EQUITY AND COMPUTERS FOR MATHEMATICS LEARNING: ACCESS AND ATTITUDES

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Equity and computer use for secondary mathematics learning was the focus of a three year study. In 2003, a survey was administered to a large sample of grade 7-10 students. Some of the survey items were aimed at determining home access to and ownership of computers, and students' attitudes to mathematics, computers, and computer use for mathematics learning. Responses to these items were examined by several equity factors (gender, language background, socio-economic status, geographic location, and Aboriginality), by grade level, and by mathematics achievement self-ratings. Equity factors were more salient with respect to computer ownership than with attitudes. Attitudes to computers for mathematics learning were more strongly related to attitudes to computers than to attitudes to mathematics.

INTRODUCTION AND PREVIOUS RESEARCH

The use of technology, including computers, is widely believed to be beneficial to students' learning of mathematics (Forgasz, 2003). The Victorian (Australia) government has instigated the *Bridging the digital divide initiative* (Department of Education and Training [DE&T], 2002a) which is said to ensure:

> equity of access to information and communication technology for all students, regardless of socio-economic or geographic disadvantage. The 2001/02 State Budget provided $23 million over three years for additional computers and networking… to bring all schools to a 1:5 computer to student ratio… (DE&T, 2002a, p.1)

Hence, it is expected that for students in Victorian government schools today there should be access to computers for learning across the curriculum, including mathematics. Through the *access@schools* program, schools in regional and rural Victoria (that is, non-metropolitan areas) are said to have been enabled "to provide their local communities with free or affordable access to the Internet and to their information and communication technology (ICT) facilities" (DE&T, 2002b, p.1).

Government initiatives such as those described above are to be applauded. Yet, findings from previous research would suggest that equity issues with respect to education generally (e.g., Teese, Davies, Charlton, & Polesel, 1995), and to mathematics teaching and learning in particular (e.g., Allexsaht-Snider & Hart, 2001), are complex. That is, by simply providing more computing equipment and cheaper access to ICT, it cannot be assumed that equity of access will automatically result, a view expressed in the UK by Selwyn, Gorard and Williams (2001).

Previous research findings on attitudes to computer use in education have also revealed inequities. Forgasz (2002) summarised a number of gender differences favouring males including: enjoyment, perceived competence, views on usefulness, parental encouragement, personal computer ownership, tertiary course enrolments, programming, and game playing. Based on three sets of items included in a survey questionnaire administered to a large sample of grade 7-10 students, Forgasz (2002) found that the students did not appear to stereotype mathematics as a *male domain*, held beliefs about computers that were consistent with the traditional perception of male technological competence and female incompetence, but were a little more ambivalent when computers were associated with the learning of mathematics. Students were reported as being less convinced than their teachers that computers help mathematical understanding; female students were less convinced than their male peers, and no differences in beliefs were noted by student ethnicity or socio-economic status (Forgasz, 2003). According to Hanson (1997), however, computer use is not an educational panacea but exacerbates inequities with respect to race/ethnicity and socio-economic status [SES]. In contrast, Owens and Waxman (1998) reported greater computer use by African American students than by white and Hispanic students and postulated that positive attitudes explain the findings.

Using an attitudes instrument that they developed, Galbraith, Haines and Pemberton (1999) found that their computer-mathematics subscale correlated more strongly with computer confidence and computer motivation than with the equivalent mathematics measures; no equity dimensions were considered in this research study.

The extent to which students in Victorian schools have access to computers for mathematics learning at school and at home is not known. Whether equity of access, based on gender, socio-economic status, ethnicity, and geographic location, has been achieved is also not known. The relationships between students' attitudes to mathematics, to computers, and to computer use for mathematics learning have not been examined by this same range of equity factors. For this paper, data on these issues have been explored and the results presented and discussed.

AIMS AND METHODS

The focus of the three-year study from which findings are reported in this paper was on the use of computers for the learning of secondary level (grades 7-10) mathematics. In summary, the research design for the three years included:

Year 1: surveys of mathematics students in grades 7-10 and their teachers; survey of grade 11 students reflecting on previous use of computers for mathematics learning – 29 schools were involved.

