementary school (e.g. Eccles et al., 1993). Although there is evidence that the level of mathematics extrinsic and intrinsic motivation, mathematics self-confidence and value beliefs decreases during schooling both for boys and girls (Fredricks, Eccles, 2002; Frenzel et al., 2010), some researchers confirm that the decline of mathematics motivation and mathematics self-assessment for girls is larger than for boys (e.g. Hyde, Fennema, Ryan, et al., 1990).

Considering gender differences in mathematics and science some researchers try to identify which school factors may effect on the gender gap in mathematics achievements and attitudes toward mathematics. Some researchers focus on the differences in teachers' attitudes toward boys and girls in mathematics and science lessons. Teachers spend more time addressing boys than girls in science lessons (Jones, Wheatley, 1990; Shumow & Schmidt, 2013). Some studies show that boys were asked more complex and abstract questions than girls (Becker, 1981; Scantlebury and Kahle, 1993). These differences can be partly explained by differences in students' achievements and participation in lessons (Altermatt, Jovanovic & Perry, 1998). Most researchers agree that teachers tend to perceive boys as more talented in mathematics than girls and have higher expectations for boys in mathematics and science (Li, 1999; Li & Adamson, 1995). At the same time teachers rate girls as trying harder than boys (Jussim & Eccles, 1992).

There is less evidence about gender differences in the perception and effect of teacher practices. Some authors suggest that effect of teacher behaviour differs for boys and girls. There is evidence that girls are more sensitive to different aspects of teacher behaviour and support than boys (Sharp, 2004; Krogh & Thomsen, 2005). Girls attribute their failure in mathematics to a lack of teacher support more often than boys (Lloyd, Walsh, & Yailagh, 2005). Other authors find that there are no gender differences in the effect of teacher practices on student performance or motivation (e.g. Assor, Kaplan, Kanat-Maymon & Roth, 2005).

Although mathematics intrinsic motivation declines during schooling, many authors believe that some teacher practices can encourage interest toward the subject both for boys and girls. Discussing the development of motivation to learn, researchers focus on the teachers' motivational style and identify two opposite approaches: autonomy-supportive practices and controlling practices (Deci, Schwartz, Sheinman, & Ryan, 1981; Reeve, 2009).

Autonomy-supportive practices can enhance intrinsic motivation because these practices help students to satisfy their needs for competence and autonomy (e.g. Ryan & Deci, 2000; Urdan & Schoenfelder, 2006; Niemiec & Ryan, 2009). Teachers can support their students' feelings of autonomy by minimizing the control and any sense of enforcement in the classroom as well as by maximizing students' feelings of having a choice in their academic activities (Niemiec & Ryan, 2009; Chirkov & Ryan, 2001).

According to Stefanou et al. (2004), there are three ways to support autonomy in the classroom. One way is to support organizational autonomy: students are allowed, for example, to choose the evaluation procedure and participate in creating classroom rules. The second way is to support procedural autonomy: students are given an opportunity to choose materials to use for class projects or to display their work in an individual manner. Finally, there is cognitive autonomy support: students are given, for example, the opportunity to find multiple solutions to problems, discuss multiple approaches and strategies, re-evaluate errors. Cognitive autonomy support can have a long-lasting effect on achievements and motivation (Stefanou et al., 2004).

Controlling practices are the opposite of autonomy supportive practices and may have a negative effect on students' intrinsic motivation and achievements (Assor et al., 2005). Teachers, who prefer a controlling style, listen to students less, do not often allow to students to manipulate instructional conditions and tasks and use direct instructions more often (Reeve et al., 1999; Reeve, 2009). Although autonomy supportive practices have a positive effect, some teachers prefer to use controlling behaviour for many reasons (Reeve, 2009).

One possible factor which leads to the preference for a controlling style is that autonomy-supportive practices do not fit well for every student. Sometimes autonomy-supportive practices have a negative effect on educational performance and are perceived negatively by students depending on their readiness for such type of learning (Furtak & Kunter, 2012). Students with low ability or low motivation may prefer a more formative and controlling style while high-ability students are more likely to prefer instructional methods emphasizing independence (Stewart, 1981; Ricca, 1994; Ames, 1992). Some authors suggest that enhancing autonomy and competency beliefs is possible if the teacher can organize lessons where every student may understand and master the tasks which are offered (Niemec&Ryan, 2009). Despite some limitations many authors believe that autonomy-supportive practices are important factors for developing academic interest (Niemiec & Ryan, 2009; Chirkov & Ryan, 2001).

