# Is Mathematics a Male Domain? The Responses of Students in Single-Sex and Coeducational Secondary Schools.

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Attitude toward mathematics has been considered an important factor in influencing participation and success in mathematics. There has a revival of interest in the potential of single-sex schools to cater for the cognitive and affective needs of students. This study uses the Fennema-Sherman Mathematics as a Male Domain Scale in a cross sectional survey to examine the attitudes of students in single-sex and coeducational secondary schools. A strong ceiling effect necessitated a qualitative analysis of the data. There were clear attitude differences between girls and boys, with girls being less stereotyped in their perceptions. There were also differences relating to the school environment with girls in a single-sex schools being less stereotyped than girls in the coeducational schools.

## Introduction

For over twenty years there has been concern about the lack of women in higher level mathematics and in careers for which mathematics was a prerequisite. Fennema and Sherman (1977) claimed that a lack of mathematical background knowledge prevented women from entering a variety of occupations. In Australia too, mathematics results are used as a critical filter for higher education and future careers (Willis, 1995) and sex differences in participation remain a concern (Cuttance, 1995; Barnes & Horne, 1996). Over the la_st two decades in Australia there have been a number of government policy initiatives concerning the education of girls (see for example, Commonwealth Schools Commission, 1984, 1987; Australian Education Council, 1993). There has also been renewed interest in the potential of single-sex environments to cater more effectively for the needs of girls (Milligan & Thomson, 1992). Since there is a growing body of literature establishing the importance of affective states in learning mathematics it is useful to compare the attitudes of girls and boys in single-sex and coeducational schools.

# Literature Review

## *Gender Differences in Participation.*

The evidence in the literature suggests that it is difficult to attribute lack of participation by girls to inferior performance. The nature and extent of gender differences in mathematical performance remains a controversial topic, because there are many confounding variables and a variety of variables are used as measures of performance (Leder & Taylor, 1995; Leeson, 1995; Malone & Miller, 1993).

Poor attitude towards mathematics has often been cited as one factor that has contributed to lower participation of girls in mathematics courses and less success in those courses (Willis, 1995; Fullarton, 1993). In fact, Schiefele and Csikszentmihalyli (1995, p. 177) state that "it is likely that affective states are crucial for achieving success in school." These authors believe that interest in mathematics is a significant predictor of experience in class, grades and course level. It is evident that gender issues pertaining to participation are linked with affective variables and that the topic remains one of importance

Among the causes suggested for gender differences in participation were sex-role stereotyping and students' perceptions of their own ability. Almost all literature on this topic points to the commonly held perception that doing mathematics is consistent with a male self-image and inconsistent with a female self-image. Boswell (1979) asserted that peer pressure is a very powerful force in the formation of stereotypic self-concept. In 1977 Fennema and Sherman claimed that boys were more stereotyped with respect to mathematics as being a male dominated domain. Still, both sexes had sex-role stereotyped opinions about mathematics. For example, Sherman (1982) found that a considerable proportion of girls in secondary school "play dumb" in their mathematics classes because it is consistent with their self-concept. This observation about the negative influence of sex-role stereotypes particularly for girls is supported by Ethington (1992) and Leder (1982). In this study, the Mathematics as a Male Domain Scale (MD) is used as an indicator of the views that are expressed within each school regarding the compatibility between female roles and the study of mathematics.

## *Single-Sex and Coeducational Schools and Classrooms*

The literature with respect to the effects of single-sex and coeducational schools on attitudes and performance in mathematics is also equivocal. Recent Australian studies, including those by Collis (1987), have indicated that single-sex school environments have tended to be more closely associated with positive attitudes towards mathematics, particularly by girls. Other authors who have argued for single-sex classes (Eccles, 1989; Faulkner, 1991; Smith, 1994; Tullock, 1995; Yates, 1993). These authors have argued that in single-sex classrooms girls experience an environment in which they are not subject to the same higher levels of sexual harassment and bullying found in mixed-sex classrooms. Further it has been observed that girls tend to prefer lower levels of social competition and a warmer teaching style and that the are more likely to be found in girls only classes (Eccles, 1989). Not all studies find support for single-sex classrooms. It has been argued that coeducation has more potential for counter-sexist practices to be effective (Mulholland, 1992; Willis & Kenway, 1986).