Year 2: in-depth studies of grade 10 mathematics classrooms at three schools – surveys, observations, interviews.

Year 3: repeat of Year 1 surveys in same schools – only 24 schools participated.

If students are to benefit from using computers for mathematics learning, they need to be able to access them, as required, both in school and at home. One of the aims of the present study was to establish the extent to which students do have such access and whether there are any issues of equity with respect to that access.

Included in the survey questionnaires administered in 2001 and in 2003 were questions about: computer organization in schools and use of them for mathematics learning; and computer access at home. Data were also gathered from students on a range of equity factors including: gender; socio-economic status (SES[1]); two dimensions of ethnicity – language spoken at home (ie. ESB/NESB[2]), and Aboriginality (ATSI[3]); and geographic location of school attended (metropolitan or rural). Grade levels and students' self-ratings of mathematics achievement level (SMA) were other variables considered important for analysis. To determine self-ratings of mathematics achievement, students were asked to rate their mathematics achievement levels on a 5-point scale: 5=excellent to 1=weak.

Previous research findings have revealed differences in attitudes towards mathematics on a range of equity factors. Thus, another aim of the present study was to measure students' attitudes to mathematics (AM), to computers (AC), and to using computers for learning mathematics (ACM), and to examine if there were differences in these attitudes on the same range of equity factors as for computer access. It was also considered important to identify the relationships between the three attitude measures to determine if students' attitudes to the use of computers for mathematics learning were more strongly related to attitudes to computers or to attitudes to mathematics. The survey questionnaire included three clusters of eight Likert-type items with 5-point response formats (strongly disagree to strongly agree) to measure these attitudes. The eight AM items were drawn from previous instruments. Slight wording modifications to some of the AM items, and items drawn from other instruments (e.g., Galbraith et al., 1999) made up the other two clusters of items.

For each cluster of items, a reliability check and a principal components factor analysis were conducted to determine if the items formed a uni-dimensional scale. As a result of the analyses, poor items were eliminated. The characteristics of the three resulting attitude scales, with sample items, are summarised in Table 1.

Attitude scale	Items	Sample items	Alpha	Mean[a]	SD
Mathematics (AM)	7	I enjoy mathematics	.745	3.70	.70
Computers (AC)	5	I feel confident using computers	.722	3.35	.76
Computers for mathematics (ACM)	5	Using computers helps me learn mathematics better	.756	3.15	.74

[a] For ease of comparison, the mean shown is the scale mean divided by the number of items in the scale.

Table 1: Summary characteristics for the three attitude scales

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1 SES was determined from postcodes (zip codes) found in ABS (1990).

2 NESB (Non-English speaking background): defined by positive responses to: "Do you regularly speak a language other than English at home?"

3 ATSI = Aboriginal or Torres Strait Islander

RESULTS AND DISCUSSION

The sample

In 2003, the sample comprised 1613 grade 7-10 students from 24 schools in the state of Victoria, Australia. There were approximately equal numbers from each grade level: 425 (26%) Gr.7, 415 (26%) Gr.8, 396 (25%) Gr.9, 377 (23%) Gr.10. More than half of the students, 917 (57%), attended schools in metropolitan Melbourne.

In Table 2, the composition of the sample is shown by a range of equity factors – gender, socio-economic status (SES), language background (NESB), and Aboriginality (ATSI); response frequencies and valid percentages are shown.

Gender		SES				
F	M	High	Medium	Low	NESB	ATSI
810 51%	794 49%	251 16%	914 59%	390 25%	359 22%	28 2%
N: 1604		N: 1555			N: 1607	N: 577

Table 2: Grade 7–10 students by equity factors

The data in Table 2 reveal that there were approximately equal numbers of females and males, most students (≈60%) were from medium socio-economic backgrounds, about a fifth (22%) of the students speak a language other than English at home, and that a very small minority (2%) was Aboriginal. The sample profile is not inconsistent with 2001 Australian census data in which it was found that: 40% of Australians live outside capital cities; 0.5% of Victorians identified themselves as ATSI; and 75.3% of Victorians reported being English speakers at home (Australian Bureau of Statistics [ABS], nd). Based on ABS (1990), the proportions of high, medium, and low SES backgrounds in the state of Victoria are: 19%, 59% and 22% respectively. Thus, the SES profile of the sample was also representative of the population of the state of Victoria.

