Equity and Technology: A Case Study

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I am researching equitable and socially just teaching practices when using technology for the mathematical learning of disadvantaged and marginalised students in junior secondary school. Using data gathered from teacher interviews and a meeting of teachers, I present a case study of one teachers' practice. The case suggests that there are some equity considerations for the use of an integrated project approach to teaching mathematics and that whole class problem solving with technology can provide access to mathematical ideas when students have limited access or skills with technology.

Introduction and Background

In this paper I report on the first stage of a project to document equitable and socially just teaching practices when using digital technologies for the learning of mathematics in the junior secondary years.

Research on the use of digital technologies in mathematics teaching and learning generally has not been focussed on issues of equity and social justice. However, researchers have expressed concern that innovators may focus on the learning of the most successful and socially advantaged students and that the use of computers may exacerbate socio-cultural inequalities and erode advances toward gender equity in mathematics (Becker, Ravitz & Wong, 1999; Hanna & Nyhof-Young, 1995; Hoyles, 1998; Vale, Leder & Forgasz, 2003; Volman and van Eck, 2001). Globally, innovations in the use of ICT in primary and secondary schooling are not targeted on socially disadvantaged and marginalised students. In a study of ICT innovation in 28 countries in which 174 cases were documented, 21% of these cases involving mathematics; only 6% of the 174 cases were designed for ethnic or language minorities, 7.5% for low socio-economic students and 3% for girls (Kozma, 2003).

Teachers report that digital technology can facilitate routine processes and accentuate features of mathematics and enable students to receive dynamic feedback, study real life applications and make links between numeric, graphic and algebraic representations (Goos, 2004a; Ruthven & Hennessy, 2002). They also use computers in mathematics in junior secondary mathematics to enhance the classroom ambience and to prepare high achieving students for senior secondary mathematics (Vale, 2003). In my previous studies of year 8, 9 and 10 mathematics classrooms in two working class schools, the culture of computer based learning environments supported the learning of the higher achieving mathematics students, especially boys (Vale, 2002, 2003). Girls and boys who were low achievers in mathematics in these classrooms were not engaged in meaningful mathematics learning when using computers and the knowledge and skills of girls were not valued in computer based mathematics lessons. Research in Australia of affective factors has found that boys were more positive about the use of computers for the learning of mathematics than girls (Vale & Leder, 2004) and that gender differences in attitudes vary according to socio-economic status (Forgasz, 2002). Students from the lowest and highest social classes hold stronger gender-stereotyped views about the use of technology for learning mathematics than middle class students.

Teaching for equity and social justice requires a commitment to 'closing the gap' in the pursuit of equal outcomes (Secada, Fennema and Adjian, 1995). Meanings of equity sometimes appear to be contradictory so that implementing policies of equity and reform involves sophisticated and multi-faceted approaches to teaching (Quiroz & Secada, 2003). Classrooms that are productive and socially just have some common characteristics (Boaler, 2002; Hayes, Lingard & Mills, 2000; Skovsmose & Valero, 2002). In these classrooms students are not marginalised and there is equal access to mathematical learning in a supportive environment where everyone is safe and respected. Student learning is connected to prior knowledge and is socially, culturally and politically relevant and empowering. Difference is respected so that the curriculum is also socially and culturally diverse, relevant and respectful. Teachers respond to individual needs, negotiate learning and use collaborative methods so that learning is constructed through social interaction among students as well as with the teacher. They have high expectations of all students that are made explicit and model mathematical thinking and scaffold students' engagement with high-order tasks.

The particular practices that teachers use and the way that they establish classroom norms for equity and social justice is elusive and need to be defined according the context and for different groups of students (Boaler, 2003; Dooley, 2003; Quiroz & Secada, 2003).

The Study

In the current study I have been researching teachers' practices with a view to identifying practices that will support the learning of disadvantaged and marginalised students when using digital technology in mathematics. Nine junior secondary mathematics teachers (grades 7 – 9) from different schools participated in the first stage of this project. They teach in some of the most disadvantaged schools in Victoria. Their schools are located in communities with below average socio-economic status and high proportions of students from non-English speaking backgrounds where the most disadvantaged students in their classrooms are recent refugees or students living in poverty. The teachers reported a diversity of literacy and ICT literacy skills and mathematics achievement among students in their mathematics classes.

I used a telephone interview of 23 teachers to select teachers for this project. Teachers who regularly used digital technologies in their junior secondary classrooms and who gave priority to enabling all students to experience success in response to a multiple-choice question about their purpose for using digital technologies were selected. I interviewed each of the teachers. The interviews were audio-taped and transcribed. The teachers were asked: Tell me about a successful technology based lesson that you've taught. Why was it successful? For whom was it successful? What equity issues did you take into account when planning and conducting lessons with technology? How did you do this in the lesson described? What does equity and social justice mean to you? The teachers in the study met together for one whole day. During this meeting they teachers presented examples of their teaching materials, in and some cases presented examples of student work, and discussed ideas concerning teaching mathematics with digital technologies and the equity and social justice issues involved. Field notes were written and samples of teaching materials collected from teachers. These data were coded and the themes compared with characteristics of equitable and socially just classrooms described above.

