

Gender, Early Encouragement, and Survival in Mathematics Studies

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Tertiary mathematics students reported on the encouragement they perceived that parents and teachers gave them to continue in their mathematics studies. Women had perceived stronger encouragement than men, and correlations between early encouragement and university achievement were stronger for women. Interviews confirmed the importance of encouragement for the women, and indicated that their confidence could be shaken by stereotyped views about gender. Men's interviews indicated that, for them, the greatest social danger to their studies was the anti-intellectual peer group.

Introduction

For some considerable time, there have been widespread efforts to encourage girls not to opt out of participation in mathematics studies, from the secondary school level onwards. There is still, however, clear evidence from Europe (for example the report edited by Alting, Brand, Groenendal, Hermanussen, van Vonderen, & Weyers, 1992), the United States (Bae & Smith, 1997) and Australia (Malone, de Laeter, & Dekkers, 1993) that gender imbalance in enrolment is still very strong. At university level, continuing gender imbalance in enrolment is obvious. Past investigations of survival factors among women doing very high levels of university mathematics have often found early encouragement important (Maines, Wallace, & Hardesty, 1983). The more recent wide ranging review of research made by Bae and Smith (1997) found that encouragement at home and at school still relates strongly to enrolment in mathematics courses. More qualitative work such as that of McSheffrey (1992) indicates similar patterns of influence among students who are not necessarily highly selected. One might therefore assume that early encouragement is a survival factor for groups of women at all university levels. That is, it seems reasonable to hypothesise that a high proportion of female university mathematics students would have received stronger encouragement at home and at school than their male counterparts did, precisely because mathematics is a field more traditional for males. Students' perceptions of parents' and teachers' attitudes on the stereotyping of mathematics as a male domain could also be relevant.

The problem about investigating such effects is that it is difficult to sort out whether higher enrolment in mathematics studies, and higher encouragement on the way, are not both purely the result of a student's existing record of good performance. One can, however, make a valid comparison between female and male university students using statistical control for past performance as reflected in entrance qualifications. Similarly, assessment of the importance of the perceived attitudes of parents and teachers would have to depend on finding links between students' achievement and these attitudes, which, although not establishing causality, do provide a *prima facie* case, especially if they go beyond school achievement. Ideally, evidence for influences going beyond school achievement would require links with university achievement to be still perceptible after control for school achievement. This is a stringent requirement, particularly for mathematics teachers' influence, so closely bound to school results. It follows that links that exist before control should also be given some attention, as well as overall patterns of relationships between different achievement and

attitudinal variables. Multiple approaches, including qualitative work, have the potential to be a rewarding supplement to quantitative work. The current project therefore uses questionnaires about home and school experience, intended for quantitative analyses, but includes also a set of interviews with a small number of the students from the survey sample, to investigate possible those aspects of students' experience that were most salient to them, and to allow open ended answers to reveal factors not foreseen in the questionnaire design.

Method

Questionnaire Section

The questionnaire sample consisted of 203 women and 523 men in first year mathematics classes at a large Australian university. Some of the calculations are based on slightly smaller numbers, because of missing scores, but numbers are always very close to being maximal. Students were selected as a half-sample of all tutorial classes at each possible time, to ensure a representative sample, because distribution into tutorial classes at a given time is random, but distribution of students into time slots reflects enrolment in different degree courses, and hence reflects selection and motivational factors.

Questionnaire data were collected in two successive years, in class time, using five-point scales adapted from the Fennema-Sherman Attitudes to Mathematics Scales (Fennema & Sherman, 1976). High scores indicate favourable attitudes. The scales covered perceived encouragement from parents and school teachers, and perceptions of their attitudes on the stereotyping issue. Achievement scores came from the New South Wales Higher School Certificate (HSC) results and university examination marks. The HSC scores were separated into scores obtained in mathematics, and scores obtained in other subjects (HSC non-mathematics scores), converted into percentages. University examination scores were used to construct a common score over three different levels of first year mathematics. The marks were pieced together as a single distribution, using performance on common examination material, together with university rules for transfers between subject levels, and conversion of scores for quota selection, to connect the three levels.

Comparisons between women and men were made using analyses of covariance, with HSC mathematics scores as a covariate. Analyses were originally factorial, with year of collection as the second factor, as a control check. Since almost no significant results involving the second factor emerged, results involving gender comparisons only have been extracted for presentation here. Correlations, partial correlations controlled for HSC mathematics, and block canonical correlations between vectors of attitude and achievement scores were calculated on samples maximal with respect to having all scores.

Interview Section

A sample of 22 women and 25 men took part in the interviews. The sample was selected randomly, subject to approximate coverage of degree types and inclusion of high and low achievers. Individual semi-structured interviews were conducted by one of the research team. Material was tape recorded, with the students' consent. Questions were about home and school experience in connection with the students' mathematics studies.

