Computers are taking mathematics into the next century: Gender differences in the attitudes of secondary mathematics students to the use of computers

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Secondary students who participated in a computer enhanced mathematics program expressed positive attitudes about the use of computers. They viewed computers as a source of pleasure, success, relevance and/or power in mathematics. Girls were more likely than boys to qualify their support for the use of computers and more likely to view computers as a source of success in mathematics. Boys were more likely to claim that computers brought pleasure or relevance to mathematics learning.

Background

Computers and other learning technologies continue to be advocated by mathematics educators and researchers as providing opportunities for new ways of learning and doing mathematics appropriate to the times (for example, Arnold, 1997). Few studies have explored gender differences in attitudes to the use of computers in mathematics. This paper reports on the results of a qualitative analysis of responses to the open ended questions in a questionnaire administered to year 8 and year 9 students who regularly used computers for mathematics. Gender differences are discussed.

Research over the past decade has consistently found that males use computers more than females (for example, Rocheleau, 1995). Studies of attitude to computers have in general found little evidence of gender difference, but the results of these studies have depended on definitions of attitude and the age of participants in the study (Kay, 1992).

Some studies have investigated changes in attitudes to mathematics due to the use of technology (Dunham, 1991), however little attention has been paid to gender differences and only a few studies have explored the reasons for these attitudes (Rowe, 1993; Schofield, 1995; Kissane et al, 1995). Dunham (1991) conducted an experimental study of tertiary pre-calculus students using graphing calculators. She found that males improved their confidence in mathematics relative to females and females improved their performance relative to males. Boers and Jones (1993) also found evidence of tertiary females performing better than males in a program involving graphing calculators. Boers and Jones attributed this finding to a difference in attitude such that, the boys relied too heavily on the calculators, whilst the girls, concerned about cheating, concentrated on pen and paper methods.

In an ethnographic study of primary aged children using laptops and LOGO across the curriculum, Rowe (1993) found that a higher proportion of the most effective users of computers in comparison to least effective users believed that the computer helped them in their learning, put them in control of their learning and was an asset for their future. She did not include a gender analysis of these beliefs but did reveal that there were more girls than boys who were rated as effective users. Schofield (1995) conducted an ethnographic study of secondary students engaged in trialing a computer aided geometry instruction program. She found that there was an increase in "friendly competition" particularly among the boys and more able students that contributed to students' positive and negative

attitudes. She also found that the students enjoyed the lessons because there was an increased sense of control (over their own learning), an association with playing games, a sense of personal challenge, an increased opportunity to express negative feelings and a decreased fear of embarrassment. She did not provide a gender analysis of these factors but did argue that these factors were related to the nature of the software and the pedagogical style embedded in the software and the classroom.

Kissane et al (1995) conducted a study to determine whether tertiary students' views on the use of graphics calculators fitted with previously developed metaphors concerning the use of technology. These metaphors were: laboratory (using it to explore mathematical ideas and learn better), tool (using it to do mathematical tasks), teaching aid (using it to help with instruction), curriculum influence (a new element of content, teaching, learning and assessment), cheating device (a negative consequence of using technology), and a status symbol (a focus on the features of the technology). It was reported that the majority of responses reflected a positive view of the use of graphics calculators, however only 39 out of 73 students surveyed provided written comments and there was no gender analysis. The most common responses fitted with the metaphors laboratory, tool, curriculum influence and a new metaphor that was created, "nuisance".

Method

The sample: Students from two mathematics classes from a lower/middle class secondary school in Melbourne participated in the study. A total of 49 students (17 girls and 32 boys) from a year 8 class and a year 9 class completed the questionnaire. The ratio of boys to girls in the sample was almost 2:1. The bias was due to the huge majority of male students in the year 9 class (18 boys and 7 girls).

