Gender Differences in Mathematics Attitudes in Coeducational and Single Sex Secondary Education

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Exploring why more boys than girls continue to study higher levels of mathematics in senior school when there appear to be no gender differences in achievement in earlier years is worthy of investigation. There are potentially many reasons why this occurs including career aspirations, interest, and attitudes. One factor explored in this study was the gender composition of classes in Years 7 to 9. Data were collected from students in a single-sex boy's school, a single-sex girl's school and a coeducational school. Data revealed differences in attitude to mathematics with girls in the single-sex school having the most positive attitudes and girls in the coeducation setting having the least positive attitudes.

At a time when there has been an explosion in the amount of data available to inform research and development, there is an increasing need for well-trained mathematicians and statisticians. However, the numbers of students continuing to study advanced levels of mathematics in senior secondary schooling and at the university level are declining (Office of Chief Scientist, 2012). There is an urgent need to arrest the decline but to do this more information is required about why students are choosing to discontinue their study of mathematics at the earliest opportunity.

It has already been established that many students find mathematics boring and frustrating (Brown, Brown, & Bibby, 2008), and attitudes toward mathematics appear to decline for many students as they progress through school (Watt, 2004). Anxiety and avoidance is a persistent and growing issue in mathematics education (Ashcraft & Moore, 2009). In addition, there appear to be gender differences in relation to attitudes to mathematics, self concept, and career aspirations (Martin, 2003; Watt, 2007). Research has a role to play in developing new understandings about these situations and investigating ways to improve the teaching and learning of mathematics in secondary school contexts.

Literature Review

Gender differences in secondary mathematics are a prominent issue that has been the focus of many studies, with reported differences in mathematics achievement between boys and girls a contentious issue. The literature has not come to a clear consensus; some studies have shown girls outperforming boys (e.g., Stevens, Wang, Olivarez, & Hamman, 2007), while others find boys outperforming girls (e.g., Preckel, Goetz, Pekrun, & Kleine, 2012). Recent research from large-scale studies such as the Trends in International Mathematics and Science Study (TIMSS) has found that "there were no gender differences in 22 of the 42 countries that tested at Year 8, including Australia", and no gender differences were found within any single state or territory, including New South Wales (Thomson, Hillman, & Wernert, 2012, p. 20). While there are studies that undoubtedly do find differences between boys' and girls' achievement in mathematics, it appears that on a national level this is not the case.

However, while studies focusing on gender differences in achievement are inconclusive, there is clearer evidence that positive attitudes, behaviours and participation rates in mathematics generally favour boys. Information from the Board of Studies,

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Teaching and Educational Standards NSW (BOSTES) shows that girls are under-represented in advanced mathematics courses. In the NSW Higher School Certificate courses of Extension 1 Mathematics and the higher Extension 2 Mathematics, girls constituted 40.0% and 35.6% of enrolments respectively in 2014 (BOSTES, 2015). Research has also shown that, compared to boys, girls are less likely to choose careers related to mathematics (Watt, 2007), feel less confident and suffer from mathematical anxiety in greater proportions (Ai, 2002; Hannula, 2002; Leedy, LaLonde, & Runk, 2003), have lower self-concept in mathematics (Kyriacou & Goulding, 2006), suffer from gender stereotyping where mathematics is viewed as a male domain among the general public (Leder & Forgasz, 2010) and among parents (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005), and also have fewer female mathematical role models as examples to emulate or follow (Lee & Anderson, 2014).

The causes of the gender differences in attitudes, behaviours and participation rates are varied, and it is likely that any truly comprehensive explanation would require a complex combination of factors. Gender stereotyping is often cited as a potential cause of these differences, as stereotyping underpins many other background factors such as parental, teacher and peer attitudes, which can in turn have an effect on the attitudes, behaviours and participation rates of boys and girls, and there is some merit to this view (Mael, 1998).

However, recently there has been some research investigating whether single-sex or coeducational schooling is a contributing factor to some of these gender differences. In an Irish study involving four schools, Prendergast and O'Donoghue (2014) found that the type of school had a statistically significant effect ($p = .02$) on student enjoyment of mathematics. The single-sex male school scored the highest, followed by the single-sex female school. Within the two coeducational schools, males enjoyed mathematics significantly more than females ($p = .02$). Interestingly, across the study females scored higher than males on diagnostic examinations, indicating that "females outperformed males even though they enjoyed the subject less" (Prendergast & O'Donoghue, 2014, p. 1125). This finding seems to confirm that enjoyment of mathematics is driven by something other than achievement and that the gender composition of classrooms may have some impact.

