Gender and socio-economic issues in the use of digital technologies in mathematics

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This paper has been prepared to address the issues and questions of the theme ‘access, equity and socio-cultural issues’. Findings from two studies are reported. In the first study gender issues in mathematical learning environments when computers were used were investigated. In the second effective practices for teaching disadvantaged or marginalised students with digital technology are canvassed. Teaching for equity and social justice in the digital age is complex. Teachers need to be aware that their beliefs and classroom practices may exacerbate gender and cultural inequalities in mathematics learning. Approaches that are consistent with social-constructivist and democratic theories need further investigation.

In this paper a synopsis of previous research of equity issues in computer-based secondary mathematics, especially gender issues, and findings from current work that is focussing on responding to diversity and disadvantage of students in mathematics when using digital technologies, are described. The issues raised in this paper concern students’ engagement in and attitudes to mathematics learning with digital technologies, teachers’ practices and pedagogical approaches that erode or enhance equity and social justice in these environments and the theoretical frameworks that inform and arise from the studies.

Equity involves equal access, equal treatment and equal outcomes in mathematics learning, participation and attitudes (Fennema, 1995). Teaching for social justice requires a commitment to ‘closing the gap’ and involves fairness, respect, inclusivity and redressing power imbalances (Boaler, 2002; Skovsmose & Valero, 2002).

Impact of digital technology on gender equity

In an earlier ICMI Study ‘Gender and Mathematics Education’ it was reported that the use of technology in mathematics might erode the advances made toward gender equity in mathematics (Hanna and Nyhof-Young, 1995). Only a few people have investigated gender issues with respect to the use of technology in mathematics. In the context of a narrowing gap in gender differences in achievement in Australia but persistent differences in senior secondary mathematics participation (Vale, Forgasz & Horne, 2004) I began to explore the proposition of threats to equity.

The research involved a grade 8, grade 9 and grade 10 mathematics class and their teachers. The classes were located in two schools where the students came from socio-economic backgrounds that were in the mid-range in Victoria, Australia. The
research focussed on classroom practices and culture when using computers in mathematics as previous studies had shown the relationship between classroom practices and differentiated learning outcomes (Fennema, 1995). It was naturalistic in the sense that it sought to study what was actually happening in classrooms rather than to invoke change or innovation using ethnographic methods. Mathematics lessons were observed and video-taped, teachers and students were interviewed, and students completed a questionnaire. Teachers determined the content and learning approaches used in the classrooms and we negotiated the timing of the study. Qualitative and quantitative methods were used to analyse the data collected.

The grade 8 class was timetabled in a computer laboratory for one lesson each week. Students in the grade 9 class owned (or leased) laptop computers that they brought to school each day. They were used for some lessons, when appropriate to the content as determined by the teacher. Students in the grade 10 class used computers for only one topic in the year. They accessed a computer laboratory for three consecutive lessons for this topic. These learning settings are typical of the range of contexts in which teachers can access computers for mathematics lessons. The content of the lessons observed included algebra, number and geometry. Grade 8 students used PowerPoint to present and explain the solution of multi-step linear equations and a spreadsheet to solve applied problems about percentage change. Grade 9 students learned to use dynamic geometry software, completed two guided investigations on geometric properties and a project on the construction of various geometric shapes. Grade 10 students learned to use Graphmatica and used it to investigate the family of quadratic functions and to solve problems about the paths of bouncing balls.

The classroom cultures and students’ attitudes and the factors influencing these findings are presented here. Data are to support these findings are published elsewhere (Vale, 1998; Vale, 2002; Vale, 2003; Vale & Leder, 2004). The students in these classrooms were motivated to complete the tasks and with a few exceptions they worked individually on their computers. While the behaviours and attitudes of girls and boys were similar in many respects, the classrooms were masculine domains since the behaviours and interests of the boys defined the cultural norms of the classroom. The boys were louder and took up more space (and in the year 9 class they outnumbered girls 2:1); they were more demonstrative and public about their computer knowledge and competitive about their achievements in mathematics and with computers, a finding consistent with previous studies of gender (Boaler, 1997; Forgasz & Leder, 1996; Schofeld, 1995). Boys benefited in these computer-based mathematics classrooms because they took control of their own learning to learn more about computers. They did this through their off-task activities such as loading software and searching the Internet. Girls and their needs and interests were on the periphery in these classrooms; they did not participate in general classroom discussions, male students denigrated their achievement and the teachers were generally ignorant of their computer skills, especially girls with lower mathematics achievement. Some high achieving girls worked individually as ‘silent’ participants.
Students were positive about the use of computers in mathematics and considered it a natural learning environment for the 21st century. However, girls viewed the use of computers in mathematics less favourably than boys. Boys believed that computers were a male domain and that they provided pleasure, relevance and success in mathematics. Girls more often commented on whether computers aided their learning or enabled success in mathematics and high achieving girls in particular were concerned that the use of computers may lead to deterioration in their mathematics skills. More positive attitudes to computers by males have been commonly observed in studies of computing in education. Forgasz (2002) found that the socio-economic status of students mediated gender differences in attitudes to computers in mathematics. Students of high and low socio-economic status were more likely to gender-stereotype the use of computers in mathematics.

