PISA –survey, Finnish schools, teacher training and math. education

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First I would like to thank for the opportunity to speak at this occasion.

I. International comparisons

International comparisons have got much attention lately. There are several, like PISA, which means OECD´s Programme for International Student Assessment and TIMSS, Trends in International Mathematics and Science Study. According to the experts of OECD, PISA measures how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today´s knowledge societies. The assessment of forward-looking, focusing on young people´s ability to use their knowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered a specific school curriculum. This orientation reflects a change in the goals and objectives of curricula themselves, which are increasingly concerned with what students can do with what they learn at school, and not merely whether they can reproduce what they have learned.

Key features of PISA –survey are, according to OECD,
-its *policy orientation*, with design and reporting methods determined by the need of governments to draw policy lessons
-the innovative *literacy concept* that is concerned with the capacity of students to apply knowledge and skill in key subject areas and to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations;
-the relevance to *life-long learning* (information on motivation, beliefs, strategies)
-its *regularity*
-the *breadth of geographic coverage* (49 countries have participated so far)

Although PISA was originally created by the OECD governments for their own needs, ***it has now become a major policy tool for many other counties and economies as well. This means that PISA –survey is very important and mathematicians should think about it and its directing influence carefully***

According to OECD fifteen-year-olds should have a solid foundation of knowledge in areas such as reading, mathematics and science… ***PISA assesses the ability to complete tasks relating to real life, depending on a broad understanding of the key concepts, rather than limiting the assessment to the possession of subject-specific knowledge***.

Each participating student spent two hours carrying out pencil-and-paper tasks.Three-and-a-half hours of testing time in math, one hour for reading, science, problem solving. All together six-and-a-half-hours, 30 minutes questionnaire

PISA had, according to OECD, content dimensions in math:
-quantity

-space and shape
-change and relationships
-uncertainty

Process dimensions:
-simple mathematical operations
-bringing together ideas to solve straighforward problems
-wider mathematical thinking

Comparing TIMSS and PISA in Mathematics

TIMSS and PISA were designed to serve a different purpose, based on a separate and unique framework and set of items, hende each gives a slightly different view into students´performance in math.

TIMSS is based on collaboratively developed frameworks for the topics from curricula in math, it involves content experts, education professionals, measurement specialists from many countries

PISA empasizes the mastery of processes, understanding of concepts, application of knowledge and fuctioning in various situations within domains. Focuses on literacy, draws not only from school curricula but also from learning that may occur outside of school.

TIMSS aims at measuring curricular attainment more closely, PISA focuses on yield and literacy.

Target populations

TIMSS target population all students from the upper of the two adjacent grades that contain the largest number of 9 -year olds, 13 -year olds (usually 4^{th} grade and 8^{th} grade)

PISA target population all 15 -year old students, regardless of grade level or full- or part-time status

Content

Content coverage and item format notable differences: TIMSS: 5 main content areas: numbers, measurement, geometry, data, algebra. About two thirds multiple choice problems
PISA overarching ideas (for ex. space and shape), not curriculum-based areas like geometry or algebra, emphasis on the contexts in which mathematics is applied. One third multiple choice.

Item content (data -algebra)

PISA greater focus on data (40%), less algebra (11%).
8^{th} grade NAEP (15%, 25%), TIMSS (11%, 23%)

II. The Finnish Educational System in the 20^{th} Century

The Comprehensive School (law at the end of 1960´s)

The slogan was "Everything can be learned by everybody"

The Comprehensive School was established for grades 1 – 9 (age 7-15). The education is compulsory for this period. Textbooks, notebooks, etc. are provided for free and if the school journey exceeds a couple of kilometers, taxis are provided free of charge.

Comprehensive school consists of two levels:
Lower Level (Primary School) for grades 1-6
Upper Level for grades 7-9.