The Irish finding of girls in single-sex settings having more positive attitudes towards mathematics than girls in coeducational settings is not an isolated occurrence. A Zimbabwean study found that girls' self-concept was higher in a girls-only school than in a coeducational school, although in this case there were no significant differences in achievement (Tambo, Munakandafa, Matswetu, & Munodawafa, 2011). An Australian study of female engineering students enrolled at the University of Technology in Sydney (UTS) found that female students from single-gender schools outscored their male counterparts on measures of self-perception of mathematical skill and ability (Tully & Jacobs, 2010).

However, a new study is needed to investigate the possibility of gender composition (single-sex or coeducational) in junior secondary mathematics classrooms having an effect on students' attitudes to mathematics in Australia. A pilot study of three schools was undertaken to investigate the following question:

Does the gender composition of classrooms in Years 7 to 9 influence students' attitudes towards mathematics?

The Study

Three independent schools in a large metropolitan area took part in the study. School MF was a co-educational school, while School M and School F were a single sex boys' and girls' school respectively. This particular investigation was undertaken as part of a larger study that focuses on interest in mathematics in the lower secondary years. The study involved the completion of a written questionnaire, followed by individual interviews with selected students. All students in Years 7 to 9 completed the written questionnaire, resulting in a total of 1,229 responses. The distribution of participants by school, year and gender is shown in Table 1.

Table 1
Distribution of Participants

School	Year	Males	Females
MF (Co-ed)	7	58	71
	8	53	65
	9	61	45
M (Boys)	7	180	-
	8	186	-
	9	168	-
F (Girls)	7	-	123
	8	-	132
	9	-	87
Total		706	523

The written questionnaire consisted of 5 items measuring the perceived interest of the respondent's female carer, male carer, teacher, friends and classmates, as well as 26 Likert-scale items (adapted from Stevens & Olivarez, 2005), in addition to open-ended questions and other basic demographic information provided by the participants. Eight of the 26 Likert-scale items specifically measured attitudes towards mathematics, and analysis of these data form the basis of the results reported in this paper.

Results and Discussion

Gender differences were examined by comparing means with an independent samples *t*-test utilising *SPSS* software. The Likert scale consisted of five points, with a score of '1' indicative of the respondent strongly disagreeing with the statement and a '5' indicating strong agreement. In accordance with common statistical convention, a *p*-value less than .05 indicates a significance difference, and a *p*-value less than .01 indicates a strong significant difference. Table 2 lists the gender differences across the whole sample for the eight Likert-scale items measuring attitudes towards mathematics. Apart from Item 4, where girls displayed higher levels of anxiety when working on maths, there were no significant differences in attitudes across the whole sample.

Having analysed the sample as a whole, the next step involved the examination of these gender differences in the coeducational School MF, and gender differences between the boys in School M and the girls in School F. This analysis would shed light on the hypothesis that the school setting (single-sex or coeducational) could have some

significance for the gender differences. Gender differences in School MF are presented in Table 3.

Table 2
Gender Differences Across the Whole Sample

Item	Means		*p*-value
1. I like maths	M = 3.283	F = 3.303	.741
2. I feel anxious when working on maths	M = 2.372	F = 2.596	.001**
3. Doing maths is one of my favourite activities	M = 2.268	F = 2.231	.569
4. I often find that the things we deal with in maths are really exciting	M = 2.562	F = 2.571	.890
5. I don't enjoy maths	M = 2.672	F = 2.678	.935
6. Maths is fun	M = 2.721	F = 2.759	.595
7. Maths is very stressful for me	M = 2.690	F = 2.787	.163
8. When I'm doing maths I feel pretty happy	M = 2.580	F = 2.583	.967

Table 3
Gender Differences in School MF

Item	Means		*p*-value
1. I like maths	M = 3.253	F = 2.939	.008**
2. I feel anxious when working on maths	M = 2.320	F = 2.702	.002**
3. Doing maths is one of my favourite activities	M = 2.183	F = 1.938	.036*
4. I often find that the things we deal with in maths are really exciting	M = 2.515	F = 2.254	.021*
5. I don't enjoy maths	M = 2.852	F = 3.153	.028*
6. Maths is fun	M = 2.562	F = 2.384	.172
7. Maths is very stressful for me	M = 2.692	F = 3.045	.009**
8. When I'm doing maths I feel pretty happy	M = 2.432	F = 2.213	.064

As can be seen in Table 3, there were significant gender differences in six of the eight Likert-scale items measuring attitudes towards mathematics, and in each case, girls had more negative attitudes than boys. Girls were more likely to feel anxious when working on maths, were more likely to say that they did not enjoy maths and found it stressful, and they were less likely to find maths exciting, likeable, or name it as one of their favourite activities. It is clear that in School MF there was a tendency for boys to have more positive attitudes towards mathematics than girls. The investigation then compared the boys of School M and the girls of School F in Table 4.

