A PowerMaths approach towards collaborative learning

Gerald Cort
Imperial College & City of London School
powermaths@aol.com.uk

D R Brough
Imperial College of Science, Technology and Medicine
drb@doc.ic.ac.uk

I J Stevenson
Institute of Education, University of London
I.Stevenson@ioe.ac.uk

Paper published in Beijing Conference
ICCE 1998

1 Introduction

PowerMaths is a collaborative project between Imperial College and City of London School. It consists of a series of computer supported modules developed to introduce the mathematics of Key Stage 3 of the British National Curriculum [1] to pupils as well as consolidating all the material of Key Stage 2. By September of 1995 the first two (of a series of six) modules that were to form the basis of the initial text had been completed. Further modules have been added on a termly basis. It is intended to be the first of a series of texts leading up to Key Stage 4 and preparing pupils for the Mathematics GCSE examination.

In this paper we will describe some of the considerations in designing a computer-based learning environment and give a few examples of our approach. The paper will conclude with a discussion of some of the more general issues associated with this mode of using computers in teaching and learning.

2 Design Considerations

The potential of computers for capturing the interest of pupils has been obvious for some time. We wished to harness this enthusiasm and the tools that computers can provide to aid the learning of mathematics. A key consideration in designing the material was to make maximum use of computer support, using a medium that was readily available to children both at home, as well as the classroom.

Spreadsheets provided us with a very attractive option. They combine spatial organisation of numerical information with graphs, giving rapid calculation and multiple representation with visibility of process, placing construction and control of the sheets in the hands of the user. They are also commonly available on PCs. From an educational point of view, spreadsheets are being used at all levels, primary, secondary and tertiary [3]. Their role in aiding the development of key mathematical ideas and processes in, for example, algebra is being actively researched [4]

This had two implications for the design of the modules which make up the course. First, the traditional presentation order of the Maths syllabus had to be modified to enable the spreadsheet to be introduced right from the start. Ordered pairs and co-ordinates for example are brought forward to lay the necessary foundation for the use of spreadsheets. In addition, suffix-notation algebra is introduced early so that cell references can be constructively used in "surface" programming. The second aspect of design was to integrate learning of EXCEL [2] into the course materials so that the children were introduced naturally to the facilities of the spreadsheet as they worked through each module.

A second area of consideration in designing the course was the pedagogical framework for the material. Two sorts of materials were needed in the modules of the course. First, there were the traditional "passive" mathematical texts which covered the content of relevant sections of the UK National Curriculum. Second there were the guides and activities which integrated the mathematics

with the spreadsheet environment providing, on the one hand, a progressive introduction to the relevant facilities of the spreadsheet, and on the other, a framework for learning mathematics through experimentation within the spreadsheet.

The role of the teacher in this process needed careful consideration. One of the potential advantages of computer-based instructional environments is that they provide the teacher with the opportunity to work intensively with individual children, while other pupils make progress at their own pace. Computational environments also provide opportunities for methods of formative assessment, giving each child immediate feedback about their progress, and offering remediation which is non-judgmental and "patient".

How these considerations were implemented in practise will be illustrated by considering examples from module 3: Angles, Circles and Triangles and Module 4: Ratios, Rationals & Fractions.

3 A few examples from the modules

Using the Spreadsheet as a thinking tool

Here the aim is to get the pupil to be actively rather than passively involved in the learning. She is first guided to tailor a spreadsheet to solve the questions given in the previous exercises. She is then encouraged and think how to modify it to cope with more difficult questions and the way of thinking required to solve them.

In tailoring their own spreadsheets the students are learning not just forward planning and design-discipline but also relatively advanced algebraic relationships necessary to express the problem as formulae in the cells.

Classroom experience with year 7 children at secondary level have suggested that such algebraic structures, when introduced in this way, come naturally to them; they see the point and immediate purpose of the algebraic representation and are subsequently rewarded with a sense of achievement. More importantly the foundations are laid for a more formal and thorough approach to the subject later.

Conventional calculators, even graphic calculators, cannot compete with the spreadsheet in promoting creative learning.

Animations

Excel, both because of its inbuilt facilities and through the use of Visual Basic for Application (VBA) lends itself to a wide range of approaches to reinforce the learning process. In addition to using it as an interactive thinking tool, very many mathematical concepts can be animated to make them clearer.

Mathematical Microworlds

We are also developing a series of microworlds where predefined tools and objects representing mathematical concept areas (such as statistics or transformations for example) allow the pupil to experiment with and possibly extend the ideas being learned.

4 Power Maths and Pedagogy

As we have noted, the model of teaching and learning used by The PowerMaths project is predominantly that of Computer-based Learning, characterised by a highly structured learning path constructed from a detailed analysis of the task domain by the designer [6]. This places control of the learning process with the computer-based material, although the student is invited at various places to investigate aspects of the mathematics. From a cognitive point of view, the student explores the

designer's model of the curriculum using the spreadsheet as the medium of instruction. [7]. It would be desirable for children to have the opportunity to work on more open-ended and investigational activities, adopting a more expressive mode of using the computational medium [7]. This would help them consolidate their understanding of the mathematics and develop their facility with the spreadsheet. This aspect and other implications of the approach is the subject of ongoing research and development work.

From a teacher's point of view, however, the relatively tight definition of the learning path has a number of attractions. First, as we indicated in section 2, teachers have more time to work with individuals since they know that other students are engaged with the material and can progress at their own pace. A second area of potential interest for teachers is in the management of technological innovation in mathematics.

