Achievement Self-Rating and the Gender Stereotyping of Mathematics

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In earlier times, the stereotyping of mathematics as a male domain was identified as a factor contributing to females' decisions not to persist with higher-level mathematics courses, and a weak positive relationship was typically found between females' achievement levels and rejection of this stereotype. Using a new instrument designed to measure the extent to which mathematics is stereotyped as a male, female and neutral domain, we explored the relationships between perceived achievement levels and the gender stereotyping of mathematics. We compared the results for males and females. Our findings confirm some previous results and challenge others.

Differences in the educational performance of males and females continue to attract the attention of educators, policy makers, and politicians. Two recent Federal government sponsored reports (Commonwealth Department of Education, Training & Youth Affairs, 2000; House of Representatives Standing Committee on Education and Training, 2002), which have attracted considerable attention from educators as well as from the popular media, illustrate this clearly. Gender linked subject choice is among the many factors raised in these reports.

> Another issue which provides a clear demonstration of discourses of gender in the school curriculum is subject choice. Students' curriculum selection is depressingly gendered-marked and stereotyped, and is a serious issue for many boys and girls. Many boys still consistently choose Mathematics, the 'hard' sciences and Technical Studies, over English, the 'soft' sciences and Home Science. (Gilbert, 2000, p. 56)

Understanding the reasons for the gender divide in students' subject choice, course selection, and career aspirations is central to the attainment of equitable educational outcomes. In the present study, we have explored the relationship between self-ratings of mathematics achievement and beliefs about the gender stereotyping of mathematics. In earlier research in this field, prior achievement levels and the stereotyping of mathematics as a male domain were included in models postulating explanations for gender differences in mathematics learning outcomes, including future subject choice. An overview of pertinent work in this field is presented below.

Models of Academic and Subject Choice

Various different, yet overlapping, models have been put forward to describe critical determinants of students' course and subject selections. Many of these have relied on elements incorporated in McClelland, Atkinson, Clark, and Lowell's (1953) classic work on motivation. In the words of Atkinson and Feather (1966):

> The strength of motivation to perform some act is assumed to be a multiplicative function of the strength of the motive, the expectancy (subjective probability) that the act will have as a consequence the attainment of an incentive, and the value of the incentive. (1966, p. 13)

The examples described below illustrate how this motivational perspective has been related to subject choice, and in particular to students' decisions to continue with mathematics once this is no longer compulsory.

Eccles et al. (1985) proposed a comprehensive model of achievement behaviour in a particular math course and to students' perceptions of the importance or incentive value of taking mathematics" (p. 96). More specifically, electing to continue with mathematics was hypothesized to be influenced by: students' valuing of success (e.g., the attributed utility value of mathematics for attaining future goals, the interest value of mathematical activities); students' expectancies of success at mathematics; students' (long term) goals; and students' self-perceptions of academic abilities.

The expectancy-value thrust of this formulation is readily apparent. Recognition was also given in the model to the broad environment in which subject selection took place. Thus students' attitudes to mathematics and subject selection behaviours were hypothesized also to be influenced by the beliefs of critical others in their environment, and their own perceptions of appropriate behaviours and goals. As Eccles et al. (1985) noted: "this theoretical model seems particularly relevant to the problem of sex differences in students' course selection in mathematics" (p. 98). Various elements of the model have been supported by experimental data provided by Eccles and others. For example, more recently Greene, DeBacker, Ravindran and Krows (1999) argued for a refined and simplified version of the Eccles et al. model for exploring gender differences in performance in, and choice of, mathematics. Their inclusion of values, perceived ability, stereotyping of mathematics (operationally defined in terms of perceptions of mathematics as a male domain), and future goals as critical predictors of achievement and effort in mathematics was again supported by experimental data.

