1 ICTs and secondary school mathematics—themes, visions and realities

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INTRODUCTION

The topic of the conference is couched in the subject domain of mathematics. It is also multi-faceted in terms of the wide range of topics and issues addressed. In order to help focus the papers and discussions, four broad themes were identified—curriculum, teachers, learners, and human and social issues—and papers at the conference were presented as strands within these streams. To provide a coherent structure for the book, the papers have been grouped thematically.

Curriculum

The book begins with a consideration of curriculum: evolution, relationships of informatics and mathematics and the implications of the availability of powerful software tools.

The first two components in the theme are concerned both with the significant changes which have taken place during the past three decades, and the prediction of key effects for the future, against the background of user requirements and the continuing importance of mathematical topics in other subjects and in the related field of informatics. The keynote papers by van Weert and Kieren set the scene, with van Weert focusing on how informatics and informatics based technologies directly impact on mathematics and its teaching, and Kieren carrying forward a theme which appeared in the two previous IFIP working conferences on mathematics, Varna, Bulgaria, 1977, and Sofia, Bulgaria, 1987—the evolution of the curriculum to take on a more pupil-centred view with the computer as a tool for personal construction of mathematics.

Curriculum issues and visions are carried forward in a paper by Romero i Chesa & Ruiz i Tarragó, in their discussion as to how the Internet enables new modes of mathematics teaching and learning, and another by Kalas & Blaho, with

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a focus on working with future teachers of mathematics and informatics in developing new Logo microworlds as creative laboratories for exploring big ideas in mathematics and informatics in the lower secondary school. Oberschelp, in the final invited paper, moves into the curricular implications of computer algebra systems in the context of informatics and discrete thinking. Two short papers are also included, the first, by Yanagimoto, addressing links of mathematics with computer science and the second, by J Johnson, indicating how the history of mathematics can provide a source of technology-rich problems for use with secondary school pupils.

A second aspect in the area of curriculum evolution, addressed in part in the papers mentioned above, is that of the exciting and innovative uses of the powerful software now becoming available on a wide range of machines. Here the four invited paper authors, J-M Laborde, Neuwirth, Oldknow, and Machida, speak to present and future considerations in the use of dynamic geometry software, spreadsheets, personal computing technology (e.g., the TI-92) and hypertext environments for learning about mathematical modelling. The insights and visions and the implications for curriculum change are further supported in a short paper by Möller which describes an approach to conic sections and planetary motion with *Cabri*.

The visions are both motivating and real—and the examples given illustrate the potential for creating exciting learning environments—but what about teachers and learners, the reality of the classroom?

Teachers

The main scope of this theme is how using technology affects the methods and ways of the teacher in order to promote the learning of mathematics. Are we concerned with teaching aids or learning aids—or both? Key issues are those of professional development, methodology and practice. A basic assumption is that technology can be strongly integrated into mathematics education only if it is also strongly integrated into pre- and in-service teacher education and amongst the teachers of teachers.

The first three paper authors in this section, Balacheff, Artigue, and Bottino & Furinghetti, all address issues and identify factors which inhibit this integration, i.e., illustrating the difficulties experienced by teachers in their attempts to change their practice, even when the tools and contexts would appear to have the potential to be highly motivational for both the teachers and the pupils. The need for careful attention and support for the teachers is made explicit—and the next two papers point to exciting developments in this area. Clarou describes strategies for providing opportunities for the acquisition of skills for personal exploration as well as, and potentially even more important, the participation in specifically designed classroom focused 'scenarios in use'. Sutherland goes on to describe a sociocultural approach in which the teacher becomes part of the 'sense-making' system involved in joint problem solving.

The short paper by Miller describes components in a programme for initial teacher training which attempts to address the issues which have come about through government policy statements in the UK, while that by Kristjánsdóttir links back to the paper by Sutherland. These in turn lead on to questions about the changing role of the learner—what might the classroom really be like? What does research and theory tell us?

Learners

Powerful tools now available in personal technology—for example spreadsheets, symbolic manipulators and dynamic geometry systems, which allow a broader range of representations of mathematical ideas and concepts—give learners more ways of accessing and understanding the methods and fundamental concepts in mathematics (see also the papers grouped under 'Curriculum tools'). In concept development, information technology has the potential of partially turning mathematics into an experimental science. Constructing and dealing with mathematical structures can now be based on manipulation of semi-concrete objects, allowing alternative linked representations—symbolic, spatial, visual. Under what circumstances do these capabilities facilitate or inhibit concept development?

Hoyles in her keynote paper discusses an alternative sequence for developing ideas of proof—the 'seeds of proving are sown' in a computer-based construction process which requires an explicit description of relevant properties and relationships. C Laborde also addresses a similar issue in her investigations as to how the dynamic nature of software (*Cabri*) changes the relationship between diagrams and the theoretical aspects of the mathematics; but not without tensions on the part of the learner in attempting to move between the two domains.