Change can provide both challenges and threats. At both personal and professional level, it can call into question values, beliefs and practices that were previously assumed and accepted by teachers. Teachers are expected to be "in charge" in the classroom both as managers and as "the one who has all the answers". Moreover, teacher's confidence both in themselves and their professional competence is related to their ability to cope with the unforeseen either by being flexible or by minimising what does not go according to plan. Technology in the classroom represents an area of anxiety. It can "go wrong" and this will render the lesson useless with possible attendant negative response of the pupils. The teacher is expected to "know the answers" by the pupils and by the teacher him/herself. Technical competence is seen, therefore, as a necessity to both maintain control in the classroom and maintain pupil's confidence in technology. [8].

The PowerMaths material and its paradigm of learning provides a way of managing the introduction of technology into the classroom. First the mathematical content is very familiar, since it relates directly to requirements of UK's national curriculum. Teachers do not have to learn new mathematics, rather they can exploit the facilities of animation and dynamic interaction which computers offer within the framework of a curriculum that is tried, and tested. Second, spreadsheets are readily available within schools, and many teachers currently make use of them in teaching and learning mathematics. Finally, although the underlying model of teaching which the PowerMaths Project adopts shifts the student's attention from the teacher to the computer, the teacher can still control and monitor the progress of learning. As an added bonus of this, much of the marking of exercises is done by the child herself as she can test her answers against those generated by the spreadsheet. In short, PowerMaths provides opportunities for teachers to evolve their classroom practice in the context of new technologies rather than requiring a revolution.

5 Beyond the Classroom

Using a spreadsheet such as EXCEL has a number of advantages, particularly when seen in the context of connectivity and distance learning. Wth the growth of personal computers in the home and the increasing numbers of individuals who are connecting to the Internet from their homes, PowerMaths materials provide an number of interesting possibilities. Three in particular are worth discussing: dissemination of materials, e-mail and NetMeeting based discussion and home-school links.

It is becoming common place for curriculum materials to be available using the Web. Activities which have been tried and refined in classrooms are routinely published for other students to down-load and use. E-mail discussion groups of teaches and students accompany the Web-pages, so that information about the implementation of the materials can be circulated and discussed. Power Maths material are being made available in this manner, and because it uses a commonly available piece of software, it can be used in the home as well as the school.

Developments in the teaching of courses on-line have highlighted the importance of focusing e-mail discussion groups around specific topics. Generalised discussions tend to de-generate into "chat" after initial introductions unless there is a specific task-orientation. Power Maths materials can provide a focus for such discussion. The materials are tightly defined in terms of their content and learning path, and this structure can make e-mail discussion effective. There is the possibility of a "virtual classroom" forming around the Power Materials through the use of e-mail groups in which students can communicate with a "remote" tutor, but also with other students who are engaged in the

same activities. We are also actively experimenting with the use of small scale Video Conferencing via the Web initially using Microsoft's NetMeeting which provides on line sound and video interaction. More importantly we have found its shared "whiteboard" facility very valuable for remote tutorials.

During trials of the materials many parents have expressed an interest in the activities of the children as they used Power Maths. Some parents have become interested in learning how to use the spreadsheet through helping their children with Power Maths activities, others were drawn into the mathematics. The fact that the materials are implemented in one of the most commonly available pieces of business software makes it accessible to many parents working at home, and provides the students with a training in computational tools that they may use in later life.

6 Conclusions

The next stage in the development is a systematic evaluation of the learning outcomes of the PowerMaths materials, and more extensive trialing in schools. As indicated in the discussion, the use of spreadsheets as a medium for students to investigate and express their own understanding of mathematics, is an area for development in designing the materials.

Further modules are being developed and trialed term by term and we are now working with a class of special needs children who have responded extremely positively to the approach. Work is progressing on fully electronic availability of the materials both on CD Rom and also via the Internet. The problems of providing the level of interactively desired via Java and Pearl are currently being addressed.

References

[1] The Maths National Curriculum for Key stages 2 and 3. Department of Education .

[2] Microsoft EXCEL User Guide - version 5. Microsoft Corporation.

[3] Beare, R. "How Spreadsheets Can Aid a Variety of Mathematical Learning Activities from Primary to Tertiary Level". In Jaworski, B. (eds.) *Technology in Mathematics Teaching. Proc.TMT93*. University of Birmingham (1993)

[4] Sutherland, R. "Algebraic Thinking: the role of the computer". In *Technology in Mathematics Teaching - a bridge between teaching and learning.* Burton, L. and Jaworski, B. (eds.) Bromley: Chartwell-Bratt.(1995)

[5] Microsoft Visual Basic (applications edition for EXCEL) User Guide. Microsoft Corporation.

[6] Sewell, D. F., and Rothery, D. R. (1987) "The Application of Computers in Education". *Prospects*.. Vol. **XVII**, No. **3**. (pp. 379 - 386).

[7] Bliss, J. (1994) "From Mental Models to Modelling". In Mellar, H., Bliss, J., Boohan, R., and Tompsett, C. (eds.) *Learning with Artificial Worlds: Computer-Based Modelling in the Curriculum.* London. The Falmer Press.

[8] Stevenson, I. J. and Hassell, D. (1994) "Modelling and Teacher Change". In Mellar, H., Bliss, J., Boohan, R., and Tompsett, C. (eds.) *Learning with Artificial Worlds: Computer-Based Modelling in the Curriculum.* London. The Falmer Press.