Mathematics education in Finnish comprehensive school: characteristics contributing to student success

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1. INTRODUCTION

The Finnish comprehensive school system and its outcomes have received wide international attention at the beginning of the new millennium (the so-called "PISA effect"). Our education system has become an attractive and internationally examined example of a well-performing system that successfully combines high quality with widespread equity and social cohesion through reasonable public financing (Sahlberg 2006). Since 2001, hundreds of foreign delegates have visited Finland in order to learn the secrets of the high performing system. Through these visits, we Finns have benefited at least as much as our visitors. Questions and doubts presented by the visitors have helped us see what is valuable in our system and, most importantly, understand that explaining the high level of our school system is not a simple and straightforward task. Consequently, we have also started to think seriously about the special characteristics and strengths of our mathematics education. What explains the high level of mathematics performance in the studies like PISA? What kinds of policies and improvement strategies have been implemented since the 1970s in raising student achievement in mathematics?

This paper will address some main characteristics of mathematics education in the Finnish comprehensive school (Grades 1–9), starting with a brief review of Finnish comprehensive school education in general. Drawing on recent articles and reports (e.g. Aho et al. 2006, Kupari 2004, Kupari & Välijärvi 2005, Kupari et al. 2007, Linnakylä 2004, Linnakylä & Välijärvi 2005, Pehkonen et al. 2007, Sahlberg 2006, Simola 2005, Välijärvi et al. 2002, Välijärvi et al. 2007), the main part of my presentation concentrates on describing essential features in our mathematics education such as the curriculum, teaching practices, assessment policies, and teacher training. Finally, some future prospects of mathematics education in Finland will be discussed.

2. FINNISH COMPREHENSIVE SCHOOL EDUCATION

2.1 *General features of the Finnish comprehensive school system*

Finland has nine years of compulsory schooling and children generally start school at the age of seven (see Appendix). Usually, for the first six years of comprehensive school, the children are taught by a class teacher, who generally teaches all or at least most subjects. Then, during the last three years, the different subjects are taught by specialised subject teachers. Almost all of the age group (99.7%) completes compulsory schooling. (Välijärvi et al. 2007)

The school network covers the whole country and schools are primarily run by local authorities, with the exception of a small number of private schools. For children, the teaching and educational equipment are free of charge since education in Finland is publicly financed from pre-school to higher education. In addition, the pupils get a free warm meal at school every day. Transportation is also arranged by the education provider for distance of 5 km and over. Presently, the smallest schools have fewer than ten pupils, and the largest ones about 900. There are some 3200 comprehensive schools in Finland. The amount of schools has dramatically declined because the number of pupils has decreased and municipalities have cut budgets.

At present, the National Core Curriculum for Basic Education prepared by the Finnish National Board of Education (FNBE) determines the core subjects which all pupils study, and the Finnish government determines the national goals for education and the number of classroom hours allocated to each subject. Besides this, learning usually takes place in heterogeneous groups. This means that all pupils study the same core subjects with similar instructional contents. However, about 20 per cent of all classroom hours are reserved for optional subjects freely chosen by the pupil and his or her parents. Furthermore, the schools can develop individual profiles by focusing on some area, such as languages, mathematics, sciences, sports, music or arts.

There is no actual graduation certificate or qualification to be gained upon completing the comprehensive school, but once a student's compulsory education is over, it opens the way to all secondary education options, i.e. different types of vocational training or upper secondary school.

2.2 *Strengths of the Finnish comprehensive education*

The Finnish comprehensive education system is not only a system. It is also a matter of pedagogical philosophy and practice. The comprehensive school is for child and, hence, has to adjust to the needs of each child. Instruction and pedagogy have been developed to adapt to heterogeneous student groups; no student can be excluded or sent to another school. Students' own interests and choices are likewise taken into account at schools when selecting contents, textbooks, learning strategies, methods and assessment devices. Of course, for heterogeneous groups to be successful class size must be relatively small. In fact, PISA 2003 data revealed that mathematics class sizes were among the smallest in the OECD countries (the mean was 18 students). All in all, the comprehensive education calls for a flexible, school-based and teacher-planned curriculum along with student-centred instruction, counselling and remedial teaching.