Results

Questionnaire Section

The comparative results of the students' perceptions of their parents' are in Table 1. All were significantly in favour of women, beyond control for HSC mathematics, indicating a helpful environment for women with respect to both encouragement and perceptions of stereotyping.

Table 1
Perceived Parents' Attitudes

	Means		Significance
	Women	Men	
Perceived encouragement: mother	3.87	3.70	0.002
Perceived encouragement: father	3.95	3.80	0.008
Perceived stereotyping: mother	4.19	3.67	0.001
Perceived stereotyping: father	3.85	3.45	.001

Correlation coefficients, and partial correlation coefficients controlled for school achievement, between students' mathematics achievement and students' perceptions of their parents' attitudes, are in Table 2. Those for encouragement are all significantly positive, but the only one to survive control is mother's encouragement of women. The stereotyping scales have zero correlations for women, while those for men tend to be weak, but negatively significant.

Table 2
Parents' Attitudes: Correlations and Partial Correlations with Achievement

	Women			Men		
	HSC Maths	Year1 Maths	University Maths	HSC Maths	Year 1 Maths	University Maths
		Initial	Controlled		Initial	Controlled
Encouragement: Mother	0.39*	0.29**	0.13*	0.19**	0.09	-0.03
Encouragement: Father	0.17**	0.17**	0.12	0.25**	0.13	-0.05
Stereotyping: Mother	0.18*	0.09	-0.02	-0.15**	-0.17**	0.12
Stereotyping: Father	0.15*	0.12	0.04	-0.08*	-0.11**	-0.10*

Note. * $p < 0.05$; ** $p < 0.01$.

Canonical correlations with achievement are in Table 3. They give no surprising information, confirming the greater importance of the same sex parent, and indicating that the main achievement link is with school mathematics. The men's relatively high link between mother's perceived acceptance of stereotyping and achievement is also consonant with the pattern of single correlations. But the main advantage of the pairing of correlated vectors is in the larger correlation coefficients arising from the combination.

Table 3

Students' Perceptions of Parents' Attitudes: Canonical Correlations with Achievement

Variables	Women	Men
HSC non-maths score	0.55	0.10
HSC maths score	-0.86	-1.01
Year 1 university maths	-0.32	-0.06
Encouragement: mother	-1.13	-0.35
Encouragement: father	0.30	-0.63
Stereotyping: mother	0.11	0.64
Stereotyping: father	-0.17	-0.10
Canonical correlation	0.44**	0.32**

Note. ** $p < 0.01$.

Results of comparisons of students' perceptions of their school teachers' attitudes are in Table 4. Here too women perceived their teachers' attitudes as more favourable than the men did, and the difference went beyond control for HSC mathematics achievement. Scores for men are reasonably high in absolute, so that one need not regard them as perceiving any absolute lack of encouragement or high levels of stereotyping.

Table 4

Students' Perceptions of their School teachers' Attitudes

	Means		Significance
	Women	Men	
Perceived encouragement	4.06	3.96	0.064
Perceived stereotyping	4.29	3.75	0.001

Correlations and partial correlations with school teachers' attitudes are in Table 5. Positive correlations and zero partial correlations with school teachers' encouragement are roughly what one might expect, given that the school teachers' influence on university mathematics achievement is so closely bound to their influence on school achievement. Perceived rejection of stereotyping has a positively significant link with school achievement for women, and a weak negatively significant controlled link with university achievement for men.

Table 5

*Students' Perceptions of School Teachers' Attitudes:
Correlations and Partial Correlations with Achievement*

	Women			Men		
	HSC	Year1 University		HSC	Year 1 University	
	Maths	Maths		Maths	Maths	
		Initial	Controlled		Initial	Controlled
Encouragement	0.40**	0.21**	-0.01	0.34**	0.26**	0.01
Stereotyping	0.22**	0.04	-0.14	-0.01	-0.07	-0.12**

Note. **p < 0.01.

Canonical correlations involving school teachers' attitudes are in Table 6. First pairings for both men and women tend to confirm the information obtainable from single correlations. The second pairing for women, though of lesser importance, indicates that some women who do well in university mathematics tend to be uncertain about their school teachers' rejection of stereotyping. The direction of the next largest coefficient, for HSC non mathematics scores links them with higher stereotyping, as is also the case in the men's second pairing, which does not involve mathematics at all. It is possible that these links reflect characteristics of the secondary schools attended by students, which the interview material clarifies below.