In these classrooms the students used the computers as a tool for doing mathematics. There were relatively few interactions between students about the mathematical concepts that they were exploring. When these did occur they were between high achieving boys, who were more likely to comment that computers aided learning of mathematics. High achieving girls also displayed efficient strategies when using the computers to solve problems in the different classrooms. Attitude to the use of computers for learning mathematics was more strongly correlated with attitudes to computers than to mathematics, and this was more strongly the case for boys than girls (Vale & Leder, 2004). Galbraith, Haines and Pemberton (1999) also observed this phenomenon among tertiary students of mathematics but they did not report any findings by gender.

**Teachers’ practices**

Teachers’ practices, beliefs about computers and mathematics learning, expectations of students and lack of experience with computers and software in junior secondary mathematics, contributed to the culture of these classrooms. The data showed that the approaches and views of the teachers were more strongly in accord with the learning preferences and views of boys.

Many of the tasks observed in these classrooms were consistent with a constructivist approach to learning mathematics, and they had the potential of promoting collaboration in the classroom and engagement in mathematical thinking but this rarely occurred and not for lower achieving students. Furthermore, the teachers in this study perceived computers to be a tool and an opportunity for student enjoyment in mathematics and the grade 8 teacher believed he had a responsibility to teach and use generic software in his mathematics program and sought ways to do this. The grade 9 teacher believed that high achieving mathematics students would benefit the most from using computers.

Teachers differentiated their interactions between girls and boys in the classrooms and according to the mathematical achievement level of students. They were more likely to interact with high achieving students about the mathematical concepts. The
grade 8 teacher spent long periods of time individually instructing students with fewer computer literacy skills or confidence. They held gender stereotyped views of students and assumed boys’ to be the computer experts in these classrooms and called on them to solve problems. They did not acknowledge the computer skills of lower achieving girls who took on different roles in these classroom settings as successful tutors. Opportunities to engage these students in mathematical thinking while using technology were missed. If mathematics teachers believe boys “know” about computers and girls “learn” computers, then teachers will have different expectations of students in computer-based mathematics lessons.

These teachers needed to be more explicit about the mathematical learning objectives of these tasks, to facilitate collaboration among students and to discuss the processes and findings of their investigations and problem solving in the public forum, for the benefit of all students. They could have provided opportunities for students to generate their own questions, draw on their own ideas, use other software or mathematics knowledge and to work in groups. According to the data gathered from student interviews these approaches would have appealed to the girls and boys in this study. The findings from this study indicate that teachers need to reflect on their own practice and beliefs and the way that these impact on the attitudes and performance of the different groups of girls and boys in their classrooms.

Type of digital technology

A range of software accessed through computers, either desktops in a laboratory or laptops were used. Did this make a difference to gender equity? One might argue that the cultural norms would be similar in normal classroom settings for these teachers and students. The “control” that students exercised with computers, especially laptops, resulted in gendered patterns of activity. Boys used these lessons as an opportunity to learn more about computers and to have fun. Girls were less likely to have computers at home and had less experience of computers. Girls with fewer opportunities to use computers relied on learning their computer skills in classrooms. Without adequate support from their peers or the teacher, students who were not computer literate were excluded from the mathematical learning. Fennema (1995) argued that there has been little progress toward gender equity for lower-achieving girls and findings from this study suggest that this phenomenon is evident in computer-based classrooms. Would hand-held digital technologies be any different? Shaoff-Grubbs (1995) reported positive achievement and attitude outcomes for girls using graphics calculators, but there have been few gender-based studies. The propensity of girls to use and perform better than boys with by hand methods for algebra items in graphics calculator and CAS environments (Forster & Mueller, 2001; Tynan & Asp, 1998) suggests that further research is warranted.

Responding to diversity and disadvantage

In the current research and work with teachers I have begun to document teaching practices that will support the learning of disadvantaged and marginalised students in
technology-based mathematics. Teachers who regularly used digital technologies in their junior secondary classrooms and who gave priority to enabling all students to experience success when using digital technologies were selected. Eight junior secondary mathematics teachers have been involved in the first stage of this project. They are teachers in some of the most disadvantaged schools in Melbourne. Their schools are located in communities with below average socio-economic status, high proportions of students from non-English speaking backgrounds where the most disadvantaged are recent refugees or students living in poverty. I interviewed each of the teachers and we spent one whole day together presenting and sharing teaching materials and strategies.

Each teacher defined equity in terms of equal treatment and fairness, and developing mutual respect. Two teachers were also committed to ‘closing the gap’ by improving the outcomes of their students relative to students from more advantaged socio-economic backgrounds. They talked about empowering their students.

The framework for beginning to document and analyse teaching practices is drawn from a number of studies on inclusive practices and social justice (for example, Boaler, 2002; Hayes, Lingard & Mills, 2000; Skovsmose & Valero, 2002). It is summarised using six main characteristics of teaching for equity and social justice: equal access to learning and the use of digital technologies; connected learning; collaborative methods; supportive environments; intellectual quality and respect for difference. Brief descriptions of these ideas and a few examples gathered through this project are presented below.

