EQUITY AND BELIEFS ABOUT THE EFFICACY OF COMPUTERS FOR MATHEMATICS LEARNING

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Members of society appear to have great faith in the educational value of computers. It is widely believed that computer use will promote learning. Unsupported by research evidence, many contemporary mathematics curriculum documents include statements advocating computer use and the benefits to be derived. As part of a larger study in which equity issues and perceptions of computer use for secondary mathematics learning are being explored, teachers' and students' beliefs about the benefits of computer use for mathematics learning were examined. The student data were also analysed across several equity dimensions. The findings are presented and discussed in this paper.

INTRODUCTION

In the developed world in particular, people seem to have great faith in the power of the computer to enhance students' learning. Selwyn, Gorard and Williams (2001) argue that "societal trust in the technological fix has been well established" (p.256). Contemporary mathematics curriculum documents include statements about incorporating technology (calculators and computers) into mathematics classrooms and of the related benefits to students. Reasons for the claims that computer use will enhance learning are put forward, but there does not appear to be strong research evidence in support of them.

One example of such claims is found in the technology principle, one of six underpinning principles of the USA's *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) which reads as follows:

> *Technology*. Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. (p.16)

A slightly less blatant perspective is put forward in the Victorian (Australia) *Curriculum and Standards framework [CSF] II* (Victorian Curriculum and Assessment Authority [VCAA], 2001a, website).

> The CSF encourages full use of the flexibility and value for teaching and learning programs provided by the increased application of information and communications technology (ICT).
>
> The CSF acknowledges that through the effective use and integration of ICT students are quickly developing new capabilities and that teachers have greater choice in creative teaching, assessment techniques and connections to students learning at home.

An *Information and Communications Technology [ICT] chart* (VCAA, 2001b, website) accompanies the *Mathematics CSFII – online*. The ICT chart reveals that students in grades 7–10 are expected to use a range of applications and computing skills for mathematics. The implied message is clear: computer use, will benefit students' learning.

To what extent, do secondary students' and teachers' beliefs match the rhetoric of the proclamations and expectations found in the curriculum documents? Do secondary teachers use computers for mathematics teaching? Do they believe that computer use improves their students' mathematics learning outcomes? To what extent do students believe that computers enhance their mathematical understandings? Are there differences in these beliefs among students categorized by a range of grouping factors?

As part of a larger study, data were gathered on teachers' and students' beliefs about the benefits of computer use for mathematics learning. The data sources included: large and small scale surveys of teachers and students, classroom observations, interviews with teachers and students, and students' post-lesson reflections. Due to space constraints, only findings from the survey data are presented in this paper.

PREVIOUS RESEARCH

There has been some research on beliefs and attitudes in relation to computer use in education with respect to equity factors: gender, socio-economic background, and race/ethnicity. Less relevant research has been undertaken in mathematics education.

Forgasz (2002a) summarised research findings on gender differences with respect to computers in general as follows:

> Compared to males, females are generally reported to be less positive about computers, like them less, perceive them as less useful, fear them more, feel more helpless around them, view themselves as having less aptitude with them, and show less interest in learning about and using computers; females are also less likely than males to stereotype computing as a male domain, to have received parental encouragement, to use computers out of school or to own one. (p.2-369)

Clarke (1990) reported gender differences favouring males in overall computer use, in course enrolments, and for programming and game playing. The gender differences were partially attributed to: expectations based on cultural beliefs about competence; associations of computing with mathematics, technology and maleness; and to the attitudes of parents and teachers.

Rather than serving as an educational panacea, Hanson (1997) maintained that computer use frequently exacerbated inequities for non-white students and for students from low socio-economic backgrounds. In a study focusing on computer use in grade 10 mathematics and science, Owens and Waxman (1998) found that females were less likely than males to report using computers for mathematics, and that African American students reported using computers more often than white and Hispanic students. Positive attitudes were postulated as the explanation for both findings. The latter finding, the researchers maintained, appeared to challenge previous claims that minority students had fewer opportunities to use computers than white students. In the UK context, Selwyn, Gorard and Williams (2001) question the assumption underpinning the UK government's claim that "providing access to technology for previous non-participants in learning will automatically lead to increased learning and decreased social exclusion" (p.262).

In a study of Australian mathematics teachers, Norton (1999) found that computers were considered equally or more effective than traditional instruction for doing calculations or providing basic skills practice. Few teachers considered computers useful in developing conceptual understandings; most argued the opposite with explanations for how computers might hinder understanding. One secondary mathematics teacher did not use computers for teaching mathematics because of beliefs about secondary level mathematics, teaching, personal teaching practices, and assessment issues (Norton & McRobbie, 2000).

