Background factors behind mathematics achievement in Finnish education context: Explanatory models based on TIMSS 1999 and TIMSS 2011 data

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Abstract: The aim of this study is to explore student, classroom and school factors behind mathematics achievement of the Finnish secondary school students. What are the background factors most strongly related to achievement in Finnish educational context, and what are the changes in the explanatory models between TIMSS 1999 and TIMSS 2011? The conceptual framework for this study is based upon the IEA thinking on curriculum, while the TIMSS curriculum model establishes a comprehensive description of factors that have been shown effective in increasing achievement in mathematics and science achievement. In total, fourteen background variables situated in student, classroom and school levels are explored. In analysing the data, multilevel modelling is applied. First tentative results show that the most significant predictors for students' mathematics achievement are very similar in 1999 and 2011. Furthermore, the three-level model of TIMSS 2011 data provides new information regarding the distribution of the total variance in mathematics achievement, suggesting that differences between classes in mathematics achievement are bigger than thought before.
Keywords: mathematics, student achievement, background factors, multilevel modelling

1. Introduction

Students' mathematics achievement is often associated with the future economic power and competitiveness of a country. Therefore, the desire to understand and identify factors that may have meaningful and consistent relationships with mathematics achievement has been shared among national policy makers and educators around the world. By collaboratively supporting and participating in a large-scale international achievement studies like TIMSS, it is believed that the rich data collected in each study would include sufficient variability to permit the revelation of important relationships that would otherwise escape detection (Wagemaker, 2003).

During the last fifteen years, the international assessment studies of mathematics – TIMSS 1999 and TIMSS 2011, as well as several PISA studies – have offered an opportunity to analyse the level of the Finnish comprehensive school in a variety of ways. All this research-based information has made it possible for us to identify strengths and weaknesses in our mathematics education.

The time period after the TIMSS 1999 study has included some changes in the Finnish mathematics education. In 2004, the mathematics curriculum for basic education was revised (Finnish National Board of Education, 2004). The new curriculum mainly followed the guidelines expressed in the previous 1994 math curriculum, but the core objectives and contents were presented now in a more detailed way than before. Today, almost two thirds of teachers think that they do not have a capacity to give enough time to all their students. The number of students needing remedial education has increased a lot and they have been integrated into the normal classes. This means in practice that on grades from seven to nine more and more schools apply mathematics groupings of students based on their performance level. However, these groupings are not permanent and do not mean any return to the tracking system. Moreover, differences between municipalities have also increased in financing and supporting schools in their educational and instructional duties. One consequence of all these developmental features might be that the differences in math performance between schools have increased in Finland during the first decade of 2000 (Kupari et al., 2012; Rautopuro, 2013). The need for analysing the state of mathematics education in our country is thus inevitable.

The purpose of this study is to examine student, classroom and school factors behind mathematics achievement of the Finnish secondary school students. Firstly, we will analyse the state of affairs based on the data collected in TIMSS 1999 (seventh-graders) and in TIMSS 2011 (eighth-graders). Secondly, it is interesting to make comparisons between the studies (12-year interval) in order to see what kind of changes have taken place both in the collection and the effects of background factors explaining student achievement. Two research questions guide the analyses:

1) What are the student, classroom and school background factors associated with students’ mathematics achievement and how much do these factors explain the variance of achievement in TIMSS 1999 and TIMSS 2011?
2) What are the essential differences in the explanatory models during a 12-year period?

2. Conceptual framework for modelling

The conceptual framework for this study is based upon the IEA thinking on curriculum at three levels: the intended curriculum, the implemented curriculum and the attained curriculum (Bos, 2002; Travers & Westbury, 1989). The TIMSS curriculum model described and explained in the TIMSS assessment frameworks (e.g. Mullis et al., 2009) establishes a comprehensive description of effective factors that have been shown effective in increasing achievement in mathematics and science achievement. Furthermore, in exploring nationally relevant and influencing background factors, we drew on research literature about educational effectiveness (Creemers, 1994; Martin et al., 2000; Reezigt et al., 1999) and on the extensive empirical research regarding the previous TIMSS data (e.g. Bos & Kuiper, 1999; Howie and Plomp, 2006; Shen & Tam, 2008).

