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TABLE OF CONTENTS

LIST OF ORIGINAL PUBLICATIONS

I. **Leopard, R.**, Kiuru, N., & Palu, A. (2011). Success of Third-grade Students in Solving Different Types of Mathematics Problems in Estonian-speaking and Russian-speaking Schools. Mikk, J.; Veisson, M.; Luik, P. (Eds.). *Preschool and Primary Education* (91–105). Switzerland: Peter Lang Verlag

II. Palu, A., **Suviste, R.,** & Kikas, E. (2012). Errors in solving arithmetic word problems. Differences between students from Estonian- and Russian-language schools. Toomela, A.; Kikas, E. (Eds.). *Children Studying in a Wrong Language: Russian Speaking Children in Estonian School. Twenty Years After the Collapse of the Soviet Union* (99–121). Switzerland: Peter Lang Verlag

III. **Suviste, R**., Kiuru, N., Palu, A., & Kikas, E. (2014). Classroom management practices and their associations with children's mathematics skills in two cultural groups. *Educational Psychology*, 1–20.
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IV. **Suviste, R**., Palu, A., Kikas, E., & Kiuru, N. (*submitted*). The role of teacher-related factors in mathematics skills between children attending Estonian and Russian speaking schools.

The author contributed to the publications as follows:

For Paper I: formulating the research questions, reordering of data, participating in conducting the main analysis, writing the paper as the main author.

For Paper II: participating in the formulation of the research questions, reordering and coding the data, conducting the analysis, and writing segments of the paper.

For Paper III: formulating the research questions, reordering the data, participating in conducting the main analysis, writing the paper as the main author.

For Paper IV: formulating the research questions, reordering of data, validating the teachers' measures and constructs, conducting the analysis, writing the paper as the main author.

1. INTRODUCTION

Students' mathematics results are influenced by society's values as well as by the purposes of education, varying not only among countries, but also among different cultural groups within specific countries (Mikk, 2007; Shipley, 2011; Välijärvi et al., 2007). In many countries (e.g., Belgium, Canada, Finland, Latvia etc.), there are different cultural groups and education is given in different languages. In Estonia, the two largest cultural groups are ethnic Estonians (69.72%) and the Russian-speaking minority (25.02%; Eesti Statistikaamet, 2015). Besides Estonian-language schools there are schools where the language of instruction is Russian. This kind of educational system's specialty occurs also in many multicultural countries (e.g., Canada, Finland and Latvia).

The first international Trends in International Mathematics and Science Study (TIMSS) conducted in Estonia in 2003 revealed that the results on mathematics tests undertaken by children attending schools where the language of study is Russian (hereafter referred to as Russian-language schools) were considerably weaker than those undertaken by children attending Estonian-language schools (Mullis, Martin, Gonzalez, & Chrostowski, 2004). In addition, the Programme for International Student Assessment (PISA) indicated that students from Russian-language schools showed lower achievement in mathematics than students from Estonian-language schools (Kitsing, 2008; Tire et al., 2013; Tire, Puksand, Lepmann, & Henno, 2010). Differences in mathematics achievement between schools with different language have also been determined in Canada, where the language of instruction is either English or French. Namely, according to the PISA 2012 study the results for students in the francophone school system were higher than for students in the anglophone school system (Brochu, Deussing, Houme, & Chuay, 2013). Also, in Finland, in the earlier PISA study the mathematics results between students attending Finnish-language or Swedish-language schools have differed, but in the PISA 2012 the first time the students attending Swedish-language schools performed equally well in comparison to the Finnish-language schools students (Harju-Luukkainen, Nissinen, Stolt, & Vettenranta, 2014). Respectively the results in PISA 2012 for schools in Latvia revealed that there were no significant differences in mathematics achievement between students attending Latvian- and Russian-language schools (Lindemann, 2011). These results indicate that differences between cultural groups in one country should be investigated inside one country taken into account the children's individual characteristics and the teaching environment, but also the teacher's contextual factors (e.g., use of teaching methods, classroom management practices etc.).

As all children in Estonia's mainstream schools study according to the national curriculum (Vabariigi Valitsus, 2002/2007, 2011/2014) and with the same textbooks, at least some of the reasons for the different results in TIMSS and PISA can be related to teachers' different beliefs, practices, and behaviours in Estonian- and Russian-language schools classrooms. In particular, studies have shown that Estonian students' mathematics skills are sensitive to teachers' teaching methods and practices (Kikas, Peets, & Hodges, 2014; Kikas, Peets, Palu, & Afanasjev, 2009). Several studies have investigated Estonian-language schools' mathematics teachers (Jukk, Lepmann, & Lepmann, 2007) and primary schools teachers who teach mathematics (Kikas et al., 2009; Palu & Kikas, 2007). Also, there is some evidence that teachers' beliefs about teaching and used teaching methods tend to differ between teachers from Estonian- and Russian-language schools (Lepik & Kislenko, 2014; Loogma, Ruus, Talts, & Poom-Valickis, 2009). Thus far, Russian-language schools' teachers have not been studied in the context of the usage of teaching practices and classroom management practices and their associations with students' achievement and development in mathematics in the primary grades. It only can be hypothesised that the different results in mathematics in the described international studies are related to teachers' use of different classroom management and teaching practices. Therefore, it is reasonable to investigate Estonian- and Russian-language schools teachers' preferences for using classroom management practices and teaching practices as well as how these practices are associated with their students' achievement and development in mathematics.

1.1. Goal of the study and the research problem

International comparative studies for older children for Grades 8 and 9 have shown that children attending Russian-language schools have weaker results than their peers from Estonian-language schools (for results for PISA 2006, see Kitsing, 2008; for results for PISA 2009, see Tire et al., 2010; for results for TIMSS 2003, see Mullis et al., 2004). When comparing third-grade children in Estonian- and Russian-language schools in the context of national mathematics tests, the results are controversial indicating that the difference between third-grade students' results differs between years (Jakobson, 2014; Taal, 2012; Tibar, 2013). Considering these pointed differences on international- and national-level tests, it would be interesting to investigate children's achievement and development in mathematics in the primary grades regarding the three cognitive dimensions defined in the PISA study (e.g. reproduction, connections and reflection cluster; OECD, 2006) and teachers' practices. Thus, it was hypothesised that the variability in mathematics results between countries and cultural groups might be related to the preference to use different teaching practices and classroom management practices. Studies have shown that students' mathematics skills are sensitive to teachers' management and teaching practices (Levpušček & Zupančič, 2009; Ly, Zhou, Chu, & Chen, 2012; Opdenakker & van Damme, 2006; Polly et al., 2015) and that teaching methods and management styles vary by countries (Hiebert et al., 2003).

The aim of mathematics education is to develop students' mathematical competence taken into account their appropriate age (Vabariigi Valitsus, 2011/2014). In school, mathematics is one of the subjects in which students acquire analytical, reasoning and generalisation skills. These skills are developed through a logical and systematic approach. As mathematics is a subject the children encounter in first grade, teachers' beliefs, knowledge and skills about teaching are essential. Students' individual characteristics play an important role in their learning; thus, child-centred teaching methods as well as authoritative and positive practices which are considered beneficial for achievement are valued today (Daniels & Shumow, 2003; Deci & Ryan, 2000; McCormick, O'Connor, Cappella, & McClowry, 2013). However, studies have also demonstrated that traditional methods (e.g., teacher-centred teaching methods) in learning and teaching mathematics contribute to children's achievement, especially in acquiring factual knowledge and applying skills (Bietenbeck, 2014; Schwerdt & Wuppermann, 2011). Studies conducted in Estonia have further indicated that the use of various methods in teaching contributes to successful academic achievement. For example, Kikas et al. (2009) showed that students' mathematics knowledge and skills were higher in classrooms where the teacher used formalist methods (using the terminology, correct use of language and symbols and presuppose strict rules of formulation; cf. Palu & Kikas, 2007) in addition to traditional and constructivist (e.g., learner-centred) methods.

Moreover, some evidence suggests that teachers' beliefs about teaching and the teaching methods used tend to differ between teachers from Estonian- and Russian-language schools (Lepik & Kislenko, 2014; Loogma et al., 2009). In addition, it has been found that teachers from Russian-language schools prefer the use of more traditional methods in classrooms than their colleagues from Estonian-language schools; they also believe more in knowledge transfer, direct instruction and importance of factual knowledge (Loogma et al., 2009). Considering the fundamental changes in Estonia's educational system during the last couple of decades (Kesküla, Loogma, Kolka, & Sau-Ek, 2012; Ruus et al., 2009), there is a good foundation for conducting studies, analysing and comparing students' achievement and development in mathematics as well as their associations with their teachers' use of different methods, management and teaching practices in Estonian- and Russian-language schools.

The main aim of the current research was to investigate students' mathematics knowledge and skills, and development in mathematics, teachers' management and teaching practices and the associations between students' achievement in mathematics and teacher-related factors (i.e., the use of management practices, teaching practices and teaching experience) in Estonian- and Russian-language schools.