A focus on Gender Differences in Mathematics Learning and Stereotyping of Mathematics

An extensive meta-analysis of mathematics education research studies incorporating affective variables and gender was conducted by Hyde, Fennema, Ryan, Frost, and Hopp (1990). They focussed on work published up to 1988 and reported that of the variables examined, *mathematics as a male domain* showed the greatest gender difference (largest effect size). In subsequent work (e.g., Greene et al., 1999), perceptions of *mathematics as a male domain* have continued to be linked to students' mathematics achievement outcomes.

The most common way of assessing *mathematics as a male domain* has arguably been through one of the subscales of the Fennema-Sherman [F-S] *Mathematics Attitudes Scales* [MAS] (Fennema & Sherman, 1976). Certainly, according to Walberg and Haertel (1992), Fennema and Sherman's (1977) first study to report findings from the MAS is among the most cited articles in mainstream journals of educational psychology. In that article, Fennema and Sherman (1977) discussed their findings from the *Mathematics as a male domain* subscale:

> Male responses differed significantly from female responses. While boys did not stereotype mathematics strongly as a male domain on this scale, they always stereotyped it more strongly than did females. (p.68)

Specifically, Fennema and Sherman (1976) hypothesized that:

- for females, the less mathematics was stereotyped as a male domain (inferred from high scores on the Mathematics as a male domain subscale), the more likely they would be to study and learn mathematics;
- the corollary of this assumption, i.e., that females who strongly stereotyped mathematics to be a male domain (inferred from low scores on the Mathematics as a male domain subscale) would be less likely to study and learn mathematics.

Indeed Sherman and Fennema (1977) found that for students in grades 10 and 11:

> Males considered mathematics as more of a male domain then females did in all groups while the girls on the whole appeared to deny (high scores, low variability) that math is a male domain. For both sexes, students in the top half of the class in mathematics achievement stereotyped mathematics less as a male domain than those in the bottom half of the class. Math as a Male Domain correlated significantly, but modestly, with achievement for girls, but not for boys... (Sherman and Fennema, 1977, p.166)

These authors (Fennema & Sherman, 1977) further reported correlations, based on responses from students in grades 7-11, between mathematics achievement and scores on the *Mathematics as a male domain* subscale of 0.21 ($p<.01$) for females and 0.07 (ns) for males. Similar findings were reported for students in grade 12.

Recent evidence suggests that low scores on the Fennema-Sherman *Mathematics as a male domain* subscale can no longer be interpreted as necessarily reflecting the stereotyping of mathematics as a male domain and that a new instrument was needed to assess the extent to which mathematics is gender stereotyped (Forgasz, Leder, & Gardner, 1999). In the next section we describe a new instrument that was developed to replace the original F-S *Mathematics as a male domain* subscale and which also allows for beliefs that mathematics is perceived as a *female domain.*

Mathematics as a Gendered Domain

A new instrument, *Mathematics as a gendered domain*, was developed[1] to measure the extent to which students stereotype mathematics as a gendered domain; that is, the extent to which they believe that mathematics may be more suited to males, to females, or be regarded as a gender-neutral domain. Previous research findings about gender issues in mathematics learning—perceptions of ability, gender-appropriateness of careers, general attitude towards mathematics (e.g., enjoyment, interest), environment (e.g., teachers, classrooms, parents), peer effects, effort and persistence, and perceptions about mathematical tasks (e.g., difficulty) guided the development of the items. Details of the development and testing of the scale can be found elsewhere (see Leder & Forgasz, 2002).

In the new *Mathematics as a gendered domain* instrument, three separate subscales, each consisting of 16 items, were used to tap the gender stereotyping of mathematics: *Mathematics as a male domain* [MD], *Mathematics as a female domain* [FD], and *Mathematics as a neutral domain* [ND]. The 48 items of the three subscales were presented in a random order. A traditional Likert-type scoring format was adopted – students indicated the extent to which they agreed (or disagreed) with each statement presented. Like the original *Mathematics as a male domain* subscale of the MAS, a traditional five-point Likert-type response format was used—strongly disagree (SD) to strongly agree (SA). As was the case with the original F-S *Mathematics as a male domain* subscale, a score of 1 was assigned to the SD response and a score of 5 to SA.