# Method

The study used a cross-sectional survey design to gather information about the attitudes of approximately 900 secondary school students in single-sex and coeducational schools.

## *Purposes*

The purposes of this study centred on three questions.

1 Do male and female students have similar attitudes about mathematics being a male domain?

2 Does this attitude vary between grades?

3 Is the type of educational setting related to students' attitudes towards mathematics being a male domain? That is, does it make any difference whether the student attends a single-sex school or a coeducational school?

## *Sample*

Four secondary schools in a large metropolitan centre in Queensland were sampled. The first was a single-sex girls' school and the second was a single-sex boys' school. Many students at the girls' school had brothers at the boys' school. This and other factors allow an assumption that the schools target similar families. A coeducational state high school in an adjacent suburb was sampled and the fourth school was a nearby coeducational private school with a fee structure similar to the single-sex schools. The similar fee structure in the three private schools is an indication that the social-economic _class of the student populations is comparable. In addition, all four schools are of approximately the same size and all are located in middle class suburbs. The three private schools have either a Catholic or Ecumenical religious ethos.

The sample was built around the decision to select, at random, 30 students of each sex from each kind of school. In each school, all levels from grades 8 to 12 were randomly sampled. A sample of approximately 30 girls and 30 boys was chosen at each grade level because it was thought to be sufficiently large to provide a stable estimate. There seems no reason to believe that the methods of sampling have not provided a fair sample of these schools' total populations. The student is used as the unit of analysis and generalisations within Grade levels within these schools made from this data should be valid. However, the data collected are specific to these schools. Since many important variables such as economic status, religious conviction, geographical location, and ethnic composition may effect attitudes towards mathematics, generalisations to a wider sample are problematic.

## *Instruments*

Attitudes were surveyed using an adapted Fennema-Sherman (1976) scale with minor wording changes to accommodate the Australian idiom. The scale has a Likert-type, five-point response format with 6 positively worded and 6 negatively worded questions. Scale

means are reported as mean item scores, so they have a range of 1 to 5, a high score represents agreement with the concept. Cronbach's alpha was used to examine the reliability of the scales for this population, yielding a value of .92. The Mathematics as a Male Domain Scale (MD) used in this study attempts to measure the degree to which students see mathematics as a male, neutral, or female domain in the following ways: a) the relative ability of the sexes to perform mathematics; b) the masculinity/femininity of those who achieve well in mathematics; and c) the appropriateness of this line of study for the two sexes. An example item is*, 'Studying maths is just as appropriate for women as men'.*

Forgasz, Leder and Gardner (1996) have suggested that low scores on the Maths as a Male Domain Scale can no longer be interpreted "as necessarily reflecting the stereotyping of mathematics as a male domain" (p. 362). They suggest that part of the reason for this may be due to cultural changes since the scale was conceived. For example some students today may consider mathematics a female domain. That is the students may believe that girls can do mathematics better than boys. This possibility is not accounted for in the scales. Forgasz et al. (1996) illustrate the effect of this cultural change on the scale's validity by taking particular items and showing that they may be interpreted differently today than they were in the 1970's. For example, a low score on the item *'Girls can do just as well as boys in mathematics*' was originally intended to indicate that mathematics was a male domain. However, today a low score on this item may indicate that the student believed that girls were superior to boys in mathematics rather than equal. Limitations such as these need to be considered when interpreting the data.

## Results

### *Overview of analysis*

Leaf-and-stem plots, Skewness (-1.1780) and Kurtosis (.7629) statistics showed that the results from this scale did not satisfy the assumptions of normality of distribution and that a ceiling effect was evident. This is one reason why the analysis of variance tests that Fennema and Sherman used to compare gender effects were not carried out on these data. This statistical test assumes the data are normally distributed and that there is equivalence of variance. Further a number of authors have pointed out the statistical significance of a statistic, by itself, is insufficient to determine the practical significance of a finding (Menon, 1993; Schmidt, 1996; Thompson, 1996). Schmidt puts the case against over reliance on significance testing "reliance on significance testing retards the growth of cumulative research knowledge" (p. 115). The skewed results and doubt about the usefulness of using tests of significance in single studies such this have prompted the use of a more qualitative method of analysis. The results are reported simply as means and standard deviations.