Based on the aim of the study, the following research questions were proposed:

1. What is the students' knowledge and skills, and development in mathematics in the primary grades and to what extent the performance in Estonian-language and Russian-language schools varies? (Papers I, II and IV)

2. To what extent do teachers in Estonian- and Russian-language schools differ with regard to their teaching experience, teaching practices and management practices? (Papers III and IV)

3. To what extent do the associations between teachers' management practices, teaching practices and teaching experience with students' mathematics knowledge and skills vary according to the study language in school (i.e., Estonian, Russian)? (Papers III and IV)

The answers to these questions should provide theoretical information and practical implications to the administrators of teacher education institutions, academic developers and researchers as well as arguments for making decisions concerning the creation of support systems and teacher training courses that would contribute to the development of children's knowledge and skills in mathematics.

2. THE THEORETICAL BACKGROUND

The following chapters provide the theoretical outline of the doctoral study. The studied constructs – mathematics knowledge and skills, general ability, classroom management practices, teaching practices and teaching experience – are introduced and described.

2.1. Students' mathematics knowledge and skills, and assessment

Research on mathematics knowledge has typically differentiated it into two major types: procedural knowledge and conceptual knowledge (Hiebert & Lefevre, 1986). Procedural knowledge comprises the symbol representation system of mathematics and the algorithms for completing mathematical tasks (Hiebert, 2013). Overall, procedural knowledge is stated as the ability to execute action sequences (i.e., procedures) to solve problems (Rittle-Johnson & Schneider, 2015). According to Hiebert and Lefevre (1986):

> 'Conceptual knowledge is characterized most clearly as knowledge that is rich in relationships. It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information. Relationships pervade the individual facts and propositions so that all pieces of information are linked to some network.' (pp. 3–4)

Conceptual knowledge allows for flexible problem solving, in that children who understand the conceptual grounds of a procedure are more likely to successfully generalise it to novel problems (e.g., Baroody, Feil, & Johnson, 2007; Rittle-Johnson, Siegler, & Alibali, 2001).

Mathematics knowledge and skills can be assessed in the content or cognitive domains. Although the cognitive dimensions (also called process competencies or common competencies) are defined in different ways in different countries (Alberta Education, 2007; Bildungstandards, n.d.; Principles and Standards, n.d.; Vabariigi Valitsus, 2011/2014), the idea that tasks that are hierarchical in nature vary in the kinds of cognitive skills needed to solve them dates back to Bloom (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) and has been developed further by several authors (e.g., Anderson & Krathwohl, 2001; Marzano & Kendalle, 2007). In Estonia, the National Curriculum of Basic Schools considers the hierarchical levels of thinking when designing the learning content and activities for mathematics. The cognitive components are described in the national curriculum as follows: (1) knowing facts, procedures and definitions; (2) applying this knowledge; and (3) using reasoning (Vabariigi Valitsus, 2011/2014). When developing tasks for international comparative studies, these cognitive components are also taken into account.

In international comparative studies, the term *competence* in mathematics is used. According to Niss and Højgaard (2011):

> '*mathematical competence* comprises having knowledge of, understanding, doing, and using mathematical competencies in general and having an opinion about mathematics and mathematical activity in a variety of contexts where mathematics plays or can play a role.' (p. 49)

The PISA study used three competence clusters to describe and assess these cognitive components: the reproduction cluster, the connections cluster and the reflection cluster. These are rather similar to the framework of TIMSS 2007 and 2011 in terms of content (i.e., knowing, applying, reasoning; Mullis et al., 2005; Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009) and the cognitive levels described in the National Curriculum of Basic Schools (i.e., knowing facts, procedures and definitions, applying, reasoning; Vabariigi Valitsus, 2011/2014).

The present study examined three cognitive components (see also Paper I). The first – knowing facts, procedures and definitions (in the PISA reproduction cluster) – is essential when practised knowledge is reproduced. This component represents the most basic level of learning and requires the mastering of associative learning, whereby simple memorising and practising are important (Boesen et al., 2014; OECD, 2006; Siegler, 2005; Walker, Bajic, Mickes, Kwak, & Rickard, 2014). Such mastery involves knowing the facts and understanding how to represent common problems, recognising equivalents, recollecting familiar mathematical objects and properties, performing routine procedures and carrying out computations. The second, applying (in the PISA connections cluster), builds on the reproduction cluster by incorporating problem solving into situations that are not routine but still involve familiar or quasi-familiar settings (Lithner, 2008; OECD, 2006). In primary mathematics, most of the tasks that require applying skills are routine arithmetic word problems. Routine problems have typically been standard in classroom exercises and are designed to provide practice in particular methods or techniques. The third, reasoning (in the PISA reflection cluster), includes skills and knowledge relating to thinking about the processes needed or used to solve a problem (Andersson, 2007; Charalambous, 2010; Lithner, 2008; OECD, 2006). These tasks require applying acquired mathematical knowledge and skills to solve problems that are novel in some respect.

A student's stage of development also influences which component is given priority during instruction. Whereas the development of knowing facts, procedures and definitions is emphasised in younger grades, learning to connect tasks and skills to routine situations as well as to new situations is given priority in older grades (cf. Vabariigi Valitsus, 2011/2014). At different levels in schools, these three components of the cognitive domain are developed and assessed with different tasks (Niss, 2003; Niss & Højgaard, 2011). In primary school mathematics, most tasks are arithmetic word problems. To solve these word problems, a child must first read the text to understand its content and the relations between numbers. It is further necessary to build a conceptual representation of the task, use numbers and find the solution. These activities require various cognitive abilities and processes (attention, conceptual knowledge, reasoning etc.), whose importance in math achievement has been demonstrated by earlier research.

2.2. The role of cognitive abilities in mathematics

Mathematical competencies are supported by different cognitive systems, such as working memory and its subcomponents (Geary, 2004). Several researchers have pointed to the relationship between mathematics achievement and intelligence (García-Madruga, Vila, Gómez-Veiga, Duque, & Elosúa, 2014; Hale, Fiorello, Kavanaugh, Hoeppner, & Gaitherer, 2001; Keith, 1999; Kyttälä & Lehto, 2008; Taub, Keith, Floyd, & McGrew, 2008; Träff, 2013). Others have referred to impairments in basic numerical processing (Geary, 2011; Landerl, Bevan, & Butterworth, 2004). The reason for this might stem from the fact that mathematics consists of various clusters and tasks requiring different cognitive processes (Marzano & Kendalle, 2007; Träff, 2013).

In order to recognise and understand mathematical properties, one needs to be able to look at all the components of a mathematical problem and recognise each item in relation to the other relevant entities. Thus, general ability plays an essential role in understanding geometric relations (Battista, 1990), formatting the mental representations of problems and recognising how well the problem fits the pattern (Das, Naglieri, & Kirby, 1994). Krutetskii (1976) claimed that understanding mathematics requires spatial ability. Research has shown that visuospatial ability is associated with achievement in mathematics (Kyttälä & Lehto, 2008; Träff, 2013; Van Der Ven, Van Der Maas, Straatemeier, & Jansen, 2013).

2.3. The role of management practices, teaching practices and teaching experience in the context of mathematics education

Teachers' use of various methods in the classroom is influenced by their beliefs and experience as well as to the demands of the curriculum (Lam & Kember, 2006; Polly et al., 2013; Stein & Kim, 2009; Tryggvason, 2009). Classroom management is a critical competency area for all teachers because these practices are related to students' achievement, including in mathematics (Levpušček & Zupančič, 2009; Murray, Murr, & Rabiner, 2012; Opdenakker & van Damme, 2006).

Definitions of classroom management vary, but usually include actions taken by the teacher to establish order or engage students. Management practices help to explain general tendencies of teachers to act in certain ways in specific situations (Entwistle, 1998; Jarvis, 2002). For example, Evertson and Weinstein (2006) describe classroom management as "the actions teachers take to create an environment that supports and facilitates both academic and social–emotional learning" (p. 4). Teachers' classroom management practices can be classified in various ways: autonomy versus control and love versus hostility (Schaefer, 1959); acceptance, psychological control, and behavioural control (Steinberg, Elmen, & Mounts, 1989); and warmth versus rejection, structure versus chaos, and autonomy support versus coercion (Skinner, Johnson, & Snyder, 2005). This study (see Paper III) refers to affection, behavioural control, and psychological control (Aunola & Nurmi, 2004, 2005) as three dimensions of management practices (Skinner et al., 2005); it also addresses inconsistent discipline (e.g., see also chaos; Matheny, Wachs, Ludwig, & Phillips, 1995; Walker, 2008). Affection involves emotional availability, support, and genuine caring. Previous research by Skinner et al. (2005), Marchant, Paulson and Rothlisberg (2001), and Wentzel (1997, 2002) has shown that teachers' warmth and support of students' autonomy positively affect students' academic and social competencies, mastery and self-esteem. Behavioural control is seen, besides affection, as of the defining features of parenting that is authoritative in communication and discipline (Baumrind, 1976). It includes providing rewards (i.e. praise, attention) and punishment (i.e. removal of privileges). Earlier research on behavioural control has shown that high teacher behavioural control (or classroom organisation) is associated with a child's high level of school performance (Downer et al., 2012). Psychological control entails restrictive, over-controlling, intrusive parenting in which strict obedience is demanded. Psychological control also refers to control by guilt (Aunola & Nurmi, 2004, 2005; cf. parenting: Barber, 1996; Barber, Stoltz, & Olsen, 2005). As a key feature of authoritarian parenting (Baumrind, 1967) or teaching, a high level of psychological control is related to lower achievement in mathematics (Aunola & Nurmi, 2004). Inconsistent discipline is described as the lack of structure which evokes confusion (Thornberg, 2007). Matheny, Wachs, Ludwig and Phillips (1995) indicated in an earlier research that inconsistent discipline is considered to be a kind of environmental chaos, which includes disorganisation.

