Working Group Reports

Technology: A summary of themes and key ideas discussed*

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Some broad themes

The role of the teacher is central (yet very few papers discussed the professional development of teachers directly).

The range of technologies available is wide (and growing); they included calculators, software, websites, e-books, podcasts, movies and 'clickers'.

The development and continuing improvement of technology specifically for pedagogical purposes was evident.

Relatively little formal empirical research was presented at the conference. Few presentations involved systematic comparison, contrast, test and evaluation of approaches to teaching and learning.

Papers focused on mathematics education at a wide range of levels, from elementary school to undergraduate mathematics and mathematics teacher education.

Some key discussion points

How teachers use technology themselves and how they guide students to use technology seem to be critical for effective use. The role of the teacher is likely to be more important than the technology itself. Many regard conceptual understanding as more important than procedural understanding and hence consider a major role of technology is to help students understand mathematics. Technology is best regarded as a complement, to rather than a substitute for, good teaching.

It is important for students to experience technology as something to *experiment* with, and not be restricted to interpreting it as a means of getting 'answers' to mathematical questions. Technology offers new ways for students to undertake mathematical problems in several ways; frequently in the past, students have been encouraged to find the one best way only, thus merely reproducing the teacher's thinking. Technology can be used to motivate students.

Even in schools with extensive computer access, students still made good use of hand-held technologies for convenience, as they were easier to access (without having to start up computers, etc.)

Some teachers (especially men?) continue to protest (sometimes angrily) about the use of technology in mathematics education, claiming that it will undermine mental capabilities of students. Some teachers resisting technology regard the pen and paper approach as the proper of way of doing maths and the computer way is considered as the 'gimmick approach by these teachers. Some students also do not approve of the use of technology. However, many other teachers have concluded, on the basis of their experience with students that, technology can support learning and thinking, provided it is used with care by teachers.

Powerful software is now available (*Geogebra* and *Autograph* were examples that were discussed) which can be used in a wide range of ways to support both learning and teaching. It is important to not regard technology as having only one purpose (such as *Geogebra* being only for 'geometry' or *Autograph* only for 'graphing').

At the pre-service level, it is important to help students see technology as a *learning tool* – a tool to see things differently. An example of this is to ask students teachers to analyse materials on the web for a certain level of students, thus requiring them to think about learning, not just about the technology.

The Internet now offers many opportunities for student learning that were not previously available. In addition, from the perspective of teachers, there are fresh opportunities to support professional life and work, some of which are concerned with students using technology. Efficient use of these opportunities requires organised access to good Internet materials for teachers and students. There are many materials presently available without costs to users.

Methods of teaching can (and should be) enlivened and made more effective through the use of technology. For example, audience survey software at the tertiary level allows students to give immediate feedback to the teacher, engaging them in the learning process and allowing the teacher to adjust instruction accordingly. Effective use of good educational technology offers many ways to motivate students and engage them effectively. Technology can help make mathematics more interesting, fun and entertaining for students to learn.

It is crucial to convince students that mathematics is important, and technology can help with this. One effective mechanism is to focus on real-life situations, which can be accessed mathematically with the help of technology tools. Technology can be powerfully used for modelling and thus understanding everyday things, including household objects and technologies. The use of technology such as *Geogebra* to find volumes of shapes and allows for realistic measurements to be used and for solutions to be sought in several ways. Recent capabilities of software to import images make it more possible than previously to bring real-world situations into the mathematics classroom successfully. New developments within technology (such as sliders in *Geogebra*) make possible attractive learning possibilities for students, fostering experimentation. International interest is increasing in integrating such opportunities into regular teaching.

E-books offer new opportunities for education and for e-learning, with some significant advantages over conventional books; these include cost of publication, time to deliver materials and the ease of including photographs and colour. Disadvantages include problems related to the rights of authors and publishers, which have yet to be resolved. In addition to these advantages, e-books can include features not possible in standard publications, such as audio and video materials, applets (such as Java and Flash) and direct linking to software such as dynamic geometry systems and CAS. There are already many e-books available on the Internet, with various levels of access.