It should be noted here that in presenting the data as means, we are ignoring student individual differences (Mael, 1998). For each item, the range was from ‘strongly disagree’ or ‘1’ to ‘strongly agree’ or ‘5’ for both males and females for all items. This suggests that in any large group of students, there is the potential for at least some students to have extremely positive or negative beliefs and feelings about mathematics. Another noteworthy point is that overall, the attitudes of students in the study were not as positive as we would have liked. Few students chose ‘strongly agree’ for the items 'I like maths' or ‘Maths is fun’.

Table 4
Gender Differences Between School M and School F

Item	Means		*p*-value
1. I like maths	M = 3.292	F = 3.494	.005**
2. I feel anxious when working on maths	M = 2.389	F = 2.541	.059
3. Doing maths is one of my favourite activities	M = 2.295	F = 2.383	.268
4. I often find that the things we deal with in maths are really exciting	M = 2.577	F = 2.736	.035*
5. I don't enjoy maths	M = 2.614	F = 2.431	.031*
6. Maths is fun	M = 2.772	F = 2.953	.032*
7. Maths is very stressful for me	M = 2.690	F = 2.652	.640
8. When I'm doing maths I feel pretty happy	M = 2.628	F = 2.776	.039*

In Table 4, five out of the eight Likert-scale items have gender differences and in all 5 cases they favour the girls, who have more positive attitudes towards mathematics than the boys. This is a strong reversal to the results of Table 3. There were few gender differences across the whole sample (Table 2) because of the combination of the opposing results of Tables 3 and 4.

The remaining items in the written questionnaire were then analysed to determine if this pattern of gender differences held true for the rest of the questionnaire. In School MF, 18 of the 26 Likert-scale items were found to have significant differences ($p < .05$) between boys and girls and in every case the differences favoured the boys in terms of more positive attitudes towards mathematics. For the single-sex settings, School M and School F, nine of the 26 Likert-scale items were found to have significant differences between boys and girls, and in every case the differences favoured the girls in terms of more positive attitudes towards mathematics.

The sheer clarity of these results was striking and required more comparisons to be made to further establish these findings. When comparing the boys of the coeducational School MF to the boys in single-sex School M, only three statistically significant differences were found in the 26 items, with all three favouring the boys in the single-sex School M. Comparisons of the girls in School MF to the girls in School F predictably favoured School F by an overwhelming margin. Therefore it appears that in order of most positive attitudes to least positive attitudes, the order of cohorts is: single-sex girls, single-sex boys, coeducational boys, coeducational girls. It must be said that the two middle groups of boys are reasonably similar, and the main disparities lie between the first and second cohort, and the third and fourth.

At this stage, it would be disingenuous to attribute these striking gender differences solely to the single-sex or coeducational nature of the schools involved. No two schools are alike and there are doubtless many other factors that may contribute to these disparities. However, all three schools are in a similar metropolitan region, and in the National Assessment Program - Literacy and Numeracy (NAPLAN), which is the national testing scheme in Australia and occurs in the high school years of 7 and 9, numeracy scores were comparable as shown in Table 5 below. Scores have been given within a 10-point range to protect the identities of the schools involved.

Table 5
Numeracy Scores in NAPLAN Testing 2013

School	Year 7	Year 9
MF (coeducational)	570-580	630-640
M (single-sex boys)	620-630	690-700
F (single-sex girls)	620-630	670-680

The single-sex schools were very similar in NAPLAN scores, with the boys' school having a slight edge in performance in Year 9, even though the girls' school generally had more positive attitudes towards mathematics. The coeducational School MF's NAPLAN scores were somewhat lower than either of the single-sex schools, which raises a potential hypothesis for future studies: since these two higher-performing single-sex schools have fewer gender disparities in attitudes toward mathematics (and where disparities exist, they favour the girls), is the gender disparity in attitudes toward mathematics a particular issue for girls in lower-performing schools?

