



**HAL**  
open science

## Introduction to the papers of TWG16: Students learning mathematics with resources and technology

Matija Lokar, Ornella Robutti, Nathalie Sinclair, Hans-Georg Weigand

### ► To cite this version:

Matija Lokar, Ornella Robutti, Nathalie Sinclair, Hans-Georg Weigand. Introduction to the papers of TWG16: Students learning mathematics with resources and technology. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.2435-2438. hal-01289324

**HAL Id: hal-01289324**

**<https://hal.science/hal-01289324v1>**

Submitted on 16 Mar 2016

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Introduction to the papers of TWG16: Students learning mathematics with resources and technology

Matija Lokar<sup>1</sup>, Ornella Robutti<sup>2</sup>, Nathalie Sinclair<sup>3</sup> and Hans-Georg Weigand<sup>4</sup>

1 University of Ljubljana, Ljubljana, Slovenia, [Matija.Lokar@fmf.uni-lj.si](mailto:Matija.Lokar@fmf.uni-lj.si)

2 University of Torino, Torino, Italy, [ornella.robutti@unito.it](mailto:ornella.robutti@unito.it)

3 Simon Fraser University, Burnaby, Canada, [nathsinc@sfu.ca](mailto:nathsinc@sfu.ca)

4 University of Würzburg, Würzburg, Germany, [weigand@dmuw.de](mailto:weigand@dmuw.de)

## SCOPE AND FOCUS OF THE WORKING GROUP

Recent discussions within the CERME technology group have confirmed the relevance of introducing information and communication technology (ICT) in mathematics education with a range of various resources, such as software, hand-held devices and online classroom activities. The scope of the working group at CERME9 was to address the opportunities and possibilities, as well as the challenges and limitations that resources and technology present for student learning. Due to the large number of participants in the technology group at the last CERME conferences, the group was divided into two strands. TWG15 concentrated on “teaching with resources and technology”, while the focus of TWG16 was on “students learning with the help of resources and technologies”.

In TWG16, we were interested in empirical results obtained in the course of the last few years and decades concerning, for example, the introduction of new learning methods and concepts, the improvement of learning within the frame of old concepts or new forms of exercises in the whole range of mathematics education. Moreover, we wanted to set the scope towards the future, to think about general conclusions for mathematics education, and the research required as well as the implications for the classroom.

A range of different issues was covered, including:

- The design and/or use of the current software and technologies concerning students’ formal and informal learning, at school and out of school;

- The design of teaching experiments with software and technologies concerning student learning;
- The influence of computers, notebooks, tablets or handheld-technology on the learning of mathematical concepts and the construction of learning environments;
- The results of empirical studies and investigations, especially those concerning long-term learning with ICT, massive courses, national programmes relating to the teachers’ professional development;
- The possibilities of present and up-coming mobile communication and representation tools like tablets, smartphones;
- The possibilities of different methods of assessment using ICT;
- The influence of web-resources and online courses on the learning of mathematics;
- The examples of “best practice” in the classroom;
- The examples of the use of technologies designed for the support of students with disabilities.

## RESULTS OF TWG16

In TWG16 we received 23 papers and 3 posters from 15 different countries. In the following sections, the topics are classified as *old questions* and *up-coming*

topics strongly represented in TWG16, which are discussed first, and finally the topics referred to as *missing topics* are discussed.

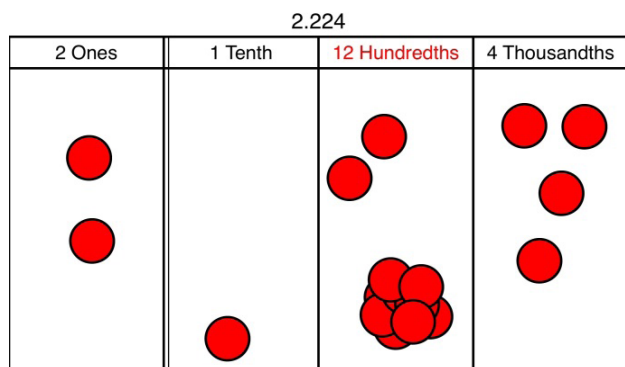
**“Old question” strongly represented in TWG16**