The teaching at Primary school is by class teachers. After comprehensive school, children can attend either an upper secondary school of a vocational school for grades 10-12 (age 16-18), in both teaching is provided by subject teachers and both can lead to higher education, Vocational school teachers have the same education as those who teach math at secondary schools.

Upper Secondary School is not part of compulsory education. Students have to take care themselves of textbooks and transportation to school.

Gradually *periodical studying* has been introduced. The year is divided into five or six periods. The same subject is taught 5 hours a week during one period. 38 lessons of the same subject form one course. For instance the contents of "short mathematics" -option is covered during three courses. Many teachers feel this is not a good system since mathematical knowledge profits from continuous building up, not intervals when the former material migh be forgotten.

The academic standard of the students applying to the upper secondary school was weakened by the fact that the *whole age group was taught the same syllabus.* For a remedy, different level groups were introduced. The level was affected despite of different level groups, which were abolished in 1985. At the same time the number of lessons in mathematics was reduced. This happened in all school levels: elementary, secondary and upper secondary. Lessons were needed for information technology in the comprehensive school.
Almost 60% of students apply for upper secondary school. We have succeeded in preserving the national matriculation exam. Over 57% of the graduates are girls.

Math. Teaching traditionally

Mathematicians were involved. Geometry based on Eukleides was first adapted to be taught in the secondary schools by mathematicians Neovius and Nevanlinna in the early 20th century. Professor Kalle Väisälä wrote algebra and geometry textbooks for school.
Geometry allowed teaching based on observation, only non-obvious theorems were proved. Geometry, algebra (equations, polynomial and logarithm functions, analytical geometry, derivatives) and trigonometry were taught in the upper secondary school. In 1963 integral calculus was introduced for the first time in the matriculation exams.

The Renewal of Teaching of Mathematics at the End of 1960's. 1970´s

Mathematicians like Rolf Nevanlinna were strongly against bringing the New Math. into schools, but were not listened to. Set theory and vectors were taken as theoretical basis for mathematics. Teaching of geometry was almost abolished in order to give room for the new material. Written information exercises were reduced, for instance percentage calculations. Calculators were introduced in schools.

A lot of new material was introduced into the subject contents of extended mathematics in the upper secondary school : probability, statistics, vectors, integral calculus, differential equations and function theory and sequences and series were added.

The basic syllabus of mathematics in the upper secondary school focused mainly on calculation according to the American model. Written information exercises were minimized.

Later on contents of the study books were reduced and set theory was put aside.

Pre-school education in schools or children´s day care centres: Before school many children go to Day Care Centres (Kindergarten). The number of hours devoted to math and math education for kindergarten teachers is slightly less than that for class teachers.

School Administration: Almost all schools are municipality schools, (only about 30 schools retained their private school status) and only Normal schools, i.e. Practice schools are state schools as part of a university. Schools have a high degree of autonomy.

Teacher education: All teachers have their pre-service education at universities. All have to achieve a Master degree, except for Kindergarten teachers, who get Bachelor degree.

Primary school teacher is one of the most favourite fields of study; in 2002 almost 20 applicants for each place. About 80% of them are female. Universities had difficulties filling places for math, physics, chemistry teachers due to the declining interest of students. Math teacher education is the responsibility of university mathematicians, educational studies by the faculty of education.

Class teacher education (grades 1-6): Class teachers have the responsability of teach all school subjects to one class. In larger schools, teachers normally teach grades 1-2 or 3-6, specialized class teachers could be responsible for teaching one foreign language or art and physical education subjects. Only 25% of applicants for class teacher studies attend math examination “long course”, 55% “short course”, 20% no examination. There have been 4 compulsory student examination subjects: Mother tongue (Finnish or Swedish), second local language (Finnish or Swedish), foreign language, math or real subjects (like Physics, Chemistry, Psychology, History).