The year 9 class in the study was a "laptop class" with all students in this class leasing a laptop computer from the school. These students were in the second year of the laptop program and elected to be in the program at the beginning of the previous year. The year 8 class was a "high achievers class" with a program that included regular use of computers. Two mathematics lessons each week were timetabled in a computer laboratory. Some students in the year 8 class had purchased a laptop computer to use. The year 8 students were in the first year of the program. At the time that the questionnaire was administered, the year 9 students were working with a dynamic geometry application, *The Geometer's Sketchpad* and had been using *Excel* in the previous semester. The year 8 students had been creating a presentation of the solution process for multi-step equations using *Powerpoint* and were completing exercises in financial arithmetic using *Excel*.

Questionnaire and analysis: A questionnaire was designed to gather data about computer use, attitudes to computers and attitudes to computer enhanced mathematics. Three open ended questions were included in the questionnaire to gather information about students' attitudes to the use of computers in mathematics. These were:

- Do you think it is a good idea to use computers as part of maths? Explain your answer.
- What do you like most about using computers in maths?
- What don't you like about using computers in maths?

This paper report the results of analysis of responses to these questions. The responses were analysed qualitatively. The responses to the first question were coded numerically

(no; yes; sometimes or 'yes and no'). Trends in gender differences are identified since a statistical comparisons of the frequency distribution was not valid due to the small number of responses in some cells.

The qualitative analysis involved a process of data reduction to analyse students' opinions about the use of computers in mathematics. A "bottom up" or inductive approach (Miles & Huberman, 1994) to coding the data was used. The process of coding for data reduction involved three stages: creating codes, pattern coding to create categories and identify dimensions within these categories and finally tracing relationships between categories and identifying emerging themes (Miles & Huberman, 1994). The responses to the questions were treated as one data set, rather than 3 separate sets of data. Students' opinions about what they liked the most and what they did not like about using computers in mathematics were often different sides of the same coin. For example, one student believed that computers were "faster, easier and more efficient" whereas another student wrote "I don't like using Geometers (sic) Sketchpad because ... it always stuffs up." As part of the process of data reduction these two responses were initially coded "quicker" and "doesn't work properly" respectively and later in the process were identified as examples of the positive and negative dimension of responses that were grouped together (pattern coding) and categorised *technology*.

The number and sex of students for each code and category (including the positive and negative dimension) were recorded. It was not appropriate to use statistical tests for analysing gender differences because the number of responses in some cells was too small to produce valid statistical comparisons. However, the major variations in the pattern of responses between the girls and the boys are described.

Results

Do you think it is a good idea to use computers as part of maths?

Most students (78%) thought that using computers in mathematics was a good idea, though a higher proportion of boys than girls believed this. See Table 1. A higher proportion of girls believed that it was only a good idea sometimes and there was a higher proportion of boys who did not think that it was a good idea.

Table 1: Do you think it is a good idea to use computers as part of maths?

Response	Female		Male		Total	
	N	%	N	%	N	%
no	1	5.9	4	12.5	5	10.2
yes	11	64.7	27	84.4	38	77.6
sometimes/yes & no	5	29.4	1	3.1	6	12.2
TOTAL	17	34.7	32	65.3	49	100.0

Analysis of open ended responses

The following discussion analyses the explanations given by students for the answer to whether using computers in mathematics is a good idea or not, and their likes and dislikes about using computers in mathematics. The process of pattern coding yielded 13 categories for the students' responses listed in Table 2. Each of these categories has positive and negative aspects. Table 2 shows the number of responses from girls and boys in each category.(Note that the totals in the column do not add to the number in the

sample. This is because students gave responses to 3 questions and some responses contained more than one idea and so were coded in more than one way.)

