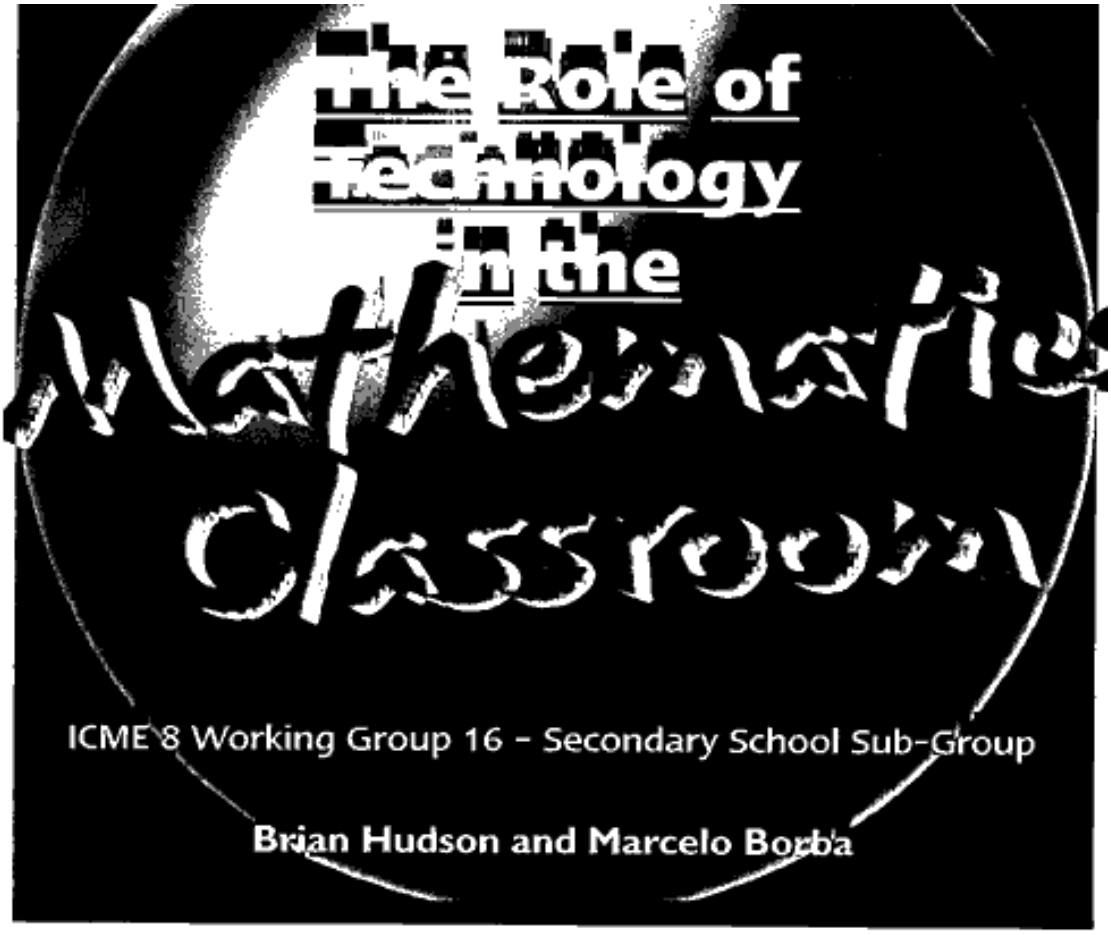

Introduction

In this paper we report on the work of the Secondary School sub-group of Working Group 16 at the International Congress on Mathematics Education (ICME 8) which was held in Seville during July 1996. The focus of the group was on the *Role of Technology in the Mathematics Classroom*.

