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Showcasing recent Australian research in gender and mathematics

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In this paper findings from a recent review of Australian research on gender issues in mathematics education (Vale, Forgasz & Horne, 2004) are presented1. In Australia (and New Zealand) the progress towards achieving gender equity in mathematics has been mapped in a series of reviews (Leder, 1984; Barnes, 1988; Leder & Forgasz, 1992; Barnes & Horne, 1996; Forgasz, Leder & Vale, 2000; Vale et al., 2004). In earlier reviews, the research was informed by developments in feminist scholarship (Forgasz, et al., 2000; Barnes & Horne, 1996). The theoretical perspectives present in the literature included deficit and assimilationist theory, difference theory, liberal feminism, radical feminism and social feminism (Jungwirth, 2003; Kaiser & Rogers, 1995). In recent research, difference theory and inclusive teaching strategies continued to be used to inform studies in which affective factors or the experience of students, especially adult women (e.g., Brew 2003; Leder & Forgasz, 2002; Watt, 2002; Wood, Viskic & Petocz, 2003), were investigated. Some researchers, however, were influenced by post-modern (post-structural) theorists who questioned the homogeneity of girls and boys (Jungwirth, 2003; Walshaw, 2001). They investigated within-gender differences and the role of discourse in the social construction of gender (e.g., Barnes, 2000; Chapman, 2001; Vale, 2002).

At the turn of the century, Forgasz et al (2000) reported a trend towards an absence of significant gender differences in mathematical performance. This included an absence of significant gender difference in achievement for Australian students aged 9 and 13 years in the Third International Mathematics and Science Study (TIMSS) (Lokan, Ford & Greenwood, 1996, 1997). Fewer and smaller gender differences in participation and achievement that favoured males than in earlier times, and research on affective variables revealing some changes in gender-related beliefs and attitudes towards mathematics were also reported by Forgasz, et. al. (2000). Claims of the educational “disadvantage” of boys had begun to gain currency in the media and teachers with experience of teaching in all male classrooms were adopting strategies to support boys in coeducational mathematics classrooms. Socially and politically there was a sense that gender equity in mathematics education had been achieved and that the feminist perspective was no longer required; we were in a post-feminist era.

1 Research studies and performance and participation data concerning gender and mathematics in New Zealand were also included in the review conducted by Vale et al (2004). In this paper we focus on Australian research and data.
according to the Prime Minister. In 2002, the Australian government concluded a parliamentary inquiry into the schooling of boys (Parliament of the Commonwealth of Australia, 2002).

In the first section of this paper, we set the scene by providing a summary of studies that have investigated gender differences in mathematics performance. An analysis of the media’s interpretation of the mathematics achievement literature is also included. Vale et al. (2004) noted that the gender differences in primary mathematics and in the use of technology for mathematical learning appeared to contradict other trends; the studies that illustrated these findings are described in the subsequent sections.

**Mathematical performance**

In their review of the most recent Australian studies of performance at all levels of schooling, Vale et al (2004) found that gender differences in mathematics achievement were inconsistent. In some studies no gender differences were found (Collins, Kenway & McLeod, 2000; Doig, 2001; Lokan, Greenwood, & Cresswell, 2001; Yates, 2000), whilst in others gender differences that favoured either males (Forster & Mueller, 2001, 2002; Mullis, Martin, Fierros, Goldberg & Stemler, 2000; Rothman, 2002) or females (Forgasz & Leder, 2001; Siemon, Virgona & Corneille, 2001) were noted.

In the Program for International Student Assessment (PISA) conducted in 2000 with 15 year old students in 32 countries, there were no significant gender differences in performance for Australian students in mathematical literacy in any of the categories of mathematics items (Lokan et al., 2001). PISA measured students’ ability to apply mathematics knowledge and skills to real-life situations. In contrast to the results of TIMSS for 9 and 13 year old students (Lokan et al., 1996, 1997), TIMSS data for Australian Grade 12 students showed that boys were significantly ahead of the girls in mathematical literacy (Mullis et al., 2000).