Hand-held technology, such as *ClassPad*, has very powerful software included, allowing undergraduate engineering students to solve advanced problems that previously were very difficult, involving searching for standard integrals. As well as hand-held versions, emulator software allows both students and teachers to do mathematics in different ways. This is more convenient than computer labs, which are not always available for student use and not permitted for examination use. So the handheld software offers students and teachers an efficient way to use technology at school and at home.

Spreadsheets can be effectively used as the main technology platform for students in a liberal arts mathematics course, allowing for many important applications, including statistical analysis, graphing, discrete mathematics, and so on. Indeed, for students without long-term intentions to study mathematics, this has been suggested (by the MAA, among others) in preference to hand-held technologies as learning platform for students. A computer laboratory environment allows students to work together and to

get help, which is not readily available to students at home. It is clear that the way in which teachers work is critical: pedagogy matters. The 'traditional' lecture environment is not helpful for many students at college, as well as secondary school.
Online teaching can be helpfully supported by both pod casts and screen casts. Experience suggests that students who are not able to attend classes find these very helpful, especially those who are visual learners. It is not necessary to have studio-quality presentations to be effective, nor to be very experienced. Free software is available for use, and an inexpensive webcam is needed. Attention to storage of materials and copyright issues is needed.
Technologies are frequently developed for English-speakers, which is quite problematic for students and teachers with other linguistic backgrounds. Computer operating systems and some international software can be adjusted to suit different linguistic environments, although there are some problems in doing so. (For example, there are differing conventions on the appropriate decimal separator: comma or point).
Tools can affect cognition in important ways, and it is important to recognise both the strengths and the limitations of this. In studies involving geometry, these differences were visible when students addressed problems through the differing environments of paper-folding, dynamic geometry systems and paper and pencil sketches. Again, the use of technology is no panacea for student learning: the role of the teacher to construct environments that support productive activity, experimentation, thinking and reasoning is critical. Similarly, curricula are likely to be affected by the availability of differing mathematical tools, some of which are technological.

*NOTE: This summary is based upon presentations and discussions within this group, although it is clear that there were also discussions elsewhere in the conference about the role of technology.

Working Group 2: Comparative Education

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The Comparative Education Working Group seven sessions, of 19 presentations, have reflected well the theme of the MEC21 10th International Conference "Models in Developing Mathematics Education" rather than present cross-national assessments. Nevertheless, the discussions of the group with models presenters had went beyond one only model to compare different presented models and add participated experience.

The number of presentations on National Models was 17. For the other two presentations, one was on cross-national assessments and the other on the results of testing samples of two countries. The 17 national models presented were taken from 11 Educational Systems of Belgium, Egypt, Iran, Italy, Israel, Russia, South Africa, Taiwan, United Arab Emirates and United States of America. The diversity of presented national models gives a chance to mathematics educators from other countries to find adequate approaches for solving problems they face in their own countries, or provides relevant tools for conducting similar researches.

One of the richness of national models, presented, was the scope it covers. Among others, where some models face the problem of students' poor learning, others dealt with gifted students and their education. In multicultural societies, and for minority cases, immigrants and indigenous groups in particular, the common problem was students' language knowledge, but solution models were different. The group discussions for this problem formed professional reflections and provided proposals for future research. For gifted students, presentations and discussions showed that success stories in one society could be repeated in another one. The affect of specialists' moving from one country to another was highlighted as an important factor in dissemination of gifted students' education traditions. Among the discussed traditions was the establishment of mathematical clubs, the arranging of competitions and the publishing of mathematical problems' books for gifted students. Our group saw the care of both students, those with learning difficulties and others of high abilities, as the way to achieve equality among the learners. Equality was seen as providing opportunities for all students.

Improving of teaching strategies and teaching approaches was discussed through three different presentations. Two of the three presentations were related to secondary school and the third for university students. The aim of the models presented was bringing better achievement. In addition, in two of these models the aimed achievement was to bring understanding of every teaching mathematical object to every student.

