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Introduction to the papers of TWG15: Teaching mathematics with resources and technology

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The technology working group continues to increase in size since its inclusion at the first CERME congress in 1999. During CERME 9, for the first time the group was divided from the beginning, giving birth to two separate groups: TWG15 focusing on issues related to the teaching mathematics and teacher education and professional development, and TWG16 focusing on students' learning with technologies and software and task design issues (see Weigand, Lokar, Robutti, & Sinclair, 2015).

TWG15 builds on the legacy of the group work at previous conferences. A number of important issues related to technologies and resources and their use by teachers and teacher educators emerged from the group discussions, such as the need to elaborate specific methodologies for analysing and evaluating the efficiency of teacher education programs, or the construction of models that facilitate analyses of the evolution of teachers' practices related to their ICT use. The research presented in the group contributions tended to be: local, focusing on a particular aspect of teaching mathematics; short-term; and often conducted in controlled laboratory conditions, which prevented general conclusions being drawn about the benefits of ICT in mathematics education. The group concluded that it was necessary not only to learn more about "real" uses of ICT in classrooms and beyond, but also to understand why ICT is not used and to conduct long-term studies with "ordinary" teachers in "ordinary" classes in order to explore the impact of the ICT on students' learning and on teachers' practices (Trgalová, Maracci, Psycharis, & Weigand, 2013).

The call for contributions thus proposed to deepen the community's understanding of these issues by addressing themes such as: the specific knowledge

and skills required for an efficient use of ICT; teacher education programs embedding these knowledge and skills and assessment of their impact on teachers' practices; theoretical and methodological approaches to the evaluation of the evolution of teachers' practices, "best practices" with using technologies, among others.

WORKING GROUP IN A FEW NUMBERS

The group involved 31 participants from 13 countries: Cyprus, Czech Republic, France, Germany, Greece, Israel, Italy, Poland, Portugal, Slovakia, Sweden, Turkey, and United Kingdom. 17 papers and 6 posters were presented and discussed during the working group sessions.

REPORT OF THE WORKING GROUP DISCUSSIONS

For each session, the group Co-leaders defined a particular theme that was discussed in relation to a group of a few papers and posters. The discussions were framed by two or three questions raised after the paper and poster presentations. In what follows, we give a brief overview of the themes discussed and the main outcomes. We conclude with an outline of some emerging perspectives for consideration at the next conference.

Teacher professional knowledge and frameworks for its analysis

Various frameworks are used to analyse teachers' practices with technology and digital resources in math classrooms: *Bozkurt and Ruthven* refer to the Structuring Features of Classroom Practice (SFCP) (Ruthven, 2009) that "identifies key aspects of the

craft of teaching that indicate the corresponding professional reasoning and craft knowledge that teachers must develop about these aspects in order to successfully incorporate new technologies". *Robová and Vondrová* draw on the technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006) to analyse teachers' specific skills needed for work with dynamic geometry software. *Rocha* introduces a new framework, Knowledge for Teaching Mathematics with Technology (KTMT) that she applies to analyse teachers' practices with the use of graphing calculators.

The participants were invited to discuss the specificities of these frameworks and their usefulness both for the observation of teachers' practice and knowledge and for structuring teacher education programs.

Fostering creativity in mathematics

Creativity in mathematics is a new issue raised within three contributions to TWG15. *Papadopoulos Papadopoulos, Barquero, Richter, Daskolia, Barajas and Kynigos* raise the issue of the design of resources fostering the development of students' creative mathematical thinking (CMT) based on teachers' representations of CMT. *Kynigos and Kalogeria* propose an analysis of a collaborative design of resources for CMT within a specific technological environment. *Jančařík and Novotná* discuss scaffolding strategies in an e-learning mathematics course attended by gifted students and their effectiveness in supporting the students' problem solving.

These contributions promoted the issue of how ICT supports creativity in the students. Two main aspects have been highlighted in this respect: encountering different registers of semiotic representations through technology, and linking communication about mathematics between teachers, students and students and teachers.

Design, appropriation, orchestration of teaching situations

Contributions to these issues include both studies on local, short-term projects focusing on particular aspects of teaching mathematics alongside studies involving teacher development within large-scale projects concerning mathematics teaching with technology. *Benacka and Ceretkova* present the results of a survey evaluation of a course involving 28 pre-service mathematics teachers centred on the use

of spreadsheets. *Sollervall and de la Iglesia* investigate how a co-design methodology can support teacher's orchestration of a didactical situation aimed at fostering so-called "logos-oriented discussions" among students and between students and teachers. *Turgut* presents the results of a pilot study of a larger research project involving the design and orchestration of teaching interventions within a linear algebra course with the use of ICT. *Clark-Wilson, Hoyles and Noss* elaborate a conceptual framework and methodological approach for research aiming at evaluating the success of the professional development part of a large-scale intervention. *Fahlgren's* study aims at identifying those elements of activities involving students in scaling coordinates system in dynamic software that can affect the process of instrumental genesis. *Lavicza, Juhos, Koren, Fenyvesi, Csapodi, Kis and Mantecón* outline the theoretical framework, the different stages and highlight initial results from the first phase of a Hungarian national project promoting technology integration into Hungarian schools.