The papers by Leron & Hazzan and Adhami, Johnson & Shayer provide instances of applicable research and theory—constructivism and, in the case of the second paper, cognitive psychology. The first of these includes examples of constructivist environments and highlights the process of 'learning by successive refinement', while the second draws upon the literature in mathematics education, social constructivism (Vygotskian psychology) and Piagetian and neo-Piagetian theories on levels of thinking, to provide a theoretical foundation for teaching and learning—teacher *intervention* and pupil-pupil interaction.

Examples of experiential projects with links to sophisticated ideas from mathematics and computer science are described in the paper by Fell. These illustrate how many of the ideas can be made accessible to children and adults with very little mathematical background.

Three short papers are also included. The paper by Blomhøj has its focus on construction of personal meaning in the area of trigonometry and that by Dettori, Greco & Lemut illustrates how the learning of the important concepts of variable, parameter and unknown can be enhanced through the use of complementary software environments. The final paper, by Lingefjärd & Kilpatrick, discusses work with prospective teachers in using technology to model difficult mathematical problems—with some interesting outcomes linked to issues of authority and responsibility (e.g., with students becoming rather uncritical of the results they obtained with the computer) and the need to address these issues directly in instruction.

It is clear that many exciting possibilities are now being realised in the theme areas of curriculum, teachers and learners and also that much more needs to be done. There is another question which also needs to be addressed—how do all the visions being espoused fit with the realities of today's world, the 'global community'?

Human and social issues

Growing demands are now being placed on mathematics by the natural and social sciences in their approach to the various problems encountered in our societies. Our premise here is that mathematics can only respond to this by relying on communication and information technologies. The issues thus raised in connection with both individual and social development require serious consideration. Key issues include the effect of this new environment on culture, the need for national policies, the special requirements of developing countries and aspects of people working in the 'global community'. We question whether 'edutainment' has anything to offer and if equity is achievable. At an individual level, the main issue is the fostering of independent thought and action as well as reduction of technophobia.

Anderson in his keynote paper provides an overview of the multiple issues in this theme—with particular attention given to the widespread student disregard of ethical standards related to unauthorised software copying and computer-aided privacy violation. He proposes the need for the development of explicit strategies for addressing many of the complex issues in the classroom. Marshall carries the theme forward with her focus on aspects of 'edutainment' software and issues related to epistemological assumptions, pedagogical style and cultural biases. Each of these issues also has implications for equity. Cultural concerns related to developing countries are then addressed in the paper by Arganbright, with a special focus on the use of spreadsheets for mathematics in a particular context (Papua New Guinea).

The paper by Graf & Yokochi addresses innovations in distance learning—classrooms in Germany and Japan interacting and sharing ideas through the use of telecommunications and multi-media. The section closes with the short paper by Cannings & Stager which presents aspects of new opportunities for mathematics teachers and educators to communicate in global learning communities via the Internet.

Focus groups

The programme of the Working Conference included focus group discussions of questions posed by participants, with the aims of contributing to the debate during the conference and of preparing position papers of conference participants' views on key issues. Eight Focus Groups were organised, each considering one of the four main themes (as indicated above). Each group then prepared a short report with recommendations, built on participants' experiences and points of view.

The last main section in this book is the outcome of the discussions which took place over four days of deliberations interleaved with other conference activities, including a Poster session presentation of preliminary ideas and a plenary Panel discussion of interim reports. The final versions of the eight reports are presented here, grouped thematically. There is considerable agreement within and across themes—reflecting again the fact that the themes are merely a matter of convenience in organisation as they all impact on one-another. However, each report also makes its own unique contribution—e.g., see the three reports on the theme 'Learners'. It is also the case that in certain instances the groups took on different, and in some ways opposing, positions—e.g., in their concerns for the balance between pupils' engagement with experimental or formal mathematical activity. Thus, it is clear that there is still a need for further discussion and debate.

It is hoped that the Focus Group reports, while serving as a means of inspiration for the future work of IFIP WG 3.1, will contribute to the thinking and planning of those having concern for ICT and mathematics at all levels.

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David Johnson took up the post of Shell Professor of Mathematics Education in the University of London in 1978, following 17 years at the University of Minnesota (USA). His teaching experience and research activity spans all levels from primary through university and he has been involved in school computing since 1963; activities which utilised hardware starting with mainframes in the early days, through time-share and leading on to today's micros and powerful new technologies, software and supporting equipment. He has been a member of WG 3.1 (and contributor to the working group publications) since its early days.

David Tinsley retired from his post as Chief Inspector of Training in 1992 and has since worked for the Red Cross and as a management consultant. His early career was in secondary school mathematics teaching, during which time he helped IBM develop the first computer for schools. After working for the National Computing Centre he was a General Inspector of schools in Birmingham and then Education Officer for further and higher education. He joined the Government Service in 1984 as Director of the Open Tech Programme and then pioneered a national quality assurance system for government training schemes for young people and adults. David has been a member of IFIP WG 3.1 since 1968 and has edited or contributed to a number of international guidelines during that time.