Based on prior studies and theoretical perspectives we hypothesize that autonomy-supportive practices are more effective for girls than for boys. We also suggest that autonomy-supportive practices are more effective for students with high prior achievements and not effective for students with low prior achievements

Data and method

Data

We used data from the Russian longitudinal study "Trajectories in Education and Career" (TrEC). The first wave of the study was TIMSS 2011 (4,893 8th grade students in 231 classrooms in 210 schools). The second wave of PISA 2012 was administered using the TIMSS 2011 sample in Russia so that the same students took part in both studies. 87% of TIMSS sample were covered by the PISA wave (4,399 students in 229 classes in 208 schools). During TIMSS and PISA survey mathematics teachers were asked about their practices.

PISA used a rotational design, so only some of the students answered questions about attitudes toward mathematics. The rotational design was such that three forms of the questionnaire contained a common part and a rotated part. The common part , which was administered to all students, contained questions about gender, language at home, migrant background, home possessions, parental occupation and education. The rotated part contained questions about attitudinal and other non-cognitive constructs (OECD, 2013). Due to the rotational design of the study only the 2839 students (50% of whom were girls) from 186 schools who answered questions about mathematics interest are included into analysis.

Variables

Mathematics Interest

Longitudinal data allows us to estimate changes in mathematics interest in one year using TIMSS (8^{th} grade) and PISA (9^{th} grade) measures of mathematics interest.

The dependent variable is the PISA index of Mathematics Interest. PISA measures students' intrinsic motivation to learn mathematics through students' saying whether they "strongly agree", "agree", "disagree" or "strongly disagree" that they enjoy reading about mathematics; that they look forward to mathematics lessons; and that they do mathematics because they enjoy it and that they are interested in the things they learn in mathematics. The PISA index of Mathematics Interest is standardized to have a mean of 0 and a standard deviation of 1 across OECD countries (OECD, 2013). The reliability of scale (Cronbach's alpha) in the Russian sample is 0.87.

In order to estimate how mathematics interest had changed we control for previous level of mathematics interest using TIMSS index of Mathematics Interest, which was created based on students' degree of agreement with the five statements (e.g. "I like learning mathematics", "I learn many interesting things in mathematics", "Mathematics is boring"). The scale scores produced by the weighted likelihood estimation are in the logit metric and range from -5 to +5. To convert to a more convenient reporting metric, a linear transformation was applied to the international distribution of logit scores for each scale, so that the resulting distribution across all countries had a mean of 10 and a standard deviation of 2 (Mullis, 2012). The reliability of scale (Cronbach's alpha) in the Russian sample is 0.86.

For purpose of our analysis both indices were transformed into a z-scores to have a mean of 0 and a standard deviation of 1.

Individual achievements

We use five TIMSS plausible values in mathematics as an indicator of previous mathematics achievements. Each plausible value was standardized before analysis. Also we use HLM 6.08 (Raudenbush, Bryk & Congdon, 2009) "plausible value" options for the correct analysis of plausible values.

Gender

We use dichotomous variable "Female" (1 = female; 0 = male).

Teacher practices

Mathematics teachers answered questions about the frequency they use some practices. They had an opportunity to choose one option from four: every lesson or almost every lesson; about half the lessons; some lessons; never. For other practices teachers say whether they use this practice or not.

Niemec and Ryan (2009) identified some of the features of autonomy-supportive teacher practices. These practices include minimizing evaluative pressure, maximizing students' sense of having a voice and a choice in learning activities, facilitating internalization by providing a meaningful rationale of why learning is useful, providing feedback to promote success and a feeling of accomplishment (Niemec & Ryan, 2009). Based on these, we identified some teacher practices which can be classified as autonomy-supportive and created dummy variables to take into account their frequency of use.

1. Work independently. Teachers ask students to work on a problem (individually or with peers) while teacher is occupied with another task.
    a. Dummy 1: Practice is used every lesson or almost every lesson;
    b. Dummy 2: Practice is used in half of lessons;

    The reference category is "this practice is used sometimes or never".
2. Own procedure. Teachers ask students to decide their own procedures for solving complex problems.
    a. Dummy 1: Practice is used often (every lesson or half of the lessons)
    b. Dummy 2: Practice is used sometimes (some lessons)

    The reference category is "never use this practice".