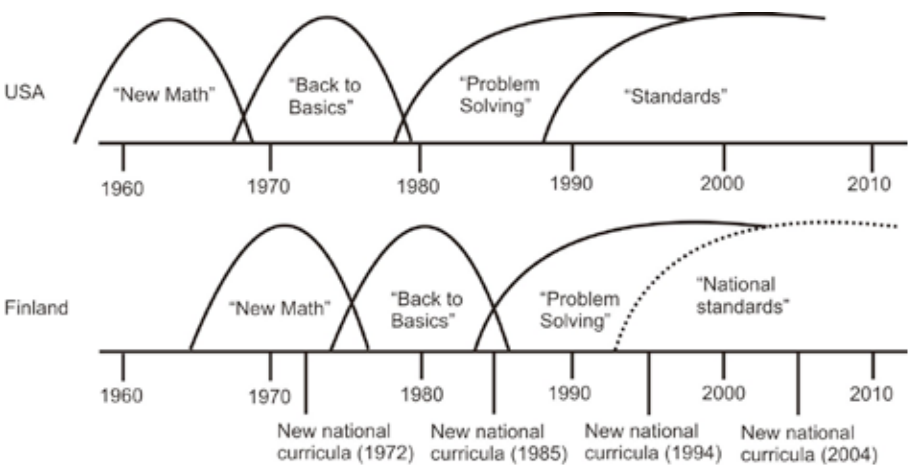
Special education has likewise played an important role in Finnish schools in catering for students who have problems following regular teaching. Special education is usually closely integrated into normal teaching and is highly inclusive by nature. Indeed, only about two per cent of students attend separate special education institutions. In practice, a student with problems for example in mathematics typically has the opportunity of studying once or twice a week in a small group of 2–5 students or even individually with a special teacher. The special teacher may, alternatively, also attend regular classes. On the primary level (grades 1 to 6), where class teachers have the main responsibility for instruction, special education is mostly focused on reading and writing skills along with mathematics skills. A student's right to special education is stipulated in the Finnish school laws.

Every student also has a right to *student counselling*. Schools are to provide students with guidance in study skills, choice of options (e.g. elective courses) and planning of post-compulsory studies. At grade levels 7 to 9, every school has a student counsellor, who provides individual guidance to those in need or desirous of it.

3. DEVELOPMENTS IN MATHEMATICS CURRICULUM

In this chapter, I will shed some light on the curricular background and development of the Finnish mathematics education. Figure 1 below describes the different phases of mathematics curriculum taken place in Finland since the introduction of the comprehensive school system in the beginning of the 1970s.

Figure 1. The developmental phases of the comprehensive school mathematics curriculum in Finland related to the curricular trends in USA



Since 1972 there has been four distinct phases in the development of mathematics curriculum in Finland (cf. Kupari 1994). The figure reveals that the curriculum changes have always tended to follow international - specifically Anglo-American – reform trends. In order to save some time, I will pass by a closer analysis of the first two phases - *New Math* and *Back to Basics* – and concentrate more on the latest curricular phases.

The agenda of NCTM at the beginning of 1980s (NCTM 1980) raised problem solving to a key position in mathematics teaching and it meant the start of the new phase in the development of mathematics curriculum in

Finland, as well (*Problem Solving –phase*). In 1985, the school legislation was reformed and simultaneously the National Board of Education (NBE) introduced the new Framework Curriculum for the Comprehensive School. The objectives of mathematics curriculum emphasised strongly both applications and problem solving and this could be seen very soon in the mathematics textbooks.

The new legislation had also impacts on the practical schoolwork especially on the upper level of the comprehensive school (grades 7-9). The number of mathematics lessons per week was reduced by one (from 10 to 9). Furthermore, the ability grouping (streaming) of students was removed and this was a very significant change for teaching and teachers. Mathematics teachers were now compelled to apply internal differentiation within heterogeneous teaching groups, but at the same time this change of the teaching environment was supported by reducing the size of teaching groups. In mathematics classes, there were about 16-19 students and it provided more opportunities for individualised teaching. During the late 1980s, both mathematics teachers and students got used little by little to work in these heterogeneous classes.