Table 2: Categories for open ended questions and number of responses

CATEGORY	POSITIVE RESPONSES			NEGATIVE RESPONSES			TOTAL
	female	male	total	female	male	total	
Technology	5	10	15	7	8	15	30
Pleasure	6	18	24	1	5	6	30
Pedagogy	2	6	8	2	1	3	11
Learning Aid	7	2	9	2	0	2	11
Tool For Thinking	2	3	5	2	1	3	8
Tool For Doing	0	2	2	0	1	1	3
Computer As Teacher	0	1	1	1	1	2	3
Maths Difficulty	5	6	11	2	4	6	17
New Medium	7	6	13	1	0	1	14
Computer Skills	6	15	21	1	0	1	22
Maths Is Changing	1	1	2	0	2	2	4
Maths Content	0	4	4	2	1	3	7
Organis'n & Manage't	2	1	3	3	2	5	8

The largest numbers of responses were categorised as *technology* or *pleasure*. For the category of *technology* students supported their opinion about the use of computers in mathematics, their likes and dislikes by referring to the attributes or quality of the *technology* and its effect on productivity, such as the speed with which they could do things or the weaknesses of computers. For example positive comments included statements such as "using Excel and powerpoint because it takes shortcuts for you" (year 8 girl) and negative responses included statements such as "They take too long to start up" (year 8 girl). Students, especially boys, commented that they liked or disliked using computers in mathematics according to the amount of *pleasure* that they derived. This was expressed in terms of the degree of challenge offered by computers, the level of interest or the amount of enjoyment or fun. For example, "I think its good because the computer makes the subject more enjoyable thus causing a greater will to learn" (year 9 boy) and "I don't mind using sketchpad because it is an interesting program to use" (year 9 boy). *Pleasure* had the highest number of positive responses.

The category with the next highest number of responses and the second highest number of positive responses was *computer skills*. That is, the students also believed that the use of computers in mathematics gave them the opportunity to learn *computer skills*. These views were often related to their perception of the relevance of computers for their lives, for example, "Yes. Because you can use excell (sic) and today, computers are taking the world into the next century" (year 8 boy) and "Yes I do because at the same time we are learning how to use various software" (year 9 boy). One student did not see this benefit: "All we learn is how to use the program" (year 9 girl). Boys were over-represented in the category *computer skills*.

The categories with the smallest number of responses included *tools for doing, computer as teacher* and *maths is changing*. This is perhaps surprising given the emphasis of mathematics educators on tools and changing curriculum practise. Examples of responses for *maths is changing* included: "In todays (sic) society many school subjects are changing with the times.... I'm glad that now we use computers for everything and maths isn't left out" (year 9 girl). One student did not believe that maths had changed enough: "No because the teacher doesn't know how to make good use of it" (year 9 boy).

A larger number of responses were categorised as *maths difficulty*. Students commented on mathematics being easier because of the use of computers and thus saw its benefit in these terms. Some students thought that particular software introduced new difficulties and others saw that computers were not always the easiest way. For some students the benefits of using computers in mathematics was more to do with a new way of producing text (typing instead of writing) and presenting work (*new medium*). But other students indicated that using computers did not always make producing text easier or better. Girls were over-represented in both these categories.

Relationships and emerging concepts: Relationships between the categories were formulated by interpreting the meaning of responses. For example responses categorised as a *tool for thinking* were interpreted as making the *maths less difficult*. Positive and negative responses from students that show this relationship included: "I like using the excel program because you put in the formula and the computer does the work for you" (year 8 boy) and "Computers help maths with the things like calculations in Excell and sketchpad, but I don't think that they are vitally important as these calculations can be done in your head.... We depend too much on them giving us the answers" (year 9 girl). The relationships between categories and four emerging themes are shown in a concept map (Figure 1).

