Factors Explaining the Interest of Czech Students in Reading and Mathematics

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Abstract: The goal of the empirical study is to identify significant predictors of student interest in reading and mathematics using data from international large-scale assessments. According to studies of interest development in educational settings, certain instructional techniques are able to evoke situational interest, whereas personal relevance and active involvement are sources of maintained interest. This study compares the effect of engaging instruction with the effect of student-related characteristics, such as gender, family background, free time preferences and perceived difficulty of the subject. The analyses were performed on PIRLS and TIMSS 2011 data for Grade 4 students from the Czech Republic separately for reading (*N* = 4556) and mathematics (*N* = 4578). In addition, data from a national follow-up study in Grade 6 was used to study interest development (*N* = 2955 for reading, *N* = 2956 for mathematics). Engaging instruction is positively associated with student interest in Grade 4 in both domains. The percentage of students declaring a positive attitude is close to 80% in both domains. A slight decrease in interest levels between Grades 4 and 6 was identified. While the most powerful predictor of interest in reading in Grade 6 is the former interest level, interest in mathematics is best predicted by perceived difficulty. Implications for instructional practice are also discussed.

Keywords: student interest; reading; mathematics; engaging instruction; PIRLS; TIMSS

Czech Republic has been participating in the activities of the International Association for the Evaluation of Educational Achievement (IEA) since the first round of TIMSS in 1995. Our country has also been involved in the assessments conducted by the Organisation for Economic Co-operation and Development (OECD) in student (PISA), teacher (TALIS) and adult (SIALS, PIAAC) populations. Studies carried out among students[1] have brought a wide range of internationally comparable data on their educational outcomes, conditions for learning and classroom activities. Not surprisingly, country results in cognitive tests always raise the greatest attention. On the other hand, results concerning student motivation, attitudes and other non-cognitive outcomes are rather neglected in the Czech Republic (Straková, 2016), although they might provide relevant information on the capacity of the school system to achieve important educational goals according to the Education Act.

This article aims to address student interest in reading and mathematics as educational outcomes that can be supported or inhibited by school instruction.

[1] This article uses the term “students” instead of “pupils” to denote children enrolled in primary and secondary schools regardless of the grade level. This is in line with the terminological conventions applied in the official reports from international large-scale studies.

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Chapters about student interest and other motivational aspects are integral part of reports from every international large-scale study. However, student motivation is seen mostly as a precondition that explains why some students achieve better than others, not as a specific outcome that has to be explained. In a different research tradition, educational psychologists devoted immense efforts to identify what aspects of school instruction can promote student interest. This article wants to build a bridge between these two strands of educational research. It will use data from international large-scale assessments to answer questions that are more typical to the research of interest development.

1 Conceptual background

1.1 Role of motivational beliefs in educational achievement and aspirations

Student motivation to learn and perform well at school can be decomposed into different components. One of the most influential theories of motivation in the field of education, expectancy-value theory (Eccles et al., 1983), differentiates two basic sets of motivational beliefs: expectancies of success and task values. Expectancies refer to one's perceived ability to accomplish a given task and are conceptually similar to self-concept and self-efficacy as defined in social cognitive theory of motivation (Bandura, 1977; Pajares & Miller, 1994). Task values are subjective perceptions of how valuable the task is. There are different types of subjective task values: attainment value or importance of doing well on a given task, interest value or enjoyment from doing the task, utility value or usefulness of the task for one's future goals, and costs or subjective assessment of effort necessary to accomplish the task (Wigfield & Eccles, 2000). Interest value is similar to the construct of intrinsic motivation from the self-determination theory (Deci & Ryan, 1985), whereas utility value refers to extrinsic reasons for action.

This article focuses on the interest component of achievement motivation. According to the expectancy-value theory, both expectancies and values are considered as important prerequisites of educational achievement. While the perceptions of one's ability ensure that the goal is experienced as attainable, value-related perceptions support persistence and commitment to the goal (Korhonen et al., 2016). Empirical evidence on the relationship between interest and achievement is, however, not so straightforward.

In a multi-cohort study conducted by the authors of the expectancy-value theory, children's competence beliefs strongly predicted their competence beliefs in the next year as well as their grades. On the contrary, students' interest predicted their next year's interest, but not the grades (Wigfield & Eccles, 2000). Cortright, Lujan and Blumberg (2013) found that interest was associated with higher grades for male students but not for females. A German study on mathematics showed that interest had no significant effect on achievement between Grade 7 and Grade 10 but more interested students tended to choose advanced courses at upper secondary level. Furthermore, interest in Grade 10 had both direct and indirect (via course selection) effect on achievement in Grade 12 (Köller, Baumert, & Schnabel, 2001). Other more recent studies confirmed the effect of interest on educational choices (Gottfried et al., 2013; Nagy et al., 2006) and aspirations (Korhonen et al., 2016), whereas academic achievement tends to be linked more closely to self-concept than to interest (Nagy et al., 2006).

Even though its effect on student achievement may be lower than one would anticipate, there is a general consensus that interest facilitates learning (Renninger & Hidi, 2011), improves the quality and depth of the learning process (Savelsbergh et al., 2016) and compensates for the lack of skills when solving difficult tasks (Springer, Harris, & Dole, 2017). The importance of student motivation for their achievement might be particularly relevant for young children in the domain of reading (Mullis & Martin, 2015). A positive attitude towards reading is also assumed to be one of the most important attributes of a lifelong reader (Mullis et al., 2009a). The role of interest in reducing achievement gaps and course selection differences between boys and girls was also documented (Gustafsson, Yang Hansen, & Rosén, 2013; Nagy et al., 2006). Interest can even mitigate, although to a more limited extent, the influence of socioeconomic background on student achievement (OECD, 2010). To sum up, interest in school subject matter is an important non-cognitive educational outcome that improves academic achievement, affects career choices and fosters lifelong learning.