Boys continue to be more highly represented than females in extreme achievement scores in primary and post-compulsory mathematics (Collins et al., 2000; Forgasz & Leder, 2001; Leder, 2001a). Males performed significantly better than females in their use of strategies for addition and subtraction in the early years (Horne, 2002, 2003), Grade 9 mathematics (Rothman, 2002), items requiring interpretations of diagrams in the middle years (Lokan et al, 2001) and when using graphic calculators in post-compulsory mathematics (Forster & Mueller, 2001, 2002).

In one study of students in the middle years, girls performed better than boys on numeracy tasks (Siemon et al., 2001). Since girls generally out-perform boys in literacy, Siemon et al. (2001) postulated that the significant difference in favour of girls may have been due to the increased focus on the discourse elements of the middle years numeracy program. Two studies of boys in mathematics classrooms supported this conjecture. Barnes (2000), using post-modern theory, illuminated two distinct masculine constructions of gender in a secondary mathematics classroom. She argued
that the hegemonic behaviour of one group and the poor communication skills of the other limited the boys’ learning in the small group problem solving settings used in this classroom. Chapman (2001) analysed mathematical discourse in mathematics lessons to show how some boys are excluded. She argued that teachers needed to use a language sensitive approach.

The Australian government’s report into the education of boys (Parliament of the Commonwealth of Australia, 2002, p.18) noted that “it is important to remember that while improvements to education outcomes for some groups of girls are real they have eluded many other girls.” Teese (2000) showed how the mathematical outcomes for girls and for boys in Grade 12 mathematics were related to gender differences in participation and to social class.

Contradictory findings for students of similar ages highlight that the direction of gender differences in mathematics achievement are sensitive to the content of the assessment tasks, the nature of mathematics knowledge and the mathematical skills being assessed, the methods used to assess students, and the conditions under which assessment is completed.

The media

Forgasz et al. (2000) claimed that societal attitudes on issues related to gender and mathematics were reflected in the print media, and that the themes explored in the popular press paralleled those in the research literature. An analysis of newspaper articles concerning gender and mathematics education for the period 2000-2003 was conducted by Vale et al. (2004). The content of the newspaper articles surveyed concerned stories of individual achievements or reports of findings from research studies or government reports. It was found that there was balance in the number of media reports about male and female students. However, it appeared that the highest mathematics achievements were still associated with males, and women with careers associated with mathematics still needed to prove themselves worthy of entry into the field. A range of perspectives on whether boys or girls are better at mathematics and why participation rates in higher level mathematics and related careers differ were evident. Vale et al. (2004) argued that readers in search of simplistic answers to questions about gender equity and mathematics learning could emerge with the view that girls are now doing better than boys in mathematics; the more discerning reader would pick up on the complexities involved. The authors indicated that a study of parents’ gender-related attitudes to mathematics would be timely.

Performance in the Early Years

In studies of mathematics performance in the primary years of schooling, significant gender differences are generally not found (Collins et al., 2000; Doig, 2001; Yates, 2000). In Australia, as elsewhere in the western world, there has recently been an emphasis on mathematics teaching and learning in the early years of primary schooling.
In some programs implemented in Australia, new instruments for monitoring mathematics performance have been developed, providing opportunities for large-scale studies of gender differences.

Findings from the Early Numeracy Research Project (ENRP) (Clarke 2000, 2001), which involved more than 13,000 students over the three year period 1999-2001, reveal that on arrival at school, there were few gender differences in mathematics performance. Boys were ahead of girls in addition and subtraction for one of the three years that the study was conducted and one cohort of girls was ahead in properties of shape. However, after three years at school, that is, at the end of Grade 2, when performance in mathematics was compared by gender with the entry performance as a covariate, the boys had moved significantly ahead in the domains associated with number concepts (Horne, 2002). In the measurement and space domains there were no significant gender differences. Horne (2003) looked at the domains of addition and subtraction at the end of Grade 3 and also found significant gender differences favouring the boys. These differences did not show up in the TIMSS Grade 3 data, nor do gender differences appear in the National benchmarks assessment at Grade 3 level (Doig, 2001). Horne (2003) suggested that the gender differences she found related partly to the nature of the assessment. For national benchmarks the focus is on outcomes and a written test is used; for the ENRP, the child’s mental solution strategies were a key aspect of the assessment and an interview was used. The gender differences found in the ENRP support a study in the US (Fennema et al., 1998) in which it was found that the boys used fewer counting strategies and more derived strategies than the girls, although the achievement levels were the same for boys and girls. In the ENRP, however, the differential use of such strategies would result in the students attaining different performance ratings. The ENRP findings highlight critical aspects of all performance comparisons - the nature of the assessment instrument, and the mode of its use.