In 1994, the NBE issued again a new Framework Curriculum for the Comprehensive School. This framework curriculum started a new kind of education and curricular culture in Finland. There was a clear shift from a centralised curriculum system to a decentralised system. Instead of uniform national curricula, the NBE now issues curricular guidelines, while the Ministry of Education determines the allocation of lesson hours across school subjects, and schools then accordingly make up curricula of their own. Another important change was that learning materials no longer needed the approval of the NBE. So, schools were given more freedom and responsibility for their own curricular preparation and development (*National Standards –phase*).

Despite rather strong aspirations for reform, the 1994 mathematics curriculum included only minor changes as compared to the previous framework curriculum from 1985. The objectives of mathematics education thus continued the accepted line by emphasising problem solving and application of mathematical knowledge and skills. The main difference compared with the earlier curriculum was that now the objectives and contents of mathematics education were presented in a concise and generic form by school level (about 2 pages in total), whereas previously they had been described in great detail and by grade level.

At the beginning of 2004, the NBE introduced the National Core Curriculum for Basic Education. This latest mathematics curriculum continues the guidelines and objectives expressed in the 1994 curriculum. However, the core curriculum for grades 1-9 is again more detailed than the previous one. The overall objective is to create uniform basic education, i.e. a continuum through grades 1-9.

In summary, the mathematics curriculum has changed about once in ten years during the comprehensive school system. An important issue is that the international trends were not transferred into the Finnish practice as such. Instead, they were transformed into the solution that fitted our national situation. Thus, it was not only a question of borrowing a curricular "ideology" from some other country. A bigger change in the national curriculum system has taken place in 1994 when the directive administration was transferred from the central level to the local municipalities (Lampiselkä et al. 2007). This meant that the local authorities became responsible for the preparation and implementation of the national curriculum at school level.

Perhaps the most significant feature behind the Finnish success in PISA mathematics has been *the systematic development of comprehensive school mathematics curriculum* which has continued since the early 1980s. During the last 25 years, applications and problem solving have been important goals in the mathematics curriculum of our comprehensive school. Step by step, these goals have become more and more established in mathematics textbooks and teaching practice. As we know, the PISA approach particularly focuses on young people's capability to apply their mathematical skills and knowledge in situations that are as authentic and close to daily-life needs as possible. Thus, the Finnish mathematics curriculum has emphasized and also implemented goals and contents comparable to those assessed in PISA mathematics surveys. In this respect, our curricular decisions have been successful and produced great results.

4. HIGHLY QUALIFIED MATHEMATICS TEACHERS ARE A NECESSITY

In the following, I will describe the education of Finnish mathematics teachers. In Finland, the university-level teacher education was implemented in 1974. Today, a research-based approach is a main organising theme integrated into our teacher education programmes. From the very beginning, the objective of teacher education has been to educate pedagogically thinking teachers who are able to think reflectively over their teaching. A teacher is seen as a reflective practitioner who has a strong personal-practical theory of education. (Lavonen et al. 2007, Kansanen et al. 2000)

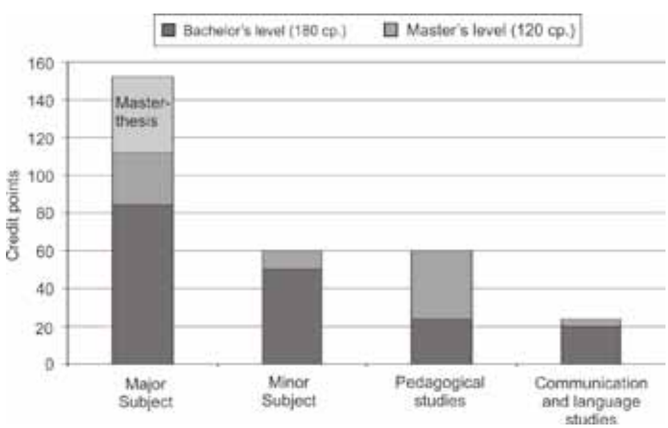
In our comprehensive school system, class teachers are teaching almost all subjects - including mathematics - in primary school at grades 1-6. Subject teachers are teaching in lower secondary school at grades 7-9. All class and subject teachers are educated in Master level programmes requiring 300 credit points (1 cp. = 27 hours work) which are offered by eight universities in Finland.

