INTRODUCTION TO THE PAPERS AND POSTERS OF WG15

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INTRODUCTION TO WG15

TECHNOLOGIES AND RESOURCES IN MATHEMATICS EDUCATION

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Technologies in mathematics education have been a topic of a working group since the CERME 1999. The last two conferences confirmed the relevance of considering information and communication technology (ICT) in mathematics education within a range of various resources, such as software, hand-held devices, online classroom activities, but also more traditional geometry tools or textbooks. A number of important issues related to the design of technologies and resources and their use by students, teachers and teacher educators emerged from discussions within the working group at the previous conferences, such as the importance of coping with a strong interconnectedness of mathematical and technological knowledge in student-tool interactions, or the necessity of including the users' feedback in the ICT and resource design processes (Trgalová, Fuglestad, Maracci, Weigand, 2011). Concerning teacher education questions appeared about the complexity of ICT and resource integration in teachers' practices due to a double instrumental genesis, both personal and professional one (Haspekian, 2011). The idea of teachers' communities, sharing resources and practices in using ICT, emerged as a powerful means to favour teachers' professional development (Wenger, 1998; Jaworski, 2005). These issues require further theoretical and methodological developments.

The call for contributions proposed to deepen these issues in the following three themes: (1) Design and use of technologies and resources, (2) students' learning with technologies and resources, and (3) technologies, resources and teachers' professional development. The group work combined plenary sessions where common issues were discussed, such as theoretical frameworks used in the field of ICT in math education or conceptualization of mathematics with ICT, and parallel sessions addressing various topics, such as software design, task design, teachers' professional development toward the ICT integration, or reports of empirical studies of ICT use. In what follows, we give a brief overview of the working group and the discussions within it, and we outline a few perspectives for the next conference.

WORKING GROUP IN A FEW NUMBERS

The group involved 44 participants from 15 countries: Brazil, Czech Republic, Denmark, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Mexico, Norway, Sweden, Turkey, and United Kingdom. The 27 accepted papers and 6 posters were distributed according to the three themes as follows:

(1) Design and use of technologies and resources	4 papers	
(2) Students' learning with technologies and resources	13 papers	3 posters
(3) Technologies, resources and teachers' professional development	10 papers	3 posters

Table 1: Distribution of papers and posters in the three themes.

REPORT OF THE WORKING GROUP DISCUSSIONS

In spite of several attempts toward building an integrative theoretical framework allowing to address the issues of ICT in math education (e.g. EU project ReMath, Artigue & Mariotti, to appear), the discussions within the WG15 highlighted a ***variety of theoretical approaches*** used, such as constructionism (*Kynigos & Moustaki*), theory of didactic situations (*Joubert*), instrumental approach (*Misfeld*), variation theory (*Attorps et al*.). *Abboud-Blanchard & Vandebrouck* proposed a new theoretical frame for studying the teachers' professional development, which integrates some of these theories, and *Tabach* developed a general framework to describe instrumental orchestration. Necessity of networking of theories appeared as an issue. Suggestions on how to proceed were formulated: look at the same set of data with the lens of different frameworks or analyse a given instrumented task from different theoretical viewpoints.

Particular importance was given to ***software*** and ***task design***. *Lagrange & Psycharis* explored the potential of a learning environment and *Mackrell et al*. designed tasks for a specific environment, both studies drawing on two complementary theoretical frames. *Libbrecht & Kortenkamp* highlighted the importance of metadata in the design of learning activities and *Libbrecht & Zimmermann* brought forward didactical design patterns that can impact software construction processes. *Pilet et al.* designed a piece of software allowing teachers to automatically generate exercises for differentiated instruction adapted to learning needs of various students' groups. Task design was explored by *Robová & Vondrová* in relation with the integration of netbooks in math classes. *Müller* proposed an instrument, drawn from history of mathematics, allowing to document changes in the type of tasks proposed in technology environment.

A number of contributions addressed the issue of ***teacher professional development***. They described and analysed various means of teacher development, formal (e.g., *Akkoç; Santos-Trigo et al*.; *Sollervall*) or informal (*Trgalová & Jahn*), in presence (*Balgalmis et al*., *Dullius*) or on-line (*Fredriksen*; *Gravina et al.*). The efficiency of these different means need to be evaluated, and for this, specific methodologies have to be developed. The participants raised a need for a model allowing to analyze the evolution of teachers' practices related to the ICT use. *Clark-Wilson* identified perturbations when teachers use technology due to discontinuities within teachers' knowledge which she calls "hiccups".

