Teachers' and pre-service teachers' gendered beliefs about students and computers

Helen Forgasz
Monash University, Australia
<Helen.Forgasz@education.monash.edu.au>

In this paper findings from various studies are brought together. While there has been much research on teachers' beliefs about mathematics and about pedagogy, less is known about their views about students and about computer use for mathematics learning, particularly with respect to gender-stereotyping. Since mathematics and computing are generally viewed as male domains, it seems appropriate to explore relevant teachers' and pre-service teachers' beliefs. A summary of recent Australian research findings is presented and the implications for the educational community and for mathematics classroom practices are discussed.

Introduction

Teachers' classroom actions are determined not only by their content and pedagogical knowledge and the context in which they work, but also by their beliefs about mathematics, their students, and pedagogy. The focus of this paper is on Australian teachers' and pre-service teachers' gendered beliefs about their students and about computer use for mathematics learning. To illustrate what is happening in these areas, I will draw on results from two studies in which I have been engaged in recent years. I will also present the findings from other relevant Australasian research studies. Based on the body of work discussed, implications for the educational community and for mathematics classroom practice are put forward.

Previous research on mathematics teachers' gendered beliefs about students and about computers

Mathematics teachers have been reported to hold higher expectations for their male students. Ernest (1975) reported that 41% of the teachers in one study felt that boys were better at mathematics and no teachers said that girls were. When teachers were presented with identical student profiles, some identifying a student as Denis and the others as Denise, and asked for their assessment of what the student would be doing a year later, Denis was considered more likely to be achieving his full potential (Open University, 1986). Parsons, Kaczala and Meece (1982) compared the beliefs and teacher-student interactions of students whose mathematics teachers had high expectancies and low expectancies for their future success. They found that high-expectancy females had the smallest proportion of their interactions praised. McDermott (1983) found that high expectancy students (teachers' expectations for their success in mathematics that year) had more interactions than lows, "partly because they initiated more interactions with the teacher" (p.2). Females received more work praise than males, but males had more criticism, more questions that were followed with other questions, and more dyads with brief feedback.

Teachers have been reported as stereotyping mathematics as a male domain (Leder, 1986), and holding conventional gender-stereotyped attitudes towards the future occupations of their students (Evans, 1982). Teachers of traditionally male-

dominated subjects have been shown to have least sympathy towards equal opportunity (Pratt, 1985).

Subtle differences in the way teachers of young children explain the successes and failures of their male and female students have been documented (Fennema, 1993). Grade 1 teachers also perceived their best male and female students differently with significant differences on several of the 20 traits assessed. Males were considered to display more "competitiveness, logicalness, adventurousness, loudness, volunteering of answers, enjoyment of mathematics, and independence in mathematics" (p.181). Fennema (1993) was cautious about generalising from these and other data about teachers' beliefs. It was suggested, however, that "teachers' beliefs are somewhat negative about females and the learning of mathematics" (p.184).

The Studies

Study 1: Pre-service teachers' beliefs about students' views about the gender-stereotyping of mathematics

Recently, the construct *mathematics as a male domain* was re-examined using two new instruments (Leder, 2001; Leder & Forgasz, 2002). A large sample of Australian grade 7-10 students' beliefs was found to be inconsistent with previous research (Forgasz, 2001; Forgasz & Leder, 2000). The vast majority of students was found not to gender stereotype mathematics. However, with respect to certain aspects of mathematics learning, students' beliefs appeared to have changed since earlier times. Girls, for example, were considered more likely than boys to be good at mathematics, to enjoy it, and to find it interesting. Boys were thought more likely than girls to find mathematics difficult and to need additional assistance. Findings such as these appear to challenge notions of mathematics as a *masculine* endeavour. On the other hand, in some respects things had not changed. Boys, for example, continued to be seen as more likely than girls to distract others in class and to tease classmates (male and female) who were good at mathematics.