Regards assessments, in a presented model, tests were used in a large-scale not for students' assessment, but for the evaluation of curriculum standards. In another model tracking students in multi-age groups according to their abilities was done upon teachers view, on a Principe of trust. In a third model assessment was used to investigate the affect of Single Sex Mathematical classes on secondary school students' achievement.

Different models and discussions of our group were on mathematical curricula, from the historical development of written mathematical curricula in an Educational System to the comparison of the different procedures used in writing the mathematical curriculum in another Educational System.

The difficulties of curriculum reforms were discussed in two presentations, where the solutions models in both were related to providing activities for changing attitudes of teachers and principles. In a presentation related to cross-national assessments' results, evident were provided on the affect of curriculum reforms on the performance of students. This outcome was conditioned by the ability of an educational system in implementing the reform.

Finally, here to remark that our group wide discussions reflect a view on comparative education as a way to every participant to improve mathematics education in his/her own region, country and as well worldwide.

Report on Innovation Working Group

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This document reports on the Innovations Working Group that met at the 10th International Conference "Models in Developing Mathematics Education" from the 11-17th September 2009 in Dresden, Saxony. It briefly describes the over arching and consistent themes that emerged from the numerous papers presented. The authors and titles of each of the papers presented will be listed in Table 2.

Active student engagement in mathematics appeared to be a major concern for a number of the authors who presented at the Innovation Research Interest Group. This concern is consistently being emphasized in many recent international, national and state contemporary policy documents and discussion papers (Luke, et al., 2003; Ministerial Council on Education Employment Training and Youth Affairs MCEETYA, 1998; National Council for Teachers of Mathematics NCTM, 2000; Organization for Economic Cooperation and Development OECD, 2004; Senate Standing Committee for Employment Workplace Relations and Education, 2007; US Department of Education, 2008). The documents highlight the need for effective teaching practices that will promote such engagement. In the findings from the Program for International Student Assessment [PISA], (2003), teaching practices were identified as having a "substantial" effect on student achievement, engagement and participation in mathematics (OECD, 2004, p. 29). Engagement, in the sense in which it is used here, refers to reflective involvement in deep understanding, valuing what is being done and actively participating in mathematical tasks (Munns & Woodward, 2006). The result is a substantial sense of satisfaction and investment in learning. Evidence from the working group papers presented suggests that a number of teaching practices are crucial to effective engagement in learning mathematics.

The following table (Table 1) provides an overview of the key themes that consistently emerged from the meeting of the Innovations Working Group. The themes have been identified as influential to student engagement in the learning of mathematics. Each theme will be briefly reported on below.

Table 1: Key themes in the Innovation Working Group

Theme	Sub-theme
Theoretical framework	constructivist/inquiry based T&L blooms taxonomy
Methodological framework	action research/reflective practitioner
Equity	language of mathematics other knowledges of mathematics parents community
Pedagogy	knowledge of mathematics crafting pedagogy pedagogy practices lesson design
Curriculum content	delivery standardisation
Resources/games	mathematics content learning/reinforcement language strategy/ies types

a) Theoretical Framework

The theoretical framework for teaching/learning processes is based on the constructivist approach. The three-part teaching model (Steele and Meredith, 1997)

offers possibilities for learning by making sense of the world in terms of the concepts the students already have, by making sense – that is, by exploring and inquiring - and by reflecting on what students have learned. A number of papers focused on good practices examples for motivating and involving students in understanding and proofing theorems. Different strategies for attaining high-level learning objectives (Bloom's taxonomy) were introduced. The most successful teaching process was considered the one that encourages students to think for themselves and engage them in thinking on the mathematical concepts and processes.
Another idea that came out from some of the papers was explicit stated by William Speer: *Students don't learn by doing – they learn by reflecting on what they are doing.*

b) Methodological Framework: Action Research and the Reflective Practitioner

Action research provides educators with an inquiry-based approach to research their practice (Carr & Kemmis, 1986). Engaging in this approach allows for the critical analysis and reflection on knowledge (understandings, skills and values) of teaching and learning in mathematical contexts in education settings. Thus, what an educator does with learners becomes an explicit object of discussion. It requires reflection on practice; the examination of this practice and how it connects with learners through social and conceptual interaction. Through action research, the educator explores the process of communication, production and social organisation, and how to improve interactions by changing the acts which constitute them. The reflective dimension and professional knowledge becoming central to the teaching and learning process. This emergence is changing the definition of what educators need to develop, since reflective practice goes beyond the concerns of the individual to critiquing, challenging and transforming practice (Griffiths, 2000).

