Trends and factors concerning gender and mathematics in Australasia

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For many years now gender differences in average mathematics achievement in Australia and New Zealand have not been significant in large-scale domestic and international studies. However there is some recent evidence, from Australia at least, that gender differences in achievement favouring males may be re-emerging and, despite some positive affective findings and trends with respect to affect and participation leading up to the turn of the century, a pattern of lower interest and declining participation in mathematics among girls is evident. In this paper, trends in gender equity with respect to participation, achievement and affect reported in the literature over the past decade will be presented and analysed. Of particular interest are the factors that may have influenced these trends. Findings from recent research will be discussed. However it would seem that the attempts made by researchers to explain these trends are either limited in their capacity to establish an explanation or imply a deficit view of girls. An alternate position on gender equity and explanation of these trends will be presented in this paper with the purpose of making a contribution to the debate on curriculum and pedagogy in mathematics education.

Introduction

Leading up to the turn of the century gender differences in achievement, participation and affect in Australia and New Zealand were closing and in some studies not significant. Since the turn of the century this trend has continued in the findings reported in some studies, but gender differences are still apparent in some studies and may be widening. Researchers have also drawn attention to gender equity in mathematics through a focus on mathematics teaching and teachers' attitudes and behaviours, the mathematics classroom environment and the mathematics curriculum. In this paper I highlight some findings from recent reviews of the gender and mathematics research in Australia and New Zealand (Vale & Bartholomew, 2008 and Vale, Forgasz & Horne, 2004) to raise some issues for consideration and to propose some explanations and actions with respect to current trends and factors concerning gender and mathematics.

Research Findings

Achievement

Findings with respect to gender differences in achievement for students in primary and secondary schools in Australia and New Zealand are displayed in Table 1. The studies reported in Table 1 include large international studies such as TIMSS (Ministry of Education, NZ, 2004a, 2004b; Thomson & Fleming, 2004) and PISA (Thomson, Cresswell & De Bortolli, 2004; Thomson & De Bortoli, 2008) as well as large-scale studies funded by governments, for example, the Early Years Numeracy Project (EYNRP, Horne, 2002, 2004), Middle Years Numeracy Project (MYNRP, Siemon et al., 2001) and the New Zealand Numeracy Project (NZNP, Young-Loveridge and Taylor, 2005). The studies measured achievement in a range of mathematics content and skills. Most studies are based on mathematics content of curriculum whereas the PISA studies and MYNRP measured achievement in mathematical literacy including application and problem solving. The EYNRP and NZNP measured student achievement according to thinking strategy used and so valued flexible thinking and more efficient strategies in calculation and problem solving in mathematics.

Table 1. Gender differences in achievement in Australia and New Zealand

Study	Australia			New Zealand		
	2000-2001	2002-2004	2006-2008	2000-2001	2002-2004	2006-2008
Primary						
Early years						
EYNRP (Horne, 2003, 2004)	M*, N, N	M*, N, N				
Middle						
TIMSS (Gr 4)	M	M		F	M	
Doig, 2001 (Gr 3)	F, N, M					
Flockton & Crooks, 1999 (Gr 4)				F, F, F		
Young-Loveridge & Taylor, 2005 (9 yr-old)				F*		
Upper Primary						
MYNRP (Siemon et al, 2001)	F*					
Flockton & Crooks, 1999 (Gr 6)				F		
Doig, 2001 (Gr 6)	F, N, M					
Secondary						
TIMSS (Gr 8)	M	M			M	
MYNRP (Siemon et al, 2001)	F*					
LSAY (Gr 9)	M*					
PISA (15-yr-old)	M	M	M*	F	M*	M*
Upper secondary						
TIMSS (Gr 12)						
Advanced Gr 12	N			M*		
General Gr 12	M*					
VCE (Cox et al, 2004)		M				
VCE – CAS (Forgasz et al, 2006)		M				

M = higher mean score, F= females higher mean score, N = no difference, * indicates significant difference.

What is noticeable is that findings favouring females occurred more often in studies of primary students' achievement and especially in New Zealand, whereas findings favoured males in secondary studies including post-compulsory (Grade 12) high-stakes formal assessment. Many studies conducted between 2000 and 2004 showed no significant differences in achievement in mathematics between males and females, though males were more likely to record higher mean scores. However, the latest study, PISA 2006 found significant differences favouring males. McGaw (2008) provided some explanation for the re-emergence of significant gender differences in the 2006 PISA results in Australia. He reported that there were no significant changes for males from 2003 to 2006 but that there were significant declines for females in Western Australia, Northern Territory and Australia overall.

While there may be no significant differences in mean scores for mathematics, significant gender differences have been reported for some content. In the primary grades, Horne (2004) found that in the first four years of schooling in Victoria boys developed more efficient strategies for counting, addition and subtraction, and multiplication and division and had a stronger grasp of place value than girls, suggesting greater fluency with operations and number sense among boys than girls. The findings of Young-Loveridge and Taylor (2005) with respect to strategies in multi-digit computation among 9-11 year old primary students in New Zealand to some extent contradict these findings. In their study girls were more likely to give an alternate strategy, suggesting more flexible thinking or fluency in number operations. Nine year-old primary girls in Australia and New Zealand recorded higher average scores for the geometry items on TIMSS than 9 year-old boys (Ministry of Education, 2004a; Thomson & Fleming, 2004).

