

Improved mathematical skills– higher competitiveness in the digital era

Report on computer-based statistics project

MINISTRY OF EDUCATION AND RESEARCH

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Executive summary

The development of technological facilities, the exponential growth of information availability and the changed expectations to people's personal competencies require fundamental changes in teaching and learning.

In 2012 – 2014, the Ministry of Education and Research conducted a project which created the preconditions for systematic innovation in mathematical education. The objective was to enhance the visual and statistical literacy; make the learning of math more attractive for students, strengthen skills for using mathematics in real life; take advantage from the modern digital technologies to enhance learning.

„The change promises to empower students with abilities to do high-level problem-solving, apply math, and gain experience way beyond what traditional STEM education has delivered — crucial both to twenty-first century economies and the enrichment of each and every student's life”.

(Conrad Wolfram, LIFE in ESTONIA, Spring 2014, p 48-49)

A conceptually new curriculum and digital educational materials were developed on the basis of the concept of computer based math (CBM™, <https://www.computerbasedmath.org/>) introduced by Conrad Wolfram. The CBM would embed computers as a natural part of mathematics education. At first place are mathematical thinking and the real life problems. The mathematical concepts and procedures are learned in course of problem solving; computers are used as quick and efficient tool for implementation mathematical tasks.

The digital lesson materials were created for the lower and upper secondary school (3-rd stage of basic school, and gymnasium). The amount of lessons and the main outcomes of the currently valid state curriculum were taken into account. However, the aims and the learning outcomes of the computer based statistics (CBS) curriculum are remarkably wider. Besides specific mathematical skills the CBS curriculum strongly aims on achievement of general mathematics skills and transversal skills.

In the 2014 spring semester, more than 1,800 students in a total of 31 schools participated in regular math lessons based on the new concept. The piloting tested the suitability of the lesson materials, but also the attitude and readiness to teach and learn in untraditional way. During the pilot, the reflection of teachers and students, and the impact on students' performance were examined (Annex 1, by Carita Hommik).

In general, students approved the new approach and the lesson materials. „Visualizations / charts, computer based learning, practical realistic tasks, working in groups, new interesting knowledge“ were the issues more frequently mentioned as pluses of the course. „Technical errors, charts, difficulty, need to provide reasoning, no new (mathematical) knowledge“ were mentioned as the most disliked issues. The opposite opinions about the similar issues exhibited the diversity of attitudes towards innovation among students. Only a small share of students (around 5%) was willing to tackle the programming exercises included in the lesson materials. The basic school students gave

higher points to their lesson materials, and their attitude to the course was more positive than the one of gymnasium students. The students' feedback was supported by experts' opinions. The academic experts highlighted positively the basic school lesson materials, but referred to the need to improve the technical and didactical quality of the upper secondary materials.

Students' performance was tested before and right after completing the course. Tests demonstrated improvement of knowledge and skills of both, the pilot group and the reference group taught in traditional way. The final test results of the two groups were nearly the same (at 5% significance level) regardless of the fact that the pilot group students enjoyed minimum workload as to homework and their performance was assessed with reference to liberal criteria (mostly formative assessment in classroom). Thus, the CBS pilot group students achieved the same learning outcomes with the less learning time.

The involved math teachers embraced the new approach, which is the most notable outcome of the project. The overwhelming part of piloting teachers expressed willingness to teach in future with the CBS materials or combine CBS approach with the traditional curriculum: 78% and 22% of basic school teachers; 33% and 56% of gymnasium teachers, respectively. All teachers coped well with the computer-based teaching. However, the superior part of teachers would like (somewhat surprisingly) to use computers only in less than a half of their math lessons.

The Project Advisory Committee recommended the step by step expansion of CBS to all schools. Committee suggested the necessary preparatory measures for expansion and mainstreaming: improve the (didactic) quality of initial lesson materials; provide in-service training on CBS to math teachers; develop new assessment tools in accordance with the CBM learning outcomes; provide technical renewal of materials and technical assistance to schools; modify the national curriculum in accordance with the changes in outside world.

The pilot phase revealed the bottlenecks of teaching CBS along with traditional curriculum, and directed to further correction of lesson materials, teaching / learning process, and assessment tools. While majority of the negative piloting feedback was classified as the easily improvable pioneering problems, some results need closer examination and development in near future.

A deficiency of the project was the absence of the appropriate student assessment principles and tools. Teachers used their traditional assessment skills, and mostly assessed students in traditional way. Insufficient attention was paid on achievement of the extended outcomes of the CBS curriculum, and transversal skills of students. Necessity to study balance of the mathematical and the context-based skills was also concluded. Students believed that in CBS lessons they learned mostly about the context-related issues (e.g. how happy are people in various countries), and did not clearly perceive the acquisition of mathematical concepts and procedures. However, they were able to apply those concepts and tools for solving the tasks of the final test. Further investigation should also explain the attitudes of teachers towards teaching with computers.

The project was an important step towards aligning maths education with the possibilities and requirements of the modern digital world. The developed curriculum and educational materials

allow systematic innovation in teaching probability, data and statistics. The individuals involved in the project have created the potential for expansion the new educational approach to other schools, other areas of mathematics education, and to other subjects. In the long run it would sufficiently improve visual and statistical literacy across the country.

The pilot project on computer-based statistics is an important step on a wider scale, not just for Estonia. A project, implementing the CBM concept in broad educational practices, is among the first of its kind across the globe.