A slightly modified version of one of the instruments devised by Leder and Forgasz (2002) was administered to a large sample of pre-service teachers in three Australian universities. The pre-service teachers were asked how they believed students in secondary schools would respond to the items presented. That is, their beliefs about students' gender stereotyping of mathematics were being tapped. The pre-service teachers were found to believe that students still held traditional stereotyped views of mathematics (Forgasz, 2000, 2001) including, for example, the complete reverse of the findings mentioned above for students. Similar findings were found with cohorts of US students and pre-service teachers (Forgasz, 2001).

Study 2: Teachers' beliefs about learning mathematics with computers

As part of a larger study on the use of computers for secondary level mathematics learning, teachers' beliefs about the efficacy of computers for enhancing students' understanding of mathematics were tapped. The teachers were also asked if they believed boys and girls learnt differently using computers. There were 96 teachers of grades 7-10 who completed survey questionnaires; six other grade 10 teachers also completed questionnaires as well as being interviewed and having their mathematics classes observed for two weeks.

Of the 96 surveyed teachers, 61% indicated that students' mathematical understandings are helped by using computers, about 10% of the teachers disagreed, and the rest were uncertain if computers helped mathematical understanding. No differences by teacher gender were found. A much smaller proportion of students was positive about the efficacy of computers on mathematical understanding. Fewer than 30% of over 2000 students agreed that computers had helped their understanding of mathematics; 41% disagreed and the remainder was uncertain. Among the students, there was a statistically significant gender difference; a higher proportion of males (37%) than females (20%) believed that computers had helped their understanding.

On the questionnaire and at interview, the teachers were asked if there were any differences in the ways boys and girls learnt mathematics and used computers in mathematics classes and whether this affected the way they taught. The responses of the six teachers who were interviewed and whose mathematics classes were observed are shown in Table 1 (drawn from Forgasz, 2003).

Table 1. Teachers' beliefs about their teaching in relation to boys' and girls' computer use in mathematics lessons.

Teacher: Jack	Boys/girls different?: Unsure	Teaching affected?: No
Survey: Since I regard computers as a tool, I treat all students the same.		
Interview: …in over twenty years of teaching, I think girls tend to be a little bit more careful with the way they're doing things whether… on pen and paper… or doing things on a computer… they will go through the activity in a more methodical manner… whereas I think boys [will] get the job done in a more haphazard fashion… as far as I'm concerned boys tend to think better in 3D, girls find drawing 3D shapes much more difficult than boys do.		
With respect to computers specifically: …I've noticed that the girls have got through the program at least as well as the boys have. I would say that a couple of the boys have finished quicker and that may be because…those particular boys…are fairly computer adept, they're only average students… but they picked up the program very quickly and they got finished. The girls… got to the same point a little slower, much more methodically.		
Teacher: Kevin	Boys/girls different?: Yes	Teaching affected?: No
Survey: Boys in this class appear to be the more confident & competent. I'm conscious of it. Let people help each other.		
Later, in writing: I feel the girls have less confidence and competence in using computers…I can think of two or three girls… Kate… who struggles in using computers and Lyn who's very quiet… so you don't know whether they're asking or needing help or whether they're getting it from others and… [there are] about two or three girls that seem to seem to hang back, they just idle through things anyway, so you're not too sure whether… that's slowing them down in computers at all… I probably noticed the boys more than the girls… it was just that a few of the boys stood out more as being… able to do things with computers… which didn't make me happy.		
Teacher: Fred	Boys/girls different?: Yes	Teaching affected?: Yes
Survey: Girls need more practice of the concepts learned.		
Interview: … my observation that girls naturally are not… as good in mathematics as boys are… [T]hey are better in language skills and they have different strengths than the boys… [It] doesn't apply to everyone, but it's the general trend… [S]o the reason is that because they're…not good in maths as naturally boys are, so I suggest to them to have a		

bit more practice so the concepts are… more consolidated and they could use it when they need. So I think they need a bit more practice than boys.