The theme of design, appropriation and orchestration of teaching situations appeared a really multi-faceted one; hence the issues proposed for the discussion concerned a lot of different aspects: the educational objective which can be pursued through the use of ICT, and how the choice of educational objectives influences the teacher's use of ICT in her/his practice; the principles which can inform the design of tasks or teaching situations and their "teach-ability"; what is needed from theories to inform the design of teaching activities, situations or sequences centred on the use of ICT; and the conditions under which short, local experimentations could be scaled, and the methodology through which scaling can be monitored and evaluated.

Assessment issues

Within the context of TWG15, the term assessment, and the role of technology within assessment, incorporates two perspectives: the assessment of teachers' individual knowledge and practice concerning their classroom technology use; and technological tools and approaches to facilitate the summative and formative assessment of students' learning. From the perspective of teachers, the paper by *Karatas and Tutak* describes a Turkish study that adopts the TPACK M Scale by Handal, Campbell, Cavanagh, Petocz, and Kelly (2013) to assess a group of 138 secondary teachers' technological, pedagogic and content knowledge,

raising important methodological questions concerning the reliability and validity of such scales. The remaining papers (and poster) focus on the assessment of students' learning. *Chenevotot-Quentin Chenevotot-Quentin, Grugeon-Allys, Pilet, Delozanne and Prévot* describe the design and uses of a diagnostic assessment tool *Pépîte* for the assessment of algebra at different grade levels in France. At the classroom level, *Aldon* focuses on how *critical incidents* arising from the students' uses of *TI-Nspire* technology provide the context for teachers' formative assessment of students' mathematical conceptions. In her poster contribution, *Juskowiak's* study concerns the assessment of students' mathematical outcomes with non-standard problem solving tasks involving the use of graphic calculators.

The discussions that arose from these contributions prompted questions concerning the different approaches to the assessment of students' learning with technology and the role of technology in supporting teachers to assess students' mathematical learning and, ultimately make decisions based on this assessment.

Teachers' support of students' conceptualisation in mathematics

Contributions to this issue explore the ways in which instrumented activities, orchestrated by a teacher, can benefit students in meaning-making of mathematics concepts. *Psycharis* presents two computational systems and discusses their potential in helping students conceptualize the notion of functions, based on both an *a priori* analysis of the systems affordances and on empirical studies of students' interactions with them. Likewise, *Stoppel* shows how the use of different media, providing different functionalities and command syntax, may lead the students to applying different methods in a problem solving activities. *Diamantidis, Economakou, Kaitsoi, Kynigos and Moustaki* explore the emergence of meaning of a concept of angle in 3D space in students working collaboratively in computer-based environment. Their study highlights the importance of technology supporting communication, collaboration and joint mathematical thinking. The learning potential of a video with mathematical content shared on the web is studied by *Palatnik*. His study evidences that Web2.0 resources can become a new source for generating interest in mathematics amongst a public audience. *Bagdat's* study highlights the role of a teacher in helping students make sense of the concept of variable while working with spreadsheets.

The discussions of issues related to this theme brought forward two main ideas: the ability to assess affordances of technological tools as one of the basic skills teachers need to develop in order to successfully integrate technology in their practices, and the awareness of the importance of social learning, either in classrooms or informally through open Web2.0 resources.

CONCLUDING REMARKS AND PERSPECTIVES

The papers and posters presented and discussed within the group encompass a wide variety of research topics. Several convergent concerns emerged from the exchanges among the participants. First, an important role of teachers in the design of appropriate instrumented tasks was acknowledged, as the expression from one of the participants "*teachers as designers of students' learning with technology*" documents. A need was expressed to redefine teachers' skills enabling them to support students' collaborative learning not only in a classroom, but also while working online or offline, and subsequently to elaborate education programs embedding these skills. The discussions brought forward a complexity of meaning-making processes in mathematics, which requires from teachers the ability of analysing affordances of computer-based tools in order to avoid situations in which the students can succeed to solve a given problem without understanding the underlying mathematics. Also, articulating syntax-related issues inherent to digital tools with mathematics appears as an important aspect in teaching and learning with technologies, which is in line with the theory of semiotic mediation (Bartolini Bussi & Mariotti, 2008).

What perspectives can be outlined for the next CERME10 congress? There is still a need to develop a more comprehensive theoretical framework to address "old" but still topical themes, such as task design and methods for large-scale dissemination of "good practices" with digital technologies use. The role of technologies in formative assessment, of networked classroom technologies and e-learning appear among the emergent issues that require further theoretical and methodological development. Finally, some topics, which are under-represented, would deserve researchers' interest: touch technology, 3D technology, including 3D printers, virtual reality in mathematics education, Massive Online Open Courses (MOOCs) and web2.0 or web3.0 environments, and technology for educational special needs.

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