1.2 Development of student interest

Numerous studies have identified a general decrease of interest in school subjects as students pass to higher levels of schooling (Krapp, 2002; Renninger & Hidi, 2011). Most of the research has been based on cross-sectional and short-term longitudinal designs, but similar results were reported for longitudinal studies, as well (e.g., Fredricks & Eccles, 2002). The loss of interest can be explained by increased task complexity, higher demands for effort and changes in social relationships during adolescence (Frenzel et al., 2010). Another factor could be a more frequent use of traditional instructional techniques in higher grades (Fredricks & Eccles, 2002).

The loss of interest applies especially to mathematics and science (Frenzel et al., 2010; Gläser-Zikuda, Stuchlíková, & Janík, 2013; Gottfried et al., 2013; Savelsbergh et al., 2016). Low levels of student motivation in STEM (Science, Technology, Engineering and Mathematics) subjects has even become a major concern of educational policy in many countries (Kearney, 2016), as expertise in STEM subjects is seen as a necessary precondition for economic progress. Another consistent finding is that boys are more interested in mathematics than girls (Frenzel et al., 2010; Köller et al., 2001), but the gender gap may not intensify as students grow older (Fredricks & Eccles, 2002; Frenzel et al., 2010).

The mechanism of interest development in learning environments has been extensively studied by educational psychologists. Hidi and Renninger (2006) proposed a four-phase model of interest development with phases of triggered situational, maintained situational, emerging individual and well-developed individual interest. A recent study by Rotgans and Schmidt (2017) demonstrated that, indeed, situational interest led to the development of individual interest. Similarly, Krapp (2002; 2007) distinguished between situational interest and individual interest (as a personal trait) and suggested a three-step ontogenetic transition from the first to the latter with an intermediate step of stabilized situational interest.[2]

Many researchers have tried to identify what aspects of school instruction have the potential to raise student interest. Whereas hands-on activities, group work, novelty and changes in the environment are among the most cited sources of situational interest, personal relevance and active involvement tend to support longer lasting interest (Renninger & Hidi, 2011). As Springer, Harris and Dole (2017) point out, so-called catch activities that sparkle students' situational interest must be followed by something more meaningful that will maintain their interest for a longer time. The teacher's emotional involvement, enthusiasm and his/her personal belief about the value of the learning material were also positively related to students' interest (Frenzel et al., 2010; Gläser-Zikuda et al., 2013). On the other hand, classroom practices like public praise and criticism, public drill or the use of competitive approaches tend to undermine the initial interest of students (Frenzel et al., 2010).

Research carried out in the Czech Republic has confirmed the general pattern of declining interest in reading and mathematics as children grow older. Whereas 93% of girls and 74% of boys aged 8–9 years liked reading, only 67% of girls and 35% of boys aged 14–15 years did so (Ronková, 2015). The author explains the weakening interest in reading among older students, especially boys, by the fact that reading as a time-intensive activity has to compete with other free time activities and loses its appeal when confronted with some less demanding and more tempting entertainments, in particular computer games. Interestingly, internet was not identified as a direct "rival" of reading for children; it competes rather with TV watching.

Moving to the domain of mathematics, Chvál (2013) examined students' attitudes towards mathematics using the method of semantic differential. He found a decrease in liking mathematics, with the most pronounced drop between Grades 5 and 6. The generally decreasing trend continued at the upper secondary level. By contrast, students' attitude towards Czech language declined up to Grades 6 and 7, but then it increased to more positive values. Foreign language was perceived positively, without dramatic changes between different years of schooling. Pavelková and Hrabal (2012) relate low level of interest in mathematics to its perceived difficulty. In their study of attitudes towards school subjects among Czech students at

[2] Although the prototypical trajectory goes from situational to individual interest, an opposite process of arousing situational interest on the basis of a strong individual interest can also be observed (Krapp, 2002). For example, students' interest in reading can be raised when the teacher offers them books on topics they are already interested in (Springer, Harris & Dole, 2017).

lower secondary level (Grades 6 to 9), mathematics was perceived as the most difficult and the third most unpopular subject. The development of students' attitudes towards mathematics was characterized by a decreasing popularity after Grade 6, coinciding with worsening marks and growing perceived difficulty.

1.3 Measurement of student interest in international large-scale assessments

Both the general public and educational research community appreciate international large-scale assessments as a valuable source of information on student achievement in comparison to other countries. Along with the widely followed results on academic achievement, non-cognitive educational outcomes are also assessed. The conceptualization of student motivation builds on prominent psychological theories and provides a solid basis for a detailed investigation of student self-concept, self-efficacy and interest. Secondary analyses of released datasets can profit not only from high-quality data collected on representative student samples, but also from repeated administration of the same items in consecutive data collections to observe the change of student attitudes in time. Another advantage is the possibility to link data on students' motivation with their cognitive achievement, family background and variables related to teaching and instruction.[3]

Student interest is generally measured through students' agreement or disagreement with statements affirming that they like reading, mathematics or science, that they are interested in solving mathematics or science problems, that they would like to have more time for reading, etc. Also included are items expressing a negative attitude, such as "I read only if I have to". Students' answers to individual items are then combined to summary scales, after re-coding of negative items. The scales are part of the final dataset and can be directly used for secondary analyses. Alternatively, individual items can be analysed.