3. Complex task. Teachers ask students to work on problems for which there is no immediately obvious method of solution.
    a. Dummy 1: Practice is used often (every lesson or half of the lessons)
    b. Dummy 2: Practice is used sometimes (some lessons)

    The reference category is “never use this practice”.
4. Relation to student’s life. Teachers ask students to relate what they are learning to their daily life.
    a. Dummy 1: Practice is used every lesson or almost every lesson;
    b. Dummy 2: Practice is used in half of lessons;

    The reference category is “this practice is used sometimes or never”.
5. Correct homework. Teachers give opportunity for students to correct their own homework.
    a. Dummy 1: Practice is used often (every lesson or half of the lessons)
    b. Dummy 2: Practice is used sometimes (some lessons)

    The reference category is “never use this practice”.
6. Different content. Teachers use different tasks for students with different ability (1 = yes, 0 = no).

We also include some practices which may be identified as controlling and may have an opposite effect on mathematics interest compared to autonomy supportive practices:

1. Memorize. Teachers ask students to memorize rules, procedures and facts.
    a. Dummy 1: Practice is used every lesson or almost every lesson;
    b. Dummy 2: Practice is used in half of lessons;

The reference category is “this practice is used sometimes or never”.

2. Test weekly. Teachers use test for evaluation student each week (1 = yes, 0 = no).
    a. Dummy 1: Practice is used every lesson or almost every lesson;
    b. Dummy 2: Practice is used in half of lessons;

The reference category is “this practice is used sometimes or never”.

3. Listen to teacher. Teachers ask students to listen to teacher explain how to solve problems.
    a. Dummy 1: Practice is used every lesson or almost every lesson;
    b. Dummy 2: Practice is used in half of lessons;

The reference category is “this practice is used sometimes or never”.

4. Direct instruction. Teachers ask students to work on problems together in the whole class with direct instruction from the teacher.
    a. Dummy 1: Practice is used every lesson or almost every lesson;
    b. Dummy 2: Practice is used in half of lessons;

The reference category is “this practice is used sometimes or never”.

Considering that using autonomy-supportive or controlling practices reflect different teachers’ styles and one practice may have no effect we created two indices for frequency of using each type of practices:

1) frequency of using autonomy-supportive practices;
2) frequency of using controlling practices.

These indices were calculated by averaging answers of teachers about frequency of using each practice. Larger values of indices indicate that the teacher uses this type of practices more often.

Covariates

We also used some students’ variables as covariates: socioeconomic status of students (SES), teachers’ years of experience, and class average mathematics scores. These variables were used as covariates because they are important predictors of academic intrinsic motivation (e.g. Trautwein et al., 2006; Ginsburg & Bronstein, 1993).

Statistical Analysis and Procedure

We used multilevel regression analysis to estimate the effect of teacher practices on mathematics interest. A multilevel approach takes into account the clustering effect, when students within the same class are typically more similar to each other than they are to students from other classes. Multilevel modelling distinguishes the effect of individual characteristics from the effect of class characteristics. Multilevel regression analysis is widely used to estimate school or class effects and evaluate how different student characteristics interact with school or teacher factors.

In order to test the effect of teacher practices on mathematics interest, a set of multilevel models were evaluated for mathematics interest as a dependent variable. We create a set of regression models for every teacher practice as an independent variable.

The first model includes a set of student variables (gender, TIMSS mathematics achievements, SES) and teacher level variables (2 dummies for each teacher practice, class average scores, dummies for teachers' years of experience). This model estimates the correlation between teacher practice and mathematics interest adjusted for the previous level of mathematics interest, gender, individual achievements and school variables (Model 1). This model was run for boys and girls separately as well as for students with high, medium and low achievements.

We divided students into three groups according to their mathematics achievements in order to estimate how teacher practices can reduce the gender gap for students with different levels of prior achievements. We use international benchmarks to identify low, intermediate and high level of achievements (Mullis, 2012).

1) Low level. In this group we included students who have scores less than the intermediate international 475 benchmark in mathematics. According to the TIMSS 2011 Report these students have only basic mathematical knowledge and can apply it in straightforward situations (Mullis, 2012).
2) Intermediate level. Students who have scores from 475 to 550.
3) High and advanced level. Students who have scores higher than 550. According to the TIMSS 2011 Report these students can apply their knowledge in a wide range of situation and solve non-routine problems.

To identify teacher practices which can reduce gender gap mathematics interest we add an interaction term between teachers' practice and gender and run analysis for whole sample and for three groups of students: with low, medium and high TIMSS mathematics achievements (Model 2).

All multilevel regressions were conducted using HLM 6.08.