THE STUDY

In this paper, findings are reported from data gathered in the first year of a three-year study [1]. The overall study aims include: (i) determining the effects of using computers on students' mathematics learning outcomes, (ii) identifying factors that may contribute to inequities in learning outcomes, and (iii) monitoring how computers are being used for mathematics learning in grades 7–10. Data on attitudes and beliefs about using computers for the learning of mathematics were gathered in the first year of the study.

Sample, instrument, and data gathering methods

Participants included grade 7–11 students and grade 7–10 mathematics teachers from 29 co-educational schools in Victoria (Australia). There were 17 metropolitan and 12 rural schools from across the three Australian educational sectors: government (19), Catholic (4), and Independent (6). Of the 29 schools, 8 were located in high, 16 in medium, and 5 in low socio-economic areas [2]. The sample sizes of the grade 7–10 and grade 11 students respectively were 2140 (F=1015, M=1112, ?=13) and 519 (F=237, M=281, ?=1). There were 96 (F=52, M=44) grade 7–10 mathematics teachers. Other characteristics of the student samples pertinent to the analyses undertaken are summarised in Table 1. None of these characteristics were relevant for the grade 7–10 mathematics teachers.

<table>
<tr><td></td><td colspan="6">Grade 7–10 students (N=2140)</td><td colspan="4">Grade 11 students (N=519)</td></tr>
<tr><td>English/Non-English speaking background [ESB/NESB]</td><td colspan="3">ESB
1643 (77%)</td><td colspan="3">NESB
491 (23%)</td><td colspan="2">ESB
365 (70.5%)</td><td colspan="2">NESB
153 (29.5%)</td></tr>
<tr><td>Aboriginal /non-aboriginal [ATSI/non-ATSI]</td><td colspan="3">ATSI
42 (2%)</td><td colspan="3">non-ATSI
2079 (98%)</td><td colspan="2">ATSI
7 (1.4%)</td><td colspan="2">non-ATSI
507 (98.6)</td></tr>
<tr><td>Student socio-economic status [high/medium/low]</td><td colspan="2">High
500
(24.2%)</td><td colspan="2">Medium
1185
(57.4%)</td><td colspan="2">Low
381
(18.4%)</td><td>High
88
(17.3%)</td><td colspan="2">Medium
328
(64.4%)</td><td>Low
93
(18.3%)</td></tr>
<tr><td>Laptop/Desktop computers used in mathematics</td><td colspan="3">Laptop
197 (9.2%)</td><td colspan="3">Desktop
1943 (90.8%)</td><td colspan="4">NA</td></tr>
<tr><td>Grade level</td><td>Gr 7
558
(26.1%)</td><td colspan="2">Gr 8
538
(25.1%)</td><td colspan="2">Gr 9
522
(24.4%)</td><td>Gr 10
522
(24.4%)</td><td colspan="4">NA</td></tr>
</table>

Table 1. Student characteristics: Frequency and valid percentages

Three different survey questionnaires were administered in semester two of the 2001 school year: (i) to grade 7–10 students, (ii) to grade 11 students, and (iii) to grade 7–10 mathematics teachers. The following items were included in each version of the survey:

Q1 Do you believe that using computers for learning mathematics helps **people** to understand mathematics better? **Yes / No / Unsure** (Please circle)

Why do you think this?

Q2 Do you believe that using computers for learning mathematics helps **you [your students]** understand mathematics better? **Yes / No / Unsure** (Please circle)

Why do you say this?

Analyses, results and discussion

The three groups of respondents

For each question, the distributions of valid responses (frequency and percentage) for each category of response (Yes/No/Unsure) for the grade 7–10 students, the grade 11 students, and for the grade 7–10 mathematics teachers are shown in Table 2.