A teaching practice is seen as a set of methods or a set of context-driven decisions about teaching a teacher uses in the classroom lesson (Glickman, 1991, p. 6). The instructional approaches and methods a teacher uses during instruction have the potential to influence students' achievement in mathematics. Generally, two major approaches to teaching have been differentiated: teacher-centred or behaviourist teaching, with an emphasis on building basic knowledge and skills and stressing practice rather than understanding, and learner-centred or constructivist teaching, which emphasises learning as a process in which the student participates in constructing new knowledge based on previous knowledge (Jones, 2007; Opdenakker & van Damme, 2006; Richardson, 2003; Windschitl, 2002). Teacher-centred practices refer to the teacher-dominated process in classroom lesson. Such practices concentrate on learning discrete skills, concepts, principles, and procedural knowledge strictly by following teachers' instructions. It is believed that receiving knowledge about mathematical operations from the teacher in discrete units is important (Stipek, Givvin, Salmon, & MacGyvers, 2001), especially for acquiring facts and procedural knowledge (Bietenbeck, 2014). Learner-centred teaching emphasises learning as a process in which the learner is an active participant in constructing new knowledge based on previous knowledge. The teaching process is related to children's previous knowledge and focuses on comprehension (Stipek & Byler, 2004). By expressing ideas, students can extend their thinking through challenging and stimulating discussions (Walshaw & Anthony, 2008). Teaching goals should promote choice and responsibility as well as more self-initiation of behaviour, which includes giving choices, and respectively, reducing control, and making available the information required to perform the tasks (Deci, Vallerand, Pelletier, & Ryan, 1991; Soenens & Vansteenkiste, 2005). The present study differentiates learner-centred practices into two dimensions of teaching practices. One includes more constructivist and student-supportive practice, where the teacher expects the students to be active participants in the learning process. The other is focused on supporting students' autonomy, emphasising the development of students' individuality, independence and co-operation in the classroom (cf. Windschitl, 2002).

The preference for using specific management and/or teaching practices is also related to teachers' teaching experience (e.g., knowledge and skill that is gained through time spent working as a practising teacher and time spent on teaching). The recent TALIS study conducted in Estonia revealed that more experienced teachers are more likely to apply activating methods in the classroom (Übius, Kall, Loogma, & Ümarik, 2014). In earlier research, Palu and Kikas (2007) showed that teachers with different teaching experience were concordant in their evaluation of the purposes of teaching mathematics. Studies related to teachers' teaching experience and achievement in mathematics have shown that children taught by more experienced teachers achieve better in mathematics (Clotfelter, Ladd, & Vigdor, 2007; Harris & Sass, 2012; Kikas et al., 2009). In addition, preferences for different classroom practices might be influenced by teachers' experience, which was proven to affect teachers' classroom behaviour in earlier studies (Shoham, Penso, & Shiloah, 2003; Stipek & Byler, 2004).

3. METHODOLOGY

3.1. Participants and procedure

The samples in all four papers were drawn from two larger projects: 'Effectiveness of Estonian primary school' and 'Development of pupils in schools with different languages of instruction'. The samples covered schools from different regions (urban and rural), of different types (secondary and elementary schools), and with a variety of class sizes. All the students attended regular classes and studied according to the National Curriculum for Basic Schools and Upper Secondary Schools (Vabariigi Valitsus, 2002/2007). The overview of the samples, measures and methods of data analyses is provided in Table 1.

The mathematics test was administered by the teacher during one mathematics lesson in the beginning of the third grade (Papers I, II, III and IV) and again in the fifth grade (Paper IV). Students had approximately 45 minutes to complete the test. Children's general ability was assessed by researchers using an online computer test in computer classes (see Papers I, II and III for subtest D from Raven's Standard Progressive Matrices test). The teacher data were collected from practising teachers. The teachers' average age was 44.47 years (Paper III) and 43.81 years (min. = 26 years; max. = 61 years; Paper IV). The teachers' teaching experience was measured as years of teaching and it varied from 1 to 39 years. All the teachers of Estonian-language schools in Paper III had studied in Estonia. Twelve of 19 teachers graduated from educational institutions in Russia (Paper III).

Table 1. A brief overview of the samples, measures and methods of data analyses used in Papers I, II, III and IV.

Paper	Students' sample	Teachers' sample	Measures	Data analyses' methods
Paper I	N = 1105 Students from Estonian-language schools (684) and from Russian-language schools (421). Grade 3, age 8–10 years		Mathematics test (17 tasks; i.e,. easy- and difficult computing, routine word problems, non-routine word problems). Subtest D from Raven's Standard Progressive Matrices test (RSPM)	Confirmatory Factor Analysis
Paper II	N = 1302 (incl. participants from Paper I) Students from Estonian-language schools (934) and from Russian-language schools (368). Grade 3, age 8–10 years		Mathematics test (4 tasks) – routine and non-routine word problems	Configural Frequency Analysis

Table 1. Continuation

Paper	Students' sample	Teachers' sample	Measures	Data analyses' methods
Paper III	N = 1734 (incl. participants from Paper I and II) Students from Estonian-language schools (1181) and from Russian-language schools (553). Grade 3, age 8 – 10 years	N = 77 Teachers from Estonian-language schools' classrooms (58) and from Russian-language schools' classrooms (19).	Math test for students (17 tasks: i.e,. easy- and difficult computing, routine word problems, non-routine word problems) Subtest D from RSPM for students Teachers questionnaire (20 statements; i.e., Affection, Behavioural control, Psychological control, Inconsistent discipline)	ANOVA Multigroup Analyses of Multilevel Modelling
Paper IV	N = 1810 (incl. participants from Paper I, II and III) Students from Estonian-language schools (1263) and from Russian-language schools (547). The same students were tested twice – in Grade 3 (age 8 – 10 years) and Grade 5 (age 10 – 12 years) with the same tasks.	N = 96 (incl. participants from Paper III) Teachers from Estonian-language schools' classrooms (54) and from Russian-language schools' classrooms (42).	Math test for students (12 tasks; i.e., easy- and difficult computing, routine word problems, non-routine word problems) Teachers questionnaire (21 statements; i.e., Teacher-centred, Constructivist, Individualisation practices)	Multilevel Latent Growth Modelling and Latent Growth Modelling ANOVA Multigroup Analyses of Multilevel Modelling

3.2. Measures

3.2.1. Students' mathematics knowledge and skills

Students' mathematics knowledge and skills (hereafter skills) was assessed with a mathematics test consisting of various tasks. The mathematics test was developed by Anu Palu (Palu & Kikas, 2010), taking into account the learning outcomes prescribed by Estonia's national curriculum for mathematics (Vabariigi Valitsus, 2002/2007). The test for the third grade (Papers I, III and IV) included 17 tasks overall, which were compiled to assess the three mathematics competency clusters (OECD, 2006): reproduction (easy and difficult computing), connections (routine word problems) and reflection (non-routine word problems; see also Paper I). In Paper II, only word problems (routine and non-routine arithmetic word problems) were included. The tasks used in the Estonian-language and Russian-language schools were identical.

The reproduction cluster, one of the most important clusters at this level of education, was assessed using two types of tasks. The first comprised six comparatively easy computing tasks (one-digit and two-digit numbers). The second comprised three more demanding computing tasks (two-digit and three-digit numbers) using numbers and kilograms (e.g., '250 kg – 50 kg + 700 kg = …'). The connections cluster was assessed using five ordinary routine word problems similar to the types practised during school lessons (e.g., 'Andy takes 10 minutes to walk 1 km. The stadium is 3 km away. How long will Andy take to get to the stadium'). Finally, the reflections cluster was assessed using two non-routine exercises (four tasks), which required the ability to integrate learnt information (e.g. 'Write two equations using the numbers 5, 9, and 14'). Each correct answer was coded as 1 while each incorrect or unsolved answer was coded as 0. The reliability and validity of these competencies were good (see pp 97–99 in Paper I).

Paper II included the specific answers to two routine word problems and two novel problems. The first routine word problem had the following instructions: 'Write a number which includes six ones digits, two more tens digits, and twice less hundreds digits than ones digits.' The second routine word problem was as follows: 'Four pies cost 20 kroons and 1 bun costs three kroons. How much do 1 pie and 1 bun cost together?' All answers to these two word problems were examined, and five categories of answers were differentiated (see also Paper II).