Starting with the Dynamic Geometrical Systems *Cabri-Geomètre* and *The Geometer’s Sketchpad* in the late 1980s, dynamic mathematics has always been a strong argument for the use of new or digital technologies. Nowadays, there are numerous simulations in mathematical and environmental settings, which use dynamism in connection with *touch screen technology*. An example is the “place value chart” (Figure 1), which visualizes the changes while moving the tokens from one column to the other (see the article of Behrens). See also the papers by Brunström and Fahlgren and Bray, Oldham and Tangney.

Multi-linked representations are another often mentioned argument for using digital technologies in the learning process. Figure 2 shows the symbolical, numerical and graphical representations of a quadratic function, which enable, for example, identifying structural analogies in the different representations (see the articles of Pinkernell and Swidan).

There are many more topics that are important and will stay important in the following years:

- ICT and problem solving and/or guided inquiry learning (see for example the paper by Schumacher and Roth)
- The relationship between hands-on materials and ICT
- The transition from activities to mathematical thinking



**Figure 1:** Changing the number’s representation within the place value chart by moving tokens

- The transition between ICT-tools and paper-and-pencil activities
- The benefits of ICT for the learning of content, e. g., calculus
- Programming and its connection to mathematics (see the paper by Misfeldt and Ejsing-Duun)

**Up-coming topics**

**a) Touch Screens and Human-Computer Interaction**

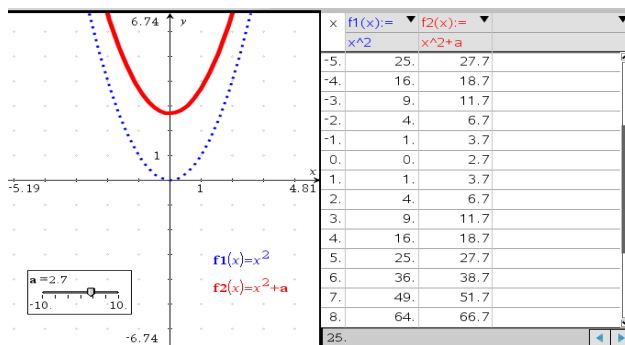
Touch screen working with tablets is already a frequently discussed topic in present classrooms. Gestures will become more important – for example, while zooming into a graph or diminishing an interval – to help visualizing and, hopefully, understanding mathematical concepts. The complexity of simultaneously changing more than one variable (by moving the fingers) should by no means be underestimated. But the empirical basis concerning these new features is still quite small. See the paper by Bairral and Arzarello.

**b) Internet resources – Social media or networks**

Although Internet resources such as Facebook, etc. are not constructed for doing mathematics, social media or networks open new possibilities, for example, “peer learning”. There might be automatic help systems available, but there will also be the possibility to get personal help from experts, tutors, students or other Internet users. See the article of Puga and Aguilar.

**c) Automatic Testing – Automatic Feedback**

*Intelligent tutoring systems* have been developed and tested in mathematics classrooms for many years (see the article of Borba, Azevedo and Barreto). Nowadays, there seems to be a new approach possible in forma-



**Figure 2:** Dynamic multiple representation environment for exploring the effects of a on the representations of  $f(x)=x^2+a$

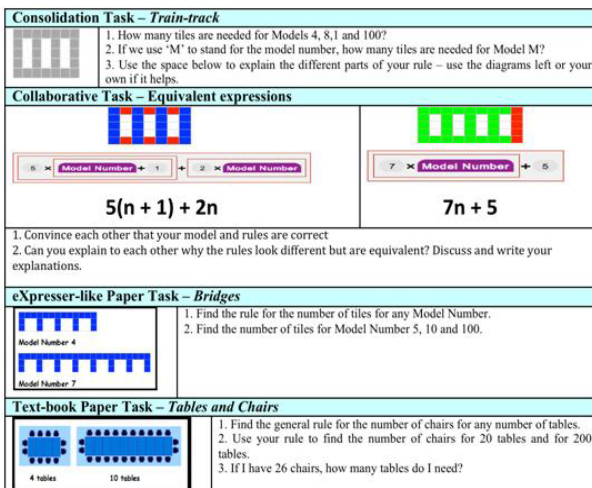


Figure 3: Transition from arithmetic to (formal) algebra (Geraniou & Mavrikis)

tive assessment within the frame of automatic testing and automatic feedback, especially in arithmetic and algebra.