Table 6

Students' Perceptions of Parents' Attitudes: Canonical Correlations with Achievement

Variables	Coefficients			
	Women		Men	
	1	2	1	2
HSC non-maths score	-0.19	0.84	0.18	1.01
HSC maths score	1.11	0.40	0.83	0.06
Year 1 university maths	-0.09	-1.02	0.08	0.06
Encouragement	0.92	-0.62	1.00	-0.02
Stereotyping	0.17	1.09	-0.07	1.00
Canonical correlation	0.38**	0.19*	0.39**	0.15*

Note. *p < 0.05; **p < 0.01.

Interviews

Women and men alike had assumed for some time while still at school that they would be going on to tertiary education (77% women, 76% men). Women more than men had chosen

university mathematics for interest and expectation of doing well (54%, 19%), whereas men were more career oriented (27%, 64%). But one should bear in mind that more men do degrees oriented to a specific occupation, in which mathematics is compulsory, so that it might seem inconsistent to them to say they had chosen mathematics.

Encouragement from parents about doing mathematics was reported more often by women than by men (54%, 32%). In some cases, parents' encouragement of women had been crucial in the overcoming of prejudice. Several female engineering students had had special encouragement from their fathers, including discussion of experiences of gender based stereotyping.

"I went to a Catholic school, and they were sort of against girls doing science and maths ... but Dad was all for it." (Marie S, Chemical Engineering)

"Dad was overjoyed. ... My father is always helping me." (Teresa M, Chemical Engineering)

Encouragement from school mathematics teachers was also reported much more frequently by women than by men (82%, 40%). Some women thought they had been well treated because they had female teachers, or because they went to a single sex school, but the sample included all types of school. Discouragement of any student by mathematics teachers was very rare, but the men tended to say they had been neither encouraged nor discouraged. About a quarter of the women had encountered gender based stereotyping of subjects by science teachers, the worst case being a man who stated he did not want any girls in his physics class (the victim, who was a high achiever in mathematics, failed Physics 1 at university). Thus, in this sample, school science was the clearer barrier.

The egalitarian, anti-intellectual peer group was mentioned as a hazard to their own progress more often by men (32% women, 54% men), but more women than men described the protective value of a studious friendship group (55%, 32%). Both sexes (27%, 32%) showed awareness of acceptable rituals to overcome prejudice against high achievers (mainly attribution of success to hard work, and enthusiastic social participation), but women (32%) also mentioned being thought strange because they were interested in mathematics, not a specific issue for the men. One should add that, unlike the graduate students interviewed by Maines et al. (1983), those who mentioned stereotyping tended to show hurt rather than boredom with the issue.

Discussion

Results of comparisons all go beyond differences predictable from school achievement, indicating that the gender factor is more likely to be a real discriminator. Encouragement scores may imply upward selection for the university group or greater encouragement of females in general, but either way they indicate that encouragement is associated with women's survival into university mathematics. Perceptions of rejection of stereotyping are a different type of factor, because the issue is not symmetrical for males and females, and the difference probably indicates that it is not a dead issue, while the high absolute scores are compatible with it not having strong implications for women.

The links between encouragement and achievement give some supporting evidence for the argument that the women are favoured. It is, however, clear from the controlled links that their going beyond school achievement is uncertain, because the only significant controlled link with university achievement is for mothers' encouragement of females. First pairings of canonical

variables give no different information about dominant patterns. Combining encouragement and stereotyping, therefore, one may assume the women are a favoured group. This may mean that, in general, they are more vulnerable, but also indicates directions for intervention. Second pairings of canonical variables are likely to reflect consonance between school types, subject choices and overall high achievement. The argument is that many of the most successful secondary schools are selective or private, and often single sex. They may therefore specialise more in subjects more traditional for each sex, so that students whose scores are high in subjects other than mathematics might tend to perceive teachers' attitudes as overall more traditional. The relatively small size of the canonical correlation coefficient, compared with those for the first pairs of canonical variables, means that it seems reasonable to concentrate on the first pairs. In the interview material, it seems very clear that women perceived more explicit encouragement from parents and mathematics teachers than men. Given that it has been more frequent to find more favourable treatment of males (from earlier observational studies, such as that of Becker, 1981, through to the work reviewed by Bae & Smith, 1997), or well-meant underestimation that has deleterious results (Walden & Walkerdine, 1986) or no differences in perceived encouragement (as in the now classic studies by Fennema and Sherman, 1977, 1978; and Armstrong, 1979), one may conclude that the present group of women was to some extent favoured. The finding that science teachers are more of an obstacle needs following up. It is also clear that the peer group is seen as a hazard, involving the stereotyping issue for women. Nevertheless, the more acute perception of anti-intellectualism by men indicates that each sex has special difficulties, and it is hard to say one is in a more favourable position than the other with respect to peer group influences.

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