A typical finding on student interest published in international and national reports consists of country comparisons of mean values and gender differences on interest scales. Interest is also routinely correlated with achievement. Generally, the more interested the students are, the higher levels of achievement they show, although the association between self-concept and achievement tends to be stronger than the correlation between interest and achievement (see also Chvál, 2013). Girls are more likely to show higher interest in reading than boys, whereas boys are more interested in mathematics than girls. Interest as outcome variable and its

[3] The measurement of different aspects related to teaching and instruction by means of teacher questionnaires was traditionally a distinctive feature of IEA studies. The OECD PISA study has recently also recognized the importance of teacher variables in explaining student achievement. In 2015, PISA included two optional questionnaires for teachers of science and other subjects. PISA 2018 can be optionally linked to the OECD TALIS study (Teaching and Learning International Survey).

relationship to teaching practices or other variables related to school instruction, while assumed, are typically not examined.

1.4 Aims of the present study

This study aims to explore the potential of instruction-related variables to explain student interest in reading and mathematics. More specifically, it compares the effect of engaging instruction with the effect of student personal characteristics, such as gender, family background, perceived difficulty of the subject and free time preferences.

Following the work of McLaughlin et al. (2005), engaging instruction was introduced as a new measure in TIMSS and PIRLS 2011 to describe the cognitive interaction between the student and instructional content. This measure complements the information on the use of various instructional techniques and strategies and connects the instruction with curriculum (Mullis et al., 2012a), which has been a central category of all IEA studies (Mullis et al., 2009b). The original concept of student content engagement, as defined by McLaughlin and her colleagues, was intended as a general framework for research on teaching quality, i.e. as a tool for defining and organizing teacher characteristics that contribute to better learning and higher achievement levels. Accordingly, engaging instruction was included in TIMSS and PIRLS 2011 as a potential teacher-related predictor of student achievement (Mullis & Martin, 2015). However, its association with student achievement tends to be rather small, at least for the Czech Republic (Mullis et al., 2012a, b). Nevertheless, engaging instruction seems to be a promising construct for analysing the role of the teacher in arousing and maintaining student interest.

This study seeks answers to the following research questions:

1. What is the effect[4] of engaging instruction on student interest in reading and mathematics comparing to the effect of student personal characteristics, such as gender, family background and perceived difficulty of the subject matter?
2. Does the effect of engaging instruction at the primary level endure to the lower secondary level?
3. Is the effect of different variables on student interest comparable for both domains?

[4] The term "effect" is used in the statistical sense as the relationship between a predictor and the outcome variable when all other predictors are held constant. Cross-sectional data collected in one time point, as is the case of all international large-scale assessments, do not allow to draw conclusions about causal effects.

2 Method

2.1 Data

The primary data source is TIMSS and PIRLS 2011 data for Grade 4 students from the Czech Republic. TIMSS is an IEA study of mathematics and science, which is organized every four years. It targets at Grade 4 and Grade 8 students, but only the younger population of fourth-graders participates now in the Czech Republic.[5] PIRLS is an IEA reading literacy study, which repeats every five years and measures reading comprehension skills of Grade 4 students only. In 2011 the cycles of the two studies met, which allowed to optionally include the same students in both of them. The Czech Republic used this option. Therefore, the datasets from the two studies can be combined together via a common (anonymised) student ID code.

The analyses for this study were conducted separately for reading (N = 4556) and mathematics (N = 4578). Slight difference in the numbers of participants is caused by the fact that some students could not attend both administrations. This study uses the link between PIRLS and TIMSS only to merge data from PIRLS parent questionnaire with TIMSS student questionnaire data. Parent questionnaire is a unique source of information on family background, which is normally not administered in TIMSS.

Analyses concerning the transition from primary to lower secondary education use data from the Czech Longitudinal Study in Education (CLoSE). CLoSE is a multi-cohort 7-year research project that focuses on the formation of skills, attitudes and preferences during school attendance and their role at the labour market. One of the cohorts included in the project consists of students who participated in TIMSS and PIRLS 2011 and were later contacted at several points of their educational career. They completed a questionnaire in Grade 5 and a test and questionnaire at the beginning of Grade 6. As some students transited to 8-year academic track after the completion of five years of primary education, their new classmates were added to the sample to collect more information about the differences between the standard and academic tracks. The next follow-up was in Grade 9 in both school types. This article analyses questionnaire data from Grade 6 students with disponible data from Grade 4 (N = 2955 for reading, N = 2956 for mathematics).

2.2 Measures

Student interest in reading/mathematics

Student interest in Grade 4 was measured with summary scales created by the TIMSS and PIRLS international study centre. These scales were included in the respective datasets under variable names ASBGSLR (*Students like reading*) and ASBGSLM (*Students like learning mathematics*). The original English wording of items used to

5 The inclusion of Grade 8 students in TIMSS has no longer been considered as a political priority after the introduction of the OECD PISA study. PISA targets at the population of 15-year-old students, who are typically enrolled in Grades 9 and 10 (cf. Straková, 2016, p. 32).

construct these scales is given in the Appendix (see Martin & Mullis, 2012 for further details). Czech translation of the items as adopted in the national versions of PIRLS and TIMSS student questionnaires is also reported to increase the transparency of the present study for readers from the Czech Republic.

Student interest in Grade 6 was assessed through questionnaire items administered within the CLoSE study in autumn 2012. For reading, three items were identical as in Grade 4. These three items were selected to create a scale of student interest in reading. The scale was created by means of principal component analysis in SPSS, without rotation. The first principal component explained 77% of the variance, the items were highly inter-correlated (Cronbach's α = .85).

Similarly, student interest in mathematics was constructed as the first principal component of four items (explained variance 72%, Cronbach's α = .87). None of them was identical to those used in Grade 4. Three items (see the Appendix for their wording in Czech and translation into English) were scored using a 4-point agreement Likert scale. The fourth item assessed the popularity of mathematics among other school subjects on a 5-point scale ranging from most popular to least popular. The items were recoded so that higher values represent higher interest.