1. Correct answers.
2. Partial: the student applied the relations in the task only partially.
3. Numbers: the student used numbers provided in the text but did not perform any operations (first routine word problem) or added these numbers (second word problem).
4. Missing answers: the student did not solve the problem.
5. Other: the remaining incorrect answers.

In order to solve the two non-routine word problems, the student had to use previously acquired knowledge and skills in a somewhat novel situation. The first non-routine word problem read as follows: 'Write two equations, using the numbers 5, 9 and 14.' The second non-routine word problem read as follows: 'Write two equations, using the numbers 2, 16 and 8.' These two word problems are not typical textbook exercises; thus, they can be considered novel problems. All the answers to these two non-routine word problems were examined, and five categories of answers were differentiated (see Paper II).

1. Correct answers
2. Partial: the student composed an equality using only the given numbers as the components of the operation, with the answer being an extra number (for example, $14 + 5 = 19$, $16 – 8 – 2 = 6$).
3. Inequation: the student used the term *inequality* instead of *equality* (for example, $5 < 9 <14$, $8 + 2 < 16$).
4. Missing answers: the student did not solve the problem.
5. Other: the remaining incorrect answers.

The exact distribution of the tasks used from the mathematics test is also shown in Table 1.

3.2.2. Students' general ability

Raven's test of progressive matrices has been used as a measure of general ability (i.e., nonverbal reasoning) in several studies (Balboni, Naglieri, & Cubelli, 2010; Hannafin, Truxaw, & Vermillion, 2008; Kyttälä & Lehto, 2008; Männamaa, Kikas, Peets, & Palu, 2012). Therefore, general ability was assessed using subtest D from Raven's Standard Progressive Matrices (RSPM) test (Lynn, Pullmann, & Allik, 2003; Raven, 1981) and used in the analyses in Papers I, II and III. This test measured the students' ability to form perceptual relations, including abstract reasoning, executive functions, planning skills, and the identification of visual analogies. The test consisted of 12 tasks. The test was carried out using a computer. The student looked at a computer screen, on which a matrix with a missing part was presented. The stuent had to choose and mark one of eight response options to complete the test. The right choice was scored as 1 while a wrong choice was scored as 0. Summed scores were used in the analyses.

3.2.3. Teachers' management practices

Classroom management practices in Paper III were studied using a questionnaire, developed on the basis of two earlier measures for assessing parenting practices and adapted for research on teachers by Maris Hinn (see Hinn, 2009; for the *Child Rearing Practices Report*, see Aunola & Nurmi, 2004; Roberts, Block, & Block, 1984; for the *Alabama Parenting Questionnaire*, see Shelton, Frick, & Wootton, 1996). Questions were formulated as statements, and the teachers were asked to rate them on a five-point Likert scale (1 = not at all; 5 = always). The affection scale included eight items reflecting the teachers' positive relationship with students, such as the encouragement of students' independence, involvement of students and support for them, and positive feedback and affection provided. The behavioural control scale included three items: firm rule setting, confrontation in rule violation and the valuing of obedience in students. The psychological control scale involved three items covering practices that expressed disappointment and control via guilt induction, while the inconsistent discipline scale included six items describing teachers' practices in maintaining discipline and demands. The scores of the management practices were calculated as the means of the summed items of the respective scale (for reliability and validity information on these classroom management practices in Estonian data, see Uibu & Kikas, 2014).

3.2.4. Teachers' teaching practices

The teachers' teaching practices used in Paper IV were studied using a questionnaire that was developed by Krista Uibu and colleagues (Uibu, Kikas, & Tropp, 2010). The questions were formulated as statements, and the teachers were asked to rate them on a five-point Likert scale in terms of how often they use a particular activity in the classroom (1 = not at all; 5 = almost every day). To structure the items in this study, factor analysis using Mplus (Version 6; Muthén & Muthén, 1998–2010) was carried out. In addition, various procedures using SPSS 21.0 were applied to determine the factors, such as eigenvalue > 1 rule, a scree plot, and parallel analysis. The communalities of the items and item loadings were also checked. In the case of low values and/or multiple loadings, the items were removed from the factor structure. The teacher-centred scale included five items reflecting the teachers' use of practices enhancing the mechanical acquisition of knowledge and skills by students and memorisation. The learner-centred constructivist (hereafter, constructivist) scale included nine items covering activities that promote understanding. The learner-centred individualisation (hereafter, individualisation) scale involved seven items reflecting the teachers' use of activities that promote students' individual interests and independence. The scores of the teaching practices were calculated as means of the summed items of the respective scale (the reliability and validity information for these teaching practices are discussed in Paper IV).

3.3. Analysis strategy

In the data analyses descriptive statistics, exploratory and confirmatory factor analyses, latent growth modelling and configural frequency analysis were carried out (see also Table 1).

In Papers I and IV, the data on mathematics skills in the Estonian and Russian samples were analysed as follows. In Paper I the factorial structure of mathematics skills was evaluated using Confirmatory Factor Analysis and a Weighted Least Square with Mean and Variance correction estimator for categorical data. The goodness-of-fit of the Confirmatory Factor Analysis models of the estimated models was evaluated using a chi-square test (χ^2), Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI). The intra-class correlation (ICC) was calculated separately for the Estonian and Russian samples in order to determine the degree of classroom differences in the students' mathematics skills and general ability (Papers I, III and IV). Finally, multilevel modelling (Heck & Thomas, 2009; Muthén, 1997; Raudenbush & Bryk, 2002) was used to show whether the children from the Estonian and Russian samples differed in terms of their mathematics skills, when controlling for classroom differences (in Paper I) in mathematics skills and general ability (i.e., nonverbal reasoning, in Paper I and III). The theoretical four-factor model for mathematics skills is shown in Figure 1 (see also Figure 1 in Paper I).

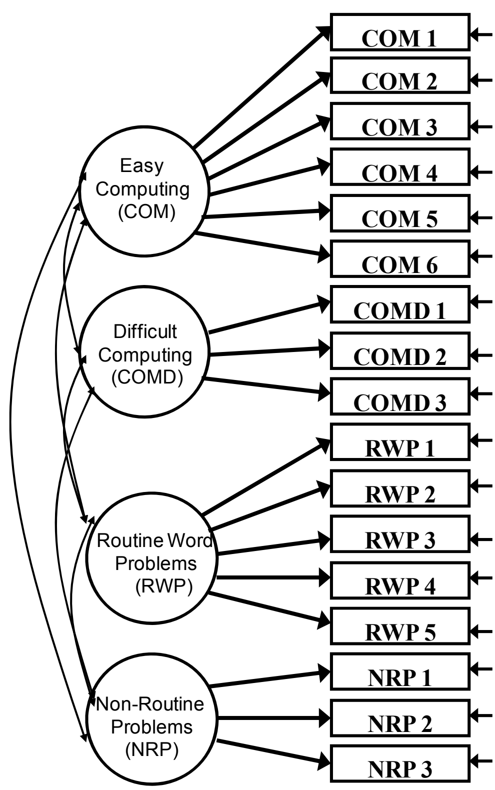

Figure 1. Theoretical four-factor model for mathematics skills (Leopard, Kiuru, & Palu, 2011)

In order to compare the solvability rate and types of errors in students of Estonian- and Russian-language schools, in Paper II Configural Frequency Analysis was used, which is an extension of χ^2 analysis and examines patterns in categorical variables (Bergman, Magnusson, & El-Khouri, 2003; von Eye, 1990).

To estimate the initial level and the change in students' mathematics skills from third through fifth grades, multilevel latent growth models were carried out for mathematics skills where there was a significant classroom-level variance and regular latent growth models for mathematics skills where there were no classroom differences for students attending Estonian- and Russian-language schools (see Paper IV). Although the shape of growth cannot be estimated when there are only two time points, two-wave growth curve models are still appropriate for estimating the amount of change between the time points (Duncan & Duncan, 2004).

The differences between teachers in Estonian- and Russian-language schools in terms of teaching experience, teaching practices and classroom management practices were investigated using a univariate analysis of variance (ANOVA) (see Papers III and IV).

To investigate the extent to which teachers' experience and their classroom management practices predicted students' mathematics skills, when controlling for their general ability as well as whether these associations differ between students from Estonian- and Russian-language schools, multigroup analyses of multilevel models (Heck & Thomas, 2009) were conducted (see Paper III). To examine the extent to which teaching experience and teaching practices predict the level of and the changes in students' mathematics skills (i.e., routine and non-routine word problems), teaching experience and teaching practices were included as predictors in each model, where teaching experience was in all models a predictor for a precise teaching practice (see Paper IV).

The confirmatory factor analysis and multilevel models were performed using the Mplus statistical package (Version 6; Muthén & Muthén, 1998–2010). The SLEIPNER 2.1 package (Bergman & El-Khouri, 2002) was used to conduct Configural Frequency Analysis. SPSS 21.0 and MPlus were used for factor analyses to determine the factors describing the teaching practices in Paper IV.