Boaler (2003) emphasised the need to document 'records of practice' so that research may have more impact on classroom practices. So in this paper I present a case study about one of the teachers. Similarities and differences with other participants in the project will be made.

Case Study

Gail has been teaching mathematics for 24 years. She is the mathematics coordinator at a girls' secondary school in the western suburbs of Melbourne. The school is ranked in the lowest socio-economic group of secondary schools in Victoria. About 60% of the students have a language background other than English and about 15% are recent refugees from the Horn of Africa with little or disrupted schooling. Four or five students in each class she teaches are still learning the English language and one or two students have a learning disability. She has three recently arrived African girls in her grade 9 class. In spite of the low socio-economic status of the students "every one of my kids has got a computer [at home of] varying qualities" but "they're not all on the Internet". She described their educational disadvantage and the approach to social justice that she and teachers at her school took:

> *Teacher:* I always use the analogy that we're all running the same race in the end, but our kids are jumping hurdles. Some kids are running flat races. If you're at [name of prestigious private school], you've got a pretty easy hundred metre run. Our kids tend to fall because they're jumping over stuff. So to me, it's trying, [the] school has to make up for that, so taking away those hurdles. It's that thing I talked to you before about, you can't presume, a lot of education is acquired and a lot of it is a very middle class construct and in a school like this … we have to teach a language that other schools don't have to teach. We have to teach kids how to access services and make demands and not be passive and all those things that I don't think other schools have to do.

Gail strongly believed that students needed to be engaged in mathematics and to see the relevance of their work. At her school they were using an integrated approach to curriculum in the middle years (grades 7-9). The school allocated staff to more than one subject per class, so that the students had a small number of teachers. Gail taught mathematics and science to each of her classes. They also had long lessons (about two hours). She talked about these longer sessions resulting in "slowing things down" and the students being "prepared to go deeper".

The school nominated themes for each grade level and the teachers planned integrated projects for students' learning of content and skills in humanities, English, mathematics and science. Typically for these projects the students used digital technologies to conduct their enquiries and to report and publish their findings (such as by web-site or magazine article). The students used a range of generic software and the Internet in these projects. The teaching of specific information technology skills was shared among the subject disciplines and the mathematics teachers took responsibility for teaching students to use Excel in particular. She described one project about water use. In this project, the mathematics component was statistics. Students collected, presented and analysed data regarding water use. In another project on the status of women in Australia, the students used data from the Internet. In both of these projects the students used Excel to analyse their data and draw graphs and imported these files into other software for publication of their work as articles, posters and web-sites. When explaining this approach during the workshop session she described the work as being presentation focussed. She spoke about them being "girlie" and even described the presentations as being about "prettiness". She also thought that the school's integrated approach was limited because the projects had involved mostly statistics and they were looking to include other fields of mathematics and other software such as dynamic geometry.

When asked to describe a successful lesson that used digital technology during the interview, Gail described a guided investigation about pi (π).

Teacher: This was just a simple one, where I had, I must admit this is for younger kids, but I had presumed that they would have done circumference and perimeter to death by year 9 [but] several in this group haven't. They were still a bit shakey on it. They did not know what pi was.

Gail went on to explain that normally she did this investigation as an individual activity but in this instance she decided to explore π as a whole class. She also thought that the students were not confident using formulae in spreadsheets so she took this opportunity to model these procedures. The students measured many different circular objects and entered the measurements of the diameter and circumference into a spreadsheet. She had prepared this spreadsheet with the whole class and included a column for the ratio of the circumference and diameter. As each student entered the measurements of their circular object, the ratio was displayed using a data projector for all to see. The average ratio was also displayed. Students then produced a report of the investigation, explaining what they had learned and the definition of a constant.

Teacher: I just got my laptop and we got the data projector. And I we went through the instructions on how to set it up … And then they just came up and entered their data… So we ended up with about 25 values for stuff. Then the big drama was when you hit enter and it calculated pi. There was lots of competition. Could they get to 3.14? How close? …The bit I loved was that some kids weren't happy with their values and went back and measured their object. And kids would come back and say: "Oh god, my diameter was out by about 2mm, will that change my answer?" "What do you think will happen?" … One of the kids said to me "How come sometimes you said: 'Oh great, great value, great measurement,' and sometimes you said: 'Oh I think your measurement was off?'" I said: "What do you think I was looking at?" And she could pick that I was looking at the pi value.

Interviewer: So why do you think it was so successful?