Engaging instruction

Engaging instruction was introduced as a new concept in TIMSS and PIRLS 2011 to capture cognitive interaction between the student and instructional content. For each study, two complementary scales were developed to measure student engagement during the classroom instruction. The first one looked at student engagement from the teacher point of view and contained different teaching practices intended to raise student interest and reinforce their learning. The second one represented the students' perceptions of classroom instruction in terms of how interesting and clear it was.

This article uses the student perspective to measure engaging instruction (student variables ASBGERL for reading and ASBGEML for mathematics). Individual items constituting the scales are described in the Appendix together with their Czech equivalents. One reason for the selection of the student-based rather than the teacher-based scale is that it generates greater variability in the student-level data. It also reflects the fact that some teaching methods may work well for some, but not for other students, depending on their learning styles, prior experience, ability and other factors. The student-based scales also had higher internal consistency and explained more variance than the corresponding teacher-based scales (see Martin & Mullis, 2012 for more technical details about psychometric properties of the scales). Engagement in classroom instruction was not measured in Grade 6.

Perceived difficulty of reading/mathematics

Following the work of Pavelková and Hrabal (2012), perceived difficulty was selected as a variable with a possible significant effect on student interest, especially in the domain of mathematics. Pavelková and Hrabal used one item to assess perceived difficulty of different school subjects on a 5-point Likert scale ranging from very difficult to very easy. The present study uses summary scales derived from several items by means of principal component analysis. It was not possible to use the same items for both domains and both grades, due to different content of the questionnaires.

The scale of perceived difficulty of reading in Grade 4 was derived from four items: I usually do well in reading, Reading is easy for me, Reading is harder for me than for many of my classmates, Reading is harder for me than any other subject, coded such that higher values represent higher difficulty (explained variance 52%, Cronbach's α = .77). In Grade 6, five items were used: I usually do well in reading, Reading is easy for me, I sometimes have troubles to exactly understand what I read, I have to read the text more than once to understand it properly, I understand well and easily what the text says, coded such that higher values represent higher difficulty. This scale had lower internal consistency (Cronbach's α = .42) and explained less variance (34%) than other summary scales created for the purpose of this study. However, I decided to keep it because the items describe quite precisely the typical reading comprehension difficulties of Grade 6 children. An alternative scale containing only the first two items (which were taken from the PIRLS questionnaire) had better psychometric properties, but conceptually could not serve as a measure of perceived difficulty of reading in Grade 6.

The scale of perceived difficulty of mathematics in Grade 4 was derived from four items with similar wording as in the case of reading (explained variance 65%, Cronbach's α = .82). The questionnaire for Grade 6 students did not specifically focus on perceived difficulty of mathematics and contained only three suitable items. Two (I was always good at mathematics, I have good marks in mathematics) were scored using a 4-point Likert agreement scale, one assessed the difficulty of mathematics among other subjects on a 2-point scale difficult vs. easy. The summary scale constructed from these three items explained 72% of the variance and had high internal consistency (Cronbach's α = .79). Both English and Czech wording of items used to measure perceived difficulty is given in the Appendix.

Other variables

Other variables whose effect on student interest was tested in the study included time spent on PC games, time spent on TV (Grade 4) / TV or video (Grade 6), gender and family background. Time spent on PC games and time spent on TV/TV or video were measured along with other free time activities on a 4-point frequency scale ranging from not at all to 4 hours a day or more (in Grade 4) and from no time to more than 3 hours a day (in Grade 6). Family background was measured by the PIRLS *Home resources for learning* scale (ABSGHRL), which synthetizes the information about parents' education, parents' occupation, number of books at home and two additional study supports – internet connection and children's own room (see Martin & Mullis, 2012 for more information). Table 1 presents descriptive statistics for all variables used in the study.

Table 1 Descriptive statistics of the study variables.

Variable (grade)	Mean[a]	*SD*	Reliability[b]	Items in scale	Source
Interest in reading (4)	10.00	2.13	.85	8	PIRLS, original scale
Interest in math. (4)	9.84	1.95	.86	5	TIMSS, original scale
Engag. instr. reading (4)	9.70	1.98	.77	7	PIRLS, original scale
Engag. instr. math. (4)	10.16	2.00	.71	5	TIMSS, original scale
Difficulty of reading (4)	0.00	1.00	.77	4	PIRLS, own calculation
Difficulty of math. (4)	0.00	1.00	.82	4	TIMSS, own calculation
Family background (4)	10.51	1.45	.69	5	PIRLS, original scale
Gender (4)	0.51	0.50	–	–	PIRLS, TIMSS
Time on PC games (4)	2.36	0.85	–	–	PIRLS, TIMSS
Time on TV (4)	2.63	0.72	–	–	PIRLS, TIMSS
Interest in reading (6)	0.00	1.00	.85	3	CLoSE, own calculation
Interest in math. (6)	0.00	1.00	.87	5	CLoSE, own calculation
Difficulty of reading (6)	0.00	1.00	.42	5	CLoSE, own calculation
Difficulty of math. (6)	0.00	1.00	.79	3	CLoSE, own calculation
Time on PC games (6)	2.55	0.93	–	–	CLoSE
Time on TV or video (6)	2.75	0.75	–	–	CLoSE

[a] The original TIMSS and PIRLS scales were standardized to have international mean 10 and standard deviation 2, scales created for the purpose of this study were *z*-standardized.
[b] Cronbach's α of the original TIMSS and PIRLS scales for each participating country is reported in Martin and Mullis (2012).

2.3 Statistical analyses

Several linear regression models were fitted to answer the three research questions. The analyses were conducted in SPSS (version 20) using syntax files created by the IEA IDB Analyzer (version 4.0.21).[6] IDB Analyzer is a software developed by the IEA Research and Analysis Unit in Hamburg for processing of large-scale assessment data. It takes into account the complex sampling and assessment design and computes correct parameter estimates together with correct standard errors.