Teacher: Irene	Boys/girls different?: Unsure	Teaching affected?: No

Survey: The instructions for the features of the computer software are given to all students. However, it seems that boys tend to NAVIGATE the software more effectively.

Interview: …some of the girls in that class are just sort of helpless types and they don't seem to want to take initiative. Not all of them… some girls who are very independent learners and get on with it. [T]he back row girls, they tend to just put their heads down and do it, and the others… seem to lack the confidence just to do it… I'm just… thinking of the girls that always seem to lag behind and always seem not sure of where to go next.

Probed further about girls' learning of mathematics, Irene added: I think the girls tend to be more reticent… but I'm generalising again, I think the boys tend to be a bit more vocal in sharing some of their ideas…[and] to be a bit physically bigger… there's more of a presence of them… I think girls tend to fade that little bit into the background…. I can think of counter examples where the girls dominate and are vocal and tend to volunteer what they know, maybe more in the junior classes… but I think maybe in the senior classes perhaps the girls tend to be a bit more quiet.

Effect on teaching: Well I have to be aware of drawing the girls in, making sure they're not ignored or feel that I'm only directing my attention to the boys …and not giving the girls a chance…

Teacher: Edna	Boys/girls different?: No	Teaching affected?: No

Interview: …some of them [students] are very resistant to actually learning mathematics when they're in the computer room. They think it's for playing games. As you noticed I had to tell quite a few of them to get out of the games and get back to the maths… [O]thers will get stuck into what ever it is you give them to do and rise to the challenge, like the girls who were working out how to do the surface area of a cone without being given the slant edge… they were really extending themselves today. But it's difficult because you spend so much time trying to keep the ones who either don't have the skills or aren't interested in doing the work on track but you don't have a lot of time to spend with those kids who are….It would be really great if we could… but it doesn't happen in real life.

Teacher: Kathy	Boys/girls different?: Yes	Teaching affected?: Yes

Survey: Style of class offered. [Unfortunately, relevant questions were omitted from interview]

Source: Forgasz (2003, pp. 355-356)

From Table 1, it can be seen that Jack, Kevin, Fred and Irene (pseudonyms) identified differences in the behaviours of boys and girls in their mathematics classrooms and/or in using computers for mathematics learning. Fred's belief that males' had *natural* mathematical superiority over females was the basis of his conclusion that girls needed more practice with computers. Neither Jack nor Kevin had reflected on their observations. They were concerned about the girls' less functional behaviours but did not appear to have strategies to address them. Although not specific to computer use, Irene had made similar observations and was able to describe the actions needed to deal with the situation. Edna's specific observations about the girls getting on with a computer-related mathematics task were consistent with previous research about girls' behaviour in mathematics classrooms. It can be

inferred from the teachers' comments that they believe that students who are competent with computers, rather than necessarily mathematically strong, gain most from computer use for mathematics learning; boys were seen as more computer savvy than girls.

Other Australasian studies

Lee (2002) observed that early childhood teachers were five times more likely to identify and nominate boys than girls for a mathematics and science enrichment program; these findings echo past research results indicating that boys are more likely than girls to be identified as gifted. Sixteen early childhood teachers who had identified students for the program were interviewed and a model of teachers' conceptions of giftedness among young children was developed. Lee concluded that the teachers' conceptions were overlaid with their beliefs about gender and that girls were disadvantaged by each of the seven categories of giftedness that guided teachers' behaviours. Lee contended that girls would have significantly fewer opportunities than boys to be identified using the model that emerged.

Wood, Viskic and Petocz (2003) examined gender differences in the use of technology in three tertiary mathematics learning environments. The teachers and students in three different mathematics subjects were involved. The teachers all adopted inclusive pedagogical practices with respect to the learning environment they created, the assessment methods and teaching materials they adopted, and in monitoring their own teaching. Students' attitudes towards the use of computers were gathered. There were no gender differences found in attitudes towards computers or the use of computers. The authors concluded that the use of inclusive practices may be a contributing factor in eliminating gender differences in attitudes to the use of computers, and that group work may account for the positive attitudes among females.