Opening session

In their paper for the opening plenary Rina Hershkowitz and Baruch Schwarz offer a view of the mathematics classroom as a community of learners involved in joint social construction, in which the role of the teacher is seen to be central. They draw on the work of Paul Cobb and Erna Yackel in developing their thinking around the notion of sociomathematical norms. They argue for the need to consider, not only social norms but also socio-mathematical norms, when describing the development of mathematical knowledge in a social context. An example of a social norm is the acceptance that collaboration can be useful to investigate and solve problems, whilst a socio-mathematical norm is that 'problem situations are seen as more valuable than the solution'. They propose that socio-mathematical norms can be renegotiated with activities around problem situations, the use of multi-representational tools and teaching actions inviting reflection. Characteristics of classroom activities include an element of pupil choice, collaborative group work, a process of comparing and critiquing and the teacher's role as co-ordinator, synthesiser, facilitator and modeller. They proceed to develop some ideas around the notion of socio-mathematical norms directly related to technological tools. An example is the idea that the products deriving from the use of technological tools cannot count as justifications although they can help.

Reports from other countries

Munirah Ghazali and Zurida Haji Ismail from Malaysia report on the use of technology in the teaching of mathematics in Malaysian Secondary

Schools and in particular on the use of spreadsheets. Their paper includes a report on a survey of teachers' attitudes towards and understanding of technology and a discussion of the use of spreadsheets in the mathematics classroom in Malaysia. The results of the survey show a generally positive attitude on the part of teachers towards technology but also that little use is currently being made of computers in Penang Secondary Schools in particular. Computer availability is not seen as the central problem, suggesting that staff development might be such. They also report on the use, with sixteen year old students, of the 'Fence problem' involving a farmer who is fencing a section of field and trying to maximise the area. They outline the use of a numerical solution (although not graphical or visual) by using the spreadsheet. The student response to the use of the spreadsheet is to see it as 'more exciting', 'not as abstract' and 'more exciting than straight forward differentiation'. The authors suggest that the students find mathematics more meaningful when using the spreadsheet by enabling them to 'focus on the underlying concepts and processes rather than on the final numerical answer'.

Yoshinori Shimizu, Miho Ueno and Kenji Tanaka from Japan report on the use of function plotting software and graphical calculators with 11th grade students. They outline classroom activities based on observing the behaviours of polynomial functions. The activities are designed to help students understand the concept of function and properties of families of functions. They involve guided exploration, observing similarities and differences in order to find characteristics of cubic functions. The use of the technology prompted activities such as trial and error methods, conjecturing and testing and working with dynamic images to explore common properties of families of functions. They characterise the use of the computer 'as a tool' for exploring characteristics of cubic functions and for checking results. They observe that the sequence of the mathematics curriculum changes as a result of the use of technology. They observe also that the roles of teachers and students changed. For example new questions arose from the interaction between students and teachers, the level of communication increased, both teacher-student and student-student. The teacher's role shifted 'from demonstrator to co-explorer and promoter of exploration'. They observe further that there was less emphasis on symbol manipulation.

A further contributor from Japan, Osamu Takenouchi, addresses the question of 'why do we use computers in the mathematics classroom?', with particular reference to function graph plotting software and graphical calculators. He argues that computers promote students' powers of visualisation and he illustrates this with reference to examples involving graphs of quadratic functions, expressions of imaginary roots of a quadratic equation, approximations of by fractional numbers and Simpson lines.

The use of graphing calculators in South Africa is reported on by Paul Laridon. In particular he reports on the findings of a research project with the aim of ascertaining the viability of the use of graphing calculators in typical South African High Schools. He finds that the use of graphing calculators is still in the initial stages and that there are only isolated instances of use. He argues the need for curriculum reform in line with developments in the technology. Some 'clear outcomes' from the High School project highlight the key role of the teacher in implementing the use of new technologies and the need for teachers to be supported on a large scale. Finance remains a serious obstacle in South Africa. General usage in High Schools is seen to be still some years away, although use in colleges and other tertiary institutions is closer.