c) Equity

Papers related to this theme were concerned with the key question of: What mathematics is important and for who? This question was addressed in papers that focused on issues related to community, parents and minority groups in mathematics. The issue of collaboration and partnering (establishing partnerships) across communities appears to be an important strategy for achieving access to various forms of mathematics needed for different communities. Also important is the role that different groups (e.g. families, women and children) play in mathematical development and how they enhance wider participation in mathematics education.

d) Pedagogy

A number of papers presented were explicit about the importance of effective pedagogy that was enabling for student engagement in learning mathematics. Current reforms in mathematics education are predicated on two related assumptions. First, that teachers should develop and adopt new strategies and practices for teaching and learning mathematics (Drake, 2006). Second that active student involvement in solving complex problems provides the context for mastering the basics skills required in understanding and doing mathematics (Schoenfeld, 2006). Advocates argue that the necessary skills would develop in meaningful problem-solving contexts, whether developed or adapted by teachers or in independent student exploration (Drake, 2006; Schoenfeld, 2006; Boaler, 2002). Mathematics is to become more enfranchising and meaningful and less likely to "cause the documented problems of the traditional curriculum" (Schoenfeld, 2006, p. 16).

The implementation of mathematics reforms has been shown to lead to substantial improvements in student achievement across classrooms and year grades (Balfanz, MacIver & Byrnes, 2006). Reforms that focus on providing a rich and demanding curriculum, well designed lessons together with well trained teachers who are able to craft their pedagogy to improve teaching and learning environments have been shown to contribute significantly to student gains (Balfanz, et al., 2006; Senk & Thompson, 2003). These gains were found to be achieved by combining evidence-based curriculum, professional development for teachers and reform practices into an integrated reform program (Balfanz, et al., 2006; Cohen & Hill, 2000).

e) Curriculum content

A number of papers directly addressed issues of mathematical content in a range of ways. Key of these demonstrated the need to move from elementary to advanced mathematics, i.e. how in working with elementary mathematics we can establish ways of gaining insights into deeper and more advanced mathematics. There are benefits in mathematics educators and researchers working across the wide range of mathematical content and contexts. We present ourselves with the opportunity of developing a rich content base for our work in mathematics education, and to contribute to the growth in elementary and advanced mathematics.

f) Resources and Games

A number of papers presented were explicit about resources and games used in maths lessons in order to provide students opportunities to work with mathematical concepts. These resources are modelling mathematical concepts, they support students learning and sometimes they can be used to overtake language barriers. Presenters introduced many types of resources (virtual manipulatives, pop-up geometric shapes, mathematical games etc.) and looked on their effectiveness, on their effects on the students' mathematical learning.

Table 2 List of presenters and papers

Author/s	**Title of Paper**
Danial Brahier	The best of both worlds: Teaching moddle school and college mathematiccs
William Speer	Virtual manipulatives: Design-based countermeasures to selected potential hazards
Ysette Weiss-Pidstrygach	Elementary mathematics from an advanced standpoint and elementary views on advanced mathematics
Marilyn Holmes	Community engagement: Home school partnership
Stefanie Meier	Identifying modelling tasks
Bronwyn Ewing	Recognising Torres Strait Islander women's knowledge in their children's mathematics education
Alexander Domoshnitsky & Roman Yavich	Internet mathematical Olympiads
Katharine Clemmer	How involving secondary students in the assessment process transforms a culture of failure in mathematics to a culture of accountability, self-efficacy and success in mathematics: Student action plans, assessment, and cultural shift
Paul Webb & Pam Austin	Family maths and complexity theory
Buma Abramovtiz, Miryam Berezina, Abraham Berman & Ludmila Shvartsman	Some initiatives in calculus teaching