In relation to the first research question of this study, it is necessary to detect those factors which are associated with mathematics achievement, particularly the factors that can be influenced and are amenable to change by educational interventions. The educational effectiveness model of Creemers (1994) serves here primarily as a classification model of potentially effective factors on achievement in mathematics, but not as a model that will be tested. According to Reezigt et al. (1999), the main assumption of the Creemers' model is that student achievement is influenced strongly by student factors: social background, intelligence and motivation, but also by the way students spend their time during lessons and by the way they use opportunities to learn. Quality, time and opportunity are key concepts which characterize all levels above the student level and these key concepts comprise plenty of different variables which have empirically established influence on achievement.

Review of previous research

At the beginning of this millennium, Kupari (2006) analysed the relationships between student, teacher and school background factors and mathematics achievement in Finland. The study was based on the TIMSS 1999 data and totally 24 variables were analysed by using two-level HLM-models. The main results of this study showed that altogether eight variables had a statistically significant effect on students' achievement in mathematics. The student's self-concept in mathematics was found to have a particularly strong (reciprocal) association with achievement. In this short review, we deliberately concentrate on the background variables which have proven their significance in our national context and received strong support in the recent research literature as well.

There is a huge body of research on *gender differences* in mathematics (Else-Quest et al., 2010; Hyde et al., 1990; Guiso et al., 2008; Riegle-Crumb, 2005). The overall observations of these studies and meta-analyses since 1990 tell us that gender differences in mathematics performance can be regarded small in many countries. Research provides also evidence that the magnitude of gender differences has also declined compared to previous decades. Else-Quest et al. (2010) meta-analyzed two large international data sets to examine cross-national patterns of gender differences in mathematics achievement, attitudes, and affect and assessed the links of these patterns to gender equity at the national level. They used data from the TIMSS 2003 study and the PISA 2003 study. The findings of this meta-analysis indicated that the gender gap in mathematics persists in some nations but not in others. Despite overall similarities in achievement, boys felt more confident and less anxious in their mathematics abilities and were more extrinsically and intrinsically motivated to do well in mathematics than girls, as consistent with previous research findings (e.g. Hyde et al., 1990). Boys also scored one third of a standard deviation higher than girls on mathematics self-concept and self-efficacy (Else-Quest et al., 2010).

The influence of *family background and socioeconomic status* in particular on student achievement has been of great interest for a long time. The results from various studies have shown that the home background of students in schools is correlated to their mathematics achievement in school (Bos & Kuiper, 1999; Brese & Mirazchiyski, 2008; Chiu & Xihua, 2008; Lamb & Fullarton, 2000; Marks et al., 2006). The study of Brese & Mirazchiyski (2008) focused on the TIMSS 2007 and PISA 2006 studies and covered five aspects of home background: home possessions, immigration status of students and their parents, language use at home, parents' education and parents' employment situation. Their results revealed that there were quite a few variables which showed strong or moderate association with mathematics achievement, and they were parents' education, number of books at home, number of students' own books and computer at home.