Marcelo Borba from Brazil emphasises the way in which the use of graphic calculators can 'reorganise activity' in the classroom, in the context of work on functions. He proposes that formulating the problem is a fundamental part of human intellectual activity. He reports on a study that combines two pedagogies - 'modelling' and 'calculator-experimental' - in relation to investigating functions and modelling data points. He argues that reorganisation of activity in the classroom is due to the mediation of the teacher-student relationship by the computer. Features of this reorganisation include an intensification of discussion and calculators becoming seen as a new 'authority' in the classroom. There is more independent investigation and more generation of conjectures. Some traditional topics are made obsolete and others become more accessible. The use of the technology is seen to have a positive influence on students' understanding. The role of teacher as is seen as 'instigator', 'helper' and 'systematizer'. It was seen as essential that the students are released from calculations and algebraic

manipulations in order to 'find the function that could model their data points'.

The paper from Miriam Amit and Hanna Perl of Israel presents an outline of a model of transition from a limited research experiment to a national project for integrating graphic calculators into the upper secondary school. They report on the mandatory use of graphic calculator technology in upper level of secondary schools in Israel as from 1995. Aspects of the project which they discuss include firstly the scope, funding and process of implementation, secondly teacher education and teaching materials and thirdly curriculum and assessment. In relation to the latter they report on changes relating to pedagogy, the nature of mathematical tasks and classroom interaction. They observe that students were more engaged in problems of enquiry and investigation of patterns and attributes of families of functions and that generally there was evidence of greater student self-responsibility. They also report on the next stages, which include an extension of the scope of the project, the development of an evaluation system and a systematic study.

An IT rich mathematics curriculum is reported on by Dave Miller from the UK. In particular he focuses on the use of Logo programming and offers a review of recent research and some examples of Logo-based activities. He observes that many schools in the UK do not make use of IT in maths and that IT is more likely to be used with younger children (12-14 years) than with 15/16-year-olds. He identifies constraints on the increased use of IT including the level of available resources, teacher expertise, beliefs and attitudes and the lack of suitable courses and texts which integrate the use of IT. He notes further that the situation is changing due to the requirement of the National Curriculum for teachers of mathematics to use IT. In relation to Logo use, he argues that Logo is widely available and is also applicable to the mathematics curriculum. He proposes that the use of Logo activities, on a regular basis, will lead to improved pupil motivation and a greater level of interest in mathematics as well as helping to improve mathematical understanding.

A comparison of two situations involving the use of the computer algebra system, DERIVE, is offered by Jean-baptiste Lagrange from France. He contrasts the use of a computer room with use of hand-held calculators. In the setting of the computer room the students were working in pairs engaged in algebraic modelling. They were generally autonomous and co-operative. The problems for the teacher were in 'trying to control the advancement of the task effectively'. In the classroom each pupil had access to a TI 92 calculator and the teacher was able to display the screen of the calculator and to 'manage the work of the pupils' as in ordinary classroom situations. As a result, pupils' attention was constantly directed towards the advancement of the task and to a collective discussion of the issues. Sometimes pupils 'could not give enough application and reflection to the task, because they were pressed to advance it'. The questions for discussion, which he offers, include how distinctive technologies give distinctive situations in a classroom and how a teacher can manage those situations so that pupils may really give meaning to the task.

A further paper on the use of computer algebra systems is offered by Nurit Zehavi from Israel. A topic from number theory is used to show how to take advantage of the numeric power of DERIVE to enable children to follow and appreciate a proof in number theory. The symbolic facility is used to solve inequalities where the goal is not simply to solve the equation but rather to understand the basic steps of the procedure. A further example involves the linking of different representations, where the computer does the formal manipulation and the plotting, whilst the student is expected to build the relational understanding linking the representations. Classroom experience using DERIVE is discussed. The teacher found that the tasks created an enjoyable challenge that helped to maintain student interest in focusing on specific aspects. Algebra became a subject to explore rather than a subject of manipulations and techniques. Questions are raised about the curricular implications, effects on student understanding and forms of relevant assessment.