Results

Gender differences in mathematics interest and mathematics achievements

First we estimate unadjusted differences in mathematics interest and mathematics achievements between girls and boys (Table 1). There is a significant difference in mathematics interest between boys and girls (in favour of boys) in the 8th and 9th grades and there is no significant gender difference in TIMSS mathematics performance in the 8th grade in the our sample.

Table 1. Mathematics Achievements and Interest, by Gender and Level of Achievements

Sample	Variables	Girls		Boys		Difference (girls-boys)
		Mean	SD	Mean	SD	
All students	Mathematics TIMSS scores	541 (1.5)	76	544 (1.6)	79.7	-3 (2.22)
	Mathematics interest (8th grade)	-.04 (.03)	.98	.04 (.03)	1.00	-.08** (.04)
	Mathematics interest (9th grade)	-.09 (.03)	.83	.09 (.03)	1.01	-.18*** (.03)
Low achievements	Mathematics TIMSS scores	436 (1.7)	37.9	431 (1.7)	38.4	5** (2.4)
	Mathematics interest (8th grade)	-.40 (.04)	.96	-.23 (.05)	.93	-.17** (.07)
	Mathematics interest (9th grade)	-.30 (.05)	.92	-.10 (.05)	.95	-.20*** (.07)
Medium achievements	Mathematics TIMSS scores	516 (1.03)	27.7	515 (1.01)	28.7	1.3 (1.4)
	Mathematics interest (8th grade)	-.14 (.04)	.99	-.14 (.03)	.95	.00 (.06)
	Mathematics interest (9th grade)	-.17 (.05)	.96	-.03 (.05)	.97	-.14** (.07)
High achievements	Mathematics TIMSS scores	603 (1.2)	42.5	608 (1.3)	45.1	-5*** (1.8)
	Mathematics interest (8th grade)	.20 (.04)	.96	.27 (.04)	1.01	-.07 (.05)
	Mathematics interest (9th grade)	.06 (.04)	.99	.23 (.04)	1.04	-.17*** (.05)

*** p<0.01, ** p<0.05, p* <0.1

Our results for students with different levels of achievements show that the gender gap in mathematics interest is significant in the 8th grade for students with low achievements only. Among students with medium or high achievements girls and boys have the same level of mathematics interest in the 8th grade.

Situation has changed in the 9th grade. The gender gap in mathematics interest becomes significant for students with any level of achievement. The mean difference between girls and boys in mathematics intrinsic motivation does not vary according to student achievement. Thus gender differences in attitudes toward mathematics increases from 8th to 9th grade.

The gap in mathematics achievements is significant in groups with low and high achievements. Among students with low achievements girls have higher mathematics scores. The opposite pattern is found in group students with high achievements where girls have a lower mathematics scores than boys.

A descriptive analysis of teachers' answers about their practices shows that controlling practices are more common than autonomy-supportive practices (Table 2).

Table 2. Frequency of Using Autonomy Supportive and Controlling Teachers Practices

Variables	N valid answers	Categories of answers	N	% (valid)
Work independently	186	Every lessons	22	12%
		Half lessons	63	34%
		Sometimes or never	101	54%
Relate to students' life	186	Every lessons	21	11%
		Half lessons	61	33%
		Sometimes or never	104	56%
Own procedure	186	Often (at least at half of lessons)	24	13%
		Sometimes	127	68%
		Never	35	19%
Solve the problem with no obvious solution	186	Often	11	6%
		Sometimes	130	70%
		Never	45	24%
Students correct their own homework	186	Often	24	13%
		Sometimes	136	73%

		Never	26	14%
Different content for different students	186	Yes	102	55%
		No	84	45%
Memorize	186	Every lessons	63	34%
		Half lessons	84	45%
		Sometimes or never	39	21%
Listen to teacher explain how to solve	186	Every lessons	132	71%
		Half lessons	43	23%
		Sometimes or never	11	6%
Direct instruction	186	Every lessons	95	51%
		Half lessons	56	30%
		Sometimes or never	35	19%
Using test for assignments	186	Once a week or more often	125	67%
		Less often than once a week	61	33%

The most popular practice among autonomy-supportive practices is to ask students to work independently on tasks: 46% of the teachers reported that they use this practice in at least half of their lessons, 13% every lesson. 44% ask students to relate their knowledge to their daily life in at least half of the lessons. The least popular practice among autonomy-supportive is to ask students to solve the problem with no obvious solution—24% of teachers said that they had never used practice and only 6% use this practice often.