Research has repeatedly suggested that *mathematics attitude* is a critical construct related to learning. Attitudes towards mathematics are positively and significantly associated with mathematics achievement in several countries: students with positive attitudes tend to achieve higher (Else-Quest et al., 2010; House, 2006; Shen & Tam, 2008; Singh et al., 2002; Winheller et al., 2013). However, mathematics attitude is a multidimensional construct and three dimensions can be clearly separated (Vandecandelaere et al., 2012). *Mathematics academic self-concept* concerns the students' perceptions of his/her capability to master the subject matter and to do well in mathematics. *Enjoyment of mathematics* contains the extent to which the student enjoys mathematics lessons and subject matter itself. *Perceived value of mathematics* finally refers to the beliefs the student holds about the importance of mathematics in every day and later life. A substantial body of research during the last three decades demonstrates that all these aspects of mathematics attitude have emerged as salient predictors of achievement in mathematics (Chiu & Klassen, 2010; Kupari, 2006; Marsh & Hau, 2004; Singh et al., 2002; Wilkins, 2004; Williams & Williams, 2010). Furthermore, the study of Vandecandelaere et al. (2012) gives support how to create the learning environment in enhancing the attitude towards mathematics.

In addition, the accumulated research evidence suggests that there are several other variables – like home language, amount of homework, students' time on homework, time spent watching television and computer games, teacher experience, class size, school climate, socioeconomic background of school – all of which can be related to students' mathematics achievement in many countries (Brese & Mirazchiyski, 2008; Köller et al., 1999; Lamb & Fullarton, 2000; Singh et al., 2002).

3. Method

In analysing the background factors to be associated with students' mathematics achievement in the TIMSS 1999 and TIMSS 2011 studies, two Finnish sets of data are applied. The TIMSS 1999 data comprised test answers and background information from a total of 2,920 students, 167 mathematics teachers and 159 school principals. It is important to notice that based on the population definitions the target grade in Finland was grade 7. In this study, only one classroom per target grade was sampled from each Finnish school. Respectively, the TIMSS 2011 data comprised test answers and background questionnaire data from a total of 4,266 students, 264 teachers and 145 school principals. In the sampling procedure of TIMSS 2011, two classrooms per target grade were usually selected for each school.

As a result of the thorough background work, altogether fourteen background variables or indices were selected for the modeling phase. We included the following student level factors: gender, home possessions (three variables), home language, time devoted to homework, computer use, attitudes towards mathematics (three dimensions) and school climate. Respectively, teacher experience, amount of homework and class size represented the classroom and school levels. In the modeling, we employed complete data sets only, i.e. we dropped out the observations with missing values in any of the selected variables. The eventual TIMSS 1999 data set contained then n=2,289 observations and the TIMSS 2011 data set contained n=3,301 observations, respectively.

Variables in the study

The mathematics achievement IRT score (Mullis et al., 2012) was defined as the *dependent variable*.

Gender was included as a dichotomous variable. A positive link between gender and other variable means that boys do ‘better’ or ‘more’ than girls.

Both the home possessions and the parental education level were considered as indicators of the students’ socioeconomic status. The home possessions were measured by three variables: the number of books at home, a computer and a study desk for a student’s use. The *number of books at home* is kept as a proxy indicator for home educational background. It was coded from 1 to 5, and the bigger number indicated that a student had more books in his/her home. *A computer* and *a study desk* were included in (the study) as dichotomous variables. In the both studies, the question related to the educational level of mother and father was presented in the student questionnaire. However, in the Finnish data, the proportion of missing values for these items was too high (in 1999 over 50% and in 2011 over 30 %) to allow plausible computations to replace missing values.

The students’ *home language* indicated if the language mainly spoken at home was the same as the instruction language (and the language of testing) at school. In our study, we used a dichotomized variable: students who always or almost always speak the same language at home and at school versus students who do it sometimes or never.

Both studies assessed the three dimensions of mathematics attitudes – like learning mathematics, mathematics self-concept and perceived importance of mathematics – but the items measuring these dimensions were not exactly similar in 1999 and 2011, and this caused some problems in creating the indices. Students responded to all attitude statements on a four-point Likert scale (1 = Agree a lot to 4 = Disagree a lot). The responses were recoded so that high scores indicate higher levels of a positive mathematics attitude.