Self-ratings of mathematics achievement (SMA)

The mean self-rating of mathematics achievement was 3.61. There was a statistically significant difference by gender: F= 3.49, M=3.74; $t=-5.86$, $p<.001$. The frequencies (and percentages) of the achievement self-rating levels are shown in Table 3. It can be seen that the vast majority of students considered themselves average or better in mathematics.

	5=Excellent	4=Good	3=Average	2=Below average	1=Weak
N=1608	228 (14%)	689 (43%)	571 (36%)	81 (5%)	39 (2%)

Table 3: Students' self-ratings of mathematics achievement

Access to computers at school and home, and student ownership of computers
According to the teachers of the students who also completed a survey instrument, each school had computing resources, regardless of its geographic location or its socio-economic categorization. Computer laboratories were found in all schools and several also had a single computer or clusters of computers in classrooms. About 52% of the students reported having a CD-ROM accompanying their mathematics textbooks; 46% of their teachers said that students had used the CD-ROMs. The survey was administered half way through the academic year. At that time 63% of the students reported having used computers in mathematics classes that year and 79% reported having used computers for mathematics in earlier years of schooling.

Of the 1533 students responding to the item computer access at home, 97% (1487) indicated that there was at least one computer available to them; 53% (808) reported having at least two computers. For those with at least one computer at home, the extent of student personal computer ownership (frequency and related percentage) by equity factors is summarised in Table 4. Chi-square tests were conducted to test for statistical significance by each equity factor. The results are also shown in Table 4.

Gender		SES			Language		Aboriginality		Location	
F	M	Hi	Med	Lo	ESB	NESB	ATSI	non-ATSI	Metro	Rural
249 33%	341 47%	184 50%	294 35%	88 38%	410 36%	177 55%	13 57%	559 39%	413 49%	179 28%
p<.001		p<.001			p<.001		ns		p<.001	

Table 4: Student computer ownership by equity factors and χ^2 results

As shown in Table 4, for all equity factors other than Aboriginality, there were statistically significant differences in the proportions of students owning their own computer. A higher proportion of males than females, of high SES than medium and low SES students, of NESB than ESB students, and of students attending metropolitan than rural schools owned their own computers.

It was not surprising to find that more high than medium or low SES students owned computers. Since more wealth is found in Australia's large cities than in rural areas, it was also not unexpected to find that students at schools outside metropolitan areas were less likely to own computers. The known migrant phenomenon of 'aspiring to upward mobility' may explain the higher computer ownership rates among NESB than ESB students. That parents are more likely to purchase computers for their sons than their daughters supports previous research results. This finding is of concern as it reflects a pattern of stereotyping that Australian educators no longer expect to find.

The results of the chi-square tests also indicated statistically significant differences in the proportions of students owning computers by grade level (p<.001) and by self-ratings of mathematics achievement (p<.05). Computer ownership increased with grade level (Gr.7: 32%, Gr.8: 37%, Gr.9: 45%, and Gr.10: 46%) and was highest among those who considered themselves *weak* at mathematics, followed by those who considered themselves *excellent*: *weak* - 58%, *excellent* - 47%, *below average* - 43%, *good* - 39%, and *average* - 37%. The second of these findings was unexpected. Perhaps some parents believe so strongly that computers will help their offspring educationally that they are prepared to buy computers for children whose mathematics achievement levels are expected to improve as a result of the purchase.

