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INTRODUCTION TO THE PAPERS AND POSTERS OF 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:
Table 1: Distribution of papers and posters in the three themes.

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<tr>
<th>Theme</th>
<th>Papers</th>
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<td>(1) Design and use of technologies and resources</td>
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<td>(2) Students’ learning with technologies and resources</td>
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<td>(3) Technologies, resources and teachers’ professional development</td>
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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”.

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**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), Storfosse (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
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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.

REFERENCES


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LIST OF PAPERS

Abboud-Blanchard Maha, Vandebrouck Fabrice - Geneses of technology uses: a theoretical model to study the development of teachers’ practices in technology environments

Hatice Akkoç - Pre-service mathematics teachers’ practice of questioning in computer learning environments

Attorps Iiris, Björk Kjell, Radic Mirko, Viirman Olov - Teaching inverse functions at tertiary level

Balgalmis Esra, Shafer Kathryn G., Cakiroglu Erdinc - Reactions of pre-service elementary teachers’ to implementing technology based mathematics lessons

Clark-Wilson Alison - How teachers learn to use complex new technologies in secondary mathematics classrooms - the notion of the hiccup

Fredriksen Helge - Mathematics teaching on the web for student teachers: action research in practice

Gravina Maria Alice, Menna Barreto Marina, Notare Marcia - Continuing professional development and digital media in mathematics education

Henning André, Hoffkamp Andrea - Developing an intuitive concept of limit when approaching the derivative function

Joubert Marie - A framework for examining student learning of mathematics: tasks using technology

Kaya Gürcan, Akçakin Veysel, Bulut Mehmet - The effects of interactive whiteboards on teaching transformational geometry with dynamic mathematics software

Kilic Hulya - The effects of dynamic geometry software on learning geometry

Kynigos Chronis, Moustaki Foteini - On-line discussions about emerging mathematical ideas

Lagrange Jean-Baptiste, Psycharis Giorgos - Exploring the potential of computer environments for the teaching and learning of functions: a double analysis from two traditions of research

Libbrecht Paul, Kortenkamp Ulrich - The role of metadata in the design of educational activities

Libbrecht Paul, Zimmermann Marc - Didactical design patterns for the applications of software tools

Mackrell Kate, Maschietto Michela, Soury-Lavergne Sophie - Theory of didactical situations and instrumental genesis for the design of a CabriElem book

Misfeldt Morten - Instrumental genesis in GeoGebra based board game design
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 Nad’a - 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