In TIMSS 1999, the index reflecting how much students *like learning mathematics* was based on the five statements (IEA, 2001). In TIMSS 2011, there were also five statements included in this index (Mullis et al., 2012). *Mathematics self-concept* included in TIMSS 1999 the six statements (IEA, 2001) but in TIMSS 2011 this dimension comprised totally nine statements (Mullis et al., 2012). The index of *perceived importance of mathematics* comprised in both studies four statements (IEA, 2001; Mullis et al., 2012).

In TIMSS 1999 and 2011, the index reflecting the level of *school safety* was based on six questions. Students were scored according to their responses to how often they experienced six bullying behaviors in their schools (IEA, 2001; Mullis et al., 2012). A high score indicates a safe and orderly (not bullying) atmosphere at school.

Teacher experience was a variable expressing the length of teacher's teaching experience in that specific school. A high score means that a teacher had a long teaching experience.

Amount of homework was a variable describing on a four-point scale (1 = never to 4 = every day) how often the teacher typically assigned mathematics homework to the students. A high score means that the teacher more often assigns homework to students.

Group size was a variable telling the number of students in the mathematics teaching group as reported by the teacher.

Modelling procedure

When comparing the models between 2011 and 1999, fourteen common background factors related to mathematics achievement were applied. Separate multilevel linear models were fitted both to the 2011 data and the 1999 data. The use of multilevel models in dealing with school data is based on the feature that they not only take account of the inherent structure of the data, but also treat variables of different levels simultaneously within the same model (Bryk & Raudenbush, 1992; O'Dwyer, 2005). Due to the sampling design, 2-level regression models were only fitted to the 1999 data. Instead, both 2-level and 3-level models were fitted to the 2011 data: 2-level models for comparison with the 1999 model and 3-level models to examine all the three sources of random variation (schools, classes and students) present in the 2011 data.

The multilevel model estimation was performed using the SAS software, with a self-written macro extending the modelling facilities of the Mixed procedure (Littell et al., 1996) to cover the plausible values methodology commonly used in large-scale educational surveys. The data were weighted by the final student-level sampling weights, which were rescaled to make their sum agree with the actual student sample size. The variance components were estimated by the REML method. The reported standard errors of the regression estimates were based on the model-based approach implemented in the Mixed procedure, because empirical experimentations suggested that the differences between them and the respective standard errors obtained by the widely used, but computationally heavier JRR replication method were negligible.

First, to get a general view of the importance of the selected variables in explaining the variation of mathematics achievement, we fitted a series of regression models, where each of the fourteen variables served in turn as a single predictor in the model. In the second phase, we searched the best-fitting multivariate regression model by backward elimination of the explanatory variables, starting from the model which includes all the variables and ending with the model which contains statistically significant variables only. The two-way interaction effects between gender and the rest of explanatory variables were examined and those found significant and offered meaningful interpretations were kept in the model. We analyzed first the set of eleven student level explanatory variables to obtain Model 1 (Tables 1 and 2) of significant predictors only. After that, we added the classroom and school level variables (and their possible interactions with gender), which appeared significant, to Model 1, to obtain Model 2. This was to find out the relative importance of higher-level variables, when the student level effects are already controlled, in explaining the variation. This procedure was carried out independently for the TIMSS 1999 data and the TIMSS 2011 data.

We also experimented with contextual effects of the student level variables; that is, we centered the student values around the respective class or school average and put the average into the model as an additional higher-level predictor. However, this did not result in any remarkable gains, either in model interpretation or in model fit. Thus, we decided to report the results with uncentered explanatory variables only.

4. Results

As a preliminary step, we fitted a fully unconditional model (null model) without any explanatory variables to estimate the unexplained ‘benchmark’ variances in the outcome variable at the student and school/classroom levels. The results of the two-level null models reveal that in both 1999 and 2011 data, the overall variation in mathematics achievement derives predominantly from the within-school variance (87 %), i.e. from the student level, while only about 13 percent of the variation comes from the between-school variance. The results are very similar in both years and suggest that differences between schools are not an important source of variation in the Finnish education context.