4. FINDINGS AND DISCUSSION

The next section provides an overview of the main findings based on the current study's research questions. A more thorough account of the study results is provided in the individual papers (i.e., Papers I, II, III and IV).

4.1. Students' knowledge and skills, and development in mathematics in Estonian- and Russian-language schools

Students' knowledge and skills, and development in mathematics in Estonian- and Russian-language schools are analysed in Papers I, II and IV.

As earlier results in PISA (Kitsing, 2008; Tire et al., 2010; Tire et al., 2013) revealed that the mathematics results of students from Estonian-language and Russian-language schools differed, Paper I focused on analysing the level of knowledge and achievement in mathematics of students in the third grade and to compare the performance of Estonian-language and Russian-language schools. The results indicated that there were mean differences between students from Estonian-language and Russian-language schools in the third grade, with the exception of solving easy computing tasks ($\chi 2_{\ diff}$ [1] = 0.02, p = .88; including one-digit and two-digit numbers). The results for other mathematics skills (skills to solve difficult computing tasks as well as routine and non-routine word problems) showed that students from the Russian-language schools had higher results compared with children from the Estonian-language schools (see pp. 100–101 in Paper III). This better performance in difficult computing might depend on the choice of tasks or greater emphasis on teaching facts and procedural skills. It is also possible that teachers in Russian-language schools have drawn more attention to the analysis and understanding of content. National third-grade achievement tests in mathematics have shown that the most difficult tasks are word problems (Jakobson, 2014; Kaasik, 2004). An earlier study (Palu & Kikas, 2010) showed that word problem exercises have been difficult for children attending Estonian-language schools. However, higher results in routine and non-routine word problem tasks among students from Russian-language schools might also indicate that classroom management practices and teaching practices differ from those in Estonian-language schools. In addition, after accounting for students' general ability and classroom differences, no mean differences between Estonian- and Russian-language schools children's achievement in mathematics occurred. This result indicates that general ability might be a considerable feature which could be taken into account in designing and developing national and/or international tests.

Paper II focused on analysing and comparing errors that students in Estonian- and Russian-language schools make when solving routine and non-routine word problems. The present study showed that, overall for the whole sample in the case of routine problems, the errors derived from misunderstanding the text and could be categorised as two types: students combined the numbers or solved the problem only partially. This finding is supported by previous research revealing that students usually make two types of errors when solving word problems: (1) they pay no attention to the relations between numbers and mechanically add, subtract, multiply, or divide whatever numbers are given in the problem (Schoenfeld, 1991; Palu & Kikas, 2010); and (2) they can comprehend the text partially and only perform some operations in a multistep problem (Ryan & Williams, 2007; Palu & Kikas, 2010). Ryan and Williams (2007) pointed out that, if students do not notice several connections at one time in an integrated manner, they solve the problem only partially. Of the two non-routine problems, the first was solved better overall (see Table 3 on pp. 107 in Paper II). The reason for this might be that this problem required knowledge that was more thoroughly rehearsed (addition and subtraction had been studied for a longer period than multiplication and division). Solving the second non-routine problem partially was more common as it was obvious that the student had understood the problem but lacked sufficient knowledge and skills to solve the problem. This finding confirms that using learnt concepts in novel situations requires their full acquisition, but also require flexibility in thinking as the students had to switch from one operation to another (from addition and subtraction to multiplication and division).

Analysis of errors between Estonian- and Russian-language schools revealed that students from Estonian-language classrooms typically solved the first routine problem partially, whereas it was an atypical solution in the children attending Russian-language classrooms (see Table 6 on pp. 110 in Paper II). The analysis of the two routine problems together showed that it was atypical for Russian-language schools students to give different incorrect answers (see Table 7 on pp. 110 in Paper II). The main difference was that the children attending Estonian-language schools typically offered a partial solution for both non-routine problems whereas those in the Russian-language schools did so for only the second problem (see Table 11 on pp. 115 in Paper II). This difference might be explained by the influence of teaching. It is possible that teachers of Russian-language schools have concentrated more on solving word problems. How to solve routine arithmetic word problems can be taught, if students are provided with the system of knowledge and skills needed to find the solution (Polya, 2001). Students understand the mathematical connections in the problem better when they have been familiarised with strategies to find the concept underlying the solution.

Paper IV examined the differences between Estonian- and Russian-language schools' students in the development of mathematics skills. Whereas the development of factual knowledge and procedural skills is emphasised in earlier grades, learning to connect tasks and skills to routine situations as well as new situations is given priority in later grades. The findings of the study supported the idea that, for both the Estonian and Russian sample, the easy computing mathematics skills increased from third to fifth grades (for Est: M = .06, SE = .01, $p < .001$; for Rus: M = .05, SE = .01, $p < .001$; see also Table 2 in Paper IV). The results also showed that, in both samples, routine word problem solving skills increased from third to fifth grades (for Est: M = .26, SE = .03, $p < .001$; for Rus: M = .25, SE = .04, $p < .001$; see also Table 2 in Paper IV). Students' non-routine word problem solving skills increased from third to fifth grade for the Estonian sample, but not for the Russian sample (for Est: M = .09, SE = .03, $p < .001$; for Rus: M = .07, SE = .06, $p > .05$; see also Table 2 in Paper IV). In mathematics, the development of procedural skills is intertwined with conceptual knowledge (see Rittle-Johnson et al., 2001); thus, it is important that, before moving on to more complex problems, procedural skills should first be developed. One of the reasons for the differences in word problem solving skills could be the associations between students' motivation to study mathematics and interest in the subject. Motivational aspects and interest in studying mathematics contribute to the development of mathematics skills (Chiu & Xihua, 2008; Mädamürk & Palu, 2015; Pimta, Tayruakham, & Nuangchalerm, 2009). The results also revealed that, although the development in routine and non-routine word problems was significant, it was still modest (see Table 2 in Paper IV). This might indicate that, when the initial level of mathematics knowledge and skills is high, then the development is more modest. In difficult computing tasks, the differences between Estonian- and Russian-language schools students' development was not significant, which is indicating that the gap between the children attending Estonian- and Russian-language schools is decreasing.

4.2. Teachers' classroom management practices, teaching practices and teaching experience in Estonian- and Russian-language schools

Teachers' use of various methods in classroom is influenced by their beliefs and experience as well as the demands of the curriculum (Lam & Kember, 2006; Tryggvason, 2009). The differences between Estonian- and Russian- language schools' teachers in terms of their teaching experience, teaching practices and classroom management practices are analysed in Papers III and IV.

The results related to teachers' use of classroom management practices indicated that teachers in Estonian-language schools reported showing more affection towards their students than teachers in Russian-language schools (see Table 3 on p. 9 in Paper III), which supports the findings of earlier research (Loogma et al., 2009; see also Remennick, 2002). Previous research has also shown that teachers' warmth and the support of students' autonomy positively affect students' academic and social competencies, mastery and self-esteem (Marchant et al., 2001; Skinner et al., 2005; Turner, Gray, Anderman, Dawson, & Anderman, 2013; Wentzel, 1997, 2002). In addition, teachers in Russian-language schools reported utilising more psychological control of their students than teachers in Estonian-language schools (see Table 3 on p. 9 in Paper III). The content of teacher training education in Estonia and Russia tends to differ which might affect teachers' actions and practices later in school (Lam & Kember, 2006). As the great majority of teachers in Russian-language schools (12 teachers out of 19) in this study have graduated from various educational institutions in Russia, they are likely to hold a stronger belief in authoritarian practices than teachers in Estonian-language schools would. Teachers' age and experience level differences between Estonian- and Russian-speaking teachers might also influence the preference for using psychological control in the classroom. There could be the possibility that teachers in Russian-language schools might still be influenced by their training which retains traces of the Soviet ideology (Temple, 2003), emphasising the importance of following the rules and obeying adults' orders by default (Tuul, Ugaste, & Mikser, 2011). Values of the Soviet ideology might manifest in less affection and higher psychological control (i.e., features of authoritarian parenting/management style).

The study revealed further that teachers in Russian-language schools reported more usage of teacher-centred practices in the classroom (for Est: M = 2.87, SD = .66; for Rus: M = 3.46, SD = .34; F[1,82] = 12.82, $p < .01$; see also Table 3 in Paper IV). Teachers' preferences for teaching practices could be related to the teachers' different cultural backgrounds (Chan & Wong, 2014). One other possible explanation for these results may be that, as the great majority of the teachers in Russian-language schools have graduated from educational institutions in Russia, they might hold stronger beliefs in teacher-centred practices than teachers in Estonian-language schools do.