The structure of a master's degree for a class teacher and a subject teacher are rather similar. As an example, I will shortly present the content of the subject teacher programme in one Finnish university based on the article of Lavonen et al. (2007, 49-59). A typical structure of the education programme can be seen in Figure 2.

Subject teacher studies are divided into two parts: mathematics is studied at the Department of Mathematics and pedagogical studies at the Department of Teacher Education and in the Teacher Training School. In general, teacher students take a major and a minor in the subjects they intend to teach in school. Typical combinations for a mathematics teacher are: mathematics – physics, mathematics – chemistry and mathematics – computer science but the students are free to choose also other combinations of subjects (e.g. mathematics – home economics).

Mathematics in the Finnish universities is very much the same as mathematics in the western world in general. The main aim of the mathematics studies is to give university level understanding of mathematics covering those subject domains taught at Finnish schools. The utilisation of new technology in teaching and learning mathematics have recently included in the studies.

Figure 2. A typical structure of a master's degree of a subject teacher (Lavonen et al. 2007)



During the pedagogical studies, the students' mathematics knowledge, knowledge about teaching and learning mathematics and school practices are integrated into students' personal pedagogical theory. The pedagogical studies are divided into bachelor's level studies (25 cp.) and master's level studies (35 cp.). Typical contents within studies are: teaching and learning mathematics, pupils' interest and motivation in mathematics, national and local curriculum including curriculum planning, teaching methods, ICT in mathematics education and evaluation and research methodologies in mathematics education. One third of the pedagogical studies consist of teaching practice (20 cp.) placed both in the Teacher Training Schools and municipal network schools. Teaching practice has been divided into two parts: the first part takes place during the bachelor studies and the second part at the end of master studies.

Finally, the mathematics teacher students carry out their master thesis (40 cp.) in mathematics. Then they can choose either a pedagogical orientation or a mathematics orientation and prepare the thesis in guidance of a professor or in a research group.

Summing-up, the teaching profession has always enjoyed great public respect and appreciation in Finland, and a lot of resources have consequently been invested in teacher education. Teachers have also been trusted as true professionals of education. This basically means that the educational decision makers believe that teachers together with principals, parents, and their communities know how to provide the best possible education for their children (Aho et al. 2006). From this it has followed that Finnish teachers have considerable pedagogical independency in the classroom and that schools likewise enjoy substantial autonomy in organizing their work within the limits of the national core curriculum (Välijärvi et al. 2007). Teachers make their own decisions related to the conduct of the teaching and learning process, they are responsible and competent for developing the local curriculum, choosing teaching methods and selecting learning materials to be used. Especially, Finnish teachers are relied on when it comes to student assessment, which usually draws on students' class work, teacher-made exams, projects and portfolios. The role of teacher-based assessment is all the more important because at Finnish comprehensive schools students are not assessed by any national tests or examinations upon completing school or during the school years.

In addition, the teacher's profession, especially that of the class teacher, is greatly valued and popular among Finnish post-secondary students. This can be seen, for example, in the popularity of the class teacher's programme provided at universities. Of all the applicants for this programme, only 10-15 per cent is admitted, which implies that those accepted are highly motivated and multi-talented students with excellent academic skills. Educating class teachers at universities and the scope and depth of their study programme seem to be the factors that make Finnish teacher education stand out as special, when compared to other countries.

