TEACHERS NOT USING COMPUTERS TO TEACH MATHEMATICS

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Unexpectedly a number of teachers teaching Mathematics in three Melbourne secondary schools did not explore extensively the use of computers in their teaching over a five-year period, even though it appeared that conditions would have encouraged this. Their colleagues teaching other subjects did take up the opportunities that came with the state government providing ample money for their schools for computer hardware and software. The unexpectedness was not only because of these resources being available, but because of the history of Mathematics teachers being at the forefront of computer use. It appears that the emphases in the external curriculum, lack of professional inservice, and the teachers already demonstrated success in teaching mathematics obviated the exploration of advanced computer applications.

Introduction

Contemplating how to deal with the use of computers when teaching Mathematics is for many teachers akin to entering a new culture. It is admittedly not completely new, but perhaps a partially known territory, since most have a working knowledge of how to use computers. They have some knowledge of word processing, probably can use a spread sheet program, have been on the internet, and if educated to teach secondary Mathematics may have completed some computer language programming when at university. But how this technology impacts on their teaching can have a number of possible outcomes.

To some extent teachers of Mathematics in Victoria's secondary schools has been ambivalent which is somewhat surprising. There has been a debate going on for many years about the place of computers in the curriculum, and in particular in teaching Mathematics. It is surprising since it was the teachers of Mathematics who were among the first to explore the implications that computers offered (Clarkson, 1980; Jones, 1996; Clarkson & Toomey, 1996).

For the teachers of Mathematics in seven particular schools in Victoria, this issue of how they were going to respond to using computers in their teaching became critical in 1995. These schools, four primary and three secondary schools that formed the Navigator Project, were allocated extra resources to the tune of a million dollars plus per schools by the state government. They were to develop independently, but within the overall group project charter, processes that would incorporate new ways of teaching and learning that would benefit the students attending their schools.

The teachers of Mathematics in the secondary schools responded in the main with the question:

> "I've got all this new software and hardware. If I have to, how do I fit it into my teaching?"

This contrasted with the question asked by teachers of other subjects in these schools:

> "What impact, if any, should access to this new hardware and software have on my curriculum. I'll need to reflect on this?"

Three issues that seem to speak to this difference for the secondary teachers are explored below.

Methodology

An evaluation of the full Navigator Project lasted for 18 months (Dunbar, Clarkson & Toomey, 2000). This present paper is based on three databases.

The first database dealt with examination results. The three secondary schools and government department released specific information on the results of the external examinations held at the conclusion of the final year of secondary schooling (year 12).

The second database resulted from data gathered from a survey instrument distributed to all the 270 teachers in the schools and completed during a teachers staff briefing. To fill out the survey staff were asked whether they believed that computers were contributing to their teaching of the student learning outcomes ‘significantly’, ‘incidentally’ or there was ‘little or no’ contribution. They were asked to tick one of three columns with these headings, and then asked to write comments for each item explaining their choice. Each subject area was represented by listing the headings for the cluster of student learning outcomes as found in the official curriculum document (Board of Studies, 1996). For example for Science there were four headings: Earth and beyond, concepts, knowledge and skills; Life and living, concepts, knowledge and skills; Natural and processed materials, concepts, knowledge and skills; The physical world, concepts, knowledge and skills. For Mathematics there were six headings: Algebra concepts, knowledge and skills; Chance and data concepts, knowledge and skills; Mathematical tools and procedures concepts, knowledge and skills; Measurement concepts, knowledge and skills; Number concepts, knowledge and skills; Space concepts, knowledge and skills.

The third database was composed of data from interviews. The responses from the surveys were analysed to select a cohort of 60 teachers teaching different subjects that were actively using computers in their teaching. These teachers were interviewed a number of times both before and after they were observed teaching. This paper reports on the comments made by the Mathematics teachers included in this cohort.

