Stars, Compass, and GPS: Navigating Currents and Charting Directions for Mathematics Education Research on Gender Issues

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In the early 1970s, gender differences in mathematics learning outcomes favouring males were identified. Research efforts revealed that learner-related cognitive and affective variables, as well as school-related and societal factors were implicated. Policy changes and funded intervention programs followed and had mixed effects. Both government and research attention have since turned elsewhere. In this paper, I present recent findings on gendered patterns in mathematics achievement and participation rates, and on the effects of technology on mathematics learning outcomes. The data indicate that any narrowing of the gender gap in the past decade now appears to be reversing. While there is a growing tendency to focus on smaller scale, qualitative studies, I argue that there is also the need to continue examining large scale data sources to monitor trends over time. I use three navigational metaphors to challenge thinking on the direction of future Australasian research on gender issues in mathematics education.

Introduction

Members of the mathematics education community share many common goals with respect to research on the learning and teaching of mathematics at all levels. We readily acknowledge the many different facets of the field, all critically contributing to the whole.

At one level, we strive to understand the underlying principles of how people learn mathematics well, identify approaches to the teaching of mathematics that are consistent with this, and then how best to structure and deliver pre-service and professional development programs. At another level, we recognise the great diversity among learners, teachers, schools, learning settings, communities, and societies, and that one size does not necessarily fit all. In aiming to achieve equitable outcomes for all, finding ways to address and overcome disadvantage while simultaneously accepting difference are the guiding principles that provide the major challenges to those conducting research in these areas.

Gender is an "obvious" category of difference and is, I would argue, a variable of disadvantage in mathematics education. The extent of the disadvantage – but rarely the disadvantaged group (females) – varies by location, socio-economic status, ethnicity, societal expectations, socio-political climate, and other factors, with each variable having differential impact in a given context (e.g., McGaw, 2004; OECD, 2007; Teese, Davies, Charlton, & Polesel, 1995). While some may dismiss research on gender as irrelevant to the main concerns within an holistic purview of mathematics education, I contend that gender is a central variable demanding inclusion in all mathematics education research studies.

Why it is Important to Incorporate Gender into Research Studies

In the early work on gender and mathematics education, persistent patterns of gender difference were found in two main spheres: achievement measures and participation rates, particularly in the most challenging mathematics subjects (e.g., Eccles, 1985; Fennema, 1974). Research efforts resulted in a range of contributing factors being identified. In attempts to explain the patterns of gender difference observed, various models were proposed (e.g., Eccles et al., 1985; Fennema & Peterson, 1985; Leder, 1990). Among the learner-related and environment factors in Leder's (1990) explanatory framework (see Figure 1), many of the variables common to the other explanatory models postulated prior to 1990 are found. To this day, Leder's (1990) model continues to provide a useful starting point for research on gender issues, particularly for those identifying with liberal feminist theory and Fennema's (1990) three equity principles: equity with respect to access and opportunity, equity with respect to treatment, and equity with respect to outcomes.

As a result of the early research findings, resources were fairly free flowing during the 1980s and 1990s to support a range of intervention programs (see Leder, Forgasz, & Solar, 1996), with mixed levels of success. Since 1990, there has been an expansion of knowledge in the field; in Australasia, for example, a chapter on gender issues has been found in each of MERGA's four-yearly reviews of the literature since they began in 1984. There have also been challenges to the theoretical viewpoint of liberal feminism which guided the early research. Some have argued that in aiming for women to reach men's levels, liberal feminism was consistent with a deficit view of females. Not all agreed. As a consequence, the field has broadened to incorporate a range of alternative feminist standpoints that underlie research efforts, all aimed at bettering females' mathematics experiences and learning outcomes. The subsequent research findings and their implications for mathematics education more generally have greatly enriched the field.