Then, we fitted models, where each of the fourteen background variables appeared in turn as a single predictor of the mathematics achievement. The results showed that in both 1999 and 2011, the mathematics self-concept was by far the strongest predictor. In 1999, it alone reduced the unexplained between-school variance by 25 percent and the unexplained between-student variance by 37 percent. In 2011, the respective reductions were 19 percent and 42 percent. The number of books at home and possessing a computer at home, both of which represent the socio-economic status of the student’s family, also showed some explanatory power, but clearly less than the variables measuring a student’s mathematics attitude. In 1999, the number of books explained 10 percent of the between-school variation and 3 percent of the between-student variation, while possessing a computer explained 8 percent and 4 percent, respectively. In 2011, the importance of the number of books had increased: it explained 14 percent of the between-school variation and 8 percent of the between-student variation. Interestingly, the explanatory power of possessing a computer at home had essentially decreased by 2011: although statistically significant, it explained less than 1 percent of both between-school and within-school variance. This results from the fact that computers have become extremely common in Finnish homes. Less than one per cent of the students in the TIMSS2011 data set did not have a computer at home. This small minority, however, performed in math clearly poorer than the rest 99 percent of students. In 1999, the proportion of students not having a computer was 80 percent.

The next step in the analysis involved adding the student background predictors (eleven variables) to the model of mathematics achievement (Model 1). This allowed differences between schools to be adjusted for those at the individual level. The results are presented in Tables 1 and 2. They show that in the TIMSS 1999 study, the differences in student background characteristics accounted for 41 percent of the estimated variance at the student level and 36 percent at the school level. In TIMSS 2011, the corresponding figures were 46 percent and 23 percent. This suggests that student background factors explained much more of the between-school variance in 1999 than in 2011.

The last step involved the inclusion of the school-level factors (three variables) which described the conditions of teaching mathematics in school. This group of variables increased the explained variance at the school level much more in 2011 (increase 10 percentage points) than in 1999 (increase only 2 percentage points). In 2011, these variables increased also a little (4 percentage points) the explained variance at the student level.

In our analyses, the final model (Model 2) explained 41 percent of the overall variation of students’ mathematics achievement in TIMSS 1999 and 48 percent in TIMSS 2011. It is important to note that for between-school variance the proportion explained was 37 percent in 1999, but only 33 percent in 2011.

Table 1. Two-level regression models of mathematics achievement, TIMSS 1999 / Grade 7.

	Model 0			Model 1			Model 2		
	coeff.	s.e.	t	coeff.	s.e.	t	coeff.	s.e.	t
Intercept	522.77	2.62	199.23***	491,10	9.91	49.55***	472.32	13.30	35.52***
Student-level variables									
Mathematics self-concept				39.71	2.22	17.53***	38.85	2.22	17.51***
Computer at home				13.29	2.78	4.77***	13.30	2.78	4.78***
Language at home				29.36	7.18	4.09***	29.36	7.18	4.09***
Number of books at home				5.14	1.25	4.11***	5.07	1.25	4.05***
Gender				-9.90	3.07	-3.23**	-9.88	3.06	-3.23**
Time for homework				-10.15	3.29	-3.09**	-10.07	3.28	-3.07**
School safety				3.60	1.36	2.64*	3.67	1.36	2.70*
Like learning mathematics				-6.39	3.08	-2.08	-6.34	3.07	-2.07
Interaction: boys*math importance				7.17	1.72	4.16***	7.16	1.72	4.16***
Classroom-level variables									
Class size							0.99	0.52	1.89*
Variance									
Total variance	4208			2502			2492		
Within-schools variance	3651			2143			2143		
Between-schools variance	557			359			349		

*Significant at the .05 level; **Significant at the .01 level; ***Significant at the 0.001 level

Table 2. Two-level regression models of mathematics achievement, TIMSS 2011 / Grade 8.