Results

Examination results database

As a measure of the performance of these three schools, the average results for the three Mathematics subjects taught in year 12, during years 1996, 1997 and 1998 were compared to the average for each of the schools 'Like Group'. The notion of the 'Like Group' comes from the Department of Education's statistics. Each school is placed in a 'Like Group' depending on a comparison of the Socio Economic Status of schools, the number of their students who speak English as a second language, the number of their students who are recipients of government welfare payments, and so on. In this comparison across the three years in the three subjects, for 24 of the possible 27 comparisons these schools were above their own 'Like Group' averages. For some years, one or other of these schools had the highest average for their 'Like Group' for one of these Mathematics subjects. When these comparisons are made with all schools in the state, on a number of occasions the results from these schools exceeded the state average. It appears that the teachers in these

schools are 'succeeding' when their students are judged on criteria that their school, the Department, and the community regard as important measures of success.

Survey results database

The three secondary schools were very different. Hence there was no attempt at combining results of the survey across the schools. It also seemed more relevant to think about the percentage of teachers teaching a subject in a school who thought that the use of computers contributed significantly to their teaching of that subject. If there were more than 40% of such teachers in a school, then may be there would be a threshold number for some development in this subject area. On the other hand if there were more than 60% of teachers who thought that computers contributed significantly, there was an excellent basis in that school to really develop the teaching of the subject in new ways.

Table 1 shows the percentage of teachers who responded that the use of computers was making a significant contribution to their teaching. For example for Mathematics, the curriculum document listed six clusters of student learning outcomes (shown as [6] after Mathematics). Thus for 'School A', for 6 of the 6 clusters of student learning outcomes, more than 40% of the teachers teaching Mathematics in that school thought that computers contributed significantly to their teaching of these 6 clusters of outcomes. However, for only 1 of the 6 clusters did more than 60% of 'School A' teachers think that computers help their teaching significantly.

Table 1: The significance of computers for teaching in different subjects

Subject areas	**School A**		**School B**		**School C**	
	>40%	>60%	>40%	>60%	>40%	>60%
Technology [3]	3	2	3	3	2	2
Study of Society and the Environment [5]	4	4	5	0	3	2
Mathematics [6]	*6*	*1*	*1*	*0*	*4*	*0*
English as a Second Language [7]	0	0	5	2	6	5
Science [4]	4	4	1	0	1	0
The Arts [6]	3	1	4	4	1	0
English [7]	2	1	3	1	2	0
Languages Other than English [6]	4	3	0	0	0	0
Health and Physical Education [7]	4	2	1	0	0	0

An inspection of Table 1 shows that there are clearly big differences between schools and between subject areas. However it seems to be that the teachers teaching Mathematics,

although seeing some relevance for computers, are not as enthusiastic about their use as might have been expected given the long involvement of Mathematic teachers debating the use of and experimenting with computers in Victoria.

Interview database

The first database suggested that Mathematics teachers could claim that their students were achieving in Mathematics. The second database suggests that Mathematics teachers in these three secondary schools have not taken up the use of computers in their classrooms as much as their colleagues. We now examine three assertions that are in line with the above results, but which rellies more on the third interview database.

Assertion 1: Students are 'succeeding' in terms of official assessment reporting mechanisms without the use of computers. Why change something that isn't broke?

This notion of continuing success, coupled with some reluctance to incorporate computers in teaching, came through in a number of statements that teachers made to us. Hence one teacher showed caution when stating, "Technology is limited to only certain topics, as it is easier to teach using chalk and talk." Another commented that "Interestingly the changes so noticeable in Science have not occurred in Mathematics. Teaching in Mathematics is mainly aligned to the text as it always has been." A small minority of teachers were still down right cynical, even after teaching in schools for more than five years where there had been many opportunities to try new ways of teaching. "I've been to Professional Development sessions and although there are a lot of sensitive and intelligent people enthused about information and communication technologies, I do not for the life of me see any future for it. People from Archimedes to the tribes of the deserts did more art and more maths with a stick and sandy surface."