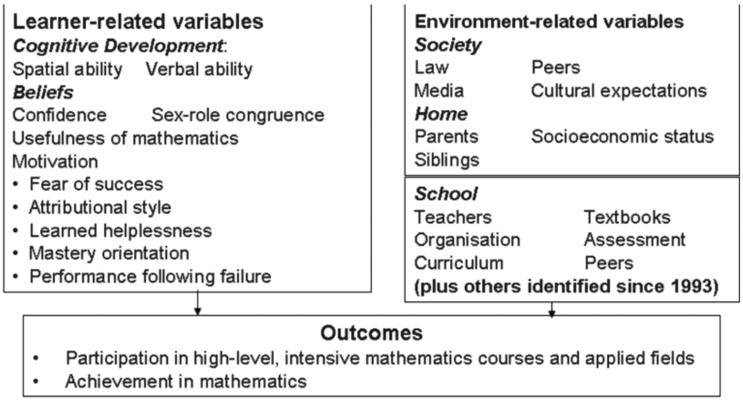

Figure 1. An explanatory framework for gender differences in mathematics learning outcomes. Adapted from Leder (1990).

Methodologically, there have also been changes in the approaches taken to investigate the gendering of mathematics as a discipline, the gender-role stereotyping associated with teachers and learners of mathematics, and the effects of external factors, including technology, on gendered patterns of learning outcomes. In the current evidence-based climate in which we work and conduct research, I believe that an emphasis on small scale, qualitative studies, is likely to have very limited impact beyond the mathematics education research community. It is difficult to convince policy makers, curriculum developers, and teachers of the need for change based on findings from small studies. This is not to say that such studies are worthless or should be abandoned. Rather, my preference has been, and remains, for mixed methods approaches. Large scale data, from which generalisable trends pertinent to a context can be determined, can then be complemented (or supplemented) by focussed, qualitative studies to understand better the identified phenomena and patterns. I consider it regrettable that in some quarters research designs including psychological constructs are increasingly viewed with suspicion, and that in the broader educational research community there is growing disdain for the inclusion of statistical analyses. The consequences include a lack of generalised evidence in many important aspects of education, as well as a loss of expertise in the gathering, analysis, and interpretation of statistical data. It is also evident that there is a lack of sustained effort to monitor trends or evaluate the outcomes of interventions and change. This might be due to poor judgment, or to a level of arrogance for which decisions made are unquestioningly considered correct.

Some of the early advances in redressing female disadvantage in mathematics achievement and participation rates now appear to be reversing. For example, there was no gender difference in the Australian mathematical literacy results for PISA 2003 (OECD, 2004), but in 2006 there was a statistically significant difference favouring males (OECD, 2007). [For New Zealand there were statistically significant differences in favour of males in both the 2003 and 2006 PISA results.]

In some international contexts, attention is only now beginning to focus on gendered patterns of disadvantage in mathematics learning. While it is heartening that researchers in these countries believe it important to understand and overcome the gender differences they have identified, I have been distressed by the lack of awareness of earlier research and of the vast knowledge base in the field that could be drawn upon to inform research agendas.

The Place of Affect in Mathematics Education Research on Gender

Leder's (1990) explanatory model (Figure 1) included a range of learner-related affective factors as contributors to gender differences in mathematics learning outcomes. Among the environment- and school-related variables, several also have affective dimensions, for example, whether teachers and parents hold gender-stereotyped beliefs about boys' and girls' capacities to learn mathematics and about their future career directions. In the field of gender and mathematics learning, affect cannot be ignored.

Various pairings of critical dimensions in mathematics education research are often seen as oppositional. More often, they are complementary and there is a need to establish 'harmony'. At the Rome conference to celebrate the 100th anniversary of ICMI, Jeremy Kilpatrick used the Chinese concept of Yin (darkness) and Yang (light) (see Figure 2) to highlight the complementary aspects of mathematics and mathematics education. The Yin and Yang concept can also be applied to emphasise the complementary notions of cognition and affect. Both receive attention in contemporary mathematics curricula. Yet, some children's misconception that there can exist a bigger and a smaller "half" also appears to hold true in this context; invariably more cognitive than affective goals are listed. Within mathematics education research, too, those focussing on affective issues represent a much "smaller half" of the community. In classrooms and the general community there also appears to be greater importance attached to cognition than affect. Yet, people's reactions to mathematics, particularly their negative reactions, are frequently couched in affective terms: "I hated mathematics at school" is likely to precede comments related to the cognitive such as "I didn't understand mathematics" or "It was too difficult". Since it is more often women than men expressing negative sentiments towards mathematics, the need to find greater harmony between affect and cognition in all areas of mathematics education research seems clear.