An example of the use of multimedia in the classroom is reported on by Brian Hudson from the UK. This approach involved the promotion of the use of group work. Particular features of the software include high quality video images of motion (on video disc and CD-ROM), a flexible mode of viewing the images, student choice on what to view and what graphs to consider, non-judgmental feedback from the computer and an

emphasis on the process of graphical interpretation. The framework for evaluation is based on a view of learning as a fundamentally social activity, the role of the teacher being seen as an active communicative participant and the computer as a medium for communication. Effective interaction was found to be dependent on engagement of the students in a cycle of observation, reflection, recording, discussion and feedback.

Summary and discussion

The issues arising from the review of the presented papers covered a number of broad areas as summarised below:

The computer/calculator was conceived as:

- a tool
- a mediator of the teacher-student relationship
- a medium for communication

The role of the teacher was seen to change as a result of using technology and was variously described as:

- orchestrator, synthesiser, facilitator, modeller, co-explorer, promoter of exploration, instigator, helper, systematizer
- the key role of the teacher was also an issue in relation to successful implementation as was the need for support in this task in terms of INSET

Mathematical processes were emphasised, such as:

- conjecturing and testing
- formulating the problem
- more independent investigation
- more student responsibility
- elaborating and validating conjectures
- enquiry and investigation

There was less emphasis on:

- manipulating symbols
- calculations
- algebraic manipulations

With regard to the curriculum, issues and questions raised were:

- the sequence of the curriculum changes
- curriculum reform becomes necessary
- how to integrate with the ongoing curriculum
- making traditional topics obsolete and others more accessible

On the issue of assessment it was generally seen to be the case that:

- assessment practices need to change

In terms of communication, aspects highlighted related to:

- increased level of communication
- more communication about mathematics
- more discussion and reflection
- group work was emphasised
- learning was seen as social activity

Motivational issues raised related to:

- the real meaning given to the tasks
- the generally more meaningful activity that was generated
- improved motivation and level of interest on the part of students.

These issues were compared with some of those raised by Rina Hershkovitz in her opening plenary and many common issues were identified. Following the small group discussions there was the opportunity for feedback from the groups. The first issue arose as a result of discussion about assessment practices. This led to a consideration of how the use of the technology changes the nature of the mathematics itself. A further issue was the importance of teachers' own subject knowledge and their confidence in their own mathematical abilities in order to work effectively in more open-ended ways. This led to another group stressing the need for teacher training both in subject knowledge and in the use of technology. Motivation was discussed and it was emphasised that this results not only from using the technology but also, more importantly, from the nature of the task. One group asked for

the evidence that the use of the technology improves or facilitates (not simply changes) the learning of certain concepts. Good examples of changes in curriculum resulting from technology use were called for which highlighted the need for pedagogic research in this area. The question was raised about how assessment practices might need to change as a result of using the technology. Issues around the 'transfer' of learning when using technology and when using pencil and paper were also raised. This led to the question of whether mathematics with pencil and paper was necessarily the 'same thing' as mathematics with technology. It was suggested that it might be useful to think about multiple forms of mathematics; for example the mathematics of different microworlds such as LogoMaths, SpreadsheetMaths, CabriMaths, etc. There were also different ways of working with the technology, such as using hand-held machines in the mathematics classroom in contrast to going to a computer room. It was further suggested that it might be useful to consider what is the same and what is different about these various practices.

The international dimension of this paper gives an unusual distinctiveness to the issues arising. Given the wide diversity of backgrounds, cultures and countries from all around the world, the degree of similarity in the issues arising seems to be remarkable. It is with anticipation that we look forward to continuing the activities that were so successful and rewarding in Seville at ICME 9 in Japan in the year 2000.

Brian Hudson works at Sheffield Hallam University and co-ordinates the Mathematics Education Research Group.
Marcelo Borba works at UNESP (State University of Sao Paulo) Brazil.

Reference

Borba, M., De Souza, T., Fey, J. and Hudson, B. (Eds): 1997, *The Role of Technology in the Mathematics Classroom: Proceedings of ICME 8 Working Group 16*, UNESP – State University of Sao Paulo, Brazil

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