Papers III and IV revealed that the teachers' level of experience is high in both Estonian- and Russian-language schools, but those from Russian-language schools still had more experience in teaching than those from Estonian-language schools (see Table 1 in Paper III and Table 3 in Paper IV). Several studies have shown that children taught by more experienced teachers have better achievement in mathematics (Clotfelter et al., 2007; Harris & Sass, 2012; Kikas et al., 2009). The present study revealed that teaching experience positively predicted the use of learner-centred constructivist methods among Estonian teachers (Standardized Estimate = .21, $p < .05$; see also Figure 3 in Paper IV). The experienced teachers might have had more chances to participate in different in-service courses. In addition, a subsequent TALIS study revealed that more experienced teachers are more likely to apply active methods in the classroom (Übius et al., 2014). An earlier TALIS study revealed differences in the pedagogical beliefs of teachers in Estonian- and Russian-language schools. The intracultural variability of teachers' classroom management practices in Estonian- and Russian-language schools is also related to factors such as teaching experience, educational level and educational institution from which they graduated (cf. Suviste, 2013).

No differences were found between the teachers' learner-centred practices, behavioural control and inconsistent disciplining, suggesting that the basis for using different teaching practices and classroom management practices in the classroom could be similar. Learner-centred constructivist, individualisation teaching practices and behavioural control were reported similarly, which might be due to several reasons, such as experience, institution from which they graduated, and courses completed (see Figure 1 in Paper III and Figures 2 and 3 in Paper IV). High behavioural control is generally treated positively, has significance in classroom disciplining and is an essential feature of both authoritarian and authoritative parenting/management styles (Baumrind, 1967). Similar results between teachers reported preferences for using inconsistent disciplining might be related to general skills and ideological views or favourable methods. In addition, quite similar results in learner-centred practices might be related to external oppression which has been informed through the results of PISA (Kitsing, 2008; Tire et al., 2010; Tire et al., 2013) and therefore teachers might be more eager to try various methods in the teaching process.

4.3. Associations between teachers' classroom management practices, teaching practices and teaching experience with students' mathematics knowledge and skills in Estonian- and Russian-language schools

As teaching practices play an important role in students' mathematics achievement, it is essential for all teachers to consider the use of appropriate teaching practices and classroom management practices. Papers III and IV analysed the associations between teachers' classroom management practices, teaching practices and experience with students' mathematics knowledge and skills in the three cognitive domains (i.e., knowing facts and procedural skills, applying skills, and using reasoning skills) in Estonian- and Russian-language schools. The final theoretical model for the associations between students' mathematics skills and teachers use of classroom management practices is presented in Figure 2 (see also Figure 1 in Paper III).

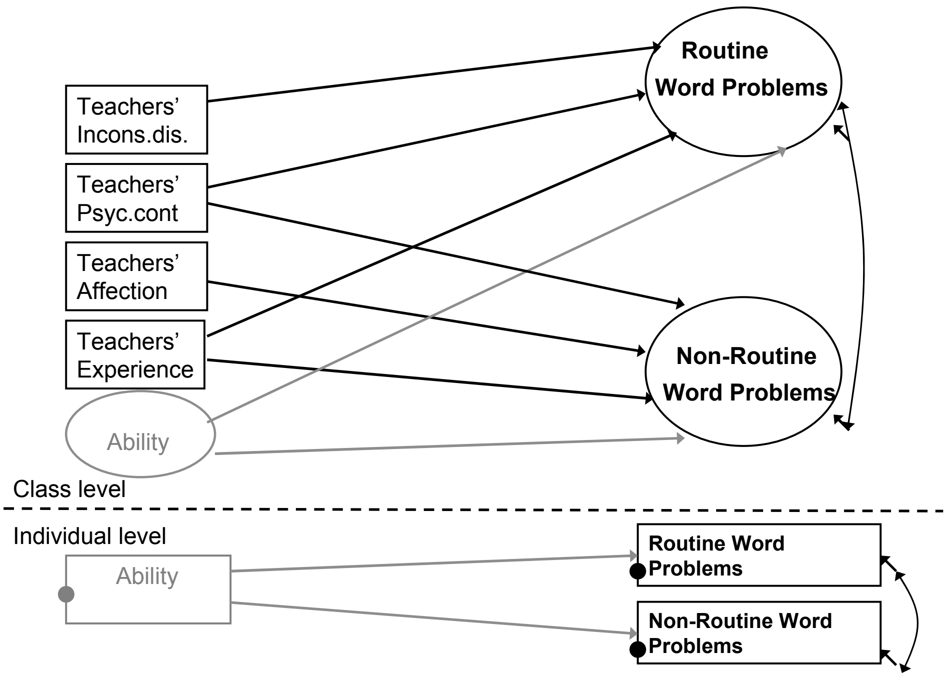

Figure 2. Final theoretical multigroup multilevel model for the associations between students' mathematics skills and teachers use of classroom management practices.

The results of the study indicated that the relations between classroom management practices and mathematics skills vary according to study language at school. In line with earlier research on solving word problems and teachers' use of positive and supportive practices in the classroom (Downer et al., 2012; Ho & Hedberg, 2005), the current study revealed that the more a teacher in the Estonian-language classroom expressed affection towards his or her students (i.e., engaged in positive practices), the better his or her students' skills were in non-routine word problem solving (see Figure 1 on p. 12 in Paper III). Thus, reasoning skills are higher when the teacher shows support and a positive attitude towards the child. Several studies have pointed that care and support for students improve their outcomes, thinking and motivation in mathematics lessons (Levpušček & Zupančič, 2009; Ly et al., 2012; Opdenakker & van Damme, 2006), which is particularly visible in the case of difficult problems that demand more effort and persistence from students.

Teachers' psychological control showed for Russian-language schools that the more a teacher exerted psychological control, the weaker the students' word problem solving skills were (see Figure 1 on p. 12 in Paper III). This result indicates that teacher's use of psychological control might suppress students' interest and autonomy in planning strategically and implementing solutions to problems. The results also complement previous literature on vocabulary and early reading outcomes (Connor, Son, Hindman, & Morrison, 2005) that are important issues in school in addition to mathematics. Several possible reasons could explain why teachers apply psychological control. It has been shown that teacher's actions and behaviour in the classroom depend on the students' characteristics, such as interest, motivation and ability (McCroskey, Richmond, & Bennett, 2006; Tournaki & Podell, 2005). For instance, high psychological control might also be evoked by a student's task-avoidant behaviour in the classroom (cf. Kikas et al., 2009). Therefore, it is possible that a teacher's high level of psychological control in Russian-language schools is conditioned by students' individual features.

In addition to variations in the managerial aspects of teaching, teachers differ in their inconsistent behaviour in the classroom. The results of the present study revealed that inconsistent discipline was related to students' poorer skills in difficult computing (Standardized Estimate = –.28, $p < .10$; see also p. 13 in Paper III). This finding is consistent with the specificity of perceiving facts and procedures in mathematics, as performing routine procedures in mathematics lessons requires rehearsal and consistent disciplining from the teacher and is important in developing procedural skills (Bietenbeck, 2014). The study also revealed that the results from Estonian students indicated that their achievement in solving routine word problems is not significantly affected by their teachers' inconsistent management practice (see Figure 1 on p. 12 in Paper III). In comparison, the more inconsistent the teachers' classroom discipline in Russian-language schools classroom was, the weaker the students' routine word problem skills were (Standardized Estimate = –.35, $p < .01$). This finding indicates that students in Russian-language schools might depend more on their teachers' routine actions and supportive behaviour in the classroom to succeed in a mathematics lesson, especially in applying skills. In addition, as routine word problem tasks need consistency and rehearsal, inconsistent disciplining in the classroom does not contribute to the systematic acquisition of knowledge, which is essential for understanding mathematics in depth. Taking into account the previously discussed findings, it is evident that achievement in mathematics is supported by consistency in teaching and reduced by inconsistent discipline.

In Paper IV the teaching practices and students outcomes were under study. The results for Estonian-language schools for routine word problems showed that, the more the teacher used learner-centred individualisation practices, the lower the classroom's students' routine word problem solving skills were in the third grade (Standardized Estimate = –.13, $p < .05$; see also Figure 2 in Paper IV). This result supports the findings from Bietenbeck's (2014) study which indicated that the competency to solve routine word problems (i.e., applying skills) is promoted by the use of traditional methods, but might also be due to the fact that solving routine word problems requires evidence of integration and the connection with material from earlier practised. It can be hypothesised that the teacher gives the problem to solve, but does not check the further process and, thus, does not support the skills of solving these problems. The most recent report on PISA 2012 results also revealed that, according to students' reports, teachers' use of formative assessment is less used and emphasised in Estonian-language schools than in Russian-language schools (Lepmann, *submitted*); and when there is lack of control and teacher's interest in the outcomes, there might be little chance of developing problem-solving skills.