Summary of findings

There appear to be some common patterns evident in the findings from the studies described above.

- The pre-service teachers in Study 1 and the classroom teachers in Study 2 seemed to be out of touch with students' views. The pre-service teachers believed that students would hold patterns of gender-stereotyped views that are likely to have been prevalent when they were in high school some years earlier.
- The classroom teachers in Study 2 whose mathematics lessons had been observed were all very experienced. Their views of boys' and girls' behaviours with computers and their explanations for them reflected fairly traditional gender-stereotyped expectations consistent with beliefs that males are more suited to mathematics (and technology) than are females, that is, that mathematics is a *male domain*..
- Gender-stereotyped expectations can also be inferred from the identification by early childhood teachers of more males than females for participation in a gifted mathematics and science programme.
- The findings from the study of tertiary mathematics learning settings suggest that pedagogical approaches may contribute to gender differences in students' beliefs about technology.

Conclusions and implications

For the educational community in general

There are some in the wider educational community who no longer believe that gender is an educational issue. Among others there is growing concern about boys' educational disadvantage. Research findings and examination results support contentions that girls excel academically over boys in many subject areas, including mathematics in some contexts. It is also clear, however, that girls are disadvantaged in the hard sciences, mathematics and computing fields, particularly with respect to enrolment numbers. Females clearly remain under-represented in many of the relevant academic fields, particularly at the highest levels, and in related careers.

The findings from the studies reported in this paper indicate that it cannot be assumed that mathematics teachers or pre-service teachers hold gender-balanced beliefs about their students or about computer use for mathematics. A second concern relates to teachers and pre-service teachers being out of touch with contemporary students' beliefs which, as has been argued elsewhere (see, for example, Leder & Forgasz, 2002), appear to be changing with respect to aspects of the gendering of mathematics.

When dealing with sensitive issues such as gender stereotyping, it is not always easy to identify or address stereotyped beliefs or behaviours. This suggests the continuing need to raise gender-related issues within political circles, and with school administrators, teachers, parents and students. Discussions should be encouraged and appropriate actions taken to eliminate any factors that have been identified as contributing to gender differences at any level of education. In pre-service education programmes, it seems important that gender issues are brought to the forefront and that the pre-service teachers are challenged to confront their own belief systems. It is important that they become aware of the potential educational consequences of holding stereotyped beliefs and expectations of students and their capabilities.

For mathematics classroom practice

What teachers believe is a subset of what they know. It can be inferred from the findings in Study 2 and the studies about the selection of gifted young children for science enrichment and of tertiary mathematics teaching with technology, that gendered beliefs can lead to actions that favour one group of students over another. In other words, girls are likely to be disadvantaged in the classrooms of mathematics teachers who hold gender-stereotyped beliefs about mathematical aptitudes and/or technological skills in favour of boys. This conclusion is not new. Yet, considering the extent of knowledge in the field of gender and mathematics, and the many interventions that have been undertaken in many Western societies to try to address girls' identified disadvantages in mathematics learning outcomes (see, for example, Leder, Forgasz & Solar, 1996), gender-stereotyped beliefs and the classroom practices consistent with them are not expected to be widespread in contemporary mathematics classroom settings.

What can be done to address these lingering vestiges of gender-stereotyped beliefs among mathematics teachers? How should efforts to effect further change be focused? Are inclusive classroom practices, as was the case in the tertiary mathematics study described above, a solution? If so, what exactly does this mean for mathematics pedagogy at the various grade levels, and how can inclusive strategies become

commonplace in mathematics classrooms? What kind of professional development is needed and what form should it take? Should teachers be asked to monitor their own classroom practices, then question and challenge what they find?

The main point that has emerged from the studies discussed in this paper is that gender issues in mathematics education have not disappeared. In the continuing pursuit of educational equity generally, and equity in mathematics education in particular, gender needs to remain on the agenda and continued research efforts in the field must be encouraged and supported.

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