5. TEACHING PRACTICES IN MATHEMATICS

Efficient mathematics instruction requires an active role both from the students and the teacher. The teacher's aim is to provide opportunities for all students to have versatile and rich learning experiences. Pedagogy in mathematics teaching pays a great attention to individual needs of students. The mathematics core curriculum lays a lot of emphasis on the student's active role in studying mathematics, but still the traditional model of the mathematics lesson including certain successive stages (cf. Pehkonen & Rossi 2007) is vital.

Typical mathematics lessons in Finland include teacher's instruction and students' own working in different forms and mathematics textbooks play an important role in teaching (e.g. Törnroos 2004). Also the term "pedagogical conservatism" has been mentioned in this connection (cf. Simola 2005). The textbook dependence is stronger at the primary level (grades 1-6) than at the lower secondary level (grades 7-9). For many teachers mathematics textbooks have almost the same position in teaching as the curriculum itself (Perkkilä & Lehtelä 2007). This means that the mathematics lessons easily follow the order and contents of the mathematics textbook.

Several publishers in Finland produce mathematics textbooks for the comprehensive school and almost all students have their own textbook. In general, the mathematics textbooks are well planned and prepared. The mathematics curriculum creates the basis for the mathematics textbooks, but naturally there can be big differences between the textbooks. One additional reason for these differences can be the fact that since 1992 there is no official control of textbooks any more.

Teaching heterogeneous student body in mathematics presupposes small teaching groups and possibilities to reorganise groups if necessary. The PISA 2003 data shows that in Finland the average size of mathematics teaching groups (18 students) is among the smallest in the OECD. In addition, the time used in mathematics instruction is an essential pedagogical issue. Table 1 below presents the minimum numbers of mathematics lessons per grade in a school week. The schools have the freedom to divide these lessons between grades. For example, on the grades 3-6 schools have totally 12 lessons mathematics, and usually each grade has 3 lessons (45 minutes) mathematics in a week.

Table 1. The minimum number of mathematics lessons per grade in Finnish school week

Subject / Grade	1	2	3	4	5	6	7	8	9	Altogether
Mathematics	6		12				14			32

Assessment in mathematics is usually carried out by the teacher and it is based mainly on the summative tests but also some formative tests and the teacher's observations during instruction are utilized (cf. Lampiselkä et al. 2007). The teacher's role in assessment is very important in Finland because students are not assessed by any national tests or examinations upon completing the comprehensive school or during the school years. The final assessment takes place twice a year after the autumn term and the spring term and then pupils will have their school report including marks in all their subjects. In the Finnish school reports the marks vary from 4 to10, and 10 is the best mark.

Changes in the pupil assessment reflect changes in the curriculum. Until 1994, assessment in mathematics can be characterized rather formal in nature but since then more versatile and informal assessment methods have been applied. Teachers have started to use for example portfolio assessment and other self-assessment tools more frequently. In the 1994 Framework Curriculum, a verbal evaluation was introduced to be used on grades 1 to 4. Five years later in 1999, the NBE introduced the new guidelines for the final assessment of the basic education. These guidelines include descriptions of good performance (i.e. the mark 8) in all common subjects of the basic education. The main purpose of the guidelines is to ensure that students' final marks would be more equitable and comparable between different schools. These guidelines, however, are far from strict, allowing students' effort and activity to be taken into consideration.

National data from the 2003 PISA sample show that Finnish students view their mathematics teachers positively, and teachers are seen as strong supporters of studying and learning (Kupari & Välijärvi, 2005). The attitude measures indicate also that the Finnish school climate for learning mathematics is positive and encouraging. Stress and anxiety among pupils and teachers is not as common as it is within many other education systems.

In 2007, the Education Evaluation Council organized the evaluation of pedagogy in Finnish basic education (Atjonen et al. 2008). The evaluation focused on the key features of basic education like the teachers' pedagogic principles, the diversity of teaching methods and the effectiveness of the studying environment. The evaluated data consisted of a survey of principals (N = 410) and a survey of teachers (N = 2310) as well as 12 visits to schools. According to the evaluation results, basic education teaching can be characterized as fair and equal, encouraging and appreciative of the student. Basic education teachers aim to at doing their best for their students and prefer applying diverse methods of teaching. There were surprisingly small differences in the pedagogic characteristics expressed by the teachers of different subject (for example between mathematics and mother tongue). However, teachers seem to be strongly bound up with the structural terms of teaching environment, and therefore they are not very eager to promote changes in the existing pedagogy.