**Technology and mathematical learning**

Forgasz et al. (2000) identified the use of technology in mathematical learning settings as an issue for further research. More recent research in this field has involved students in primary, secondary and tertiary classrooms using technology for the learning of mathematics. The technology used in these studies included mathematics specific and generic software, with computers in laboratory and laptop settings, as well as the use of graphic calculators. Some researchers have investigated gender differences in attitudes towards the use of computers in mathematics learning at the secondary and tertiary levels.

**The primary level**

Yelland (2001) was interested in gender differences when young children work in pairs using technology for mathematics learning. She presented the results of a study of
Grade 3 children (N=30) who worked in pairs on two mathematical tasks with Logo software. The students worked in girl-girl, boy-boy, or boy-girl pairs. Data were gathered and interpreted to compare the performance and problem-solving strategy use of students in these three different gender-pairings. Two components of problem-solving were considered: accuracy and efficiency. Evidence to support the finding that girl pairs were more efficient in their problem solving and more likely to collaborate than other groups were presented. Yelland argued that girls were the initiators of the interactive style observed in mixed-gender pairs. The strategies used by girls in this study were indicative of higher level thinking and reasoning. Yelland argued that the findings showed that girls, through their interactive behaviours, were able to demonstrate technological expertise that is often assumed to be the skill of boys.

The secondary level

Vale (2003a) described the cultures of a Grade 8 and a Grade 9 mathematics classroom in which computers were regularly used, and investigated how boys' and girls' identities were positioned in the discourse of computer-based mathematics. During the period of observation the students in the Grade 8 classroom used generic software while in the Grade 9 class the students had laptop computers and used dynamic geometry software. Vale (2003a) described both these classrooms as male domains; the learning environments were individualised and competitive. Within these environments boys shared their knowledge of software and computers or, in a few cases, collaborated on mathematics tasks. These behaviours enhanced the individual and collective knowledge of the boys about the software, computers and related mathematics. At the same time, the boys excluded other boys and girls. In general, the girls felt 'overpowered' by the boys.

Vale (2002) presented six cases studies of girls from the same two classes to show how the interactions in the classroom contributed to the social construction of identities. The identities included the passive high achieving girls (the 'outsiders'), the girls who remained outside the masculine discourse of the classroom but who took risks and interacted with the computers in ways more usually associated with masculine culture ('outsiders/within' or 'geek girls'), and the 'bad girls'. The teachers thought that these girls had a 'bad' attitude, whereas the girls were dissatisfied with the pedagogy, resisted 'geek girl' identity, or challenged the passive, 'good girl', feminine identity. Vale argued that the girls in these classrooms were marginalised and that their achievements in computer-based mathematics were not acknowledged. In these two studies Vale argued that the teachers' methods and attitudes, the use of laptop computers in one class, and the gender imbalance in the number of girls and boys in the classes (especially in the Grade 9 class) contributed to these findings. She concluded that teachers needed to be aware of possible gender-stereotyped views of computer competence and to design tasks that provide an appropriate balance between learning mathematics and computing skills. It could be argued that Vale's findings are hardly
surprising given the gender imbalance in the Grade 9 class (boys out-numbered girls almost two to one), yet similar patterns of gender imbalance are common in some senior secondary and tertiary mathematics settings (see the section below on participation). Changes in gender-related beliefs towards girls being viewed as more mathematically competent than boys that were previously reported (Forgasz, et al., 2000) were confirmed in follow up studies of the construct ‘mathematics as a male domain’ (Forgasz, 2001; Forgasz & Leder, 2000; Leder, 2001b; Leder & Forgasz, 2002; Leder & Forgasz, 2003). Forgasz & Leder (2000) reported that most Australian Grade 7-10 students in their study did not gender stereotype mathematics. However, in some respects mathematics could now be considered the domain of females. On average, girls, for example, were considered more likely than boys to be good at mathematics and to enjoy it. Boys, however, were still regarded as more likely than girls to distract others in mathematics classes and to tease classmates who were good at mathematics. Watt (2000), however, found that Grade 7 boys had more positive self-concepts of mathematics ability and greater interest in mathematics than Grade 7 girls. Findings from studies of attitudes to mathematics in computer based learning settings suggested that the trend away from stereotyped beliefs was also not evident.