Equal access is non-trivial. Ensuring that students in schools that are poorly resourced with digital technologies or from poor family backgrounds means that this concept extends beyond merely ensuring that students in a class have equal time hands on with materials and digital technologies. Furthermore as observed in the previous study, the cultural norms of the classroom are critical if students are to be included in mathematical practice and thinking. Teachers in the current study talked about the strategies that they are using to get access to digital technologies for their students and also to find ways of ‘closing the gap’ for their students. These included school initiatives to provide computers for some families and the provision of additional hands on time in class and homework sessions for students who do not have computers or the Internet at home.

The teachers used some approaches related to constructivist, inclusive and democratic theories of connectedness and empowerment. They described learning tasks that enabled students to build on their prior knowledge, in particular their skills with technology. This was especially the case for two of the teachers who used integrated projects that were socially and culturally relevant to their students. In these projects students explored mathematical concepts or applications and presented their findings using a range of digital media or conducted other inquiries using mathematics and statistics with technology to communicate their findings. These
projects were open-ended and aspects of the tasks were negotiated with students. Making mathematics relevant was clearly a goal for teachers. But what are the empowering mathematical concepts, skills and teacher practices in the context of digital technologies? Four of the teachers believed that a focus on the language of mathematics was particularly important for their empowering their students.

Selecting or designing tasks based on what students knew and understood about mathematics was less apparent in their practise. One teacher described an investigation of the relationship between the diameter and circumference of a circle after discovering that her grade 9 students held some misconceptions about pi. Each student in the class entered data into a spreadsheet on one laptop connected to a data projector. This teacher described a strong sense of community inquiry as students discussed and asked questions in response to the immediate feedback available by the technology being used in this way.

Collaborative practices recognise the importance of discussion and social interaction for the learning of mathematics and students are encouraged to share their knowledge and skills and to explain their thinking. Presentation and discussion of findings from integrated projects and problem solving tasks was important practice for two of these teachers, but group work with technology was not a common practice. Perhaps this was because all but one of the teachers used computers rather than graphic calculators with their students and they wanted to ensure hands on access for all students. Three teachers used particular seating plans in computer laboratories in order to facilitate peer tutoring and assistance, but effective practices for group work with computers needs to be documented.

In supportive learning environments students feel safe, free from abuse, and respected. Expectations for mathematical thinking and practices are made explicit for students and teachers model and scaffold mathematical thinking in the classroom. The concept of fairness, equal treatment and respectful relationships with students were common meanings of equity and social justice given by the teachers. One teacher deliberately used the grouping of students and seating plans in the computer laboratory to develop more understanding, respect and harmony among his students of diverse cultural backgrounds and educational talents. Each of these teachers demonstrated the technical skills to model mathematical practices with technology and they used guided investigations. Three of them believed that detailed step-by-step instructions were important. In three of the schools students accessed learning tasks through the school network. One of these teachers included voice-overs and another imbedded hints as comments in the instructions and examples that she provided her students for problem solving tasks. Another teacher talked about the need to design questions in written instructions that would support students to interpret the dynamic visual feedback afforded in digital environments.

High expectations and engagement of all students in meaningful mathematical thinking are central to social justice. One way in which teachers in the current study
conveyed their expectations was through the dissemination of criteria for assessment tasks, especially the integrated projects. One teacher showed her students examples of similar projects. She gave particular importance to thinking creatively and providing the opportunity to display high-level skills with technology. Four of these teachers regularly used non-routine problems in digital environments to engage students in higher-order thinking and provide challenge. They commented that the instant visual feedback of the digital environment afforded students the freedom to experiment without the fear of failure and public disclosure.

Two teachers in particular talked about the need to understand students’ cultural background and create tolerance and respect within their classrooms. While teachers generally recognised gender differences and used real data and applications of mathematics related to the interests of their students, both boys and girls, only one was concerned that they were using mono-cultural contexts for their real life applications of mathematics.

**Conclusion**

Australia is one of the few countries that have consistently shown no significant gender differences in achievement in the large international studies over the last decade (TIMMS and PISA studies) but socio-economic differences in achievement are more dramatic in Australia than for the OECD average. The research into gender issues summarised in this paper reveals practices that threaten advances toward gender equity. Paying attention to gender issues when using digital technology in mathematics is necessary if further progress is to be made in achieving gender equity in achievement and participation in mathematics around the world.

Further there is reasonable concern that the use of technology in mathematics may focus on the learning and needs of the most successful and socially advantaged mathematics students (Hoyles, 1998). Indeed, a report of a recent global survey to gather cases of exemplary innovative practises in the use of digital technology in education included very few cases that focussed on disadvantaged or marginalised groups (Kosma, 2003). I have attempted to shed some light on the practice of teachers working with disadvantaged students. We need to continue to work toward empowering disadvantaged and marginalised students in the digital age.

**References**