The Current Study

As discussed earlier, an assumption underpinning the development and use of the original Fennema-Sherman *Mathematics as a male domain* subscale was that girls who stereotyped mathematics as a male domain were less likely to persist with mathematical studies. The new *Mathematics as a gendered domain* instrument included a background item asking students to rate their mathematical achievement levels (1= weak to 5= excellent); they were also requested to indicate their gender.

Thus, the data file could be split by gender and mathematical achievement ratings to find mean scores on the MD, FD and ND subscales for males and females at each self-rating level.

Based on the assumptions underpinning the original Fennema-Sherman *Mathematics as a male domain* subscale and on previous findings from its use (discussed above), we expected to find the following:

- males agree more strongly than females (i.e., have a higher mean score) that mathematics is a male domain MD;
- for males: there is no relationship between perceived achievement levels and either neutral domain (ND) or male domain (MD) scores; the relationship of perceived achievement to the female domain (FD) measure is uncertain; and
- for females: those who rate themselves as excellent/good at mathematics will score high on the neutral domain (ND) – i.e., a positive correlation with perceived achievement – and low on the male domain (MD) subscales - i.e., a negative correlation with perceived achievement; the relationship of perceived achievement to the female domain (FD) measure is uncertain.

The Sample. The sample consisted of 824 grade 7-10 students (407M, 411F, 6 unknown) from 10 coeducational schools in Victoria[2].

Analyses and Results

The response frequencies to each self-rating of mathematics category (1 =weak to 5=excellent) were examined. Very few students (27) rated themselves as *weak*. Hence it was decided to collapse together responses to the categories 1 =*weak* and 2 =*below average* to form a new category, *weak*, and 4 =*good* and 5 =*excellent* to form a new category, *good*. The resulting response frequencies to the three categories, 1 =poor, 2=average, 3=good by student gender are shown in Table 1.

Table 1
Response Frequencies of Self-Rating of Mathematics Achievement by Gender

Self-rating	Male	Female
weak	49	36
average	146	198
good	206	170
Total	401	411

$SPSS_{WIN}$ was used for the statistical analyses. Mean scores were calculated for each of the three subscales—MD, FD and ND—of the *Mathematics as a gendered domain* instrument. These means were divided by 16, the number of items on each subscale, to obtain subscale mean scores ranging from 1 to 5. One-way ANOVAs were conducted to explore whether subscale mean scores were significantly different by gender and by mathematics self-rating levels for each of the MD, FD and ND subscales. Two-way ANOVAs, by gender and mathematics self-rating, were then conducted to explore for interaction effects (School of Psychology University of New England, nd). Between 723 and 741 valid subscale mean scores were included in the various analyses. Subscale mean scores and ANOVA results are shown in Table 2.

Table 2

Subscale Means by Gender and Mathematics Achievement Self-Rating Levels, and ANOVA Results

		MEANS			ANOVA results: F, p-level		
					Main effects		Interaction
Scale	***Mathematics Self-rating***	***M***	***F***	***All***	***Gender***	***Maths self-rating***	***Gender x Maths self-rating***
MD	Weak	2.42	2.02	2.23	F=81.75 p<.001 ES=.10	ns	ns
	Average	2.49	2.17	2.31			
	Good	2.61	2.07	2.36			
	All	2.54	2.12				
FD	Weak	3.01	2.40	2.75	ns	ns	F=8.61 p<.001 ES=.01
	Average	2.73	2.68	2.71			
	Good	2.62	2.75	2.67			
	All	2.71	2.69				
ND	Weak	3.56	3.86	3.69	F=14.20 p<001 ES=.02	F=8.84 p<.001 ES=.03	ns
	Average	3.66	3.87	3.78			
	Good	3.89	3.98	3.93			
	All	3.76	3.92				