Using an instrument with ten items tapping students’ stereotyped beliefs about using computers for mathematics learning, Forgasz (2002) investigated differences in a range of equity factors within a large sample of Grade 7-10 students. The equity factors included gender, socio-economic factors (home location, school location, and school type attended), and ethnicity (language background and aboriginality). Overall, the sample held views that were fairly consistent with expected stereotypes – boys taking control and girls less competent with the computer. Gender was the equity category with the largest number of items (8) with statistically significant differences in mean scores. Students from higher SES backgrounds, those attending schools in high SES locations, and those enrolled in Independent schools held the most traditional beliefs; Aboriginal and Torres Strait Islander students (small sample), and those attending Catholic schools, schools in medium-level SES locations, and rural schools held the least stereotyped views.

Based on data from the same study, Forgasz (2003) examined students’ and teachers’ beliefs about whether using computers helped mathematical understanding. A much higher proportion of teachers (about 60%) than students (about 30%) believed that computers helped. When students’ beliefs were examined by a range of equity factors, statistically significant differences were noted by gender, with more males agreeing that understanding was aided by using computers. Other equity factors for which differences were noted included: school type, school location and Grade level; gender, however, produced the greatest number of noteworthy differences.

Vale (2003b) developed an Attitude to Computer-based Mathematics scale. The scale and four self-rating items were administered to students in one Grade 8 and one Grade
9 classroom in which computers were used regularly: laptops in Grade 9 and desktops in Grade 8. The data were analysed by gender and class grouping. No gender or class grouping differences were found on the four self-rating items: mathematics and computing self-efficacy and aspirations. Grade 8 students were more positive about computer-based learning than Grade 9 students and, at each grade level, the males were more positive than the females. Based on correlational analyses, Vale (2003b) concluded that for boys, the opportunity to enhance their computer skills was valued, irrespective of the effects on their mathematics learning. However, only girls with high perceptions of computing achievement were likely to value computer-based mathematics learning. Interestingly there was no relationship found between perceptions of mathematics achievement (or aspirations to achieve well) and attitudes to computer-based learning.

The post-compulsory level

Forster and Mueller (2001, 2002) investigated responses on the Grade 12 calculus examination in WA with particular attention to the impact of graphic calculators. They found that the girls do better on questions requiring solely algebraic methods and where marks (grades) related to analytic reasoning. The two questions where the boys significantly out performed girls were graphical questions requiring visualisation and use of the graphic calculator with high demands on graphical interpretation. Haimes (2000) found that graphic calculators appeared to have an impact on the results of some examination questions. There was a general tendency for girls to outperform the boys on the calculus questions, while in other areas of mathematics the boys outperformed the girls on the graphic calculator advantage questions.

In Australia at Grade 12, the gap between the participation of girls and boys in mathematics has been decreasing but still exists (Parliament of Commonwealth of Australia, 2002). However boys continue to be more highly represented in the most demanding mathematics subjects (Collins et al., 2000; Fullarton & Ainley, 2000; Teese, 2000). Forster and Mueller (2001) wondered whether the use of hand-held graphing technologies was one of the factors contributing to the falling participation of girls in the most demanding mathematics subjects in Western Australia. The role of technology in mathematics was not included in studies in which gender-stereotyped self perceptions and career interests were found to be the main factors influencing students' intentions to study mathematics or pursue mathematics-related careers (Bornholt, 2001; Watt 2002).