Figure 2. Symbol for the Chinese concept of Yin and Yang

Research on Gender Issues and Metaphors for Research Pathways

The focus of the rest of this paper is on examining patterns of gender difference in mathematics achievement and participation, two outcomes of mathematics learning central to researchers in the field, and on some of the affective and other factors contributing to them. I draw heavily on findings from my own research. I comment on the relationships of these findings to three navigational metaphors that I have used. The metaphors represent aspects of the types of research and research approaches which I believe have the potential, at different levels, to steer meaningful and effective future Australasian research agendas on gender issues. I conclude the paper with personal reflections on the field of gender and mathematics learning and its future research directions.

Let me begin with brief explanations of the three metaphors – stars, compass, and GPS.

The Stars

As the basis of early navigational instruments, the stars (including the sun) represent what can be learnt from history (Navigation and related instruments, nd). The (mariner's or sea) astrolabe, said to originate in ancient Greece (Early navigational instruments, nd) and known to have been used by the Persians in C11th (Navigation and related instruments, nd), was used to measure latitude and is claimed to be the first scientific instrument for navigation. The 'star' metaphor can be extended. During the day, and when the night stars are obscured by clouds, the boundaries surrounding the usefulness of instruments such as the astrolabe are obvious. Similarly, the limitations of the early research studies, and the data gathering and analytical approaches adopted, need to be recognised. However, there are clear advantages in being able to fall back on earlier knowledge and methods when more contemporary approaches may be inappropriate or fail, or when particular phenomena are being examined for the first time in a new context.

The (Magnetic) Compass

While Christopher Columbus may have said that the compass "always seeks the truth" (Navigation and related instruments, nd), the direction shown on the magnetic compass is not "true north". Still used today, the magnetic compass is independent of the time of day and the weather, and requires no external energy source. Yet, it, too, has its limitations. Not only does it not point true north, it does not always point towards the "magnetic north" either. Variations are due to distortions in the Earth's magnetic field, as well as the effects of other localised magnetic fields formed in the presence of iron/steel, electric currents etc. User knowledge and navigational skills can compensate. The magnetic compass represents what is valid, reliable, and relatively stable in our research endeavours – the focus of the research studies conducted; the research instruments, approaches, and methods of analysis used to extend current knowledge and seek new knowledge; and findings that can be compared to those conducted earlier and/or in different locations.

The GPS

A navigational tool for "dummies" is one way of regarding the GPS. A wonder of modern technology, the car version with its human voice can take you wherever you want to go. If a road is blocked or you take a wrong turn there is no problem, as an alternative route will be worked out. However, to use the instrument there is total dependence on being in range of satellites and having access to battery energy. If either fails, users are left floundering. Thus the GPS can signify research efforts dependent on the vagaries and ebb and flow of funding availability and other external factors – human, contextual, technological, and socio-political – that apply pressure to meet immediate perceived need and popular demand. The GPS can also be seen to represent the research context in which we in Australasia have recently found ourselves: beholden to government prerogative, with a focus on product, and consequently starved of funds for "basic" research.

Research Studies on Gender and Mathematics Education

Participation

Findings from large scale studies, with their concomitant limitations, provide broad brush overviews of phenomena that invite explanations to be sought through additional studies. The three Johns – Dekkers, de Laeter and Malone – began monitoring enrolment patterns in grade 12 mathematics and science subjects across Australia quite early, and repeated their investigations regularly (Dekkers et al., 1986, 1991, 2000). In 2006, I conducted a study for ICE-EM on enrolment numbers for grade 12 mathematics subjects across Australia (Forgasz, 2006) that built on this earlier work. I was interested in determining patterns of enrolment over the years 2000-2004 in the various mathematics options available and, of course, whether there were gender differences. Of interest, too, was how these enrolment patterns would compare with those reported earlier.

I generally followed the methodology of Dekkers, de Laeter, and Malone, but made some variations. Their work only looked at enrolment numbers. I gathered data on overall grade 12 cohort sizes and calculated the percentages of grade 12 students enrolled in each category of mathematics subject. Dekkers et al. used three categories – high, intermediate, and low – that were related to tertiary entry requirements and career pathways. Barrington and Brown (2005) classified the subjects offered in 2004 by content demands into three levels – advanced, intermediate, and elementary. Strict comparisons with earlier results were tricky because the bases for the subject categorisations differed, subject names had changed, and there had been curricular changes. I included many caveats to my report.