Study at university for class teachers takes about 5 years, 160 credits, more than half educational content. 9 school subjects together form a minor “Multi disciplinary Studies”, 35 credits. Math and math education is one of these 9: each student has to choose at least one or two fields of specialisation for 35 cr. Class teacher education ends with a master thesis in education. Less than 5% of those are related to math education. Practices could mean for example to organize activities related to games, problem-solving, manipulatives, visualisation, possibilities of using

information technology. One aim of a national development project was to offer 15 cr of math or science to about 15% of class teachers, now this is almost achieved, courses could be geometric construction, experimental geometry, numeracy, computer-based instruction, arithmetic and algebra, discrete mathematics, introduction to analysis.

Math teacher education (grades 7-12):Subject teachers receive their education at the faculty of mathematis and natural sciences. In most cases, students train for math teaching and physics teaching and/or information technology teaching. In addition he/she could be a chemistry teacher. For grades 7-9 math could be second or third field of spesialisation. When math is the major field, not less than 60 cr in math are needed, otherwise the study could be for only 35 or in less than 25% 15 cr. All math teachers have 35 cr in education at the faculty of education. All math teachers get teaching practice of about 10 cr. Teacher education at the faculty of science ends with a master thesis in the major field of study (12 cr).
Typical courses of math study are: Analysis, Logic, linear algebra, differential equations, geometry, metric geometry, metric spaces, complex analysis, matrices, probability theory, discrete math, topology, functional analysis, complex analysis, mathematical computing.

In-service education: In-service education of teachers is well organised in Finland. Ministry of education and nationalboard of education provide differenttypes of in-service education in math. Also local educational authorities of different levels and universities and teachers´associations provide in-service education. Summer universities, open university, free institutions also offer courses. Either teachers get it free or have to get funding from the school, or pay themselves.

III. **Some reasons behind the success of PISA:**

1. **Teachers**:

The success in pre-service education (keeping high the teaching qualification and recruiting motivated students)
All school teachers have to get a master degree, in education for primary school (grades 1-6) and master of science for math for grades 7-12. For math the recruitment is more problematic than for primary school.

Teaching profession culture; teaching, for the majority of teachers is a mission, teachers´ interest in students learning has long tradition.

The success of in-service teacher education; it is well organised in Finland.

2. Hard efforts to develop math education, also many universities are involved

3. The welfare of schools
Relatively low number of students in classes, teachers can pay special attention to those with learning problems The pleasant work environment at schools:
no inspection at schools, teachers feel free and responsible. Teachers also have freedon with curriculum, based on the curriculum published by the National Board of Education, more detailed curriculum has to be accepted by the school. Teachers can also choose the textbooks. School everyday life tradition lessons last 45 min, during 15 min break windows are opened and pupils go to schoolyard – one or more teachers have to serve as observers there.

SUMMARY 1 - 3:
Teacher profession is appreciated, teachers trained at universities, obtain a masters degree. The number of applicants greatly outnumbers the places available for class teachers. Teacher education involves university practice schools, where theory and practice are engaged. School life offers an appreciated work environment.In-service education is well organised and universities are involved in it.

OTHER REASONS:

4. Homogenous schools
Comparative studies each time show that the dispersion of Finnish students is smaller than in other countries. Comprehensive school is one reflection of Finnish tradition of equality. In Finland there are very few private schools, so far people trust public schools and teachers.
The school´s social(social, economic and cultural) status does not affect the students´skills. The situation in Finland is exceptional, as in all other countries except Iceland the school´s social status affects the students´skills. The level of learning does not depend on which school one chooses.

5. Care for weak performers
Teachers are interested in assisting the advancing of each student, especially those with some weaknesses. This is on the other hand one of the main problems in math education, the need for more care for gifted students.
In fact weakest students raise Finland to the top in PISA.

The 25th percentiles of some countries were: Belgium 456, Netherlands 471, Korea 479, Japan 467, Hong Kong 485, Lichtenstein 470, Spain 426, France 449, Finland 488 (best), OECD average score 432. The difference of Finland to the OECD average score 56 in math, 61 in problem solving, 64 in reading literacy.