Annalisa Cusi	Analyzing the effects of a linguistic approach to the teaching of algebra: students tell "stories of development" revealing new competencies and conceptions
Valentina Dagiene & Inga Zilinskiene	`Localization of learning objects in mathematics
Mona Hanna & Carrie Chiappetta	Each and every student: the Stamford, Connecticut model for change in mathematics
Buma Abramovitz, Miryam Berezina, Abraham Berman & Ludmila Shvartsman	Proofs and "puzzles"
Vivekanand Mohan-Ram	Modelling geometric concepts via pop-up engineering
Mandy Parnell	Reflective practices – a means to instil a deep learning approach to mathematics or another time consuming fad: Work in progress
Paul Swan & Linda Marshall	Mathematics games: Time wasters or time well spent?
Ariana-Stanca Văcărețu	Math lessons for the thinking classroom

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Working Group for Teacher Education and Development

MARJORIE HENNINGSEN, BEVERLY FERRUCCI, ANGELA PESCI

The education and development of teachers who will have the capacity to engage their students in high level thinking, reasoning, and communication in mathematics continues to be of paramount importance in furthering of mathematics educational reform around the world. One underlying assumption is that mathematics teaching is a multi-faceted, complex problem solving activity. Success requires the ability to collect, interpret, organize, and select useful information and the ability to think independently, flexibly, creatively, and logically about the subject matter, about how to teach it, and about how students think about it. There are a variety of points of view about what constitutes good mathematics teaching and there are many important goals for the development of good teachers, many of which were discussed at this conference. The research papers and workshops in the strand represented a variety of perspectives on teacher education and development, including university and pre-university teaching, preservice and inservice professional development programs and professional networking. A variety of research perspectives were represented as well. Attendance at sessions in the strand averaged about 20 persons and ranged from 15-25, including the session chairpersons. The key overarching issues addressed at this conference were:

- Relating Theory and Practice
- Learning Community and Collaborative Work
- Knowledge Needed for Teaching
- Mathematical/Professional Identity

Many papers addressed more than one issue simultaneously, though usually one of the four overarching themes was more prominent than others. Below, each of the key overarching issues is elaborated according to what aspects were prominent in the work presented.

Relating Theory and Practice

The main focus on this issue was about the importance of engaging teachers in reflective experiences that will enable them to make crucial connections between theories of teaching and learning on one hand, and their classroom practice on the other hand. Beaudoin and Lanaris shed light on the disconnect often found between theories of classroom management covered in teacher education programs and problems encountered in mathematical reform practices when students do not engage as intended and management needs to be put into practice. Wagner and her colleagues identified the teaching of explanatory competencies as a gap in many teacher education programs and they raised the question of how explanatory competence can be taught and designed a program to address the gap. Kuntze and colleagues addressed the theory-practice divide through the design of a preservice program that would provide more practical experience and feedback on practice for teaching interns. Henningsen and Ibrahim described several strategies used at one school to help teachers gain a concrete understanding of data modeling processes, a teaching approach that the teachers had read about and discussed in professional development sessions and were expected to put into practice. Suurtamm and Graves conducted a large scale study of teachers' understanding and implementation of curriculum reform and found that establishing shared meanings in a collaborative context and coherence between understanding of new teaching practices and the level of support and expectations on the ground are huge factors in successful enactment of reform ideas.