	Model 0			Model 1			Model 2		
	coeff.	s.e.	t	coeff.	s.e.	t	coeff.	s.e.	t
Intercept	514.94	2.44	211.41***	444.00	16.47	26.95***	344.44	17.85	19.30***
Student-level variables									
Mathematics self-concept				39.81	1.14	34.95***	39.25	1.11	35.25***
Number of books at home				8.46	0.77	11.03***	7.70	0.74	10.43***
Time for homework				-6.74	1.59	-4.24***	-7.35	1.55	-4.75***
Gender				-8.04	1.89	-4.25***	-7.80	1.84	-4.23***
Computer at home				49.13	15.49	3.17**	49.16	14.94	3.29***
Like learning mathematics				-3.27	1.18	-2.76**	-3.45	1.15	-3.00**
School safety				1.29	0.45	2.88**	1.18	0.44	2.71**
Classroom-level variables									
Class size							4.24	0.31	13.79***
Amount of homework							5.34	1.90	2.81**
Teacher experience							0.21	0.11	1.88*
Variance									
Total variance	3996			2298			2098		
Within-schools variance	3451			1879			1735		
Between-schools variance	545			419			363		

*Significant at the .05 level; **Significant at the .01 level; ***Significant at the 0.001 level

Tables 1 and 2 present also the regression coefficients of the variables with a statistically significant effect on students' mathematics achievement in both studies. The results show that quite a few significant effects could be found. Furthermore, the collection of significant predictors for mathematics achievement was almost similar in TIMSS 1999 and in TIMSS 2011.

In the both years, the most influential variables for students' mathematics achievement were their mathematics self-concept and family background. As already noted, the explaining power of the self-concept was especially strong because, when analyzed separately, it explained even 36–39 percent of the total variance. Also, like previous studies have shown, students with more family cultural resources (as measured by number of books at home and computer at home) tend to have higher performance in mathematics.

The final model for TIMSS 1999 revealed two variables (activity of computer use in free time and liking learning mathematics) having no significant effect on the students' achievement in mathematics. Students' perceptions on the school safety had a significant positive effect on math achievement suggesting that performance was better in schools with higher safety. Furthermore, students' language at home was a significant predictor of mathematics achievement implying that students from non-Finnish-speaking backgrounds had lower levels of achievement than those from Finnish-speaking backgrounds. Two variables (gender and time for homework) had a significant negative effect on achievement suggesting that boys and the students using less time for their homework performed better in mathematics.

The final model for TIMSS 2011 confirmed the similar significant effects regarding school safety, gender and time for homework, whereas there were no significant differences linked to students' language at home and computer use. Now, liking learning mathematics was an influential variable for students' performance expressing a significant negative effect on mathematics achievement: students with less liking mathematics did better.

Just 1–3 significant school-level variables appeared in the final models. In the both years, the class size had a significant positive effect on math achievement suggesting that performance were better in bigger classrooms. In TIMSS 2011, the teacher experience, as measured by years of teaching, had a small but significant positive effect on student achievement, suggesting that the more experienced teachers achieved better results. In addition, the 2011 results showed that classes where teachers assigned more often homework to students were associated with higher levels of achievement.

The possible reasons for the differences between the final models in 1999 and 2011 could be searched from different grade-levels (7 vs. 8), deviations in some indices and changes taken place in the learning environment of mathematics.

In the last stage of analysis, we also wanted to improve our model for TIMSS 2011 by adding other potential variables included in the questionnaires. However, this effort was not successful and did not reveal any new effects on students' mathematics achievement. Since in 2011 two 8th-grade classrooms were sampled from the majority of schools, we had a possibility to formulate a three-level regression model and try to estimate which proportion of the total variance in mathematics achievement is due to differences between classes.