	Do you believe that using computers for learning mathematics helps people to understand mathematics better?			*Do you believe that using computers for learning mathematics helps you [your students] understand mathematics better?*		
	Yes	**No**	**Unsure**	**Yes**	**No**	**Unsure**
Gr 7-10 students (Q1: N=2072[a]) (Q2: N=2009)	598 28.9%	602 29.1%	872 42.1%	525 26.1%	816 40.6%	668 33.3%
Gr 11 students (Q1: N=513) (Q2: N=381)	159 31.0%	134 26.1%	220 42.9%	122 32.0%	161 42.3%	98 25.7%
Gr 7-10 teachers (Q1: N=93) (Q2: N=80)	59 63.4%	9 9.7%	25 26.9%	49 61.3%	7 8.8%	24 30.0%

[a]Frequency of total valid responses to each item

Table 2. Frequencies and valid percentages of responses to the two items for grade 7–10 students, grade 11 students, and grade 7–10 teachers

The data in Table 2 reveal that:

- for grade 7–10 and grade 11 students, the percentages of "Yes" responses are very similar across the two items; the percentages of "No" and "Unsure" responses are reversed across the two items.
- for grade 7–10 teachers, the percentages of "Yes", "No" and Unsure" responses is very similar across the two items.
- grade 7–10 mathematics teachers are more convinced than both groups of students that computer use enhances people's and students' understanding of mathematics.

An interesting difference in the patterns of responses is that both groups of students appear more convinced that their own understanding of mathematics was not promoted by using computers (approximately 40%) than their views about the effects of computer use on other people (under 30%).

Reasons for beliefs that computers help in understanding mathematics

Enjoyment and the speed at which computers display 'solutions' were common reasons provided by teachers who believed that computers helped their students' understanding:

> Enjoyment, different to just doing paper calculations, produce accurate good looking graphs etc. – make predictions (gr.9 teacher, M)
>
> Particular software saves time and verifies their understanding. Computers allow them to carry out problems/exercises/questions quicker (gr.7 teacher, M)
>
> Students have different learning styles and many are very familiar with using a computer. This can then be used as a tool for learning mathematics (gr.9 teacher, F)

Most students did not provide explanations for their beliefs about computers helping their understanding. Among the grade 7–10 and grade 11 students who did (many more females than males) and who believed that computers had helped, common responses included: computers were fun; made the work more interesting; provided alternative perspectives; helped more than teachers; and/or had assisted in the understanding of particular mathematical concepts. Representative examples included:

> Because they are motivating + fun but you learn at the same time (gr.9, F)
>
> They put things in different ways (gr.7, M)
>
> Because it's visual (gr.8, F)
>
> Because computers explain more than the teacher does. When the teacher says something the students might forget it (gr.8, M)
>
> Because in some programs (eg., Excel) it is a good way to see/understand patterns & algebra (gr.7, F)
>
> It helped me with graphs, circular functions and with triangles, tangent, cos, sin (gr.11, M).

Reasons for beliefs that computers do not help in understanding mathematics

Teachers who used computers in mathematics teaching but did not believe that they helped their students' understanding of mathematics were somewhat cynical and negative about computers, and about students' behaviour with them. Typical examples included:

> It is just an instrument to arouse enthusiasm (gr.9 teacher, M)
>
> The students still see a computer lesson as a 'slack' lesson – or a 'fun' lesson. Because they mostly need to read instructions, they rarely understand exactly what we are trying to get them to master (gr.8 teacher, F)
>
> These students learn just as well without computers (gr.10 teacher, F)

The reasons provided by students were more perceptive and realistic than those provided by the teachers; the students had used computers in mathematics classes. Their views reflected: limited use of computers or inadequate computer skills; lack of appreciation of how the computer (software) works; the computer made no difference; a preference for teachers to assist; and a preference to work problems out for themselves. Representative examples included:

> We didn't really use them enough & I prefer to see how the equation is done (gr.11, M)
> 'Cos I didn't know how to make the computer do it properly (gr.11, F)

Because the computer does everything I don't need to think & therefore I don't learn (gr.10, F)
Because I still don't understand it, and it's just the same as doing it on the board or calculator (gr.10, F)
It is no difference to work with computers or maths books (gr.7, F)
Because I would prefer if someone told and explained it to me in person (gr.8, M)
I find it easier by hand (gr.9, M)

Differences in beliefs by various grouping factors

Chi-square tests were used to explore for differences in distributions to the categorical response data for each item by a range factors including several equity groupings.

For the grade 7–10 and grade 11 student data, the responses were analysed by:

- school factors: type (government/Catholic/Independent), school location (metropolitan/rural) and socio-economic location (School SES) [2]
- student factors: gender, socio-economic status (Student SES) [2], and two ethnicity factors: language background (non-English speaking/English speaking) and Aboriginality.

It should be noted that:

1. for grade 7–10 students only, the data were also analysed by: use of lap-top or desk-top computers in mathematics classrooms; and grade level, and
2. for grade 7–10 mathematics teachers, the data could only be analysed by: school factors (as above); and teacher gender.