Learning Community and Collaborative Work

The concept of *learning community* and the problem of how to develop effective collaboration within communities has been of great interest to practitioners in mathematics education for the past decade. These ideas are relevant for understanding and describing the roles and development of individuals and groups of all sizes in the context of mathematics teaching and learning processes in a variety of settings. All of the work discussed in the previous section underscored the importance of learning and collaborating in a community for mathematics teachers at all levels as a part of coming to understand how various theories should be enacted in practice, while others put learning community and collaboration in the forefront. Hsu and colleagues addressed the idea of learning community in the sense of establishing professional networks that facilitate links between teachers and mathematicians as learning partners. Franks, however, put the spotlight squarely on understanding the nature of particular learning communities in the elementary school context. He pointed to the important notion that the development of a well-functioning learning community is an ongoing process that consititutes a cultural transformation. His work addressed questions about how to make professional learning communities viable and sustainable and he also raised a crucial question about accountability—what should the community be accountable for and to whom and what are fair ways to establish accountability structures? In her research on *lesson-study* groups, Kakhbaz highlighted the question of to what extent or in what ways is engagement with *lesson-study* is culture bound?

Knowledge Needed for Teaching

The problem of theorizing what knowledge is needed for teaching and how it can be developed goes back more than two decades when Lee Shulman brought it to the forefront of concern for mathematics educational researchers in his landmark discussion of Pedagogical Content Knowledge. Several presenters in this strand looked at questions about particular areas of knowledge needed for teaching. Suurtamm and Graves looked at how teachers understand curriculum and shed light on some of their uncertainties and dilemmas in implementing reform ideas. Beaudoin and Lanaris found that when it comes to essential knowledge of classroom management needed to teach in the reform context, teachers tend to equate the knowledge they feel confident about with what they need to know or what it is important for them to know. Wagner and colleagues' focus on explanatory competencies pinpointed a particular type of knowledge that teachers need in order to support student learning. Both Carbone, and Ferrucci, Carter & Lee delved into teachers' understanding of and misconceptions about rational numbers and proportionality. Both studies compared groups of preservice teachers from different countries and found some similarities and some differences in teachers' conceptions of ratio and proportion and also in approaches used in different countries to solve such problems. Ng used the model developed by Ball et al. to look at knowledge for teaching school geometry and shed light on possible influences of language and culture in assessing teacher knowledge. Neiss discussed a large scale program (TPACK) concerned with what knowledge teachers need to teach mathemtics with new and emerging technological tools. She aptly pointed out that teaching with technology can have a strong impact on teachers' knowledge of mathematics. The dynamic nature of dealing with data using technology can change teachers's dispositions toward problem solving to be more exploratory and inventive. Most teacher development programs are far behind in developing the use of technology for teaching mathematics compared to the tools available. Finally, Frauenholtz and Webb described a professional development program aimed to enhance teachers' understanding of mathematics and also tried to discern the impact of teacher participation in the program on student learning. There was agreement that not enough work focuses on linking theories of knowledge needed for teaching directly to student learning and this would be a fruitful area for researchers to focus.

Mathematical/Professional Identity

Other work in our strand touched upon all three of the previous themes but actually forefronted the ideas of mathematical identity and also professional identity and sometimes how the two are intertwined. Teachers should reflect on their how their own beliefs and knowledge about what mathematics is and what it means to do mathematics will impact on how they engage with students and what experiences they choose for their studens. But they also need to view themselves as part of a larger community of mathematics education professionals who are involved in creating learning environments for children that emphasize thinking, reasoning, problem solving and the communication of mathematical ideas. Eaton and O'Reilly carried out a study of teachers' mathematical identity and found that engaging the teachers in reflecting upon and exploring their mathematical identity had an impact on their understanding of teaching and learning processes. Barnes put the focus on using triangulation of various types of data to characterize in a visual model teachers' mathematical identities in terms of the areas of knowledge needed for teaching (beliefs, content and pedagogical knowledge) in either reform or traditional contexts. She then found a link between mathematical profiles and how teachers teach, as well as a link between changes in mathemtical profile over time and changes in instructional behavior. Dhlamini looked at teacher identity with respect to integrating mathematics with arts and culture in teaching. While teachers saw the value of integration of these subject matter, they weren't always able to do it very well;

moreover, one of the main factors was their view of their own knowledge of the subject matter involved. In a large scale study of teacher turnover in a teaching fellowship program, Cooley found that issues of professional identity and beliefs about the profession of teaching mathematics had a big impact on who decided to stay in teaching and who decided to leave the profession. All of this work suggest that there should be a much stronger focus on developing mathematical and professional identity in teacher education and professional development programs. The role of fundamental beliefs in these areas with respect to how someone teaches mathematics and how they engage their students with mathematical experiences in the classroom should not be underestimated.