According to this new model, the most of the variation (72 %) is attributable to the (student-level) variance within classrooms, 26 percent is attributable to the variance between classrooms and only 2 percent represent the between-school variance. However, unfortunately, no less than 44 percent of the schools had only one classroom in the eventual sample. Thus, the school and classroom effects are largely confounded and the variance estimates are just suggestive. Considering only schools with at least two classrooms in the sample (80 schools out of total 142 schools) we obtained a result that 61 percent of variation comes from within classrooms, 36 percent from between classrooms and 3 percent from between schools. Thus, it anyway seems safe to state that a remarkable share of the total variation is contributed by the classroom differences. Special classes for students with learning difficulties met in several schools probably play an important role in this.

5. Discussion

The main objective of the present study was to to examine student, classroom and school background factors associated with mathematics achievement of the Finnish secondary school students. By applying multilevel modelling, we analysed how much and how strongly these background variables predicted mathematics achievement in TIMSS 1999 and TIMSS 2011. Additionally, we made comparisons between the studies (12-year interval) in order to see what kind of changes have taken place both in the collection and the effects of background factors explaining student achievement. During the last decade, a lot of studies focused on similar issues have been published (e.g. Singh et al., 2002; Vandecandelaere et al., 2012; Wilkins, 2004; Winheller et al., 2013).

This study brought out a few interesting findings that have relevance to the development of Finnish education policy and mathematics instruction in particular. Here, we will analyse two of these findings more closely. Firstly, our results revealed that most of the variance in mathematics achievement is situated at the student level indicating that the majority of the variance in the achievement is situated between individuals within classes and schools. In both studies, the between-school variance was about 13 percent of the total variance in mathematics achievement based on the two-level models. However, the tentative finding produced by the three-level model of TIMSS 2011 suggested that altogether 28 percent of the total variation in achievement comes from between-class and between-school variance. And further, the final model of 2011 explained just 33 percent of the between-school variance in mathematics achievement which was 4 percentage points less than in 1999. Do these observations indicate that the variation in math performance between Finnish schools and classrooms has increased during the last 12 years or have we other explanations to be presented?

Secondly, our results proved that the most significant predictors for students' mathematics achievement were quite similar in 1999 and 2011. Student's mathematics self-concept – expressing confidence in learning mathematics – was by far the most significant predictor for their performance. Meanwhile, self-concept was associated with other dimensions of mathematics attitudes (like learning mathematics and perceived importance of mathematics) in a complex way. In both final models, students' self-concept concealed totally the effect of the importance of mathematics. The relationship of "like learning mathematics" to students' academic performance was especially interesting since in both years this factor had negative impact on mathematics achievement and in 2011 the effect was also statistically significant (cf. Winheller et al., 2013). This is somehow a surprising result because there is strong consensus that interacting with the teacher leads to enhanced academic performance, motivation and attitudes. Winheller et al. (2013) explain this by saying that in the eyes of students, interactions with teachers generate negative affect towards the subject, even though this liking is positively correlated with confidence in learning mathematics. In other words, students who indicate much interaction with teachers sense that they are 'in trouble' and consequently like this subject less.

Attitudinal factors in mathematics are highly important in mathematics education because these variables are amenable to change by educational interventions. Furthermore, the mutual influence between mathematics self-concept and performance has been addressed (Williams & Williams, 2010). These factors have the potential of being enhanced and modified by new and innovative curricular and instructional approaches to teaching and learning. To increase mathematics performance, teachers should focus more on enhancing the quality of learning and students' mathematics self-concept than on prioritizing peer or teacher–student relations and liking of mathematics. Students who have confidence and belief in their ability to control their engagement and learning activities achieve more (Singh et al., 2002; Winheller et al., 2013).

All in all, our study and its findings reveal that there were many similarities, but also some differences when analysing the background factors behind mathematics achievement in TIMSS 1999 and TIMSS 2011. This study has brought out important and useful findings that have relevance in our country. Especially now, when the preparation work for a new mathematics curriculum has started, these findings have important implications for policy regarding the improvement of mathematics curricula and education in Finnish schools.

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