Across Australia in 2000-2004, females comprised about 53% of the grade 12 cohorts each year. To be representative, M:F ratios in all grade 12 subjects should have been about .89. Focussing only on data for intermediate level mathematics, the most common pre-requisite for tertiary study, Australia-wide enrolment data by gender are shown in Figure 3 for the years 1990-2004. In Figure 4, the same enrolment data are shown but expressed as percentages of grade 12 cohort numbers. Slightly different stories about intermediate level mathematics enrolments can be inferred from the data in Figures 3 and 4.

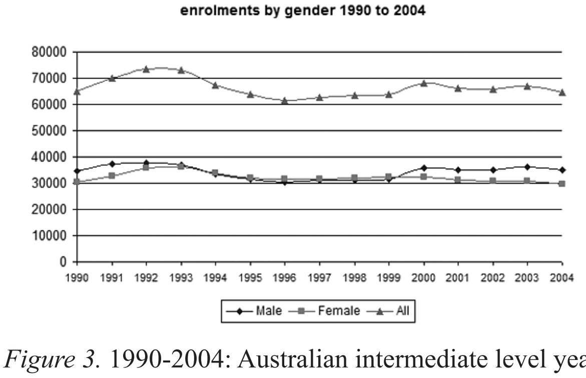

Figure 3. 1990-2004: Australian intermediate level year 12 mathematics enrolments, by gender.

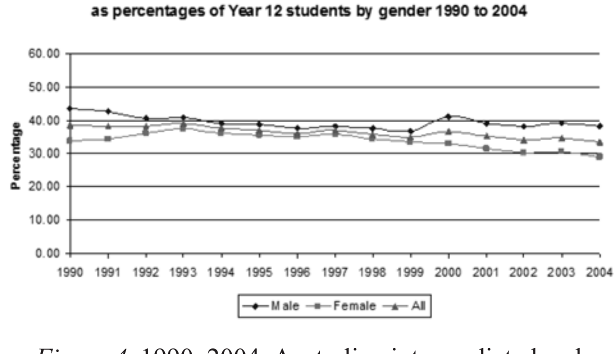

Figure 4. 1990–2004: Australian intermediate level mathematics enrolments as percentages of year 12 cohorts, by gender

In Figure 3 it can be seen that from 1995-1999 about equal numbers of males and females were enrolled, female enrolments were fairly constant from 1995-2004, and male enrolments increased suddenly in 2000 and then stabilised.

The data in Figure 4 show that from 1995-1999 there was a small but steady decline in the proportions of male and female students, in 2000 there was a jump in the proportion of males, and from 2000 the steady decline in the proportions of males and females continued.

So which story should be told? Which story is correct? Why are the stories different? I believe that speaking in terms of enrolments alone, without considering grade 12 cohort sizes, can be misleading. However, it could also be argued that the proportions of cohort data can be misleading, particularly if the composition of the cohorts is very different (as would be the case for 1990 compared to 2004). Both sets of data require additional information. We are dealing here with methodological and epistemological issues. An appreciation of the socio-political context affecting the composition of grade 12 cohorts over time is important. For the years 2000-2004, both sets of data tell virtually the same story since the economic and educational conditions for students across Australia were fairly stable with respect to mathematics curricula, tertiary pre-requisites, and employment.

In Table 1, male to female ratios for enrolment numbers in 2000-2004 are shown for advanced, intermediate and elementary levels of mathematics subjects, with state-wide data for the intermediate level subjects only.

Table 1

M:F ratios for grade 12 mathematics enrolments across Australia in advanced, intermediate, and elementary level courses, 2000-2004

	2000	2001	2002	2003	2004
Advanced	1.70	1.71	1.63	1.60	1.58
Intermediate	1.11	1.12	1.14	1.17	1.19
ACT	*.81*	*.89*	*.74*	*.83*	*1.00*
NSW	*1.04*	*1.05*	*1.09*	*1.13*	*1.14*
NT	*.79*	*1.38*	*1.08*	*1.22*	*1.56*
Queensland	*1.09*	*1.14*	*1.16*	*1.15*	*1.15*
SA	*1.21*	*1.29*	*1.29*	*1.40*	*1.44*
Tasmania	*1.13*	*1.29*	*1.18*	*1.29*	*1.46*
Victoria	*1.19*	*1.14*	*1.15*	*1.18*	*1.20*
WA	*1.29*	*1.26*	*1.33*	*1.38*	*1.43*
Elementary	.85	.89	.90	.93	.91

The data in Table 1 reveal that:

- males were over-represented in advanced and intermediate level mathematics subjects (M:F >>.89)
- there was a small, but steady decrease in the M:F ratio for advanced level subjects
- there was a small, but steady increase in M:F ratios for intermediate level subjects overall, with large variations in the M:F ratios by state/territory and different patterns of change over time from one state/territory to another
- there was a small overall increase in the M:F ratio for elementary level subjects; at the elementary level, the M:F ratios are fairly representative of grade 12 cohorts.