Teacher: It was fun, 'cos they liked measuring the stuff…[And] I think because it was visible and changing. Like they were still treating it like it was some magical thing that this value would come at the end and there was a real suspense thing of 'would the pi value work out?' … And I could hear them saying "You could measure anything and put it in there." You know they've got this idea, you know the constant idea … And it was very communal. The whole group was contributing.

At the teachers' meeting, Gail gave another example of a problem-solving task that she used with her year 9 students, also about measurement for which her students used a Java applet and spreadsheet template provided by the author of the task. She explained that with investigations such as these the students could "see the calculation before their eyes."

Interviewer: So how do you cater for this diversity, say with the language in the things that you're doing?

Teacher: … being a bit careful about how you write stuff. Making sure if you are using Excel that you absolutely have a written set of instructions, model it in front of the class, often use groups, use peer teaching… I had to do some explicit teaching for the African girls because they didn't know how to look up a web-site or use a search engine or anything like that. It would be very rare now that you have to do that with other kids.

Discussion and Conclusion

Elements of Gail's practice that I have reported in this case include an integrated curriculum model of learning, the communal learning environment, enjoyment in mathematics that is not solely based on digital technology, the dynamic feedback of information for students during investigations, and a focus on literacy and the use of peer teaching strategies to address the particular needs of students. She used digital technology for real applications in mathematics, to solve problems and to provide dynamic feedback about mathematical concepts. The other teachers in the project also used technology for these purposes. They also used the Internet as a source of information for mathematical learning and to access Java applets. These resources were not used by teachers in my previous research and are a relatively new development in mathematics classrooms in Victoria.

While Gail was the only teacher to follow an integrated curriculum involving many disciplines, two other teachers used project work that assumed students would use digital technologies in various aspects of their learning and assessment. Project work that demonstrates the relevance of mathematics or uses personalised data is certainly not new to teachers and researchers interested in equity and social justice (Boaler, 2002). The key question here is whether the particular investigations used in classrooms are empowering mathematically and technologically? And do these investigations provide students with knowledge and skills that are socially, culturally and politically empowering? Certainly the other teachers were very interested to observe the quality of students' mathematical thinking and level of statistical literacy in the students' integrated curriculum project reports. Other researchers have argued previously that the knowledge and skills to investigate the status of particular social groups is very important (Skovsmose & Valero, 2002). So too is knowledge about the impact of human activity on the environment. Teachers need to think carefully about the authentic tasks and investigations in mathematics if all students are to feel included. One of the other teachers in this project who is teaching students of very similar social background to Gail's students used audio-visual material to introduce his refugee students to cultural phenomena before commencing investigations. Even though he made attempts to inform his students he was still concerned that he was imposing one cultural representation.

Reflecting on the integrated projects that they had completed, Gail thought that the topics for their projects and perhaps even the expectations for the products of their inquiries were influenced by the gender of the students in her school. Including the interests of students and building on their strengths has been an important strategy for gender equity in mathematics. Her comments suggest however that the structure of these inquiries may reinforce gender-stereotyped use of computers (Vale, 2002). She conceded that their projects were limited to one area of mathematics and talked about the need for a more balanced approach to the use of digital technology in mathematics; one that would enable the student to move from one technology to another in order to solve the problem.

One interesting aspect of Gail's classroom was the reference she made to a communal environment. Even though she conceded that there was a competitive atmosphere, normally associated with male domains (Vale, 2003; Schofeld, 1995), she conveyed a sense of support among the students in her class. The lesson that was described in detail suggested a community of inquiry in which teachers structure students' social interactions and connect their ideas to mathematical language and symbols (Goos, 2004b). The use of data projection technology was important in the practice of all teachers in the current study; something that was missing in the junior secondary classrooms of my previous research (Vale, 2003). Not only did the teacher in the case study described, use this as an opportunity for modelling digital technology skills, but the visual display of data (or graphs and diagrams in other contexts) gave access to the mathematical ideas afforded by technology that students with limited access or digital technology skills would otherwise be denied. The teacher gave some insight into the nature of social interactions in this lesson and the scaffolding of students' thinking, but it is not possible to infer how this actually occurred. Boaler (2003) argued that scaffolding of students' thinking was most effective when students were presenting preliminary findings before a problem was finished.

The description of practise presented in this paper is a very coarse grained analysis. A mathematical practice of working together to solve problems, share results and justify findings would seem to be important for equity and social justice in mathematics classrooms. An integrated curriculum may enable students to connect mathematical ideas to the real world in ways that are socially and culturally relevant to them. However social and cultural stereotyping needs to be avoided if students are to access powerful mathematical ideas. It is not clear whether the approaches described by this particular teacher are related to successful outcomes in mathematics that 'close the gap' for her students. A finer-grained analysis (Boaler, 2003) is needed to understand how teachers effectively guide disadvantaged and marginalised students' learning of mathematics when using digital technology.

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