Given that the academic performance in NAPLAN does not strictly predict the findings on attitudes toward mathematics - if it did, one would expect the boys' school to be slightly ahead of the girls' school on attitudes, which was earlier seen not to be the case - it does appear that academic performance is an insufficient explanation in and of itself for the gender disparities. Therefore there is still some credence for the study's original hypothesis that the coeducational or single-sex nature of schooling has some effect on the gender differences in student attitudes towards mathematics.

One final avenue of investigation was to analyse the five perceived interest items where respondents were asked to rate the level of interest in mathematics of their female carer, male carer, teacher, friends, and classmates. If there were significant differences in these items across the schools that matched the pattern of gender disparities, then there is the possibility that it is these differences that could be responsible for the gender disparities, rather than the schooling system.

Table 5
Means of Perceived Interest Items Across Schools

Group	School MF Girls	School MF Boys	School M (Boys)	School F (Girls)
Female carer	2.350	2.114	2.399	2.631
Male carer	3.059	2.820	3.016	3.172
Teacher	3.637	3.730	3.853	3.875
Friends	1.787	2.037	1.863	1.924
Classmates	2.092	2.346	2.284	2.551

At first glance, the means listed in Table 5 have a better correlation with the attitudes displayed, as it follows the stated order of single-sex girls and single-sex boys followed by the coeducational groups. However, upon closer inspection, it is not immediately clear how the perceived interest items could have generated the gender disparity in the coeducational school, as the School MF girls' female and male carers are significantly more interested in mathematics than the School MF boys (p=.037 and p=.047 respectively), despite the more positive attitudes of the School MF boys towards mathematics than the School MF girls. Examination of the remaining three perceived interest items proves equally problematic;

the similarity of teacher interest in School M and School F despite the clear attitudinal differences between these schools discounts the teacher as a potential source of gender disparities, while the higher scores in the friends and classmates items of the School MF boys over the School M boys despite their attitudinal similarities (and slight favouring of School M) discounts these as potential causes.

Conclusions and Implications

In this study, attitudes towards mathematics were clearly divided into three distinct groups. The most positive group was the single-sex girls' school, followed by the single-sex boys' school and the coeducational school. The differences between each of these groups were statistically significant. When the coeducational school was split into two further divisions of girls and boys, it was found that the coeducational boys were similar to (albeit slightly more negative than) the single-sex boys, while the coeducational girls had significantly more negative attitudes than the coeducational boys. When the sample was taken as a whole, boys and girls had very similar attitudes towards mathematics. For the girls involved in this study, students in single-sex settings resulted in much more favourable attitudes towards mathematics than those in coeducational settings.

The potential exists for other factors to have caused these phenomena rather than the gender of the school setting. However, academic achievement in the form of NAPLAN scores, as well as the perceived interest of key people of influence (female and male carers, teachers, friends and classmates) could not accurately explain the gender disparities that were found. The correlations were not strong and suffered from some aberrant cases. Therefore, the potential for school setting to have affected the attitudes towards mathematics of boys and girls cannot be discounted.

Care must be taken when interpreting these results, as a study involving three schools is unsuitable for broad generalisations regarding single sex or coeducational settings. However, these results are in strong agreement with other international studies (Prendergast & O'Donoghue, 2014; Tambo et al., 2011) as well as related studies in Australia (Tully & Jacobs, 2010). The robust sample sizes within each school also lend validity to the findings, even if the number of schools involved was comparatively small.

The suggestion that gender differences in attitudes to mathematics may be more pronounced in coeducational schools than single-sex schools raises the larger issue of gender stereotyping and the possible impacts of school setting. It may be that in a coeducational school, students are more likely to conform to gender stereotypes, whereas in single-sex schools there is more freedom for students to not 'live up to' gendered expectations. This has implications for the way in which educators and other stakeholders might address problems associated with negative attitudes towards mathematics. For example, some coeducational schools have implemented single-sex classrooms for mathematics as a strategy to address boys' underachievement (Jackson, 2002) but it may be a useful strategy to address girls' negative attitudes to mathematics. Further research in this area could provide fruitful for a greater understanding of the challenges and possible solutions of gender differences in attitudes to mathematics.

References

Ai, X. (2002). Gender differences in growth in mathematics achievement: three-level longitudinal and multilevel analyses of individual, home, and school influences. *Mathematical Thinking and Learning, 4*(1), 1-22.