The trends over time suggest that compared to females, males were less likely to choose advanced level mathematics subjects, and more likely to opt for intermediate and elementary level subjects. Also, while there was an overall decline with respect to intermediate level mathematics subjects, the decline was slightly greater among females.

These data are open to multiple interpretations. Advanced level mathematics courses are very rarely stipulated today as pre-requisites for tertiary study. Thus, in the competitive tertiary entry environment, it could be argued that by moving away from advanced level mathematics courses, some males are being pragmatic. Perhaps, too, males are more certain than females of their future career trajectories, less swayed by the idea of keeping options open, and more aware of pre-requisites, hence opting for elementary and intermediate rather than advanced level courses. A potential positive from these data is that with relatively more females studying advanced level mathematics subjects, this may, over time, be reflected in the field of mathematics itself.

Missing from this study was a qualitative dimension in which the effects of socio-political factors on mathematics enrolment patterns could be explored, a better understanding of why some boys may be opting out of advanced mathematics sought, and reasons for the large variations in male and female enrolments across the states examined.

This research study demonstrates how the "stars and compass" can be used together to advance knowledge in the field. [A GPS energy source would have been welcome.]

Performance (of High Achievers)

I undertook an analysis of the 2007 Victorian Certificate of Education [VCE] results in the three mathematics subjects offered, by gender, for the highest achievers. In the Victorian newspaper, *The Age*, the names and schools attended by students obtaining *study scores*[1] of 50 (highest) down to 40 are listed for each VCE subject. Table 2 includes the 2007 VCE cohort size by gender, and enrolments in each mathematics subject by gender.

Table 2

VCE enrolments by gender

	All	**M**	**%**	**F**	**%**
VCE cohort	48840	22588	46.2%	26252	53.8%
Specialist mathematics	4804	3012	62.7%	1792	37.3%
Mathematical methods & CAS[2]	15427	8600	55.7%	6827	44.3%
Further mathematics	24787	11623	46.9%	13164	53.1%

The figures in Table 2 indicate that females comprised 53.8% of all grade 12 VCE students, and that for all mathematics subjects, including Further mathematics, males were over-represented in relation to their VCE participation. The analysis of the gender break-up of the highest achieving students revealed that the gender gaps favouring males were even wider. In 2007, students with study scores of 46-50 represented about 1.3% of the cohorts in each mathematics subject. The numbers of students scoring 46-50 in each subject, and the numbers and percentages by gender are shown in Table 3. [NB. When students' genders could not be determined from given names, they were classified 'unknown' (?).]

1 Standardised scores such that for each VCE subject: mean ≈ 30, sd ≈ 7

2 Combined enrolments for the two parallel subjects, Mathematical Methods and Mathematical Methods CAS

Table 3

Male and female achievements by study score (50-46) in VCE mathematics subjects, 2007. [in bold: gender group over-represented]

	Specialist mathematics				Mathematical methods (& CAS)				Further mathematics			
Score	All	M	F	?	All	M	F	?	All	M	F	?
50	14	**12**	1	1	36	**24**	9	3	60	**43**	13	4
		86%	7%	7%		**67%**	25%	8%		**72%**	22%	7%
49	5	**5**	-	-	29	**24**	5	-	36	**19**	14	3
		100%				**83%**	17%			**53%**	39%	8%
48	12	6	6	-	27	**18**	6	3	48	**30**	17	1
		50%	50%			**67%**	22%	11%		**63%**	35%	2%
47	13	**11**	2	-	41	**29**	11	1	60	**37**	22	1
		85%	15%			**71%**	27%	2%		**62%**	37%	2%
46	21	**15**	6	-	66	**38**	19	9	108	**58**	48	2
		71%	29%			**58%**	29%	14%		**54%**	44%	2%

When the data in Table 3 are compared to the proportions of male and female students enrolled in each of the three VCE mathematics subject (Table 2), it is very clear that males dominate over females at the highest levels of performance – study scores of 50-46.