The results of the chi-square analyses for the two items are summarised in Table 3.

		Gr 7-10 students		**Gr 11 students**		**Gr 7-10 teachers**	
Factor	**Grouping**	**Q1**	**Q2**	**Q1**	**Q2**	**Q1**	**Q2**
School factors	School type (Gov/Cath/Indep)	**	**	ns	ns	ns	ns
	School location (metro/rural)	ns	ns	ns	ns	ns	ns
	School SES (high/medium/low)	ns	*	ns	ns	ns	ns
Personal factors	Gender (male/female)	***	***	***	*	ns	ns
	Student SES (high/medium/low)	ns	**	ns	ns	-	-
	English/non-English speaking	ns	ns	ns	ns	-	-
	Aboriginality	ns	ns	ns	ns	-	-
Other factors	Grade level (7/8/9/10)	*	***	-	-	-	-
	Lap-top/desk-top computer	*	ns	-	-	-	-

* = p<.05 ** = p<.01 *** = p<.001 ns = not statistically significant

Table 3. Results of Chi-square tests for each of the two items by grouping factors: Levels of statistical significance

The data in Table 3 indicate that:

- there were no statistically significant differences in teachers' views about the efficacy of computers for helping people or their students understand mathematics by teacher gender or by any of the three school factors
- among the comparisons by common grouping factors, there were more statistically significant differences in the responses to both questions among grade 7–10 students than among grade 11 students

- gender appears to be the most significant equity factor in respect of students' differing beliefs about computers promoting mathematical understanding.

Among grade 7–10 students, differences in views on the efficacy of computers helping their own understanding of mathematics (Q2) were as follows:

- government school students were more convinced than Catholic and Independent school students that computer use helped their mathematical understandings (Yes: 28.3% cf. 23.6% & 21.2%); Independent school students were more convinced than the others that computers did not help (No: 45.2% cf. 41.0% & 38.0%)
- the higher the SES location of the school attended, the more convinced students were that computers did not assist their mathematical understandings (No: high – 45.6%; medium – 39.4%; low – 35.1%); a similar pattern was evident with respect to students' background SES (No: high – 47.1%; medium – 40.1%; low – 35.7%).
- males were more convinced than females that computers helped their understanding of mathematics (Yes: M – 31.3%; F – 20.3%); females were more convinced that they did not (No: F – 44.8%; M – 36.9%)
- as grade level increased, the students seemed less convinced that computer use helped their understanding of mathematics (Yes: grade 7 – 29.4%; grade 8 – 29.1%; grade 9 – 24.2%; and grade 10 – 21.5%)

Among grade 11 students, there was only one grouping factor on which statistically different views on the efficacy of computers helping their own understanding of mathematics. Males were more convinced than females that computer use had helped their understanding of mathematics (Yes: M – 34%; F – 29.8%); females were more convinced that they had not (No: F – 29.6%; M – 21.3%). It is interesting to note that across Australia at this grade level and beyond, more males than females are found to be enrolled in the most difficult mathematics courses.

CONCLUDING COMMENTS

Computer use for mathematics learning in Victorian (Australian) secondary schools is fairly widespread – about 70% of the participating teachers reported using them at some time (Forgasz, 2002b). Whether or not computers had been used in classrooms, the teachers appeared to believe more strongly than their students (approximately 60% cf. 30%) that mathematical understandings are enhanced by doing so. Many of the teachers' reasons seemed to be contradicted by the students' reasons for disagreeing. When students' beliefs were examined by various grouping factors, statistically significant differences were found in response distributions to the question on the effect of computer use on their mathematical understanding by school type, school location, grade level, students' SES, and gender. Statistically significant gender differences were also found for the beliefs of grade 11 students. These findings raise issues that invite further exploration: why do teachers' and students' beliefs differ so widely; are there specific mathematics content areas for which computer use does/does not enhance conceptual understandings; how can the effects of the grouping variables by which students' views differed be ameliorated? Answers to these questions will have important implications for the future implementation of computer applications for mathematics learning.

Endnotes

1. This study is funded through the Australian Research Council's Large Grant scheme. My thanks are also extended to Nike Prince for assisting in the data analyses.

2. The Australian Bureau of Statistics [ABS] provides an index of socio-economic categories – high, medium, and low – based on area postcodes (zip codes). Data on school location postcodes and students' home postcodes were gathered.

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