Finland was best for 75th percentile in the OECD only in reading literacy, in math surpassed by 4 OECD countries:
Belgium 611, Netherlands 608, Korea 606, Japan 605, and Hong Kong 622, Lichtenstein 609, Finland 603, Spain 546, France 575 OECD average 571.

6. Almost all students are taught in their mother tongue, very few immigrants

7. Finnish children are good readers. Finland has a good network of municipality libraries. Childrens´programs and movies on TV have subtitles. This is a very good system and gives children lots of practice in reading and listening to (mostly) English.

8. Training of PISA –type problems at school. Finnish math textbooks contain lots of PISA-type problems.

IV. PROBLEMS:

PISA has a strong effect on politicians and administrators. The type of problems posed tend to direct teaching and practicing at school. Finnish mathematicians think that too much time is devoted to these presentation of data and simple reasoning problems, while a

basic construction of mathematics knowledge and skills would be essential for future studies in practically all fields (their opinion is attached later).

Mathematicians should get heavily involved in deciding what will be asked in these international comparisons. Also more content-oriented comparisons are very important, TIMMS, Kassel, etc.

Class teachers´math knowledge. Most class teachers (grades 1-6) only study math for 10 – 13 days, 8 - 6 hours a day out of the 5 years of study, 2 – 2.5% of the total credits. Most students who apply to class teacher education are mainly interested in teaching art, music, physical education, not mathematics. In total, the study program is more relevant to a researcher in education than to a teacher, 47% - 69% of credits are in education, most of them oriented for research in education.

Amount of math. classes: In the UNESCO survey of 1986, from 27 European countries Finland devoted less time to math teaching than any other country. UNESCO 1986, 35 and 61-71). After that a little improvement has happened.

Gifted students: Mathematics and science teaching are not emphasized, while competition between children for enrolment in music classes is appreciated. Is the teaching of gifted students of the same importance as that of students with special needs? Do they also get a specialized teacher?

Math teacher education problems:

The educational studies is the same as the first 35 credits for class teachers. The centre of interest is related to general issues of education. A teacher may have to teach math, physics, chemistry especially in grades 7-9. This does not give opportunity to develop subject teaching. Math teaching education also has a drop out problem. Only about half finish their study.

General problems:

The age of applicants is high, in 2002 the median age of applicants to the faculty of education was 21.7 years, to faculty of science 20.2. In many cases they do not succeed to get in the first time. The tendency to decrease teaching hours for “saving” seems to have rooted at the universities.
Primary school education puts emphasis on art and physical education, secondary school, especially upper secondary puts emphasis on foreign languages. The final examination included four obligatory disciplines, three of them languages. The new law is that only one subject is obligatory, mother tongue, three others can be chosen form 4 examinations: the second national language, foreign language, math or real subjects. This might increase a little the number of students who take math.

PISA address: www.pisa.oecd.org

V. Mathematical content when finishing comprehensive school

Numbers and calculations: Four basic operations, natural numbers, whole numbers, rational numbers, real numbers, negative, inverse, absolute value, time problems, prime number, division into prime factors, divisibility, simpifying fractions, decimals as

fractions, multipying and dividing by decimals and fractions, simplifying formulas, ratio and proportion, calculating with percents, estimation, use of calculator, power, a whole number as an exponent, the concept of a root and calculating with a squareroot,

Algebra: formulas and simplifying them, powerexpression and simplifying , polynom, addition, subtractions, multiplication, variable, equation, inequalit, set of definition, solution, solving 1st order and some 2nd order equations, solving a pair of equations both algebraically and geometrically, forming sequences

Functions: concept of a fnction, coordinates, drawing graphs of simple functions, zeros, maximal and minimal value, increasing, decreasing, linear function, directly and inversely proportional

Geometry: basic concepts and relations of angles, triangles, regular polygons, circle, calculating areas and perimeters in plane, areas and volumes in space, similarity and congruence, geometric constructions, reflection, rotation and translation in plane, Pythagorean theorem, trigonometry and solving a rectangular triangle

Probability and statistics: concept of probability, frequence and relative frequence, mean, mode, median, standard deviation, reading diagrams, collecting, changing and presenting data.