Controlling practices are used more often. 71% of teachers asked students to listen his or her explanation of how to solve problems every lesson. More than half of teachers ask students to work on problems together as a whole class with direct guidance from the teacher every lesson. 67% of teachers gave mathematics tests about once a week.

The effect of teacher practices on mathematics interest

The analysis of the effect of the autonomy-supportive practices on mathematics intrinsic motivation for the whole sample, and for boys and girls separately are shown in Table 3.

Table 3. The Effect of Autonomy Supportive Practices on Mathematics Interest

Practices	Variables	All		Girls	Boys
		Model 1	Model 2	Model 1	Model 1
Work independently	Every lesson	-.03 (.08)	-.07 (.08)	.05 (.11)	-.09 (.08)
	Half of lessons	.05 (.05)	.02 (.08)	.05 (.07)	.01 (.08)
	Every lesson* Female		.08 (.10)		
	Half lessons* Female		.05 (.09)		
Relate to daily life	Every lesson	.15* (.08)	.001 (.09)	.30*** (.11)	-.01 (.09)
	Half of lessons	-.01 (.05)	-.06 (.07)	.05 (.06)	-.08 (.07)
	Every lesson* Female		.32*** (.12)		
	Half lessons* Female		.12 (.08)		
Own procedure	Often	.14* (.08)	.07 (.11)	.29*** (.10)	-.03 (.11)
	Sometimes	.14 (.10)	-.01 (.09)	.15** (.07)	-.04 (.09)
	Often *Female		.26** (.13)		
	Sometimes *Female		.14 (.10)		
Complex task	Often	-.01 (.09)	-.09 (.14)	.08 (.14)	-.14 (.14)
	Sometimes	.11* (.06)	.05 (.07)	.17** (.07)	.05 (.08)
	Often *Female		.16 (.19)		
	Sometimes *Female		.11 (.09)		
Students correct their homework	Often	-.10 (.10)	-.08 (.12)	-.06 (.12)	-.11 (.12)
	Sometimes	-.02 (.08)	-.02 (.09)	.01 (.10)	-.04 (.09)
	Often *Female		-.05 (.12)		
	Sometimes *Female		-.01 (.10)		
Different	Different content	.04 (.05)	.11 (.08)	.02 (.06)	.07 (.08)

content	Different content*Female		-.13 (.09)		
Index of using autonomy-supportive practices and controlling practices	Autonomy practices	.04 (.04)	.02 (.03)	.09** (.04)	.00 (.03)
	Controlling practices	-.04 (.04)	-.04 (.04)	-.04 (.04)	-.04 (.04)
	Autonomy * Female		.06 (.04)		.
	Controlling practices* Female		.01 (.04)		

*** p<0.01, ** p<0.05, p* <0.1

For the whole sample among the six different practices which are assumed to encourage student autonomy, three practices (“Relate to student’s life”, “Own procedure” and “Complex task”) have a positive correlation with mathematics interest. It should be noted that two practices have a positive effect only if they are used every or almost every lesson. Regression coefficients for other practices are not significant in Model 1.

The results of Model 2 show which practices have different effects on mathematics interest for boys and girls. The interaction term between practices and gender is significant for two practices: “Relate to student’s life” and “Own procedure”. The results of this model for both practices mean that using these practices has no effect on mathematics interest for boys but has a positive effect on mathematics interest for girls. However, it matters how often these practices are used. There is a positive effect if practices are used often. These two practices can decrease the gender gap in mathematics interest. The results of the regression analysis for boys and girls separately confirmed these results.

The regression analysis separately for boys and girls also shows that autonomy-supportive practices in general are more important for girls than for boys. The regression coefficient for variable “Using autonomy supportive practices” is positive and significant for girls only.

Results of analysis the effect of controlling practices are presented at the Table 4.