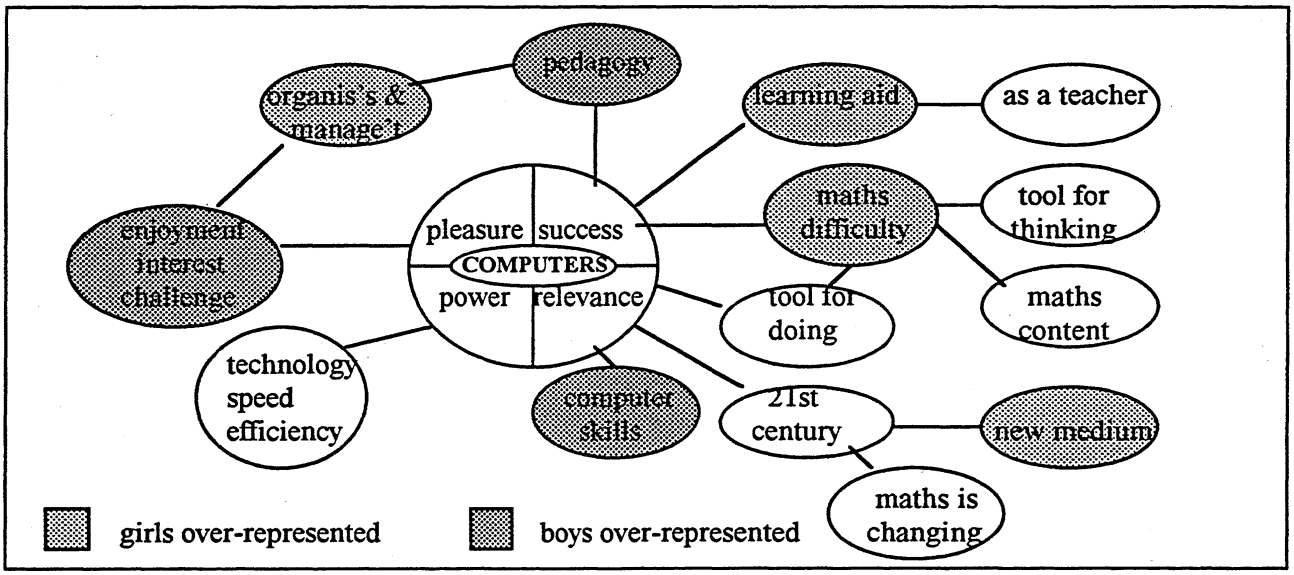

Figure 1: Attitudes to the use of computers in mathematics

The other categories that could be associated with *maths difficulty* included *tool for doing, maths content, learning aid* (for example, "Using computers in maths ... makes

it easier for me to understand what I'm doing." - year 9 girl), *computer as a teacher* and *pedagogy - new ways of learning* (for example, "Doing projects cause then you can use most of the software packages eg. Paint, word, exel." - year 9 boy). These relationships show that using computers in mathematics were a source of success or enhanced performance in mathematics. Conversely negative views in these categories were seen as contributing to a belief that computers were a source of failure or at least not enhance performance in mathematics.

Another set of categories indicated that students viewed computers as a source of pleasure or otherwise in mathematics. These categories not only included the one concerning *pleasure* as enjoyment, interest and challenge, but also *pedagogy - new ways of learning* and *learning organisation and management*. The category concerning *pedagogy* related to pleasure because some of the responses in this category made explicit or implicit causal relationships to enjoyment: "I like using the laptops because it varies from pen and paper which gets boring sometimes" (year 9 boy). Similarly responses in the category *learning organisation and management* implied that they are happy or not about the way their learning was organised when using computers: "We don't get to do what we want. We always have to do the work" (year 9 boy).

The idea of the future and the 21st century brought together another set of categories. Some students who made responses categorised as *computer skills* made explicit reference using these skills in the future, or for other subjects. More than one response implied that the usefulness of the software was important. Similarly the responses categorised as *tool for doing* implied usefulness and relevance. The idea of the future was also present in responses categorised as *maths is changing*. Responses concerned with using computers as the *new medium* implied an acceptance of changing technology and the improvements that can be made to presentation. The categories *computer skills, tool for doing, new medium* and *maths is changing* together indicated that students believed that using computers in mathematics was a source of relevance for mathematics.

The final category, *technology* (speed and superiority) sat on its own. The responses in this category indicated that students believed that computers were just better (or not). For some students this implied an over-riding concept of computers as a source of power. For example one student's response to the question about what he liked wrote: "POWERPOINT and MICROWORLDS. They rule" (year 8 boy).