Research on Learning Working Group

Overall, the papers were of a reasonable good quality covering a variety of interesting topics, and employed appropriate research methodologies.

Some major topics that appeared throughout the conference included:

- Teaching and learning models
- Relationship between language and mathematical learning
- Relationship between algebra and arithmetic
- Importance of teaching number sense and estimation, and
- Connections to real world contexts for problem solving.

Many of the papers took into consideration the students' mindsets and beliefs. For example "students would see value in learning mathematics".

Researchers utilized both qualitative and quantitative methodologies with qualitative approaches appearing more often. Within the qualitative approaches, multiple modes of inquiry were implemented including interviews, analysis of group processes, observations, auto-ethnographic techniques, etc. Subjects who were the focus of the research studies ranged from preschool children through college level students which included students in mathematics courses as well as students who were part of teacher education programs of study.

Constructivist models of teaching and learning were the primary theoretical framework for the paper presentations, though there were some alternative viewpoints offered in a few of the presentations. This common theoretical underpinning supported elaboration during rich discussions following the papers.

While technology was a secondary issue in a few papers, it was not a focus in the WG. The one exception was a study focusing on the use of Microsoft Excel in the teaching of linear functions. This is likely due to the existence of the Parallel Working Group on Technology which included many excellent papers.

Recommendations

Papers could include a stronger discussion of the need for future research in related areas and what specific questions might be addressed to extend knowledge related to the particular area of study. It is important for researchers to situate their current studies within the broader literature and provide explicit direction relative to the focus of future research in that area.

Points raised in the final discussion session:

1- The time assigned for each paper was an effective factor for good presentations. It is hoped that this time (40 minutes) will be a feature of future conferences of MEC21.

2- Some important topics such as "assessment" were not covered. A recommendation is to consider this in the future, possibly in a separate session (and not in a WG).

3- Young researchers could benefit from feedback regarding their papers by senior scholars. This could be before, during, or after the conference where some volunteers can help in this respect.

4- For some papers, a more carful editing is absolutely. In this regard non-native English speakers should be asked to have their paper looked at by a native speaker before it is submitted. (Badly written papers can have a negative impact on the perception of the Proceedings, certainly when the book comes in the hands of people who were not at the conference.)

Summary of the Working Group „Problem Solving"

Günter Graumann

A) <u>The main aim of the working group "Problem Solving" was named as follows</u>: Future mathematics teaching has not only to focus on concepts and teaching techniques of computing but also on problem solving and problem posing to reach general aims like creativity, ability of systematisation, abilities of communication, argumentation, presenting mathematics results and ability of working in a team as well as getting a vivid view and a positive belief about mathematics and its application in real world.

B) <u>About the presentations in the working group "Problem Solving" (Session 1 to 9):</u>
In this group there have been presented different themes with different correlations to problem solving. We can group them into three parts.

B1) <u>Problem solving in the sense that students have to work on problems</u>
In this direction about the half of all presentations can be attributed. The themes focused on "Improving students attitudes while working with problems", "Problem posing and solving in an unknown context like taxicab geometry", "Training groups of lower achiewement via problem solving", "Working with concrete geometric objects and paperfolding", "Learning combinatorics via working on different problems", "Learning general competences by working with problem fields in elementary arithmetic", "Experiences with real life problems and the computer", "Competences of students about modelling tasks". In the workshop of session 2 there was also one theme ("Students work close to mathematical researchers") focussing in the named direction.

B2) Ideas about teaching in the sense of more open teaching or more self-acting
The themes focus on "Integration of teaching and computer science", "Combining addition and subtraction in grade 1 and 2", "Introduction and use of parameters in real analysis in grade 11 and 12", "Visualisations for better understanding", "Combining computer and proof with in view of students belief about it", "A special teaching method called chapter-spanning review", "Building better concepts in the way of the phenomology of Husserl".