Preliminary analyses revealed that the pattern of responses in the state and private coeducational schools were almost identical. For this reason the results of the two schools were combined for the reporting of the results.

Table 1 documents the means and standard deviations of each of the classes in the schools studied. The generally high mean scores in all grades show a ceiling effect, particularly for girls in single-sex schools, that has resulted in the skewed distribution. It is clear that at each grade level, within each school type, there is a difference between boys' and girls' responses. Clearly, girls more than boys believe that mathematics is not a male domain and these differences are quite large, particularly between girls in the single-sex school and boys in the coeducational schools. For example the mean score for girls in grade 12 in the single-sex school is 4.81 with the standard deviation of .29 indicating that almost all girls in this group strongly agreed that girls could do mathematics as well as boys. By contrast, the mean of responses from grade 12 boys in coeducational schools was 3.94 with a standard

deviation of .74 indicating that they expressed less confidence in the ability of girls to do mathematics as well as boys and that they had responded in a more divergent manner. That is, most girls in the single-sex school choose "strongly agree" on the Likert scale response for statements such as "Studying mathematics is just as appropriate for women as men." By contrast, most of the boys in coeducational schools demonstrated less conviction by choosing "agree" and many must have chosen "uncertain" or "disagree" in response to such statements. Put another way, Table 1 indicates that boys have a lesser regard for girls' potential to do mathematics, and are more likely to regard mathematics as a male domain. Table 1 shows that in the senior grades, school type differences between girls' beliefs in mathematics being a female domain become more apparent. The _belief that mathematics is not a male domain remains strong in girls in single-sex schools while this belief declines among girls in the coeducational settings. The high mean scores in the single-sex girls school indicates that the concerns of Forgasz et al. (1996) discussed above probably do not play a major role in reducing the validity of the data.

It should be noted that although Fennema and Sherman (1976) also found a ceiling effect with the mean of all girls' scores being 4.49 and the mean of all boys' scores being 3.82, neither of these means were as high as those found in this study (all girls' mean 4.65 and all boys' mean of 4.05). Forgasz et al. (1996) noted that high scores on the MD scale were sometimes inconsistent with the levels of gender stereotyping observed in classrooms. In particular, they observed that some boys acknowledged in their survey response that mathematics was not a male domain, but their classroom behaviour was hostile towards girls and was likely to reduce girls perceptions of their ability and liking of mathematics. That is, there was an apparent contradiction between boys' responses and their behaviour. Forgasz et al. (1996) speculated that the relatively high scores of boys might be due to the awareness of what was considered to be socially acceptable. That is some boys responded with political correctness when questioned but behaved in a sexist manner in the classroom. It is possible that the improvement in mean responses of both girls and boys may be due more to the expression of political correctness rather than a change in actual beliefs about the abilities of each sex, the relative abilities of the sexes and the appropriateness of mathematics for the girls and boys. There is evidence that this is the case for some boys (Forgasz et al., 1996). However, a search of the literature has not found evidence that girls are giving superficial recognition to political correctness with respect to sex role stereotyping in mathematics study. Still, the question warrants consideration.

Neyland (1996) emphasises the importance of language in either maintaining or changing beliefs. Clearly at the level of official curriculum documentation the gender neutrality in language has improved. However, as has been noted there is some evidence that in some classrooms that this has not resulted in gender neutral behaviour by some boys (Forgasz et al., 1996).

The school moto at the single-sex girls school is "girls can do anything". The greater belief of girls in this school that girls can do mathematics as well may as boys can may be a result of cultural and language factors that have been fostered in this school. Whether it is equally easy to foster this positive affect in girls attending coeducational schools is an interesting question. The girls in the coeducational schools in this study expressed less conviction in the appropriateness of mathematics study for girls and had less trust that women were as good at mathematics as men.