Attitudes to mathematics, computers, and computers for learning mathematics

Mean scores on the three attitude scales by the various equity factors, by self-ratings of mathematics achievement, and by year level were compared using independent groups t-tests or one-way ANOVAs as appropriate. The results are summarised in Table 5 - space constraints precluded inclusion of mean scores in each sub-category.

	Gender	SES	Language	Aboriginality	Location	SMA	Grade
AM	M>[a]***	Hi>***	NESB>***	non-ATSI>***	Metro>***	5>***	7>*
AC	M>***	ns	NESB>*	ns	ns	5>***	7>***
ACM	M>***	ns	NESB>*	ns	ns	5>***	7>***

[a] M> means that Males scored higher on average than did Females

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

Table 5: Attitudes by equity factors: t-test/ANOVA results

The data in Table 5 indicate that for all three attitude measures, males, NESB students, students who consider themselves *excellent* at mathematics, and grade 7 students consistently held more positive attitudes than their peers in the respective equity categories. There were also statistically significant differences in mean scores by each equity factor on the AM scale and fewer statistically significant differences were found for the other two, similarly behaving, attitude scales.

Relationships among the attitude scales

Pearson bi-variate correlations between the three attitude scale measures, students' self-ratings of mathematics achievement (SMA), grade level, and student SES are shown in Table 6.

	AC	ACM	SMA	Grade level	SES
AM	.20*	.18*	.58*	-.07	.06
AC		.57*	.15*	-.11	.02
ACM			.12*	-.25*	.04
SMA				-.03	.06
Grade level					-.06

* p<.01

Table 6: Bivariate Pearson product-moment correlations

The bivariate Pearson product-moment correlations found in Table 6 reveal: moderately high correlations between AM and SMA (0.58) and between AC and ACM (0.57); small positive correlations between AM and AC, AM and ACM, and between AC and SMA; a small negative correlation between ACM and grade level; and no significant correlations at the $p<.01$ level with SES.

The high correlation between AM and SMA (0.58) supports earlier reported findings relating mathematics achievement and positive attitudes, particularly confidence, towards mathematics (e.g., Leder, 1992). The high correlation between AC and ACM (0.57) and low correlation between AM and ACM (.18) mean that attitudes to computers for mathematics learning are more closely associated with attitudes to computers than to attitudes to mathematics. These results are consistent with Galbraith et al.'s (1999) findings with tertiary mathematics students. These correlations need to be monitored and explanations found for them.

The small negative correlation between ACM and grade level supports previous findings that younger students are more positive about mathematics than older students (e.g., Cao, Forgasz, & Bishop, 2003). The finding of no significant correlations with student SES is important in that it suggests that attitudes towards mathematics, computers, and computers for mathematics learning, do not seem to be affected by the inequity of SES in student personal computer ownership.

FINAL WORDS

In summary, the findings reported in this paper indicate that there are equity issues associated with grade 7-10 students' personal computer ownership and with their attitudes towards mathematics, computers, and computers for mathematics learning. As discussed above, many of the findings reported here were consistent with earlier published research results.

Interestingly, SES and geographic location were equity factors implicated in computer ownership and in attitudes to mathematics, but not in the two attitude measures associated with computers. Compared to their respective counterparts, males, students from non-English speaking backgrounds, and students with higher self-ratings of mathematics achievement, appear advantaged with respect to computer ownership as well as holding more positive attitudes on all three attitude measures. Based on previous research linking attitudes to participation (e.g., Leder, 1992), they are the ones more likely to persist with higher level studies in mathematics.

That the attitudes to computers for mathematics scale was found to be more highly correlated with the attitudes to computers scale than to the attitudes to mathematics scale raises a number of issues worthy of further research. As computer use becomes more widespread in mathematics classrooms, what will be the impact on students' attitudes towards mathematics and to their longer term participation in mathematical studies? Will there be differential effects that re-inforce or challenge more traditional patterns of disadvantage with respect to mathematics learning outcomes? What will become of those who hold less positive attitudes towards computers? Issues of equity and affect associated with computer use in mathematics classrooms must not be ignored if students' opportunities to learn mathematics are to be optimised.

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