This study is again representative of the 'stars' and 'compass' working together.

Attitudes Towards Computers for Mathematics Learning

In a three year ARC-funded project, I was able to conduct a mixed methods study examining grade 7-10 students', and their teachers', beliefs about the effects of computers on mathematics learning, and to identify factors contributing to the patterns of belief found. Among a range of findings, the following, I believe, were most noteworthy.

In 2001 and 2003, large samples of students were asked if computers helped their mathematics learning. Their responses, and the results of chi-square tests by gender, are shown in Table 4.

Table 4

Students' beliefs about computers helping mathematics learning, 2001 & 2003

2001: N=2140						**2003: N=1613**					
F (n=1015)			***M (n=1112)***			***F (n=810)***			***M (n=796)***		
Yes	*Unsure*	*No*	*Yes*	*Unsure*	*No*	*Yes*	*Unsure*	*No*	*Yes*	*Unsure*	*No*
194	334	429	326	331	384	185	269	300	239	237	256
20%	35%	45%	31%	32%	37%	25%	36%	40%	33%	32%	35%
Gender difference: $\chi^2 = 32.5$, $p<.001$						Gender difference: $\chi^2 = 12.1$, $p<.01$					

The data in Table 4 reveal that males believed more strongly than females that computers helped their mathematics learning. The students (2001: 26% and 2003: 29%) were much less convinced than their teachers (61% in both years) that computers assisted mathematics learning. This study also included a qualitative component in which six grade 10 mathematics classrooms were observed when the students used computers, a number of self-report instruments were completed, and teachers and four students from each class were interviewed. The teachers were asked to rate, on 5-point scales (excellent – poor), each student's mathematics achievement, level of co-operation, persistence with and confidence in using computers. T-tests conducted on the pooled ratings by gender revealed statistically significant differences favouring males for confidence (M=3.93, F=3.32, p<.001) and persistence (M=3.69, F=3.3, p<.05). On the large scale teacher surveys (2001: N=96; 2003: N=76) and at the interviews with those whose classes were observed, teachers were asked if there were differences in the ways boys and girls worked with computers. Their comments indicated that they believed that it was students who were competent with computers, rather than necessarily mathematically strong, who gained most from computer use for mathematics learning; boys were considered to be more computer savvy.

Gender stereotyped comments were also evident. For example:

> … my observation [is] 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… [B]ecause 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.

Methodologically, this study again reflects the "stars" and the "compass". However, the topic, and the funding support, suggest that the "GPS" had a role to play.

Effects of Technology on Performance

In another study of VCE results, I looked at students' performance, by gender, on the two parallel running VCE courses – Mathematical Methods and Mathematical Methods CAS – during the three year trial of the CAS subject. The numbers taking the CAS option were small and only the data for the final year of the trial 2004 are presented here. The within gender percentages and M:F ratios of percentages for students gaining A+ for the three assessment tasks for the two subjects are shown on Table 5.

Table 5

A+ results, by gender, for each assessment component for Mathematical Methods and Mathematical Methods (CAS), 2004

	Mathematical Methods					**Mathematical Methods (CAS)**				
	Male		**Female**		**M:F**	**Male**		**Female**		**M:F**
	N	%	N	%		N	%	N	%	
School-based	1747	18	1261	15	**1.20**	42	17	20	13	***1.31***
Examination 1	1102	12	793	10	**1.20**	35	14	16	11	***1.27***
Examination 2	1013	11	593	7	**1.57**	33	14	12	8	***1.75***

In Table 5 it can be seen that while the percentage of male students gaining A+ in all three assessments in both subjects was consistently higher than for females (M:F ratios > 1), it is clear that the gender gap was greater for each assessment task in the CAS version of the subject (bold italics on Table 5). Forgasz and Griffith (2006) reported that with very few exceptions this pattern was repeated across the three assessment tasks for the two subjects for each year of the trial, 2002-2004, and for each of three levels of achievement: A+, A, and B+. The reasons behind the apparent increased gender gap in the CAS results need to be explored. Considering that small sample sizes associated with the enrolments in the CAS option, the trends that were evident in this study demand future monitoring. Interestingly, Thomson and De Bortoli (2008) noted that Australia's significant gender difference for mathematical literacy in PISA 2006 was higher than the OECD average and:

> appears to have come from the higher end of achievement; 18 per cent of females achieved at Level 5 or 6 in 2003, compared to 13 per cent in 2006. For males the corresponding proportions were 22 per cent and 20 per cent respectively. (p. 245).