Teaching practices in mathematics are changing slowly. Moving towards active learning requires less teacher's talk during the time reserved for face-to-face teaching (Sahlberg & Berry 2003). Rather than deliver the curriculum and transfer information to students, teachers should become facilitators of the mathematics learning process and promoters of social interaction of their students. When students learn to communicate their mathematical thinking, it will also improve their attitudes towards mathematics and reinforce their self-confidence as learners of mathematics (Kupari 2007). During the last fifteen years, there has been promising signs of the positive development. For example, the development program of mathematics and science education during 1996-2002 (called LUMA) created new educational opportunities, produced active collaboration between teachers and schools and aroused new enthusiasm within mathematics education. Since then, many mathematics teachers have actively sought for alternative and more pupil-centered methods in their teaching. Mathematical modelling, activity tasks, learning games, problem solving, investigations and project work are all the more applied in mathematics lessons (Pehkonen & Rossi 2007). Explanations, argumentations and lively discussions are also more common during the Finnish mathematics lessons.

6. DISCUSSION

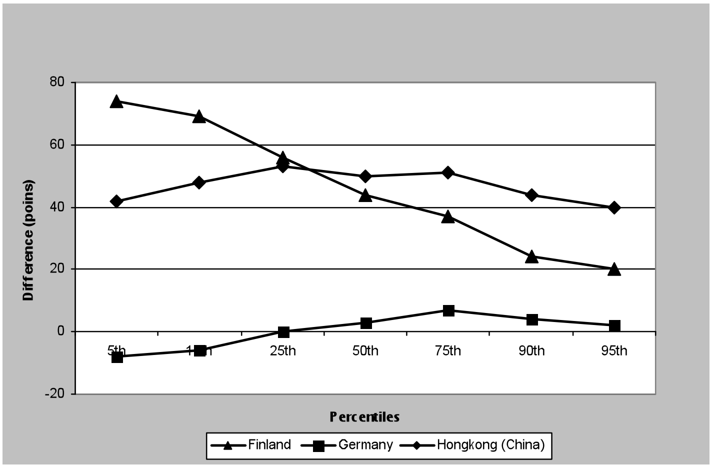
Attaining high overall performance while, at the same time, evening out disparities in performance is one of the key aims of national education policy in most OECD countries. In Finland and also in the other Nordic countries, this thinking has a long tradition. Providing all students with equal educational opportunities and removing obstacles to learning especially among the least successful students, have been leading principles in Finnish education policy for the comprehensive school system. In the light of PISA findings, Finland seems to have managed extraordinarily well in combining these two principles. (Välijärvi et al. 2007)

In this part of the paper, I briefly summarise the essential results related to equality in Finnish mathematics performance on the basis of PISA 2003 data.

6.1 Equality in mathematics achievement

The Finnish strategy for improving education is based on *the principle of equity*, and particularly on *an effort to minimise low achievement* (Linnakylä & Välijärvi 2005). One of the most important findings of PISA, therefore, has to do with the fact that in Finland the gap between high and low performers is relatively narrow. In mathematical literacy, the standard deviation for Finnish student scores was the smallest (84) in 2003 among all OECD countries. Likewise, the number of low performers – whose performance was at or below PISA proficiency level 1 – was significantly smaller in Finland (7%) than it was in the OECD countries on average (21%). Indeed, it seemed to be a characteristic of the Finnish performance profile that *the lowest scoring students performed better than their fellow students in the other OECD countries*. The difference between the top performers, on the other hand, was much less pronounced. This becomes evident when comparing the distributions of Finland and some other countries against the OECD average distribution on a percentile scale (see Figure 3).