Regression parameters were estimated separately for reading and mathematics. In the first step, models for Grade 4 students were run using PIRLS and TIMSS student datasets for the Czech Republic to which a scale of family background was added from the parent questionnaire data. A set of national items including questions about free time activities was part of the original datasets. In the second step, models for Grade 6 students were run using a sub-sample of the CLoSE dataset containing students who had records for both grades. The data was weighted by the appropriate total student weight, which was included in the Grade 4 datasets. Weighting by

6 http://www.iea.nl/data

a weight calculated for Grade 6 dataset to reflect the changes in the data structure led to similar results.

3 Results

Several linear regression models were fitted to estimate the relative strength of variables related to classroom instruction and student personal characteristics to predict student interest in reading and mathematics. The following sections present standardized regression coefficients and their standard errors. Statistical significance is reported at .05 confidence level.

3.1 Effect of engaging instruction on student interest in Grade 4

The initial step to answer the first research question consisted in performing several analyses whose results were then compared. Table 2 shows results of two models estimated for reading. Model 1 contains two conceptually relevant variables, namely engaging instruction and perceived difficulty of reading, and two other student-related variables that served as controls (gender and family background). Model 2 adds time spent on PC games and TV watching as two typical free time entertainments that potentially compete with reading.

All predictors are statistically significant at .05 confidence level. Engaging instruction is the most powerful predictor, suggesting that certain instructional activities, such as bringing attractive texts to the classroom, setting clear and interesting tasks or explaining things clearly (the exact description of these activities is given in the Appendix), are strongly associated with higher interest in reading among students. Perceived difficulty of reading is inversely related to interest, but the relationship is only half as strong. This suggests that engaging instruction can stimulate interest in reading even among children with reading difficulties. Both playing computer games and TV watching have a small negative effect on reading interest above the effect of other variables. They also partially explain the role of family background and gender in the sense that lower interest in reading among boys and children from disadvantaged families can be partly attributed to their free time preferences. An additional (unpublished) model tested also the role of watching videos or DVDs, with an insignificant effect.

Similar models were specified for the interest in mathematics (Table 3). It was not supposed that playing computer games or TV watching would be related to interest in mathematics, but these variables were included for comparative purposes. The results for interest in mathematics differ mainly in that perceived difficulty has approximately the same effect (in absolute values) as engaging instruction. This means that teaching activities intended to engage students are associated with higher interest in mathematics, but only for students who do not perceive it as difficult. Boys and girls have approximately the same interest in mathematics when controlled for other variables. This is not surprising given that gender difference was not significant already without other controls in TIMSS 2011.

The correlations between individual predictors were also calculated to see whether multicollinearity could be a problem. Multicollinearity occurs when an independent variable is highly correlated with one or more of the other independent variables in a multiple regression model. Multicollinearity is a problem because it increases the sensitivity of the regression coefficients to small changes in the model specification and complicates the interpretation of the results. In the case of models presented in this section the intercorrelations between independent variables were not high. The highest correlations were found between engaging instruction and perceived difficulty of mathematics (−.36) and time spent on PC games and time spent on TV watching (.34).

Table 2 Linear regression models predicting student interest in reading – Grade 4.

	Model 1		**Model 2**	
	Beta	*SE*	*Beta*	*SE*
Engaging instruction	.40*	.02	.38*	.02
Perceived difficulty of reading	−.22*	.02	−.23*	.02
Family background	.15*	.02	.13*	.02
Gender (boy)	−.19*	.01	−.16*	.02
Time spent on PC games			−.08*	.02
Time spent on TV watching			−.07*	.02
N (listwise)	4223		4017	
R^2	.34		.36	

* $p < .05$

Table 3 Linear regression models predicting student interest in mathematics – Grade 4.

	Model 1		**Model 2**	
	Beta	*SE*	*Beta*	*SE*
Engaging instruction	.42*	.02	.42*	.02
Perceived difficulty of mathematics	−.44*	.02	−.45*	.02
Family background	−.06*	.01	−.06*	.01
Gender (boy)	−.01	.01	.00	.02
Time spent on PC games			−.03	.02
Time spent on TV watching			−.01	.02
N (listwise)	4148		4001	
R^2	.51		.51	

* $p < .05$

3.2 Changes in student interest at the transition from primary to lower secondary education

First of all, a series of descriptive comparisons between Grade 4 and Grade 6 was performed to describe the change of student interest in time. For reading, three identical items were used in both grades. The percentages of students declaring positive attitudes to reading (strong or little agreement with positively formulated statements and strong or little disagreement with a negatively formulated statement) decreased by 10 to 20%. For example, student agreement with a statement "I enjoy reading" dropped from 80 to 69%. For mathematics, none of the items used in Grade 6 corresponded exactly to items administered in Grade 4. However, a rough comparison of student agreement with items "I enjoy learning mathematics" (Grade 4) and "I don't want to give over mathematics because I enjoy it" (Grade 6) showed a similar decrease in student interest from 77 to 68%.

In the next step, regression models were specified to see what factors can be held responsible for the interest decrease. Only the coefficients of full models are presented here (Table 4). The analyses were performed on longitudinal data of students for whom the answers from both Grades 4 and 6 were available. This allowed to include prior student interest as an additional predictor. Unfortunately, the measure of engaging instruction was available only for Grade 4. It was therefore not possible to estimate the association between the momentary engagement in classroom instruction and student interest in Grade 6. Instead, an enduring effect of previous instruction was analysed.

As in the previous section, correlations between individual predictors were checked to control a possible occurrence of multicollinearity. Given the association between the students' engagement in classroom instruction and their momentary interest in the subject, which was confirmed by the models for Grade 4 (Tables 2 and 3), high intercorrelations between these two variables were expected. For reading, the correlation between engaging instruction and prior interest was .45, for mathematics it was .60. Nevertheless, the variance inflation factor and tolerance, which are commonly used to estimate the magnitude of multicollinearity (O'Brien, 2007), had acceptable values.