For secondary school students Thomson and Fleming (2004) reported that on average 13-year old Australian boys performed better than girls on number and measurement items in the TIMSS 2002-3 whereas 15 year-old Australian boys performed better than girls on space and shape and uncertainty items in the 2003 PISA study (Thomson, et al., 2004). Significant gender differences favouring males were recorded for each mathematics content domain in the 2003 PISA study for New Zealand students. At the senior secondary level Forgasz, Griffith and Tan (2006) found that higher proportions of male than female students were awarded the highest grades in the computer algebra system (CAS) mathematics subject than in the graphics calculator subject.

Most of these studies also report the distribution of achievement scores for males and females. Consistently there were a higher proportion of boys than girls with scores in the highest band of achievement.

Affect

In contrast with findings regarding achievement, studies of students' attitudes to mathematics consistently show significant gender differences favouring males, see Table 2. These studies cover both primary and secondary students and measure a range of affective variables such as self-confidence, interest, enjoyment, self-efficacy and self-concepts. Only for anxiety do females significantly outscore males.

Table 2. Gender differences in affect in Australia and New Zealand

Study	Australia 2004-2007	New Zealand 2004-2007
Primary		
TIMSS (Gr 4)		
self-confidence	M*	
enjoyment	M	
Secondary		
TIMSS (Gr 8)		
self-confidence	M*	
enjoyment	M	
PISA (15 yr-old)		
enjoyment & interest	M*	M*
self-efficacy	M*	M*
self-concept	M*	M*
anxiety	F*	F*
Watt et al. (Gr 10)		
self-perception	M*	

expectation of success	M*
intrinsic value of maths	M*
Digital technology in mathematics	
Vale & Leder, 2004 (Gr8 & 9)	M*
Pierce et al, 2007 (Gr 8-10)	M*
Forgasz, 2004 (Gr 7-10)	M*

M = higher mean score, F= females higher mean score, N = no difference, * indicates significant difference.

Correlation between affective factors and achievement has been explored. Thomson and Fleming (2004) found that self-confidence was more strongly correlated with achievement than value of mathematics in the TIMSS study and Thomson, Cresswell and De Bortolli (2004) found that self-efficacy and self-concept had the strongest relationship with mathematical literacy among the affective variables measured in the PISA study.

Three studies explored gender-related attitudes to the use of digital technology in mathematics among secondary students. These studies consistently show that males have more favourable attitudes to the use of technology for learning mathematics. Furthermore, these studies also identified relationships between these attitudes and other affective factors. Vale and Leder (2004) found that boys' attitudes were more strongly correlated with the desire to perform well at computing than were girls' attitudes, and Pierce, Stacey and Barkatsas (2007) found that attitude to learning with technology was positively correlated to confidence with technology for boys and negatively correlated with mathematics confidence for girls. In common with the other two studies, Forgasz (2004) also found a strong and significant correlation between attitudes to computers for learning mathematics and attitudes to computers but not with attitudes to mathematics.

Participation

Vale, Forgasz and Horne (2004) reported that higher proportions of boys than girls were enrolled in a tertiary accredited grade 12 mathematics subjects and other grade 12 mathematics subjects in Australia, but that there were more girls enrolled in mathematics subjects overall than boys because there are greater numbers of girls in grade 12. These findings reflected a steady increase up to the turn of the century in participation by girls in grade 12 mathematics of various levels of difficulty. Forgasz (2006) reported on a study of enrolment in year 12 mathematics subjects of Australian students from 2000-2004. She focussed her analysis on the mathematics subjects in the different state jurisdictions in Australia that are the minimum pre-requisites for continued mathematics study in tertiary education (normally the algebra and calculus based subject). She found that there were more males than females enrolled in these subjects in each state, except the Australian Capital Territory, and that for the five-year period enrolments in these particular mathematics subjects had declined. Declining enrolments by girls during this period contributed to the overall fall in enrolments. It is likely that the trend of girls choosing to enrol in a less demanding mathematics subject rather than the pre-requisite mathematics subject for tertiary mathematics is one reason for this decline identified by Forgasz (2006).

In a series of articles Watt (2005, 2006; Watt, Eccles, & Durik, 2006) explored the interplay between a range of affective factors and students' participation in mathematics courses among students in New South Wales. Watt (2006) found a statistically significant tendency for boys to plan and take higher-level mathematics subjects than girls, and for boys to be more likely to plan mathematical careers than girls. Gender differences in mathematics subjects taken and planned careers were not accounted for by differences in achievement (Watt, 2005b). Although prior success in mathematics was found to influence subject choice, students who rated the intrinsic value of mathematics, and their self-perception higher, took higher-level mathematics subjects, even when prior success was controlled for. Furthermore, while boys who saw mathematics as moderately useful were likely to aspire to mathematics related careers, only girls who saw mathematics as highly useful were likely to do so.