Is there a link between the Thomson and De Bortoli (2008) finding and my results that suggest that CAS use increases the gender gap in mathematics performance? Are the latest PISA results associated with an increased emphasis, Australia-wide, on technology use for mathematics learning across all grade levels? These questions invite further investigation.

The effects of technology on learning outcomes, the topic of my research study, aligns with the "GPS", but only a basic model with very low energy demands and restricted map coverage. Methodologically the study was indicative of the steady, reliable "compass".

Other Studies

There are two other studies I would have liked to tell you about but am unable to do so. Both were DEST projects for which confidentiality was required. What I can tell you is that the findings would have added to what is known on gender issues. Metaphorically speaking, total seduction by access to the latest model GPS has resulted in the findings from these two studies being lost to the mathematics education research community. The GPS, it seems, was only on short term loan!

Concluding Comments

The research findings I have presented show that gendered patterns from the past are still evident in the context of contemporary mathematics education in Australia. While I have no hesitation in acknowledging that there are inequities in the system disadvantaging boys as a group of learners, particularly in literacy and related areas, the same cannot be said for mathematics education. It is clear that equity, at least from Fenemma's (1990) standpoint, has not yet been achieved. Despite interventions, curricular change, and a better understanding of the relationship between assessment types and male-female performance outcomes (e.g., Cox, Leder, & Forgasz, 2004), females remain under-represented in higher level mathematics subjects, their performance levels are below those of males and there are signs that the gender gap may be increasing. Less functional belief patterns with respect to the impact of technology on females' mathematics learning are also evident.

In this presentation, I did not discuss findings on the more traditional affective variables associated with gender issues and mathematics learning. Recent research on beliefs about the stereotyping of mathematics as a male domain included many traditional affective variables – enjoyment, interest, confidence, attributions for success and failure, sex-role congruity, perceived usefulness, and perceptions of parents' and teachers' views. Findings defying established stereotyped patterns were reported for students in grades 7-10 (Forgasz, Leder, & Kloosterman, 2004), but not among pre-service teachers (Forgasz, 2005). International comparisons have revealed differences in the extent to which the gender stereotyped views have been challenged, with Australian students faring well in this regard (e.g., Barkatsas, Forgasz, & Leder 2002; Forgasz et al., 2004; Forgasz & Mittelberg, 2007).

In the real world, I love my GPS and the stress-free liberty it provides when travelling to unknown destinations, although I still cope pretty well with maps. At the same time, I greatly admire those who can skilfully navigate by the sun and stars, and those for whom a magnetic compass is all that is needed in open terrain. Metaphorically, the "stars" (the past) and "compass" (reliable but with limitations) are my preferred navigational tools as they reflect the rationale for my research and the methodological approaches I adopt. Post-positivism is the epistemological perspective informing my world view – the knower cannot be separated from the known and there is no single truth, although it is the ultimate goal. Since the socio-political context, the times, the location, and the setting all impact on the particular "truth" uncovered by the research I conduct, it is the limitations of the "stars" and the "compass" that sit comfortably with my perspective of the research enterprise. I am not fazed by research results that vary from one time and place to another; in fact, knowing about them can be used to inform the directions of future investigations. However, persistent patterns in findings present a dilemma and demand continuous monitoring.

I believe that the metaphors for the stars, compass, and GPS that I have used are equally applicable in all research areas within mathematics education. Experienced and novice researchers must be cognisant of the past in order to build upon and extend the knowledge base. While the precision of the GPS can only be admired, the instrument has a more devastating inherent weakness than the stars and compass in that it has the potential to fail us completely. Governments come and go, one topical issue is replaced by another, money flows and then is cut off. Worthwhile research is fundamental, aimed at expanding knowledge to better the human condition, and must be shared with the community. Despite the obstacles and temptations put before us, working this way is my suggested path forward if we are to remain true to our moral obligations as mathematics education researchers.

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