It is evident that classroom engagement in Grade 4 is not associated with student interest in Grade 6 in any of the domains. When tested without other controls, previous engagement had a significant effect .18 for reading and .24 for mathematics. When other variables are included in the model, the net effect of previous classroom instruction on student interest is no longer significant. Its impact is most likely mediated through previously aroused interest, which is a significant predictor of student interest in Grade 6 for both reading and mathematics. There are, however, notable differences between the two domains: whereas prior interest tends to be a dominant predictor of future interest in reading, the role of prior interest in mathematics is relatively less important while perceived difficulty is much closely connected with (low) interest in Grade 6.

Table 4 Linear regression models predicting student interest in Grade 6.

	Model 1 – Reading		Model 2 – Mathematics	
	Beta	*SE*	*Beta*	*SE*
Engaging instruction (Grade 4)	−.04	.02	.01	.02
Perceived difficulty (Grade 6)	−.14*	.02	−.68*	.02
Prior interest (Grade 4)	.36*	.03	.14*	.02
Family background	.06*	.02	−.04*	.02
Gender (boy)	−.13*	.03	.02	.02
Time spent on PC games (Grade 6)	−.13*	.03	−.07*	.04
Time spent on TV or video (Grade 6)	−.10*	.03	−.01	.02
N (listwise)	2727		2402	
R^2	.30		.56	

* $p < .05$

The decrease of the interest in reading can be explained by the fact that reading as a time-intensive and cognitively demanding activity has to compete with other less demanding and more alluring free time activities, whose effect tends to be stronger than in Grade 4. Moreover, the percentage of students who spend more than one hour with watching TV and playing computer games increased between Grades 4 and 6 from 55 to 64% and from 37 to 50%, respectively. Perceived difficulty also plays a role, but its effect is weaker than in Grade 4. Interestingly, the percentages of students indicating that reading is easy and that they usually do well in reading are almost identical in Grades 4 and 6 (approximately 50% of students declare strong agreement and around 35% little agreement with the two statements). However, 40% of Grade 6 students admit that they sometimes have troubles to exactly understand what they read.

Contrary to reading, increasing difficulty of mathematics can be regarded as the main reason why students lose their interest as they pass to higher grades. The effect of perceived difficulty is stronger than it was in Grade 4 and older children also tend to assess mathematics as more difficult. Although a direct comparison is not possible, the percentage of Grade 6 students who disagreed with the statement "I was always good at mathematics" (29%) was more than twice higher than the percentage of students who rejected a similar statement "I usually do well in mathematics" in Grade 4 (13%). In general, 38% of Grade 6 students regard mathematics as difficult rather than easy. Gender does not have a significant effect on student interest in mathematics when other predictors are accounted for. This is in line with the results for Grade 4. The small, but significant effect of time spent on PC games is difficult to interpret, but it can signalize a differential identity building during adolescence as outlined by Frenzel et al. (2010).

4 Conclusion and discussion

This study contributes to the discussion of interest development in educational settings through a secondary analysis of data from international large-scale assessments. To my best knowledge, this has not yet been done. In this study, I used PIRLS and TIMSS 2011 data to address three research questions. First, I estimated the role of classroom instruction in arousing student interest in reading and mathematics as compared to the role of student personal characteristics. Second, I examined the enduring effect of classroom instruction on student interest. Third, I analysed the commonalities and differences between reading and mathematics. Data from PIRLS and TIMSS 2011 appeared to be suitable for these purposes. In 2011, the same students were administered both reading and mathematics/science assessments, which facilitated the comparison of reading and mathematics. Further, a new scale of engaging instruction was introduced, which allowed to include a promising teacher-related variable in the analyses. And finally, student interest and its development could be studied on longitudinal data thanks to the CLoSE project that followed up the respective cohort of students.

As regards the first research question, engaging classroom instruction in Grade 4 is closely (with a net effect of around .40) associated with higher interest in both domains. Its estimated effect on student interest in reading is markedly higher than the effect of any of the student variables included in the models. In mathematics, however, the relative position of engaging instruction among a set of different predictors is not as dominant as in the domain of reading. Rather, it tends to be comparable to the position of perceived difficulty of mathematics, which has a similar effect but in the opposite direction. The effect of engaging instruction on momentary student interest in Grade 6 could not be tested with the available data.

With regard to the enduring effect of classroom instruction on student interest in higher grades, which was the subject of the second research question, it is clear that engaging instruction in Grade 4 does not have an independent effect on student interest in Grade 6 when the interest level in Grade 4 is accounted for. Rather, its effect is mediated through previously evoked interest in the subject, which was the most powerful predictor of future interest in reading and significantly related to future interest in mathematics.

Concerning the third research question, the results show that despite the general similarities related to the role of different factors in explaining the level of student interest in both domains, there are also some important distinctions. Most remarkably, perceived difficulty of the subject is a crucial predictor of (low) interest in mathematics with a strengthening effect from Grade 4 to Grade 6. Prior interest partly counter-balances the negative effect of perceived difficulty but only to a limited extent. Relatively high values of explained variance in the models for mathematics indicate that perceived difficulty is an essential variable that has to be considered when thinking about practical measures to raise student interest in mathematics. By contrast, the net effect of perceived difficulty of reading in Grade 4 was comparatively weaker than in mathematics and further decreased in Grade 6. On the other hand, the effect of free time entertainments, such as watching TV and playing computer games, on the interest in reading increased between Grades 4 and 6. Time spend by these free time activities is practically negligible when it comes to the interest in mathematics.