Contrary to previous studies (Bietenbeck, 2014; Kikas et al., 2009), the results revealed for Estonian sample that the more the teachers used constructivist practices, the lower the students' non-routine word problem solving skills were at the beginning of the third grade and the faster the students' non-routine word problem solving skills in the classroom increased from third to fifth grades (see Figure 3 in Paper IV). These results might be related to conceptual knowledge development. According to Rittle-Johnson et al. (2001) and Hiebert (2013), the procedural skills and conceptual knowledge are intertwined; when students' knowledge of facts and procedures is weak, they are in difficulties with conceptual understanding and therefore it is also problematic to solve the task or problem given. The teacher is the one who can support the student and use different constructivist and supportive methods in the classroom to promote understanding of the phenomena. The results also suggest that the use of learner-centred constructivist practices contributes to the development of non-routine word problem solving skills (for Est: Standardized Estimate = .14, $p < .01$; for Rus: Standardized Estimate = .44, $p < .05$; see also Figure 3 in Paper IV), which is concordant to Bietenbeck's (2014) study investigating teaching and skills in mathematics, suggesting that modern and learner-centred methods have a significant effect on students' reasoning skills.

The present study revealed that teachers' longer teaching experience and students' higher general ability were associated with students' higher mathematics results. Akyuz and Berberoglu (2010) indicated that the teacher's experience is related to achievement in problem solving, and several studies have concordantly shown that general ability skills (the skill of completing patterns presented visually) are related to success in solving mathematical word problems (e.g., Farrington-Flint, Canobi, Wood, & Faulkner, 2007; Fuchs et al., 2006; Taub et al., 2008). Teachers' experience positively predicted achievement in routine and non-routine word problems among students in both Estonian- and Russian-language classrooms (see Figure 1 on p.12 in Paper III). One possible explanation might be found in teachers' training. The longer a teacher has had practice, the more chances he or she has had to participate in different courses and acquire suitable modes for teaching skills and methods of solving word problems (for older students, see Harris & Sass, 2012; Kukla-Acevedo, 2009). The study also demonstrated that teachers' teaching experience positively predicted the initial level (but negatively predicted the change in non-routine word problem skills among Estonian-language students (see Figure 3 in Paper IV), although not among Russian-language students. These results indicate that those teachers who have more teaching experience have better classes in the beginning and must deal with covering less development of mathematics skills in these classes. For Russian-language schools, the external oppression for using a wider range of teaching methods and practices, more so than for Estonian-language schools teachers, might be due to the results of PISA (Kitsing, 2008; Tire et al., 2010; Tire et al., 2013) as the latter's results in mathematics have been consistently poorer in earlier studies. Contrary to the Russian-language schools' teachers, the Estonian teachers might hold on to these methods in teaching in which they know work better and they are not so eager to take risks in using newer or unfamiliar methods in teaching. Due to higher experience, the Russian-language schools teachers might also take into account the students' individual characteristics or use different practices appropriately, thereby promoting their comprehension of mathematics in the context of the three cognitive levels.

To sum up, the results of this study indicate that the differences found in the PISA 2006 and PISA 2009 tests were not evident in Estonian- and Russian-language schools. Contrary to international studies, in the current study, children attending Russian-language schools showed higher achievement in solving word problems than their peers from Estonian-language schools, but the difference did not occur after controlling for general ability and classroom differences. Regarding the associations between teachers' use of classroom management practices and achievement in mathematics, the findings suggest that using positive and supportive practices in the classroom contributes to higher achievement in mathematics; thus, promoting them in teacher training is important. Furthermore, how teachers use learner-centred practices is related to students' development in mathematics, especially in terms of solving word problems. Overall, teachers from Estonian- and Russian-language schools adopted different classroom management and teaching practices, leading to different effects on the students' development of mathematics achievement in these schools.

4.4. Limitations of the study

The present study has some limitations that have to be considered when generalising the findings. First, the present study was based on teachers self-reports and evaluations of their use of teaching practices and classroom management practices. Further research should focus on the observation and analysis of actual teaching practices and teachers' behaviour and use of certain teaching methods in the classroom. Therefore, the study could be continued and the sample expanded in certain domains.

Second, although at the national level, teachers from Estonian- and Russian-language schools should teach according to the same curriculum and have the same textbooks; unfortunately, the publishing process for textbooks promoting learner-centred teaching has been delayed in Russian-language schools. This limitation might influence the usage of textbooks in lessons, which suggests that approaches to incorporating content-based teaching materials and textbooks in mathematics differ in Estonian- and Russian-language schools.

Third, it would be important to know the students' socio-economic status or the educational background of the parents. These measures might likewise provide a more detailed overview of the sample and confirm that differences cannot be attributed to aspects other than those under study (Agirdag, Van Houtte, & Van Avermaet, 2012; Casey et al. 2015).

Finally, there could be other factors that have influenced the learning of students that have not been taken into account in the study. For example, it would be valuable to know the students' motivational level because it might enable the investigation of the extent to which motivational aspects affect achievement in mathematics (Cvencek, Kapur, & Meltzoff, 2015; Jõgi, Kikas, Lerkkanen, & Mägi, 2015; Mägi, Lerkkanen, Poikkeus, Rasku-Puttonen, & Kikas, 2010)

5. CONCLUSIONS AND PRACTICAL IMPLICATIONS

Earlier results from TIMSS (Mullis et al., 2004) and PISA (Kitsing, 2008; Tire et al., 2013; Tire et al., 2010) revealed that students' mathematics skills in higher grades (Grades 8 and 9) from Estonian-language and Russian-language schools differed. As previous findings from the national mathematics tests in Grade 3 have been inconsistent and the basis for further learning is built in lower grades (Jakobson, 2014; Taal, 2012; Tibar, 2013), it was of interest to investigate students' achievement in mathematics in the primary grades. The instructional approaches, teaching practices a teacher uses during instruction and teachers' behaviour have the potential to influence students' achievement in mathematics. It has been stressed that the main issue concerning teaching mathematics in Estonia is the different level of Estonian- and Russian-language schools, so the differences between students' achievement in mathematics associated with teacher-related contextual factors (teaching practices and classroom management practices) and teaching experience were under study.

The results of this doctoral dissertation have both theoretical and practical importance.

The conclusions that are of interest to teachers and teacher educators are as follows:

1. According to the cognitive levels in mathematics education in Estonia and in PISA competency clusters, third-grade students in Russian-language schools performed better than those in Estonian-language schools in terms of both routine and non-routine word problem tasks. This result indicated that in primary grades there are no such differences like referred in the PISA studies that the Estonian-language schools students perform better. Contrary, the current study showed that, when not taken into account the effect of students' general ability, children attending Russian-language schools have higher results in solving word problems. Thus, the point at which the difference emerges could be in higher grades.
2. The results also revealed that after accounting for the effect of students' general ability and classroom differences, there were no differences between Estonian- and Russian-language schools students' achievement in mathematics in the three cognitive levels under study. This result indicates that students' general ability and also classroom differences might have an effect on their achievement in mathematics and could be considered as additional characteristics to investigate in the national and international comparative studies.
3. When examining the skills of solving routine and non-routine word problems in different languages of instruction, it emerged that the skill of solving word problems was higher in the results of students attending Russian-language schools. This difference could be explained by the influ-

ence of teaching. Teachers in Russian-language schools might have concentrated more on solving word problems or have the methodological tools or handbooks for teaching the relevant skills. Students understand the mathematical connections in the problem better when they have been familiarised with strategies to find the concept underlying the solution.

4. The analysis of errors when solving routine word problems revealed that Estonian students typically solved the problem partially, whereas this was an atypical solution approach in the Russian-speaking classrooms. When solving non-routine problems, the main difference was that the Estonian-language schools students typically offered partial solutions for non-routine word problems. Students from Estonian-language schools might be more eager to try solving a task whereas those in Russian-language schools might want to solve the problem when they are confident in their knowledge to do so.
5. Teachers from Estonian-language schools reported more frequent use of positive and supportive practices in the classroom. Regarding the use of teaching practices and classroom management practices, teachers in the Russian-language schools reported more use of teacher-centred practices and psychological control. These results might be related to teachers' cultural background as well as the demands of the curriculum. In primary grades, it is essential to become familiar with mathematics and argumentation as well as apply these skills to develop procedural skills; therefore, the teacher-directed approach might be more effective in introducing and developing students' procedural skills and factual knowledge. It also has to be pointed out that, when a teacher's behavioural control is required in teacher- and learner-centred practice, then high psychological control inhibits the students' development in mathematics.
6. The study revealed that the more a teacher in the Estonian-language classroom engaged in positive and supportive practices towards his or her students, the better his or her students' skills were when solving non-routine word problems. This outcome might stem from the fact that care and support for students improve their outcomes, thinking and motivation in mathematics lessons (Levpušček & Zupančič, 2009; Ly et al., 2012; Opdenakker & van Damme, 2006), which is particularly evident in the case of difficult problems that demand more effort and persistence from students.
7. Teachers' psychological control was found to be associated negatively with students' routine and non-routine word problem solving skills in Russian-language schools. The more a teacher exerted psychological control, the weaker the students' word problem solving skills were. A high level of psychological control might suppress students' interest and autonomy while enhancing their anxiety, thereby leading to low persistence. Another possible explanation could be that students are taught by one teacher. The teacher's actions and behaviour in the classroom depend on the students'

characteristics, such as interest, motivation and ability (McCroskey et al., 2006; Tournaki & Podell, 2005). Teachers' high level of psychological control might be conditioned by students' individual features.