Students' learning of mathematical concepts with specific software was discussed in numerous papers. Students' conceptualisation processes with dynamic geometry were explored by *Henning & Hoffkamp* (the concept of limit), *Kilic* (elementary geometry), *Kaya et al*. (transformational geometry) and *Pettersson* (linear functions). The use of CAS and handheld calculators was investigated by *Persson* (development of problem solving skills with TI-Nspire), *Rieß & Greefrath* (lower achieving students' learning of functions with CAS-calculator), *Storfossen* (primary school mathematics with graphic calculator) and *Grønbæk* (use of professional CAS to teach upper secondary mathematics). *Weigand* explored the interplay between mental, digital and paper representations in a CAS environment in tests and examinations.

A general issue of a ***capitalisation of research results*** was raised in the light of an important number of research studies on ICT in mathematic education. First steps toward this was done by *Bray* who provided an overview of recent technological interventions in mathematics education and examined the educational affordances of the technology, and *Scheffer* who proposed a survey of research conducted by undergraduate, master and doctoral students, aimed at promoting reflections about the ICT integration.

CONCLUDING REMARKS AND PERSPECTIVES

The papers and posters presented and discussed within the group show a big variety of research topics, theoretical and methodological approaches, which is undoubtedly a sign of a richness of this scientific domain. However, the feeling is that the research presented in these contributions is rather local, focusing on a particular aspect of teaching and/or learning mathematics, rather short-term, not allowing to draw general conclusions about the benefits of ICT in mathematics education, and quite often conducted in controlled, laboratory conditions.

Thus, the participants expressed a need to know more about the "real" use of ICT in mathematics classrooms and outside, but also why ICT is not used. Long-term studies focusing on "ordinary" teachers and "ordinary" classrooms are necessary to explore the impact of the ICT use on students' performances and on teachers' practices. Such studies require developing specific methodologies enabling to assess the effectiveness of ICT in learning processes.

Moreover, research working toward a definition of recommendations or guidelines for teachers suggesting how to use efficiently ICT is missing. For this, surveys of international comparative studies highlighting best practices with ICT use could/should be conducted.

Little or no studies focus on how mathematics as a school subject matter is impacted by the ICT use. We know since many years that computers can perform complex calculations and that educational software provides multiple representations offering reliable visualisations of mathematical concepts. But some "old" questions are still

present and valid: Do we still need to teach and learn the same mathematics as before the rise of technology? How can we define the educational added value of ICT use for the learning of mathematics given the explosion of new tools and functionalities provided in technology-rich environments? How can we connect the mathematics embedded within particular ICT tools and curricular mathematics?

In addition, there are emerging research themes in education which are still underrepresented in CERME: the design and use of innovative technologies such as Web 2.0 or mobile technologies, or the design and use of technologies and resources for learners with special educational needs.

Clearly, these concerns could define a research agenda for the coming years. On a CERME working group scale, especially the following two tasks can be carried out:

- Working towards common understanding of theoretical constructs and research vocabulary used in various national contexts. This can be done for example by organizing during the sessions a group work on the analysis of concrete material (e.g. a task, an ICT tool, a set of data) from different theoretical perspectives;
- Working towards capitalising research outcomes, especially from previous technology working groups at CERME conferences. Each contribution to the working group should draw, when relevant, on the results of studies presented at previous conferences.

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LIST OF PAPERS

Persson Per-Eskil - A problem-solving experiment with TI-Nspire

Pilet Julia, Chenevotot Françoise, Grugeon Brigitte, El Kechaï Naïma, Delozanne Elisabeth - Bridging diagnosis and learning of elementary algebra using technologies

Rieß Michael, Greefrath Gilbert - Results on the function concept of lower achieving students using handheld CAS-calculators in a long-term study

Robová Jarmila, Vondrová Naďa - Pupils' role and types of tasks in one-to-one computing in mathematics teaching

Santos-Trigo Manuel, Camacho-Machín Matías, Moreno-Moreno Mar - Using dynamic software to foster prospective teachers' problem solving inquiry

Sollervall Håkan - Threshold constructs instrumenting teachers' orchestration of an inquiry with GeoGebra

Storfossen Per - Graphic calculator use in primary schools: an example of an instrumental action scheme

Tabach Michal - Developing a general framework for instrumental orchestration

Trgalová Jana, Jahn Ana Paula - The impact of the involvement of teachers in a research on resource quality on their practices

Weigand Hans-Georg - Tests and examinations in a CAS-environment – the meaning of mental, digital and paper representations

LIST OF POSTERS

Bray Aibhín - Mathematics, technology interventions, and pedagogy – seeing the wood from the trees

Dullius Maria Madalena - Continuing formation and the use of computer resources

Grønbæk Niels - Professional computer algebra systems in upper secondary mathematics

Müller Matthias - A new instrument to document changes in technological learning environments for mathematical activities drawn from history

Pettersson Annika - Using ICT to support students' learning of linear functions

Scheffer Nilce Fátima - Information and communication technologies and mathematics teaching: researches conducted from elementary to higher education