Table 1. Mathematics as a Male Domain

| | Single sex girls | | Single sex boys | | Coed. Girls | | Coed. Boys | |
|---|---|---|---|---|---|---|---|---|
| _Grade | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 8 | 4.68 | .48 | 4.20 | .81 | 4.47 | .54 | 3.75 | .83 |
| 9 | 4.83 | .30 | 4.14 | .84 | 4.61 | .42 | 4.20 | .66 |
| 10 | 4.75 | .35 | 4.29 | .64 | 4.69 | .41 | 4.07 | .55 |
| 11 | 4.73 | .37 | 4.08 | .70 | 4.50 | .61 | 3.96 | .74 |
| 12 | 4.81 | .29 | 3.92 | .95 | 4.45 | .54 | 3.94 | .74 |

## Conclusion

tx5040 The results of this study need to be considered in the context of its limitations. Factors contributing to the ceiling effect and the problems associated with using scales designed and validated in the mid 1970s to infer student beliefs in the 1990's have been discussed noted. Only four schools in total were sampled and the possibility cannot be discounted that differences between schools may be due to factors idiosyncratic to the schools. Further, this study is cross sectional in nature. A longitudinal study could plot changes in the same students' attitudes within the studied school environments, and thus provide stronger evidence to determine whether the school environment may have contributed the change. Even a longitudinal study, which documents a change in students' attitudes, is unlikely to uncover reasons for those changes. In order to untangle the interactions between the variables of interest, different data collection techniques, which make more central the students' voice, are needed to provide illumination of the complex interplay between the socially constructed variables of gender and school environment, and students' attitudes towards mathematics. However in spite of these _limitations, the results indicate that in the schools sampled girls at the single-sex school stated more strongly than their colleagues at coeducational schools, that mathematics was not a male domain. That this observation becomes more evident in years 11 and 12 indicates that the single-sex environment in this study was better able to sustain a positive attitude among girls that they could do mathematics as well as boys. It may not be a coincidence that boys expressed

increasing gender bias in senior grades. In the spirit of constructivist research the reader is encouraged to decide if the findings have any relevance to their own circumstances.

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Key word for subject index:

Mathematics, attitudes, stereotyping, school type

Readers are encouraged to "make their own sense of the situation"

# Is Mathematics a Male Domain? The Responses of Students in Single-Sex and Coeducational Schools.

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## Literature Review

- Gender differences in mathematics participation are concerning (Willis, Fullarton)

- Affective states are crucial for achievement (Schiefele & Csikszentmihalyli)

- Sex-role stereotyping important (Ethington)

- Peer pressure is important in self-concept formation (Boswell)

- Mathematics has been consistent with a male-self image (Fennema & Sherman)

- _Single-sex schools may engender more positive attitudes towards maths especially in girls (Collis, Yates)

- Less sexual harassment, bullying and social competition in single-sex classrooms

## Purposes

- Do male and female students have similar attitudes about mathematics being a male domain?

- Does this attitude vary between grades?

- Does it make any difference whether students attend single-sex or coeducational schools?

## Methods

- Cross sectional survey methodology

- Fennema Sherman (1976) Mathematics as a Male Domain Scale (5 point likert type, 12 questions)

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- Four schools
- Single-sex boys (private)
- Single-sex girls (private)
- State coeducational
- Private coeducational

- 887 students surveyed
- 30 each gender in each class
- unit of analysis is the student

## Analysis

Background-

- Data is skewed (Skewness - 1.1780 & Kurtosis .7629)

- Can not use tests based upon assumption of normality of variance.

- Statistical significance alone insufficient to determine practical significance of a finding (Menon, Schmidt).

Use of Qualitative Methods

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- Comparison of two groups shows most students in group 1 choosing a different coding value on Likert scale items to most students in group 2.
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- Results

| | Single-sex | Single-sex | Coed. Girls | Coed.Boys |
|---|---|---|---|---|

| | Girls | Boys | | |
|---|---|---|---|---|
| Grade | Mean SD | Mean SD | Mean SD | Mean SD |
| 8 | 4.68 .48 | 4.20 .81 | 4.47 .54 | 3.75 .83 |
| 9 | 4.83 .30 | 4.14 .84 | 4.61 .42 | 4.20 .66 |
| 10 | 4.75 .35 | 4.29 .64 | 4.69 .41 | 4.07 .55 |
| 11 | 4.73 .37 | 4.08 .70 | 4.50 .61 | 3.96 .74 |
| _12 | 4.81 .29 | 3.92 .95 | 4.45 .54 | 3.94 .74 |

- Ceiling effect is evident
- Girls more than boys believe that maths is not a male domain
- Boys' responses more spread
- Differences between gender beliefs more pronounced in senior grades