Table 4. The Effect of Controlling Practices on Mathematics Interest

Practices	Variables	All		Girls	Boys

		Model 1	Model 2	Model 1	Model 1
Memorize rules and facts	Every lesson	-.08 (.06)	-.09 (.08)	-.08 (.08)	-.09 (.08)
	Half of lessons	.04 (.06)	.02 (.08)	-.09 (.09)	.03 (.08)
	Every lesson* Female		.02 (.10)		
	Half lessons* Female		-.12 (.10)		
Listen to teacher how to solve problems	Every lesson	-.14 (.09)	.001 (.11)	-.30*** (.10)	.01 (.12)
	Half of lessons	-.17* (.10)	-.03 (.11)	-.32*** (.12)	-.03 (.13)
	Every lesson* Female		-.29** (.12)		
	Half lessons* Female		-.29** (.13)		
Direct instruction	Every lesson	.01 (.07)	-.04 (.08)	.06 (.08)	-.05 (.08)
	Half of lessons	-.01 (.07)	-.05 (.09)	.02 (.08)	-.05 (.09)
	Every lesson* Female		.10 (.09)		
	Half lessons* Female		.08 (.09)		
Test weekly	Test weekly	.01 (.06)	-.04 (.07)	.07 (.07)	-.04 (.07)
	Test weekly *Female		.11 (.08)		

*** p<0.01, ** p<0.05, p* <0.1

Among the four controlling practices only "Listen to teacher" has a significant negative effect on mathematics interest. The results of Model 2 show that this practice has a negative effect for girls, not for boys. Other controlling practices have no significant effect on mathematics interest.

In order to estimate which teacher practices can reduce the gender gap for student with low, medium and high achievements regression analyses were run for each group separately. The results of the analysis of autonomy-supportive practices are shown at the Table 5.

Table 5. The Effect of Autonomy Supportive Practices on Mathematics Interest for students with low, medium and high achievements

		Low achievement		Medium achievement		High achievement	
Practices	Variables	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Work independently	Every lesson	-.04 (.11)	-.15 (.13)	-.19 (.12)	-.16 (.14)	.08 (.12)	.05 (.12)
	Half of lessons	.03 (.09)	.00 (.15)	-.02 (.08)	-.05 (.12)	.07 (.08)	.09 (.09)
	Every lesson*Female		.24 (.19)		-.05 (.17)		.07 (.11)
	Half lessons*Female		.06 (.18)		.07 (.14)		-.04 (.11)
Relate to daily life	Every lesson	.13 (.11)	-.06 (.19)	-.02 (.15)	-.12 (.21)	.24** (.11)	.13 (.12)
	Half of lessons	.11 (.08)	.00 (.13)	-.10 (.07)	-.13 (.10)	.02 (.08)	-.08 (.10)
	Every lesson*Female		.40 (.24)		.20 (.23)		.24* (.14)
	Half lessons*Female		.23 (.16)		.06 (.13)		.20** (.10)
Own procedure	Often	.02 (.13)	-.20 (.20)	.00 (.13)	-.06 (.18)	.38*** (.12)	.21 (.17)
	Sometimes	-.13 (.10)	.16 (.16)	.11 (.09)	-.02 (.13)	.20** (.10)	.12 (.15)
	Often *Female		.41* (.23)		.13 (.22)		.33* (.17)
	Sometimes *Female		.06 (.21)		.25* (.14)		.15 (.14)
Complex task	Often	-.08 (.21)	-.39 (.36)	-.36 (.30)	-.43 (.43)	.17 (.15)	.11 (.18)
	Sometimes	.07 (.10)	.10 (.15)	-.08 (.09)	.09 (.12)	.25*** (.09)	.20* (.11)
	Often *Female		.41 (.26)		.15 (.47)		.14 (.20)

	Sometimes *Female		-.06 (.18)		.03 (.15)		.12 (.13)
Students correct their homework	Often	-.03 (.16)	.08 (.23)	-.18 (.15)	-.34* (.19)	.00 (.15)	.07 (.16)
	Sometimes	.10 (.14)	.17 (.17)	-.14 (.10)	-.17 (.14)	.03 (.11)	.01 (.12)
	Often *Female		-.20 (.26)		.28 (.23)		-.16 (.15)
	Sometimes *Female		-.12 (.20)		.05 (.15)		.01 (.12)
Different content	Different content	.13* (.07)	.16 (.12)	.07 (.07)	.19** (.09)	.03 (.07)	.01 (.09)
	Different content*Female		-.08 (.15)		-.23** (.11)		.03 (.09)
Index of using autonomy-supportive practices and controlling practices	Autonomy practices	.03 (.05)	.00 (.06)	-.01 (.04)	-.05 (.05)	.08** (.04)	.07 (.05)
	Controlling practices	.02 (.05)	-.02 (.07)	-.04 (.04)	.01 (.06)	-.01 (.04)	-.04 (.05)
	Autonomy * Female		.06 (.07)		.08 (.07)		.03 (.05)
	Controlling practices* Female		.07 (.10)		-.10 (.07)		.07 (.05)

*** p<0.01, ** p<0.05, p* <0.1

For students with low achievements only “Different content” has a positive effect and this effect is the same for boys and girls. For boys with medium achievements this practice has a positive effect while for girls with medium achievements it has no effect. For student with medium achievements when they are allowed to correct their own homework often, there is a negative effect for boys only.