8. The study also revealed that Estonian students' achievement is not significantly affected by their teachers' inconsistent management practices. In comparison, the more inconsistent the Russian-language schools teacher's discipline was in the classroom, the weaker the students' routine word problem skills were. This finding indicates that students in Russian-language schools might depend more on their teacher's routine actions and supportive behaviour in the classroom to succeed in mathematics lessons. In addition, as routine word problem tasks need consistency and rehearsal, inconsistent discipline in the classroom does not contribute to the systematic acquisition of knowledge, which is essential for understanding mathematical concepts and the connections between them. It is evident that achievement in mathematics is supported by consistency in teaching and reduced by inconsistent discipline.
9. The results for routine word problems showed that, in Estonian-language schools, the more the teacher used learner-centred individualisation practices, the lower the students' routine word problem solving skills were in third grade. As solving routine word problems require guidance and directed instruction from the teacher, the findings suggest that, in primary grades, supporting children's autonomy and independent work should be preferred after profound consideration.
10. The results revealed that, for the Estonian sample, the more the teachers used learner-centred constructivist practices, the lower the classroom's students' non-routine word problem solving skills were in the third grade, but the development was greater, indicating that in the long term using constructivist practices contributes to solving non-routine word problems. These results might be explained with the development of conceptual knowledge. Rittle-Johnson and colleagues (2001) pointed that procedural skills and conceptual knowledge are intertwined; when students' knowledge of facts and procedures is insufficient, they will have difficulties with conceptual understanding.

In relation to the three main research questions, the following practical implications and future directions should be highlighted:

1. When examining the differences between Estonian- and Russian-language schools, mathematics sub-skills, students' general ability and age should be taken into account. Therefore, longitudinal studies investigating students' achievement and development in mathematics are of importance and should be pursued in the future. In light of the results related to word problem solving skills, teachers might admit to focusing more attention on solving word problems during lessons. In addition, in-service training courses on teaching the children the necessary methods and strategies to

solve arithmetic word problems could be organised to achieve a profound understanding of teaching problem-solving skills.

2. Teachers from Estonian- and Russian-language schools differed in their preference for the usage of classroom management practices and teaching practices. This might be due to the teachers' cultural background, but also related to their beliefs or in-service training courses completed. A wider range of different courses regarding the introduction and use of classroom management practices and teaching practices could be added to the in-service training program, to broaden the teachers' horizon and encourage them to use various methods and practices in the classroom.
3. Support and encouragement in primary grades can contribute to higher achievement in solving novel word problems. Teachers' higher psychological control had a negative effect on students' math skills. The use of psychological control during lessons might suppress students' interest and autonomy, making it ineffective for knowledge acquisition. Thus, such control should be avoided. The results indicate that the use of learner-centred constructivist practices contribute to the development of non-routine word problem solving skills in primary grades over the long term and therefore could be advantageous.

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SUMMARY IN ESTONIAN

Õpilaste matemaatikateadmised ja nende areng ning nende seosed õpetajate kasvatustegevuste, õpetamispraktikate ja õpetamiskogemusega: eesti- ja venekeelse kooli võrdlus

Õpilaste tulemusi matemaatikas võivad mõjutada nii ühiskonnas levinud väärtused kui ka haridusele seatud eesmärgid, seega võivad need erineda kultuuriti, aga ka ühiskonna sees, nt rahvuskultuuriti (Mikk, 2007; Shipley, 2011; Välijärvi et al., 2007). Esimene Eestis tehtud rahvusvaheline tasemeuuring TIMSS 2003 ja hilisemad PISA uuringud (2006, 2009, 2012) tõid esile, et vene õppekeelega koolide õpilaste tulemused matemaatikas on märgatavalt nõrgemad eesti õppekeelega koolide õpilaste tulemustest (Kitsing, 2008; Mullis et al., 2004; Tire et al., 2010; Tire et al., 2013). Arvestades, et kõik Eesti õpilased õpivad kehtiva õppekava järgi (Vabariigi Valitsus, 2011/2014), võivad õpilaste erinevad tulemused olla tingitud nende õpetajate uskumuste, väärtuste, õpetamispraktikate ja kasvatustegevuste rakendamise erinevustest. Eestis on matemaatikaõpetajate (Jukk et al., 2007) ja matemaatikat õpetavate klassiõpetajate (Kikas et al., 2009; Palu & Kikas, 2007) õpetamispraktikaid uuritud eestikeelsetes koolides. Uuringud näitavad, et õpetajate uskumused ja kasutatavad õpetamismeetodid erinevad eesti ja vene õppekeelega koolide õpetajatel (Lepik & Kislenko, 2014; Loogma et al., 2009). Lisaks on leitud, et õpilaste oskused matemaatikas on seotud õpetajate õpetamispraktikatega (Kikas, Peets, & Hodges, 2014; Kikas et al., 2009).

Senistesse õpetajate õpetamispraktikate ja kasvatustegevuste uuringutesse pole haaratud vene õppekeelega koolide õpetajaid sellisel määral, et vaadelda algklassides matemaatikat õpetavate õpetajate ja klassiõpetajate õpetamispraktika ja kasvatustegevuste seost õpilaste tulemuste ja arenguga. Võib vaid oletada, et eelkirjeldatud tasemeuuringute erinevad tulemused võivad olla seotud õpetajate erinevate õpikäsitluste ja tegevustega. Seetõttu oli põhjendatud uurida, mil määral eesti ja vene õppekeelega koolide õpetajate õpetamis- ja kasvatustegevused erinevad ning kuidas on need näitajad seotud õpilaste matemaatikaalaste oskuste ja teadmiste arenguga.

Doktoritöö eesmärk oli uurida õpilaste matemaatikateadmisi ja nende arengut, õpetajate õpetamispraktikaid ja kasvatustegevusi ning õpilaste tulemuste ja õpetaja kasvatustegevuste vahelisi seoseid eesti ja vene õppekeelega koolide võrdluses.

Eesmärgi täitmiseks püstitati järgmised uurimisküsimused.

1. Millised on eesti ja vene õppekeelega koolide õpilaste teadmised ja areng matemaatikas ning mil määral need erinevad? (Artiklid I, II ja IV)

2. Millised on eesti ja vene õppekeelega koolide õpetajate kasvatustegevused, õpetamispraktikad ja töökogemus ning kas need erinevad? (Artiklid III ja IV)

3. Kuidas on eesti ja vene õppekeelega koolide õpilaste tulemused ja areng matemaatikas seotud nende õpetajate kasvatustegevuste, õpetamispraktikate ja töökogemusega? (Artiklid III ja IV)

Uurimistulemused kinnitasid, et algklassides ei ilmne eesti ja vene õppekeelega koolide õpilaste matemaatikatulemustes erinevusi sellisel määral, nagu kirjeldavad neid rahvusvahelised TIMSSi ja PISA uuringud. Vastupidi, uuringust ilmnes, et vene õppekeelega koolide õpilased lahendasid tekstülesandeid paremini kui eesti õppekeelega koolide õpilased. Sama erinevus esines ka tekstülesannete lahenduste vigade analüüsimisel. Kui matemaatikateadmiste analüüsimisel arvestati ka õpilaste võimekust ja klassierinevusi, siis eesti- ja vene õppekeelega koolide õpilaste matemaatikateadmistes erinevusi ei esinenud. Lisaks näitas uuring, et eesti ja vene õppekeelega koolide klassiõpetajad ja algklassides matemaatikat õpetavad õpetajad erinesid kasvatustegevuste ja õpetamispraktika poolest. Eesti õppekeelega koolide õpetajate vastustest selgus, et nad rakendavad positiivseid kasvatustegevusi õppetunnis rohkem kui vene õppekeelega koolide õpetajad. Lisaks nõustusid vene õppekeelega õpetajad rohkem väidetega, mis kinnitasid psühholoogilise kontrolli ja õpetajakeskse õpetamispraktika kasutamist. Tulemused viitasid, et positiivsete kasvatustegevuste rakendamine õppetunnis aitab kaasa paremate tulemuste saavutamisele matemaatikas. Ühtlasi näitas uuring, et individuaalsust ja iseseisvust toetav õpilasekeskne õpetamispraktika on negatiivselt seotud õpilaste rutiinsete tekstülesannete lahendamise oskusega. Seevastu konstruktivistlik õpilasekeskne õpetamispraktika on pikas perspektiivis positiivselt seotud õpilaste arenguga tekstülesannete lahendamisel. Siinne väitekiri võimaldab mõista eesti ja vene õppekeelega koolide õpilaste matemaatikatulemusi ning nende tulemuste seost õpetajaga. Kokkuvõtvalt võib öelda, et piirangutest hoolimata on saadud tulemused olulised nii teoreetilisest kui ka praktilisest aspektist.

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Suviste, R., Kiuru, N., Palu, A., & Kikas, E. (2014). Classroom management practices and their associations with children's mathematics skills in two cultural groups. *Educational Psychology*, 1–20. Doi: 10.1080/01443410.2014.993927.

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