Editorial: Special Issue "Technology in Mathematics Education"

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It is important to get more knowledge about the impact of the use of technology on the learning of mathematics. Recent research shows that the use of digital equipment and software is related to better mathematical skills, but excessive use of digital resources may disturb concentration on learning. This special issue presents five papers on different areas of technology in mathematics education.

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1 Remarks on the use of technology in mathematics education, particularly in Finland

Technological tools play an important role in teaching and studying mathematics. Calculators have aided straightforward computations for many decades, but nowadays curricula more and more demand the use of modern computer programs in school mathematics. However, it is not clear how and at which stage this technology should be implemented in mathematics education. Also, what is the impact of the use of technology on the learning of mathematics? At the latest, the covid-19 pandemic showed that technology and digital teaching materials are vital in education and must be developed and studied further. In this special issue we present several interesting technology related mathematics education research articles.

Finnish national core curricula for basic and for general upper secondary education (Finnish National Agency for Education, 2020b; 2020c) emphasize digitalization and the use of technology at schools. Moreover, Finnish national core curricula for early childhood education and care and for pre-primary education (Finnish National Agency for Education, 2020a; 2021) express that day care and pre-primary education should prepare children to the digitalized world. However, one notable and distracting observation in just released PISA 2022 results (OECD, 2023) is that 41% of Finnish 9th graders feel that the use of digital resources disturbs their concentration on learning mathematics. This is clearly more than the international average 31%. From the positive side, moderate and controlled use of digital equipment seems to be related

to better mathematical skills. Anyhow, due to PISA 2022 results (OECD, 2023) mathematical ability of 15-year-old school pupils is deteriorating in almost all over the world.

The Finnish matriculation examination is organized digitally and the last exam to become digital was the mathematics exam in spring 2019 (Finnish Matriculation Examination Board, 2023). Students in Finland use computers heavily in their studies during the whole three-year period they spend in upper secondary school. This is comprehensible since learning materials are mainly digital and students are required to be fluent computer software users when they complete their studies and take part in the matriculation examination. However, the change to digital school environment has occurred so fast that it has been somewhat uncontrolled. Therefore, new research is needed to indicate strengths and weaknesses of digitalized education.

Recently Mertala et al. (2022) made a descriptive and critical analysis of highly cited educational technology articles. They observed that in high impact factor journals by major publishers it is easier to publish positive than critical findings of the use of technology in education. This is a bit alarming since politicians and education authorities base their decisions on current research. During the editorial process of this special issue, we noticed that articles primarily including critical findings were not even submitted.

2 Papers included in the current issue

This special issue contains five papers on different areas of technology in mathematics education. They provide various aspects on how the use of technological tools influences teaching and learning of mathematics.

In the first paper, Gladys Sunzuma reviews integration of digital technologies into teaching and learning of geometry at the secondary school level. Due to the systematic literature review the most used technologies were augmented reality and dynamic geometry software GeoGebra and Cabri. Most of the reviewed articles focused on the effectiveness of technological tools for learning geometry, minority focused on implementation and development of technological tools. Quantitative, qualitative, and mixed methods research approaches were all used, but the majority of reviewed articles used qualitative methods mainly for empirical studies.

Nadine Yılmaz examines the technology-enhanced statistical problem-solving task design assignments prepared by pre-service teachers who will be mathematics teachers in the future. Participants of the case study prepared 28 task design

assignments which were analyzed in terms of the characteristics of the data and the need of data, for example, in terms of learning goals, features of the data, being interesting/suitable for the level of the students and using statistical problem solving. Statistical problem-solving components (pose, collect, analyze, interpret) of the tasks were described with three levels, and majority of the tasks were found to be at mid-level which requires reading the data, reading between the data and reading beyond the data.

Anneli Dyrvold and Ida Bergvall study validity of computer-based assessment in mathematics. Empirical data was collected in an eye-tracking analysis of grade nine students who were divided into two groups that received different instructions about how to work with mathematics items with five types of functions. The results revealed that students are not equally equipped for a computer-based assessment that depends on preparatory instructions for the dynamic functions. They conclude that students need to be comfortable and very familiar with using dynamic and interactive functions to ensure validity of tests.

In a related article, Dyrvold and Bergvall study how students interact with digital teaching material including dynamic and interactive elements supplementing the static parts of the material. The data for this study was collected using an eye-tracking analysis of grade nine students from four different schools. The students worked on five mathematics items each of which was designed in five versions with increasing interactivity and dynamism. The results of the study showed that the students spend more time and attention on dynamic mathematical content than static content which can be useful to know when designing digital teaching material.

Raimundo Elicer, Andreas Tamborg, Kajsa Bråting and Cecilia Kilhamn compare the integration of programming and computational thinking into Danish and Swedish elementary mathematics teaching resources. They analyzed 165 tasks from teaching modules developed for a Danish pilot project integrating technology comprehension into school subjects, as well as 390 tasks from Swedish mathematics textbooks. They found that the two countries had taken quite different approaches to integrating computational thinking into school mathematics. The Danish tasks included a lot of data and statistics whereas the Swedish tasks emphasized patterns, sequences and following stepwise instructions.

3 Future research

There is a huge need for new research which is focused on the learning of different topics of mathematics when various technological tools are used. Using computer software like GeoGebra in geometry differs significantly from arithmetic and manipulation of algebraic formulas. Therefore, one uniform scheme for the use of technology on learning and teaching of all mathematics cannot be optimal. However, without targeted recommendations in curricula it is straightforward for teachers to let students to use computers for solving all kinds of mathematical problems, even though learning certain topics, and solving problems would benefit using paper and pen.

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