Using autonomy-supportive practices is more important for students with high achievements. The index of using autonomy-supportive practices has a positive effect on mathematics interest only for students with high achievements. Three practices (“Relate to student’s life”, “Own procedure” and “Complex task”) have a positive correlation with increased mathematics interest. Two of them (“Relate to student’s life”, “Own procedure”) can reduce the gender gap in mathematics interest.

Table 6. The Effect of Controlling Practices on Mathematics Interest for students with low, medium and high achievements

		Low achievement		Medium achievement		High achievement	
Practices	Variables	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Memorize rules and facts	Every lesson	-.01 (.10)	-.09 (.15)	-.15 (.10)	-.08 (.13)	.01 (.10)	.01 (.12)
	Half of lessons	-.21 (.16)	-.01 (.14)	-.20** (.09)	-.07 (.13)	.12 (.10)	.19 (.12)
	Every lesson* Female		.15 (.20)		-.13 (.17)		.00 (.12)
	Half lessons* Female		.03 (.19)		-.23 (.16)		-.13 (.13)
Listen to teacher how to solve problems	Every lesson	-.03 (.21)	.18 (.19)	-.14 (.13)	.05 (.18)	.02 (.12)	.07 (.19)
	Half of lessons	-.12 (.22)	.13 (.19)	-.06 (.15)	.15 (.20)	-.07 (.13)	-.06 (.20)
	Every lesson* Female		-.40 (.31)		-.42*** (.14)		-.09 (.22)
	Half lessons* Female		-.49 (.32)		-.45** (.19)		-.03 (.24)
Direct instruction	Every lesson	.12 (.09)	-.08 (.14)	.00 (.09)	.06 (.11)	-.03 (.10)	-.11 (.12)
	Half of lessons	.05 (.10)	-.14 (.16)	-.05 (.10)	-.07 (.14)	-.04 (.10)	-.06 (.12)
	Every lesson* Female		.36** (.18)		-.11 (.13)		.17 (.12)
	Half lessons* Female		.34 (.22)		.04 (.15)		.05 (.12)

Test weekly	Test weekly	-.06 (.08)	-.05 (.12)	-.03 (.08)	-.04 (.11)	.10 (.08)	-.03 (.09)
	Test weekly *Female		-.02 (.16)		.02 (.12)		.28*** (.09)

*** p<0.01, ** p<0.05, p* <0.1

The effect of some controlling practices is also different for students with low, medium and high achievements. Memorizing rules and facts has a negative effect on mathematics interest for students with medium achievements and is insignificant for students with low or high achievements. Listening to teachers for how to solve problems has a negative effect on mathematics interest for girls with medium achievements only. Direct instruction has a positive effect on mathematics interest for girls with low achievements. One controlling practice ("Test weekly") has a positive effect for girls with high achievements. Hence controlling practices can reduce the gender gap for students with low achievements and the increase gender gap for students with medium achievements.

Discussion

We tested some hypotheses about the relationships between teacher practices and mathematics interest for boys and girls with different levels of prior mathematics achievements. Our results are in agreement with previous studies which demonstrated that teachers prefer controlling practices. Most teachers prefer to use both types of practices during lessons although controlling practices are more popular.

Following previous studies we hypothesised that autonomy-supportive practices may have a positive effect on mathematics interest while controlling practices are likely to have negative effect. Our analysis has demonstrated that among the six autonomy supportive practices three practices ("Relate to student's life", "Own procedure", "Complex tasks") have a positive effect on mathematics interest for the whole sample. At the same time, controlling practices except "Listen to teacher" have no negative effect

Further analysis shows that some autonomy-supportive practices may reduce the gender gap in mathematics interest and have a positive effect for girls only. Controlling practices may have a negative effect on girls' mathematics interest and can increase the gender gap. Girls are likely to be more sensitive to different types of teacher practices and their mathematics interest is more dependent on teachers. Boys are likely to have an interest in studying mathematics independently of teachers, but girls initially have lower levels of mathematics intrinsic motivation and this motivation needs to be supported by teachers. Some previous findings showed that for girls their relationships with teachers are more important than for boys (Sharp, 2004; Krogh & Thomsen, 2005). Our results show that autonomy-supportive practices can sometimes be more important for girls' mathematics interest than for boys'.