Figure 3. Means of country percentiles compared to OECD-means (0-level) on the combined mathematical literacy scale in PISA 2003



The PISA 2003 results also revealed that in Finland, parents' socio-economic status has a relatively low impact on student performance compared to other OECD countries. The gender difference was also relatively small – 7 points in favour of boys. Furthermore, the differences found between Finnish schools were among the smallest in the OECD countries. While in 2003 these differences accounted for 34 per cent of the variation in student mathematics performance in the OECD countries on average, in Finland only 5 per cent of the total variance within the country was between schools (OECD 2004). In Finland, even the weakest performing schools achieved the OECD average in mathematics.

Small between-school variation is a characteristic of all the Nordic countries. This is largely due to the fact that these countries have non-selective education systems in which all students are provided with the same kind of comprehensive basic education from age 7 to age 16. In contrast, variation between schools tends to be more pronounced in countries where students are enrolled into different kinds of schools, streams or tracks at an early age. The results of PISA indicate that small between-school variation is one of the key factors associated with high and relatively equal performance. From this equity perspective, the PISA results are most encouraging for Finland, where the differences among schools, between the different regions, and between urban and rural areas proved small. In Finland, it matters little where a student lives or which school he or she attends. The opportunities to learn seem to be virtually the same all over the country, whether the student lives in the far North, in the remotest districts of Lapland or in the Helsinki capital area. (Linnakylä & Välijärvi 2005)

7. CONCLUSIONS

The PISA results clearly show that the Finnish comprehensive school yields high achievement in mathematical literacy. In all three PISA-studies, Finland has been within the best-performing countries in the mathematical literacy. Furthermore, the mathematics performance of our seventh-graders was clearly above the international average in the TIMSS 1999 –study. However, Finnish mathematics education has many challenges to which we need to react in future. Here, I will mention just some of them.

One major challenge to Finnish mathematics education seems to be students' attitudes towards mathematics, particularly in the case of girls. Finnish students showed surprisingly low interest in mathematics in international comparison. Especially girls' interest in mathematics, girls' confidence in their possibilities of learning mathematics and enjoyment in studying mathematics were inconsistent with their high performance in PISA 2003. The high prevalence of negative attitudes is worrying because interest in and confidence with mathematics is considered to have a strong steering influence when young people select their further studies. Increasing students' confidence and enjoyment in learning mathematics is thus a major pedagogical concern that requires a critical evaluation of the methods of learning and materials used in mathematics instruction. Students' attitudes can be improved, for example, by creating more interesting and meaningful classroom practices and by providing positive experiences during mathematics lessons. In part this is, however, a larger cultural concern as there seems to be a strong tradition of labelling mathematics as a male domain in Finland.

A serious challenge in future relates to a growing number of immigrant students in our country. Although Finland is officially a bilingual state, it has been a culturally homogeneous country. The official languages are Finnish (94 per cent of the inhabitants) and Swedish (6 per cent). Both of these language groups are equally entitled to and have equal resources for education in their own language from the pre-school up to the university. Other minorities, however, are still relatively small.

The pursuit of equal opportunities to learn has been a leading principle in the development of the Finnish educational system. Despite the relative homogeneity of Finnish population, this pursuit has been put to a severe test during the last decades due to a growing number of immigrant students and growing cultural heterogeneity. This presents a special challenge to literacy education and therefore to mathematics education as well.

During the last decade or so, many suburban schools in Finland have experienced increasing social and behavioural problems as more pupils live in broken homes, engage in drugs and alcohol at younger ages, and spend more time with computers, electronic games, and television. Schools in Finland must now compete with media and entertainment more than ever. Sustaining the genuine interest of pupils in learning is the premier goal for education development in the future. (Aho et al. 2006)

In summary, all experiences in relation to Finnish mathematics education give support to the notion that a high average performance can be achieved also in mathematics by taking equally care of learning across the whole age cohort. The high overall standard of our mathematics education in the comprehensive school is an asset that allows providing support for the low achievers while also motivating the top performers to use their potential to the full. This kind of positive thinking which is founded on our own national strengths provides a good basis for the development of mathematics education that aims at even better achievements.

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