Discussion and Conclusion

Unfortunately many of the researchers conducting studies of gender differences in achievement, affect and participation use deficit theory to explain gender differences favouring males with an emphasis on fixing up the girls by attending to deficit skills or attitudes. For example, Forgasz claimed that the data "indicate that females are continuing to limit their career options" (p. 220) and Watt (2006) suggested that teachers should explicate the high utility value of mathematics to girls.

Thomson, Cresswell and De Bortolli (2004) implied a more critical stance when commenting on the gender differences in affect in the PISA study. They argued that:

> This finding suggests that approaches to reducing these gender differences need to start at an early age in order to increase females' engagement in mathematics and build their confidence in their mathematical abilities. (p. xvi)

Other researchers have been more inclined to look at mathematics pedagogy for explanations and solutions. For example, Horne (2004) asked how the teacher and teaching practices, in other words, the socialisation practices within the classroom may have contributed to the likelihood of girls being "rule compliant" and boys being "risk takers" in early years primary classrooms. Studies of classrooms and learner identity show how teachers' attitudes and the classroom environment may be influencing students' attitudes and identities with respect to mathematics. These studies revealed how the gendered pedagogies that teachers implemented in a range of classroom environments including single-sex classrooms, digital technology learning environments and tertiary mathematics reinforced rather than challenged hegemonic masculinities and disadvantaging girls in these environments (for example, Martino, Mills and Lingard, 2005; Vale and Leder, 2004; Darragh, 2005). Shannon (2004) argued that mathematics teaching and curriculum needs to change:

> I see encouraging girls into advanced mathematics as a noble goal. However, 'fixing' mathematics so that girls are not alienated by its current pedagogical structure is, in my opinion, a much more important and critical goal to be addressed. Until girls *enjoy* mathematics, I believe that we will find it difficult to justify to them that it is socially relevant and a way of improving their quality of life. (Shannon, 2004, p. 515)

However identifying and adopting teaching approaches and curriculum that girls will enjoy is complex. The use of 'girl friendly' strategies such as collaborative learning were found to be effective for both girls and boys (Barnes, 2004) but in a single sex setting did not allow girls to take responsibility for their own learning (Bartholomew, 2004). Studies in which the teacher paid attention to the mathematics that mattered for learning were successful in engaging girls (for example, Vale, 2006 and Norton, 2006).

The political context, I believe has contributed to the findings reported in this paper. Firstly following a decade of policy and curriculum development that focussed on gender equity and improving the education of girls, the Australian government adopted anti-feminist policies and, in education, conducted an inquiry into the educational disadvantage of boys (Parliament of Australia, 2000). Hence teachers and schools became focussed on the needs of boys and began to implement strategies such as single-sex classrooms as interventions to benefit boys.

Secondly, during the period since the turn of the century revised mathematics curricula, while advocating gender equitable approaches to teaching and learning did not, in general, provide advice to teachers about the ways in which to approach the teaching of mathematics to avoid disadvantaging girls or particular groups of girls or boys and to bridge the gap in mathematics achievement and affect (for example, National Statements of Learning). In contrast the government of New Zealand have provided detailed advice to teachers on effective mathematics pedagogies (Anthony and Walshaw, 2007). Teachers have been advised that:

> Setting up equitable arrangements for learners requires different pedagogical strategies and paying attention to the different needs that result from different home environments, different mathematical identifications, and different perspectives. (Anthony and Walshaw, 2007, p. 10)

It is important that at this time in Australia, when we have just embarked on the development, for the first time, of a national common curriculum for mathematics, that we examine the ways in which mathematics and its pedagogical structure results in poorer performance, attitudes and participation for girls than boys. The national mathematics curriculum needs to provide opportunities for mathematics learning and post-compulsory mathematics subjects that are engaging, valued and enjoyed by both girls and boys.

Furthermore, an absence of pedagogical leadership in curricula is especially concerning in the current context of a crisis in the supply of qualified mathematics teachers. In Australian secondary schools significant numbers of teachers of junior secondary mathematics (almost 50%) and even teachers of (usually less advanced) senior mathematics subjects (32%) do not hold the recommended tertiary mathematics qualifications for teaching secondary mathematics (McKenzie, Kos, Walker and Hong, 2008). These teachers, who also do not have qualifications in teaching mathematics or engage in mathematics professional learning programs, are unlikely to be aware of the way in which their mathematical content knowledge, their attitudes and their pedagogical knowledge and approach may be contributing to persistent gender differences in affect and re-emerging gender differences in mathematics achievement and participation. Engaging teachers, and especially unqualified mathematics teachers, in professional learning programs in which they develop reflective practices, examine the outcomes and needs of students and work toward the continual development of their mathematical and pedagogical knowledge is critical for advancing gender equity in mathematics.

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