The system described in the paper by Geraniou and Mavrikis supports the transition from arithmetic to algebra by visualizing the variables in different representations. The article of Mackrell shows how real-world problems will be solved in a CABRI environment through the provision of effective feedback. There are a lot of didactical problems in the construction of systems like these: the problem of the right feedback in problem solving activities, the possibility of different kinds of feedback and feedback as step-wise help, feedback on task level or/and process level, and so on. Haddif and Yerushalmy focus their research on e-assessment of challenging calculus construction e-tasks designed to function as a dynamic interactive environment of multiple linked representations (MLR) that provide feedback to the learner (Figure 4).

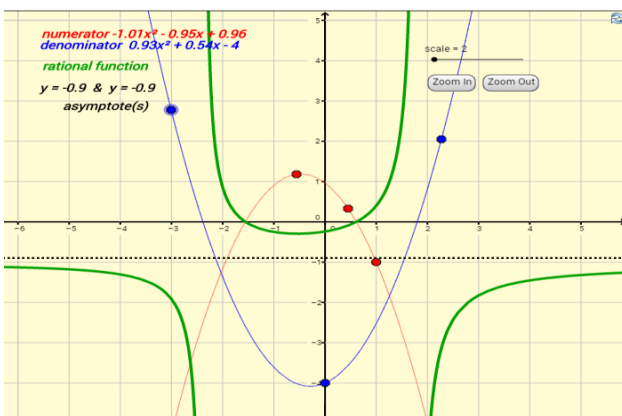


Figure 4: Construction of rational functions by given "dots" of the graph of the function

#### d) The significance of "games" for mathematics learning

Young students often play games on their tablets and smartphones, which raises the possibility of integrating mathematical games into the environment that is already present. Soldano, Arzarello and Robutti want the users to improve their proving abilities in a geometric environment, while Avraamidou wants the users to build houses, while adjusting the budget in relation to some variables such as the size of the building, the cost of the furniture and the mood meter.

#### e) ICT-support and special needs students

We only received one contribution referring to the learning style of a special needs student. Particularly students with physical disabilities might benefit from the possibilities of digital technologies. However, empirical research is still quite rare and the results are quite individual anyway, and generalizations almost impossible because of the great variety of special needs.

#### Missing topics

In TWG16 we have "only" received 26 papers and posters and, of course, these contributions represent a relatively small array of all possible topics. This just might be an indication of the waning importance of some topics, which were quite intensively discussed only a few years ago.

- The new possibilities of ICT concerning creating videos, doing screen recording, gathering and analysing big data ... were not discussed in TWG16.
- Digital technologies allow more individuality, for example, the creation of portfolios and personalized e-textbooks.
- Communication is the norm and the goal in the NCTM standards (2000) and nowadays in many curricula all over the world. DT might support cooperation between communities and enable the "opening" of the classrooms.
- Completely new and emerging technologies have not been discussed in our group: sensor devices, augmented reality, mobile technology ...
- Symbolic calculators are not discussed in any paper. They seem to be disappearing because they cannot compete with laptops, tablets and smart-

phones. But there are still strict regulations (in some countries, for example in Germany), and these tools are not allowed during examinations.

There are also some topics that might be called traditional and will be an ongoing problem in mathematics education, not only in relation to the use of digital technologies:

- We need more long-standing quantitative empirical investigations;
- We – as researchers – have to use proper research methods, which are informed by contemporary theories, and base our work on the existing and growing research in mathematics education;
- We have to get some more information about the actual use of digital technologies in real classrooms.