Secondary school

Long math
Obligatory courses. Functions and equations, polynomials, geometry, analytic geometry, vectors, probability and statistics, derivative, root and logarithmfunctions, trigonometric functions and sequences, integral calculus

Short math
Obligatory courses
Formulas and equations, geometry, mathematical models (contains linear and exponential models, solving power equations, solving exponential equations with logarithms, linear optimization, sequences, algebraic and geometric sequence and sum), mathematical analysis (derivative and applications), probability and statistics

VI. Opinion of mathematicians and mathematics teachers

The text below was published in the biggest Finnish newspaper in the beginning of 2005. After that during the whole spring we had a good debate on mathematics teaching in the same newspaper (Helsingin Sanomat)

The PISA survey tells only a partial truth of Finnish children´s mathematical skills

The results of the PISA survey (http://www.jyu.fi/ktl/pisa/) have brought about satisfaction and pride in Finland. Newspapers and media have advertised
that Finnish compulsory school leavers are top experts in mathematics.

However, mathematics teachers in universities and polytechnics are worried, as in fact the mathematical knowledge of new students has declined dramatically. As an example of this one could take the extensive TIMSS 1999 survey, in which Finnish students were below the average in geometry and algebra. As another example, in order not to fail an unreasonably large amount of students in the matriculation exams, recently the board has been forced to lower the cut-off point alarmingly. Some years, 6 points out of 60 have been enough for passing.

This conflict can be explained by pointing out that the PISA survey measured only everyday mathematical knowledge, something which could be - and in the English version of the survey report explicitly is - called "mathematical literacy"; the kind of mathematics which is needed in high-school or vocational studies was not part of the survey. No doubt, everyday mathematical skills are valuable, but by no means enough.

Out of the 85 assignments in the survey about 20 have been published. The assignments are simple numerical calculations, minor problems or deductions, interpretation of statistical graphics and evaluation of situations where text comprehension is an essential part. However, hardly any algebra or geometry is included. Nevertheless, the assignments are well in agreement with the goals of the survey; in fact, the goal was to study everyday mathematical knowledge.

The PISA-survey leaves us, thus, with unanswered questions regarding many skills, like computing with fractions, solving elementary equations, making geometrical deductions, computing volumes of solid objects, and handling algebraic expressions. Still algebra is perhaps the most important subtopic in mathematical studies after the compulsory comprehensive school.

In comprehensive school, the goal should be to learn the basic concepts of mathematics so that they can be used as a basis for more. Even the use of calculators does not change this situation: although calculators nowadays might be able to handle fractions, manual computation is essential to master since it is part of the foundations in handling algebraic expressions. Further study becomes impossible if the basics are not learned properly.

One reason for the increase of poor standards in the matriculation exam and in the beginning of university studies is, undoubtedly, the weakness of the foundation received in the comprehensive school. New, more difficult concepts are hard to learn because still in upper secondary school much energy is spent in reviewing concepts that should have been learned in the comprehensive school. This vicious circle continues in tertiary education: the high-school concepts are not properly learned, and further learning becomes more difficult. The PISA survey provides us with useful information regarding the mathematical literacy needed in everyday life and the ability to solve simple problems. These skills are simply not enough in a world which uses and utilizes mathematics more and more.

A proper mathematical basis is needed especially in technical and scientific areas, biology included. The PISA survey tells very little about this basis, which should already be created in comprehensive school. Therefore, it would be absolutely necessary that, in the future, Finland

would participate also in international surveys which evaluate mathematical skills essential for further studies.