These finding are consistent with some previous studies of gender differences in attitudes toward math. Some studies of math self-concept and math self-efficacy have shown that girls may be more sensitive to the influences of parent-, teacher- and peer-support and the vicarious experience that they provided (Lent, Lopez, et al., 1996; Zeldin & Pajares, 2000; Pomerantz et al., 2002, Zeldin, Britner, & Pajares, 2008; Goodenow, 1993). Girls are more likely to rely on other's judgments about their ability than on their own experience (Usher & Pajares, 2006). Math interest has a strong correlation with math self-concept (Valas and Sovik, 1994; Skaalvik and Valås, 1999). Beier and Rittmayer (2008) in their literature review of motivation factors in STEM suggest that interest and self-concept develop through a reciprocal relation with achievement and that a positive self-concept lead to increasing of academic interest (Beier & Rittmayer, 2008). As girls' math self-concept is more sensitive to teachers and parents' behaviour mathematics interest can be more sensitive too.

Boys have a higher level of mathematics interest and mathematics self-concept because their mathematics behaviour and self-efficacy are closer to gender stereotypes (VanLeuvan, 2004; Preckel et al., 2008; Gunderson, Ramirez, Levine, & Beilock, 2012). Gender stereotypes may be translated through teachers' expectations and attitudes. Teachers tend to perceive boys as more talented in mathematics than girls and have higher expectations for boys in mathematics and science (Li, 1999; Li & Adamson, 1995). If boys have a high level of mathematics interest this is supported by others. At the same time if a girl has a high level of interest in mathematics she may not have support from peers, teachers or parents (Gunderson, Ramirez, Levine, & Beilock, 2012; Lazarides & Ittel, 2013). Hence perceived teacher support was more closely related to motivation for girls than for boys (Goodenow, 1993; Wang, 2012).

Our results show that gender differences in mathematics are mostly related to motivation rather than to actual achievements. Girls, on average, have the same level of mathematics achievements as boys although among students with high level of achievements boys have higher achievements than girls. These findings are supported by previous studies of gifted students which show that the gender gap in math test results may be higher in groups of gifted students (e.g. Ellison & Swanson, 2010; Preckel, Goetz, Pekrun, & Kleine, 2008).

Gender differences in attitudes toward mathematics increase during schooling for students with any level of achievements. It is possible that a lack of teacher support and autonomy-supportive practices decrease mathematics interest for girls. At the same time, some studies show that decreasing intrinsic motivation may be part of the natural processes related to progressive declines in student commitment to their class work (Epstain& McPartland, 1976), academic self-concept (Eccles, Roeser, Wigfield, & Freedman-Doan, 1999), their pursuit of learning goals (e.g., Anderman & Midgley, 1997), their perception of the usefulness and importance of mathematics (Wigfield et al., 1991).

During adolescence academic activity becomes less important compared to social activities and relationships with peers (e.g. Berndt, 1982; Ryan, 2000). Some studies show that adolescent girls are more likely to value social goals (e.g., having friends, helping others) than non-social goals compared to boys (e.g., getting good grades, earning money; Ford, 1982). The increasing interest in social life can be an important factor of decline in mathematics interest.

We also confirmed the hypothesis that autonomy-supportive practices may be more effective for students with a high level of previous achievements and not effective for students with low achievements. This can be partly explained by the readiness of students for such type of practices. Blumenfeld et al. (1991) found that students may perceive tasks negatively if they involve high-level cognitive processing and need more time and effort. Ames (1992) supposed that if students do not have the desire or ability to regulate their own behaviour, it is unlikely that autonomy-supportive practices will lead to an increase in motivation (Ames, 1992). In light of these studies it is clear why some practices have an effect only for high level students. Practices for eliciting cognitive autonomy demand more effort from students, and often these tasks are not well-structured, which may cause discomfort or anxiety. We suggest that students should have a certain level of academic competency for cognitive supportive practices to have a positive effect on their motivation.

Most of autonomy-supportive practices which were included in our study related to cognitive autonomy support. Further research should account for different types of autonomy support and evaluate which of those practices are more efficient for students of different genders and levels of abilities.

In addition, our results have demonstrated that the effect of teacher practices should be analysed in regard with to gender and achievements of students. Even if some practices have no significant effect on outcomes for the whole sample they may have an effect on girls or boys separately or may be more effective for students with high (or low) achievements.

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