To summarise the main themes then, students who believed that using computers in mathematics was a good idea viewed computers as a source of success in mathematics, a source of pleasure, a source of relevance, a source of power or a combination of these factors. Those students who did not think they were a good idea or wished to qualify their approval indicated that using computers in mathematics does not necessarily lead to success in mathematics, provide pleasure or relevance or yield power.

Gender differences: The differences in proportional representations of boys' and girls' responses were mentioned above. It needs to be remembered that this is a small sample in which the boys out number the girls almost 2:1 and some categories have very small numbers of responses. Table 2 provides information on the number of responses from boys and girls in each category. Girls and boys were represented in all categories except *tool for doing* for which only responses from boys were recorded. However there was a very small

number of responses in this category. There were seven categories for which there was a disproportionate representation of boys or girls. Those categories in which females or males were over-represented are highlighted in Figure 1.

Girls gave disproportionately more views about computers:

- as *technology*, especially the negative view, that is that computers were not always the best or the fastest and that they were not infallible;
- helping with learning and understanding (*learning aid*), both positive and negative;
- making mathematics easier (*maths difficulty*);
- improving the presentation of their work, (*new medium*) - interestingly it was a girl who contributed the only negatively coded response in this category; and
- the way that learning was organised and managed in the classroom.

In summary, girls were more likely to give responses that indicate a belief that using computers in mathematics may enable them to succeed or enhance their performance in mathematics and they are more likely to value computers as a new medium and hence a source of relevance for their future. Some girls also see that using computers in mathematics does not necessarily provide them with power.

Boys were over-represented in the *pleasure, pedagogy* and *computer skills* categories. They provided disproportionately more comments than girls that computers:

- were enjoyable, interesting and challenging (and negative comments in this category);
- brought positive changes to teaching and learning activities in mathematics; and
- enabled them to learn to use software that was useful for their future or other subjects.

Figure 1 shows that boys viewed using computers in mathematics as a source of pleasure and a way of making mathematics relevant. Computers as a source of success in mathematics or enhancement to their performance was a more indirect relationship concerning changing the ways of learning and it seems just as likely that changing the ways of learning may be more directly related to pleasure for this group of boys.

Discussion and conclusion

The results suggests that whilst both girls and boys would like to use computers as part of their schooling, they have different reasons and perhaps experiences of using computers in mathematics. There were some consistencies between the categories and themes that were identified in the current study with previous studies (Rowe, 1993; Schofield, 1995; Kissane et al., 1995). However some factors from previous studies were not evident in students' responses, for example, the ideas of control over learning and no fear of embarrassment (Schofield, 1995). The emphasis on computer skills made by boys was not identified in previous studies. The teaching and learning approach used by the teachers or the type of software that were used may explain the difference in findings. A comparative study of the introduction of computers (Goodson et al, 1995) found that particular implementations of computers are related to subject culture, defined as teaching practice.

Gender similarities and differences in student explanation of their views about using computers in mathematics were identified. Boys were more likely to be positive and negative about the use of computers in mathematics, and girls more likely to qualify their support for the use of computers in mathematics. The girls were more likely to associate the use of computers in mathematics with success, whereas boys were more likely to associate computers with pleasure and relevance of developing computer skills. These

results indicate that an implementation of computers in mathematics programs that emphasise the learning of particular computers skills and knowledge of a range of computer software is likely to be favourably received by boys. Whilst some boys did acknowledge that using computers enabled them to succeed in mathematics, a use of computers in mathematics that includes activities that boys find enjoyable is likely to enhance their attitude to mathematics. Alternately an implementation of computers in mathematics that focuses on improving understanding of mathematics or eliminates difficult tasks is likely to be viewed favourably by girls who will see that the use of computers in mathematics provides them with an avenue to success, though some girls will remain cautious about relying too heavily on computers.

These findings, and the extent to which they differ from other studies, indicate that classroom culture, the nature of the software, the curriculum context and the teaching and learning activities may play a role in determining the way that students view the use of computers in mathematics. A study that includes classroom observation and embraces these factors to provide some explanation for the differences in opinions expressed by boys and girls is the next stage to research.

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