B3) Several other themes
"Presenting a special journal", "Discussing differentiation with functions of natural numbers", "The role of mathematics three hundred years ago and today while describing real world respectively physical problems".

C) Some ideas for future working groups

- Give more time for discussion in the working groups (e.g. maximum 30 minutes presentation and 10 minutes discussion plus 5 minutes for change as well as 15 to 30 minutes discussion after three such parts)
- There should be at least in each session no change of participants into other sessions so that discussions about general aspects of the working group are possible
- Summary reports and its discussing should not only be done at the end of the conference but also in the middle
- A first presentation in the working group "Problem Solving" should focus on different definitions respectively different aspects of problem solving to find a basis (one to three fundamental directions) for the later discussions
- Problem Solving should be combined with views of other sciences (e.g. in a special session) and other working groups like "Application" and "Technology" (e. g. in a special session)
- In at least one session of the working group "Problem Solving" the participants should work on some problems by themselves and later discuss their different views on the problems (e. g. these problems could be given to the participants in the first session of the working group and discussed in a session two days later).

Report from the working group on Applications and Statistics

Members: Ivan Meznik, Gail Burrill & Viktor Freiman

General comments

I. Overall structure:

- Maybe a poster session for the first day rather than just the open time.
- Maybe finish at 3 pm two days instead of having Tuesday afternoon off.
- Food was very good, and the staff is to be commended.
- Good instructions and keeping posted on what we were to do as well as very helpful students. Technology assistance was excellent and made things run very smoothly.
- Plenary the last day makes it difficult even for the speaker.

- It would be a good idea to have the papers on web before the conference so attendees could read them ahead of time.

II. Working groups: (These really were not working groups as they played out; different people every time so not working on a common theme.) Maybe change the name to sessions? Or sections? Or make more explicit what a working group is to be.

- Decrease the number of working groups to maximize the attendance. (Average attendance at sessions was about 12) Perhaps have a few major plenary sessions with a key person well known in the field. Maybe each group could have a plenary – with a longer paper? Might have some poster sessions for smaller papers.

- The scheduling and time allotment was too long; 20 minute presentation plus 10 minutes for question/discussion would be enough.

- The time cards (5 min, 1 min) were good. Changes should be avoided and if they have to be made, working group leaders and other speakers in the session should be notified.

III. Our working group
1. General observations
  - It dealt with a wide diversity of topics. No one stayed for every session so there was really no common group. (Some interesting applications such as music and geometric transformations, ancient Greece interface with modern work in mathematics, interface with technology)
  - Perhaps find a better way to group the papers as some seemed in the wrong place. Maybe ask the authors what group they think their paper goes into.
  - Group leaders should only present papers in the group they are leading.

2. Common themes
  - Strong sense of interdisciplinarity through the sessions used to motivate students and help them make connections
  - Tension between standards and innovation – changing the standards to open to new approaches
  - Technology used in many ways – online environments, simulations, calculus, -- creating and making accessible technology resources that support learning
  - Obstacles to the use of applications were both helping teachers understand and use the ideas and the challenges of doing this in light of high stakes assessments in many countries, differentiation among abilities and levels

3. Based on the 2007 report from this group, we used the following categorizations to characterize presentations in our working group:
- A applications (uppercase “A” indicates paper had a strong applications based; lower case “a” indicates less focus on applications)
- S, s: (S → strong statistics focus, s → weaker statistics focus)
- T → strong technology focus
- ID → Interdisciplinary

- O → other category

Day 1 (Saturday) Session 1: • Fosner: A • Beckman: ID	Day 3 (Tuesday) Session 4 • Hvastija & Kos: ID • Pavlika: S Session 5 • Klembalski: A • Jan & Amit: S • Golez: ID (A)
Day 2 (Sunday) Session 2 • Bidwell S • Jerde: A Session 3 • Burrill: S(T) • Freiman: ID	Day 4 (Wednesday) Session 6 • Galante:ID • Kemp: S Session 7 • Oldenburg: A • Porter: T • Zell: ID Session 8 • Karim: A