The tertiary level

Galbraith, Pemberton and Cretchley (2001) explored attitudes related to the use of two mathematics software packages, Maple and Matlab, among first-year undergraduate mathematics students at two universities. The instruments used at the two institutions were different but tapped similar constructs. Both instruments
included measures of mathematics confidence, computer confidence, and attitudes involving the interaction of mathematics and computers. The scales involving mathematics and computers/technology were more strongly correlated with computer confidence than with mathematics confidence. It was found that females were more confident than males about mathematics, and that males more confident than females about computers.

In their study of gender differences in the use of technology in tertiary mathematics, Wood et al (2003) speculated whether the new technological tools were merely "toys for boys". Participants in the study were students from three different tertiary or pre-tertiary mathematics subjects. The three researchers claimed to have used inclusive practices in terms of the learning environments they created, the assessment methods and teaching materials used, and in the monitoring of their teaching. Students in the three classes used different software packages: Mathematica, a statistics package (Minitab), or the Internet. Using different methods for each group, data were gathered on students' attitudes towards the use of computers in their classes. No gender differences were found in the use of, or attitudes towards, computers. In their explanations, the authors were careful to point out that their practices may have differed in substantial ways from other tertiary teachers. The findings, however, indicate that using inclusive practices may be a contributing factor in eliminating gender differences in attitudes to the use of computers. All three teachers encouraged students to work together in groups. The authors speculated that the use of group work might have been a contributor to the findings of more positive attitudes among the females.

**Conclusion**

In Australia, gender differences in achievement and in attitudes towards mathematics that have favoured males in previous decades are now small or non-existent, and in a few cases favour girls. However Vale et al. (2004) reported that these differences were not consistent across socio-economic groups, levels of education, assessment instruments and the mathematics content and skills being assessed, or in the meanings of the attitude items and scales used. It appears that whether boys or girls benefit more and which particular girls and boys are disadvantaged in classrooms depend on the mathematical discourse, the teaching methods, the use of technology, the attitudes of teachers, and the type of assessment used.

The gender-related differences in achievement in primary mathematics and in attitudes towards mathematics at the tertiary level reported in this paper indicate a need for studies aimed at investigating these learning environments more closely. In contexts where technology is used for mathematics learning, gender differences in attitudes towards mathematics may be widening in favour of males rather than closing, teachers' gender-stereotyped views of students' 'ability' were evident, gender differences in spatial reasoning may be re-emerging, and girls may be rejecting the use
of technology. The need for further research to understand the factors contributing to these findings and to identify equitable curriculum and teaching approaches when using technology for mathematics learning at all levels of education is clear.

It is important that it is not assumed that there are no gender differences to be found in media reports. The findings from recent reviews of research in Australia suggest gender and mathematics is a complex matter. At a time when other researchers have identified conservative social trends in Australia, for example Summers (2003) has proclaimed the current political period as "the end of equality", it is imperative that research into gender and mathematics continues.

References


Lokan, J., Greenwood, L., Cresswell, J. (2001). *15-Up and counting, reading, writing, reasoning... How literate are Australia's students? Programme for International Student Assessment (PISA).* Melbourne: ACER.


Questions...

**What did you think of this paper? There are some questions below designed to stimulate discussion among IOWME members. Send your thoughts on any or all of these questions or any other responses to the paper so that they can be included in the next newsletter**

1. Where should we focus gender equity research in mathematics: achievement, attitudes, participation or teachers’ practice and pedagogy?
2. Do you think the use of digital technology threatens gender equity in mathematics?
3. If the current era is "the end of equality" as Anne Summers has claimed what strategies should we be using to make sure that research into gender equity in mathematics continues and is funded?
4. Australia is one of the few countries where gender differences in mathematics achievement have not been identified in some of the large international studies. What evidence is there that there have been improvements in educational outcomes for girls in mathematics and for which girls?
5. A range of meanings of gender equity are evident in Australasian research. How is the theory developing and what are useful directions to pursue?