The present study has confirmed a general decrease of interest in both domains as students grow older. On the other hand, the results do not show a dramatically low interest in mathematics. Although Czech students tend to have lower interest levels than their peers from other countries (Chvál, 2013; Mullis et al., 2012b), the majority of them still likes mathematics. Almost 80% of students liked mathematics in Grade 4, which was similar to the percentage of students who liked reading. Moreover, similar interest decreases by approximately 10% were observed in both domains between Grades 4 and 6. Based on the previous research (Chvál, 2013; Pavelková & Hrabal, 2012), a more substantial drop of interest in mathematics is to be expected in the next period.[7] A parallel steep decrease of interest in reading was registered only among boys (Ronková, 2015). The trajectories of interest development during Grade 6 and after were outside the scope of this study and remain to be analysed in the future, for example using the data from Grade 9 students collected within the CLoSE project.

An important contribution of this study consists in the inclusion of variables related to student engagement in classroom instruction. When the results from TIMSS 2007 were published, the decline of Czech students' mathematics achievement attracted wide attention of policy makers, experts on education, teachers and the general public. Low student interest in mathematics as compared to other countries has also been discussed (Chvál, 2013) and related to student, teacher and school characteristics (Federičová & Münich, 2015). However, teacher variables that were selected as possible predictors (gender, age and length of teaching experience) explained only a low proportion of variance in interest levels. The present study, by contrast, suggests that certain classroom activities, such as an easy-to-understand instruction, a clear task formulation, working on interesting tasks and with attractive materials, can effectively arouse student interest. However, it has to be emphasised that cross-sectional data do not allow to draw causal conclusions. Another possible interpretation of the association between the two variables could be that students who are *a priori* more interested also feel more engaged during lessons. Most probably, both processes occur, reinforcing each other. The longitudinal extension of the dataset does not allow to decide which one is predominant, as Grade 6 students were not asked about their momentary classroom engagement and the effect of prior interest on future engagement could not be tested. The exploration of student engagement in classroom instruction in higher grades including best ways of its measurement are open for future research.

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7 Data collection in Grade 6 was at the beginning of the school year.

The relationship between student interest in Grades 4 and 6 is generally consistent with the theory of ontogenetic interest development from situational to personal interest (Hidi & Renninger, 2006; Krapp, 2002, 2007). This study could not prove the validity of this theory, but it drew attention to the fact that the development and stabilisation of student interest evoked by a favourable classroom instruction might be by inhibited by other factors, most importantly by seductive free time activities that divert the children from reading and by perceived difficulty that counteracts the effect of prior interest in mathematics. As noted before, the role of continuously engaging classroom instruction in this development could not be examined due to the lack of appropriate data and deserves further investigation. A proper understanding of the complex process of interest development will most likely need not only better measures, but also more sophisticated analytical methods, such as structural equation modelling. A further limitation of this study is a problematic scale of perceived difficulty of reading in Grade 6, which has a low reliability. Possibilities of improving the scale should be investigated in future studies.

Several implications for educational practice could be drawn from this study. As for reading, targeted use of engaging instructional methods in primary education and offering interesting reading materials that would motivate children to limit their time spent on computer and TV in favour of reading in lower secondary education could lead to interest increase. An unresolved question is how to motivate boys who demonstrate a significantly lower interest in reading when all other variables are controlled. It is important to note that boys in Grade 6 show lower interest in reading even when controlled for prior level of interest, which means that they lose their interest more easily than girls. One possible option could be to offer a wider selection of reading materials including non-fiction texts dealing with topics that could attract boys' attention.

In mathematics, the use of engaging instructional methods seems to be less important than targeted efforts to convince students that mathematics is not as difficult as they may perceive it. It would be very useful to find out which classroom practices can potentially reduce the fear from mathematics and to share them as examples of best practice. It needs to be recognized, however, that this study did not analyse other factors that might be responsible for the decline of student interest in mathematics. For example, lower secondary school students might develop a deeper interest in another subject (physics, biology, history, foreign language …), which leads to changes in their relative interest in mathematics compared to other domains.

This study has also broader implications for educational policy and research. It showed that secondary analyses of data from international large-scale assessments can be used to gain a better insight into questions related to the development of student interest in core school subjects. Although it is not always easy to connect variables from international studies to specific characteristics of national educational systems and their particular problems, student attitudes are obviously one of the research fields that can benefit from a more extensive use of large-scale assessments data. It would be more than welcome if local researchers proposed and national educational authorities and granting agencies supported more projects that relate findings from international large-scale assessments to issues relevant for the local context.

Although the Czech School Inspectorate, which is responsible for the implementation of international large-scale assessments in the Czech Republic, has recently made significant progress in building bridges between international large-scale assessments and local educational research, as exemplified for instance by a series of publications following TALIS 2013, there is still a lot of gaps to be filled in. Especially, advanced secondary analyses of the data collected in international studies are still exceptions performed by a few researchers. There are at least three reasons why international assessments can serve as valuable source of data even for one-country studies. First, the test and questionnaire items are grounded in solid assessment frameworks that incorporate latest theoretical and empirical production. Second, the wording of the test and questionnaire items are thoroughly piloted before real administration. Third, the data are collected on representative samples under standardized conditions and carefully cleaned. Very few national studies yield quantitative data of such quality.

Secondary data analyses can contribute to an effective exploitation of resources invested in international large-scale assessments, and they might be worthwhile in at least two other ways: they can not only help focus further research on important questions that cannot be answered solely by international large-scale assessments, but they can also help formulate proposals for national adaptations and amendments of international instruments so that they better reflect specific issues that need to be investigated. Hopefully, more researchers will use the opportunities to publish their analyses in the future.

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Appendix – Items used to construct the scales and their Czech equivalents

Students interest in reading (ASBGSLR) – Grade 4

The scale was formed of six items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot" and two additional items scored on a 4-point frequency scale ranging from "never or almost never" to "every day or almost every day". Items indicating negative statements about reading were recoded so that higher values represent higher interest.