Another teacher looked to the government curriculum on which their school curriculum was based. Her insightful response was summarised as follows:

> The current Mathematics curriculum is an amalgam of the previous school based Mathematics curriculum and the present government one, and by its own admission "provides quite a crowded program". It is a linear curriculum relying substantially on textbooks as a source of information and activities, and uses tests as significant (but not the only) measures of achievement. For example, in years 7 to 9 the semester 2 grade "is determined by the percentage mark calculated from topic test results (min. 70%), an end of year common test on the full year's work (20%), and assignments/ classwork / homework (max. 10%)". Within such a curriculum, computers largely are treated in the same way as calculators; as tools for calculating.

The present Mathematics curricula in secondary schools is in the main "closed", offering few opportunities for open-ended learning activities where students can, in fact, be "autonomous learners". This is less the case with say the Science and English curricula. Generally, Mathematics teachers have not had the incentive to integrate information and communication technologies into their teaching. Mathematics curricula have yet to value the kinds of learning which are so well supported by the new technologies, and which are recognised as being valuable in higher learning and the world of work.

The limited response of many Mathematics teachers in these three schools to the uses of computers has not lead to any drop in achievements in Mathematics. Ironically perhaps, several Mathematics teachers are at the forefront in experimenting with learning technologies and in-servicing others.

Assertion 2: After many years of arguing, the hand held calculator, particularly the 'graphics' calculator, has finally been accepted as a legitimate and important resource for teaching Mathematics. What more can a computer do?

Within such a curriculum where the boundaries are tightly defined, computers can be largely treated in the same way as calculators. One teacher of junior grades commented, "As tools for calculating". As such they have a valuable contribution to make to Mathematics learning, but their vast potential is missed.

It is a little different in the senior secondary years. For example students jointly used the computer and the graphics calculator for a statistics project. Their teacher noted that "This was an investigative project involving obtaining statistics and analysing the data by creating regression lines and other data fitting techniques. The project used graphic calculators and the use of the Internet to obtain the raw data." Indeed it appeared that the main impetus for year 12 use of computers for learning came from students themselves. Another teacher commented that "Mathematics students use graphic calculators in Mathematics classrooms, but the computer is largely confined to student's own work outside the classroom. All students use word processing for the production of reports; none would dream of producing a handwritten final draft."

Mathematics teaching in these schools, as else where in Victoria, does use hand held calculators, including, in the senior years, graphic calculators. It is asserted here that the use of calculators has blocked the wider use of desktop and laptop computers. It needs to be recognized that calculators themselves are mini computers, especially the graphic calculators. However calculators at this time do not allow the exploitation of the much wider variety of possibilities brought on by desktop computers.

The use of graphic calculators is expected in these schools since they are used in year 12 external examinations. As well the most recent supporting curriculum document suggests the use of calculators from the middle primary school years, although it does not mention computer use (Curriculum Corporation, 2000). There is also active support for the use of calculators at the annual Mathematics teachers conference by academics, calculator companies and teachers. But this is not balanced by an active pursuit of the computer in such an arena, as will be shown in the next section.

Assertion 3: There is little professional development provided for teachers concerning more advanced applications for use in teaching Mathematics.

As noted above, teachers of Mathematics in these three schools use computers as calculating devices, searching the Internet for information, and for the production of assignments. Some other applications are also used. One staff member commented "Students have participated successfully in EXCELL activities this year". Another teacher's comments were summarised as follows: 'The advantages of using a spread sheet instead of pencil and paper are a large amount of information can be entered, information can be sorted in different ways, graphs can be easily drawn and time can be spent on analysing and interpreting the information. This allows the application of higher order thinking skills.'

This is good as far as it goes, but it also suggests that there has been a limited view of how computers can be used in teaching Mathematics. This was emphasised by another teacher who commented in passing, "In any case there is not enough software for Mathematics."

However some teachers were starting to find other applications. A Mathematics / Science teacher noted that "Graphmatica is used, for example to compare and analyse mathematical information (for example, developing the rules of quadratics), solve simultaneous equations,

and investigate trigonometric graphs." Geometer Sketchpad and Inspiration were also being used to some extent.