As shown in Table 2, there were statistically significant differences in the subscale means on MD and ND (but not FD) by the main effect variable, *gender*. These findings indicate that:

- females (mean =2.12) rejected mathematics as a male domain (MD) to a greater extent than males (mean =2.54); the effect size of .10 is small (Cohen, 1969) but noteworthy;
- there was no significant difference in males' and females' perceptions of mathematics as a female domain (FD); and
- females (mean =3.92) believed more strongly than males (mean =3.76) that mathematics is a neutral domain (ND); effect size of .02 is very small.

By *mathematics achievement self-rating* levels (MS-R), a statistically significant difference was found only for the neutral domain, ND. The results indicated that as students' self-ratings increased from weak to good, so too did their agreement that mathematics is a neutral domain (mean scores: weak=3.69, average=3.78 and good= 3.93). The effect size of .03 is again very small.

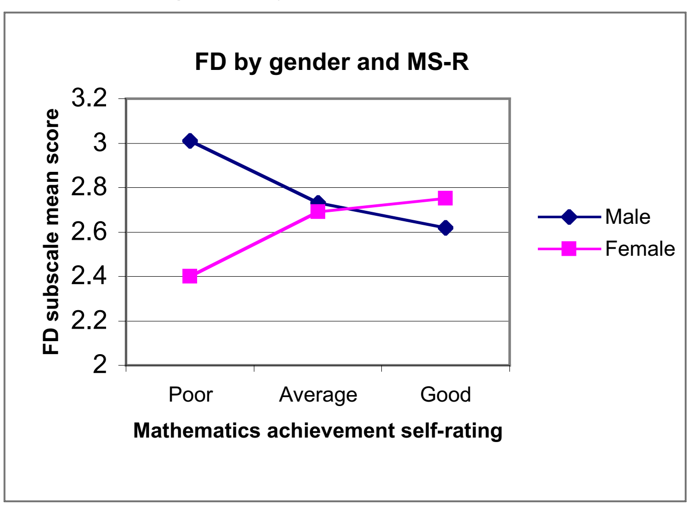

Figure 1. FD by gender and MS-R: Interaction effect.

The only statistically significant interaction effect for gender and MS-R was found for the FD subscale; the effect size of .02 is very small. The pattern of mean scores is illustrated in Figure 1. A post-hoc (LSD) test revealed that there was a significant gender difference for mean subscale scores on the FD among students who rated themselves *poor* at mathematics (mean difference=.62, $p<.05$); females disagreed more strongly than males that mathematics was a female domain.

Pearson product-moment correlations were calculated separately for males and females on the mean subscale scores of MD, FD and ND by mathematics self-ratings [MS-R]. The results are shown in Table 3.

Table 3

Pearson Product-Moment Correlations and Levels of Statistical Significance for Males and Females: Mathematics Achievement Self-Rating (MS-R) by Subscale Means on MD, FD and ND

		MD	FD	ND
Males	MS-R[1]	.10	-.17**	.23**
Females	MS-R	-.02	.12*	.09

From Table 3, it can be seen that for females:

- there was only one correlation significantly different from zero – a small positive correlation between MS-R and FD (.12), that is as self-rating of mathematics achievement increased, agreement that mathematics was a female domain also generally increased; and
- the correlation between MS-R and MD was not significant – unlike the significant positive correlation reported by Sherman and Fennema (1977).

For males, there were two statistically significant correlations:

- a small positive correlation between MS-R and ND (.23), that is as self-rating of mathematics achievement increased, agreement that mathematics was a neutral domain also generally increased; and
- a small negative correlation between MS-R and FD (-.17), that is, as self-rating of mathematics achievement increased, agreement that mathematics was a female domain generally decreased.

It was of interest to note that the small, positive correlation for males between MS-R and MD was not statistically significant.