English source (PIRLS)	Czech wording in PIRLS questionnaire
I read only if I have to (reverse coded)	Čtu, jen když musím
I like talking about what I read with other people	Rád/a si s ostatními lidmi povídám o tom, co čtu
I would be happy if someone gave me a book as a present	Měl/a bych radost, kdyby mi někdo dal knihu jako dárek
I thing reading is boring (reverse coded)	Myslím si, že čtení je nuda
I would like to have more time for reading	Chtěl/a bych mít na čtení více času
I enjoy reading	Čtení mě baví
I read for fun	Čtu si pro radost
I read things that I choose myself	Čtu to, co si sám/sama vyberu

Students like learning mathematics (ASBGSLM)– Grade 4

The scale was formed of five items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot".

English source (TIMSS)	Czech wording in TIMSS questionnaire
I enjoy learning mathematics	Baví mě učit se matematiku
I wish I did not have to study mathematics (reverse coded)	Nejraději bych se matematiku neučil/a
Mathematics is boring (reverse coded)	Matematika je nudná
I learn many interesting things in mathematics	V matematice se naučím mnoho zajímavého
I like mathematics	Matematiku mám rád/a

Students engaged in reading lessons (ASBGERL)– Grade 4

The scale was formed of seven items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot". The introductory part of the question directed the students to think about reading in school.

English source (PIRLS)	Czech wording in PIRLS questionnaire
I like what I read about in school	Líbí se mi, o čem ve škole čteme
My teacher gives me interesting things to read	Učitel mi dává číst zajímavé věci
I know what my teacher expects me to do	Vím, co učitel chce, abych dělal/a
I think of things not related to the lesson (reverse coded)	Při čtení myslím na něco jiného
My teacher is easy to understand	Učitel vysvětluje srozumitelně
I am interested in what my teacher says	Zajímá mě, co učitel říká
My teacher gives me interesting things to do	Učitel mi dává zajímavé úkoly

Students engaged in mathematics lessons (ASBGEML) – Grade 4

The scale was formed of five items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot". The introductory part of the question explained that the statements relate to mathematics lessons.

English source (TIMSS)	Czech wording in TIMSS questionnaire
I know what my teacher expects me to do	Vím, co učitel chce, abych dělal/a
I think of things not related to the lesson (reverse coded)	Při matematice myslím na něco jiného
My teacher is easy to understand	Učitel vysvětluje srozumitelně
I am interested in what my teacher says	Zajímá mě, co učitel říká
My teacher gives me interesting things to do	Učitel mi dává zajímavé úkoly

Perceived difficulty of reading – Grade 4

The scale was formed of four items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot".

English source (PIRLS)	Czech wording in PIRLS questionnaire
I usually do well in reading (reverse coded)	Čtení mi většinou jde
Reading is easy for me (reverse coded)	Čtení je pro mě snadné
Reading is harder for me than for many of my classmates	Čtení je pro mě těžší než pro spoustu mých spolužáků
Reading is harder for me than any other subject	Čtení je pro mě těžší než ostatní předměty

Perceived difficulty of mathematics – Grade 4

The scale was formed of four items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot".

English source (TIMSS)	Czech wording in TIMSS questionnaire
I usually do well in mathematics (reverse coded)	Matematika mi většinou jde
I am just not good at mathematics	Matematika mi moc nejde
Mathematics is harder for me than for many of my classmates	Matematika je pro mě těžší než pro spoustu mých spolužáků
Mathematics is harder for me than any other subject	Matematika je pro mě těžší než ostatní předměty

Student interest in reading – Grade 6

The scale was formed of three items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot".

English translation	Czech wording in CLoSE questionnaire
I enjoy reading	Čtení mě baví
I would like to have more time for reading	Chtěl/a bych mít na čtení více času
I thing reading is boring (reverse coded)	Myslím si, že čtení je nuda

Student interest in mathematics – Grade 6

The scale was formed of one item assessing the popularity of mathematics on a 5-point scale and the following three items scored on a 4-point Likert agreement scale ranging from "disagree a lot" to "agree a lot".

English translation	Czech wording in CLoSE questionnaire
I sometimes get so engaged in solving mathematics problems that I don't notice the world around me	Někdy se tak zaberu do řešení matematických úloh, že nevnímám svět kolem sebe
I don't want to give over mathematics because I enjoy it	Nechtěl/a bych nechat matematiky, protože mě matematika baví
Mathematics is one of my favourite subjects	Matematika je pro mě jedním z nejlepších předmětů

Perceived difficulty of reading − Grade 6

The scale was formed of five items scored on a 4-point Likert agreement scale ranging from “disagree a lot” to “agree a lot”.

English translation	Czech wording in CLoSE questionnaire
I usually do well in reading (reverse coded)	Čtení mi většinou jde
Reading is easy for me (reverse coded)	Čtení je pro mě snadné
I sometimes have troubles to exactly understand what I read	Někdy mám problem přesně porozumět tomu, co čtu
I have to read the text more than once to understand it properly	Musím si text přečíst vícekrát, abych mu pořádně porozuměl/a
I understand well and easily what the text says (reverse coded)	Dobře a snadno rozumím tomu, co se v textu říká

Perceived difficulty of mathematics − Grade 6

The scale was formed of one item assessing the difficulty of mathematics on a 2-point scale (difficult vs. easy) and the following two items scored on a 4-point Likert agreement scale ranging from “disagree a lot” to “agree a lot”.

English translation	Czech wording in CLoSE questionnaire
I was always good at mathematics	Matematika mi vždycky šla
I have good marks in mathematics	Mám dobré známky z matematiky