Given the history of teachers of Mathematics and computers in Victoria, and the wealth of computer resources available in general in these three schools, it is however surprising that more has not been attempted in this subject. But there are some real reasons for this. As one teacher said, "There is much less time to prepare lessons because the workload has increased enormously. Many new areas (both technology and general demands of the curriculum) have to be learned and sometimes I feel that I am doing many more things but not as well." Our field notes also recorded that, 'In LOTE, Mathematics and Science nearly one third of the teachers were still searching for applications that support their curriculum. It is suggested that this lack of awareness may be in part due to teachers having high expectations of themselves in exploring new applications, but also in part due to difficulties in accommodating past practice within a learning area to the benefits of learning technologies.'

There was actually little support for Mathematics teachers in these schools, and in the broader professional development opportunities, for exploring more advanced applications such as Cabri Geometry, Mathematica, Derive, etc. For example at the most recent Mathematics teachers annual conference there were 180 individual sessions, most of which were run at least twice for the 2000 odd participants. An analysis of the paper abstracts suggested that 20 sessions dealt with laptop or desktop computers in the teaching of Mathematics. Only one of these sessions was not dealing with the use of the Internet, spreadsheet programs or LOGO. This one session centred on the use of Mathematica. There were also no articles in the teachers journals, nor professional development sessions run by the systemic authorities dealing with 'more advanced' applications. At recent education research conferences (eg. those of Mathematics Education Research Group of Australasia and of Australian Association of Research in Education), there were no research reports on using high-level software applications for the teaching of Mathematics. However there were a handful of presentations that discussed teaching Mathematics using computers. Interestingly these sessions focussed more on the students than teachers.

Discussion

Most teachers of Mathematics in these three schools did not make a cultural shift during the life of the five-year Project, even though there were plenty of opportunities to do so. But such a shift is difficult, as others have noted when surveying the use of technology in the teaching of Mathematic (eg. Asp & McCrae, 2000; Balacheff & Kaput, 1996). One message that this present study again suggests is that there needs to be more thinking about teachers in this technology revolution in the classroom, not just about students. How do we help teachers to become more than 'technicians' who are practical straightforward solver of problems? Or even to become more than 'creative problem solvers' who have knowledge of many strategies and are prepared to choose different ones for particular context? What can be done so they are helped to be 'metacognitive professionals', who can compare and contrast strategies, can decipher different nuances of possible contexts, and are prepared to act accordingly? What is it that allows an individual to develop sets of characteristics such as these? One probable context that helps such movement is if a teacher is part of a like minded group. But what is it that builds the relationships in such groups so the transition between the cultures can take place? What is it that sustains such groups?

We suspect that for transitions to be made there needs to be contact with problems that are perceived as 'real' and the situation is difficult. The teachers need to have access to reasonable resources. They will be helped if there is interaction with 'experts' and work with mentors. The group and individuals may need to have the ability to incorporate knowledge

from non obvious sources, to be prepared to go and look elsewhere for solutions, which might be a pointer to a particular type of an attitude of openess.

We would argue that the groups of teachers of Mathematics in these three secondary schools exhibited a number of the above characteristics, and yet did not change their culture, did not progress very far with innovations with computers in their teaching. Hence it is not enough to examine characteristics of individual teachers, or even groups of teachers within schools, to see whether a cultural change and the degree of such a change has occurred. The external pressures that are also present need to be seen for their influence as well. In this case, ironically these teachers' success in terms of traditional external assessments, the type of curriculum that had to be adhered to, and the success with a 'competing' technology, combined to be a threshold that these groups of teachers did not surmount. Interestingly this was in schools that we believed had used their access to computer technology as the vehicle for 'successful' whole school change, and where some groups of colleagues teaching other subjects embraced the notion of teaching with computers that had redirected their teaching comprehensively.

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