Discussion

The results using the new instruments were mixed with respect to the original Fennema-Sherman findings. Consistency was evident with respect to gender differences in beliefs about mathematics as a male domain. Both groups generally disagreed that mathematics was a male domain, but males were less convinced of this than were females. There were also similarities in findings with respect to perceptions of mathematics as a neutral (i.e., non-stereotyped) domain. Both groups agreed that mathematics was a neutral domain but females were more convinced than males that this was the case. There was no difference in the extent to which males and females perceived mathematics to be a female domain.

There was a trend in our findings that was opposite to the pattern noted in the Fennema-Sherman results. Sherman & Fennema (1977) reported that males and females in the top half of the grade 10 and 11 classes surveyed stereotyped mathematics as a male domain to a lesser extent than those in the bottom half of the classes. In the present study, both males and females who rated themselves *good* at than their counterparts who rated themselves as *weak*: males (means = 2.61 and 2.41 respectively) and females (means = 2.07 and 2.02 respectively). This trend must be treated very cautiously as there was no statistically significant difference found for the main effect of MS-R on the MD subscale, and because the sample sizes for male and female students who rated themselves as *weak* were considerably smaller than for those who rated themselves as *good*.

With respect to the correlational findings, the results in the present study were also not fully consistent with those reported in the Fennema-Sherman studies. Unlike the Fennema-Sherman findings, in the present study there was no significant correlation for females between (perceived) achievement levels and perceptions of mathematics as a male domain (MD); the lack of significant correlations on these variables for males did, however, replicate the Fennema-Sherman findings.

Conclusions

In the original Fennema-Sherman studies there was no measure of perceptions of mathematics as a female domain. In the mid-1970s, it was not expected that anyone would hold such views. The new instrument does allow for such measures. The correlational findings in the present study are, thus, noteworthy. Caution is needed, however, in drawing definitive conclusions from the correlational findings because of the imbalance in cell sizes (see Table 1) for MS-R – there were far fewer in the *weak* category.

It is important to note that when the actual subscale mean scores are considered, both males and females generally disagreed that mathematics was a female domain. However, the directions of the significantly non-zero correlations between MS-R and FD differed by gender. For the males, the correlation was negative, indicating that as self-rating of mathematics achievement increased, the males tended to disagree more that mathematics was a female domain, that is, boys who rated themselves as *weak* at mathematics were more likely to believe that mathematics was a female domain. The opposite trend was the case for females; the higher their self-rating of mathematics achievement, the stronger their agreement that mathematics was a female domain.

The non-significant correlation found in this study for females between perceived achievement levels and our new MD subscale challenges the assumptions underpinning the original Fennema-Sherman *Mathematics as a male domain* subscale. The only correlation revealed as significant for females in our data was between perceived levels of achievement and the new FD subscale – it was not possible to explore this relationship with the original Fennema-Sherman (1976) scales. Based on these findings, it is interesting to speculate whether girls who are less likely to consider mathematics as a female domain – that is, those who are also more likely to perceive themselves to be *weak* at mathematics – are those who decide not to choose to pursue further studies in mathematics or make career decisions in the mathematics/science fields. In other words, does sex-role congruity with mathematics take on a new dimension from that postulated in earlier research? Is it the positive view of mathematics as a female domain, rather than the rejection of mathematics as a male domain that is a contributing factor in the subject, course and career choices made by girls? Finally, we echo the remarks made by Fennema and Sherman (1977) with respect to their own findings "while the evidence is weak, there are some important clues that these more direct measures of sex-role aspects may be important. Certainly more investigation is warranted" (p. 166).

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[1] Two versions of this instrument were developed—see e.g., Leder and Forgasz (2002) for more details. However, since descriptions of both scales is beyond the limited space constraints of papers submitted to MERGA conferences only data gathered using the *Mathematics as a gendered domain* instrument are included in this paper.

[2] The sample sizes in the Fennema-Sherman studies to which we have referred and with which we compare our findings were comparable.