Ashcraft, M. H,. & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment, 27*(3), 197-205.

Board of Studies Teaching and Educational Standards NSW (2015). *Student entries by sex - 2014 Higher School Certificate*. Retrieved 28 February 2015 from http://www.boardofstudies.nsw.edu.au/ebos/static/EN_SX_2014_12.html

Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": reasons given by 16 year-olds for not continuing their study of mathematics. *Research in Mathematics Education*, *10*(1), 3-18.

Hannula, M. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics 49*, 25-46.

Jacobs, J. E., Davis-Kean, P. E., Bleeker, M. M., Eccles, J. S., & Malanchuk, O. (2005). "I can do it but I don't want to." The impact of parents, interests and activities on gender differences in math. In A. Gallagher & J. Kaufman (Eds.), *Gender difference in mathematics* (pp.246-263). New York: Cambridge University Press.

Jackson, C. (2002). Can single-sex classes in co-educational schools enhance the learning experiences of girls and/or boys? An exploration of pupils' perceptions. *British Educational Research Journal*, *28*(1), 37-48.

Kyriacou, C., & Goulding, M. (2006). *A systematic review of strategies to raise pupils' motivational effort in Key Stage 4 mathematics.* London: EPPI Centre, Institute of Education.

Leder, G. C., & Forgasz, H. J. (2010). I liked it till Pythagoras: The public's view of mathematics. In L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education* (Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia, pp.328-325). Fremantle, WA: MERGA

Lee, K. J., & Anderson, J. A. (2014). Who is really interested in mathematics? An investigation of lower secondary students' mathematical role models. In J. Anderson, M. Cavanagh, & A. Prescott (Eds.), *Curriculum in focus: Research guided practice* (Proceedings of the 36th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 397-404). Sydney: MERGA.

Leedy, M. G., LaLonde, D., & Runk, K. (2003). Gender equity in mathematics: Beliefs of students, parents and teachers. *School Science and Mathematics, 103*(6), 285-292.

Mael, F. A. (1998). Single-sex and co-educational schooling: Relationships to socioemotional and academic development. *Review of Educational Research*, *68*(2), 101-129.

Martin, A. J. (2003). Enhancing the educational outcomes of boys: Findings from the ACT investigation into boys' education. *Youth Studies Australia*, *22*(4), 27-36.

Office of the Chief Scientist. (2012). *Mathematics, engineering and science in the national interest*. Canberra: Commonwealth of Australia.

Preckel, F., Goetz, T., Pekrun, R., & Kleine, M. (2008). Gender differences in gifted and average-ability students: Comparing girls' and boys' achievement, self-concept, interest, and motivation in mathematics. *Gifted Child Quarterly*, *52*(2), 146-159.

Prendergast, M. & O'Donoghue, J. (2014). Influence of gender, single-sex and co-educational schooling on students' enjoyment and achievement in mathematics. *International Journal of Mathematical Education in Science and Technology 45*(8), 1115-1130.

Stevens, T., & Olivárez, A., Jr. (2005). Development and evaluation of the Mathematics Interest Inventory. *Measurement & Evaluation in Counseling & Development*, *38*, 141–152.

Stevens, T., Wang, K. Olivarez Jr., A., & Hamman, D. (2007). Use of self-perspectives and their sources to predict the mathematics enrollment intentions of girls and boys. *Sex Roles*, *56*, 351-363.

Tambo, L. K., Munakandafa, W., Matswetu, V. S., & Munodawafa, V. (2011). Influence of type of school on self perception of mathematical ability and achievement among girls in secondary school in Harare. *Gender and Behaviour 9*(2), 3897-8915.

Thomson, S., Hillman, K., & Wernert, N. (2012). *Monitoring Australian Year 8 student achievement internationally: TIMSS 2011*. Camberwell, Victoria: Australian Council for Educational Research.

Tully, D., & Jacobs, B. (2010). Effects of single-gender mathematics classrooms on self-perception of mathematical ability and post-secondary engineering paths: An Australian case study. *European Journal of Engineering Education 35*(4), 455-467.

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values and task perceptions according to gender and domain in 7th- through 11-th grade Australian students. *Child Development*, *75*, 1556-1574.

Watt, H. M. G. (2007). A trickle from the pipeline: Why girls under participate in maths. *Professional Educator, 6*(3), 36-41.