Kari Astala, Professor of Mathematics, University of Helsinki, President of Finnish Mathematical Society
Simo K. Kivelä, Senior Lecturer, Helsinki University of Technology
Pekka Koskela, Professor of Mathematics, University of Jyväskylä
Olli Martio, Professor of Mathematics, University of Helsinki
Dr. Marjatta Näätänen, Senior Lecturer, University of Helsinki
Dr. Kyösti Tarvainen, Senior Lecturer, Helsinki Polytechnic Stadia
and 201 mathematics teachers in universities and polytechnics

VII. Activities for talented students

The Finnish mathematics web magazine.

Finland has made massive investments in equipping schools with computers and Internet connections. To take advantage of these we started in 1996 a mathematics web magazine "Solmu".

http://solmu.math.helsinki.fi

Solmu contains files related to mathematics on a broad perspective:

- general articles on the importance of mathematics
- history of mathematics
- organized link collections for different levels of school
- mathematical problems
- a question and answer service is provided
- ideas of teaching math.
- articles on international mathematics achievement comparisons
- women and mathematics
- http://solmu.math.helsinki.fi/1999/2/tilastot.html shows a map of Europe colored to indicate the percentage of women among tenured mathematicians at university level (the map of the video of European Women in Mathematics www.math.helsinki.fi/EWM)

International collaboration: Translations from several languages have been made and collected in Solmu. For spreading them Solmu is ideal; relatively easy for us and free for anybody interested, for ex. Hungarian mathematical problems --interesting for Finns due to their different mathematical approach – and files on how to teach mathematics starting from preschool.

Benefits of a webmagazine
- Internet is good for accumulating databases
- It is freely available when and wherever, an easy and cheap distribution channel - once the technology has been purchased anyway
- It is relatively easy to update (this is also a problem, since constant updating is needed and ofter forgotten)

English files where Finnish mathematics teachers express their opinion on the recent PISA study are at the address http://solmu.math.helsinki.fi/2005/erik/PisaEng.html

EU -project called M-buttons

In 2004 an, a multilingual mathematics context help for school level, was officially finished. It offers pupils a possibility to "surf" with mathematics concepts. The original countries involved were: England, Denmark, Poland, Slovakia, Lithuania, Hungary and Finland.
http://thesaurus.maths.org

Mathematics clubs, camps etc. are also organized in different parts of the country. The initiatives come from university mathematicians.

It would really be a shame if these young people who are enthusiastic to learn more mathemaaics would not be given a chance for it.

Presentation on theme: "Finnish Teacher Education and PISA: Some Reflections"â€” Presentation transcript: 1 Finnish Teacher Education and PISA: Some Reflections Eero Ropo Professor of Education School of Education.Â 7 PISA Results and Finland PISA = Program for International Student Assessment by OECD Overall, Finland has been among the three best countries in reading, mathematics and science results in 2000, 2003, 2006 and 2009 PISA studies It is difficult to say what exactly is the reason for good performance in Finnish schools Nature of Finnish language?Â the university practice schools Scientific Basis of Teacher Education Programs Theory â€œThe Programme for International Student Assessment (PISA) is a triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students. In 2015 over half a million students, representing 28 million 15-year-olds in 72 countries and economies, took the internationally agreed two-hour test.Â So it does not matter if theyâ€™re selling non primary school education systems. These businessmen can be selling Finnish technical education, executive education, university education and industry know-how. The idea is to talk about PISA and then conclude that Finnish education at all levels are truly the â€œworldâ€™s bestâ€. Again, anyone can say â€œtruly at the worldâ€™s bestâ€, then itâ€™s an opinion. All math teachers get teaching practice of about 10 cr. Teacher education at the faculty of science ends with a master thesis in the major field of study (12 cr).Â Teacher profession is appreciated, teachers trained at universities, obtain a masters degree. The number of applicants greatly outnumbers the places available for class teachers. Teacher education involves university practice schools, where theory and practice are engaged. School life offers an appreciated work environment.In-service education is well organised and universities are involved in it. OTHER REASONS: 4. Homogenous schools.