# Predictors of Female Participation in HSC Mathematics and Mathematics-Related Careers

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Abstract

Students' planned participation in Higher School Certificate (HSC) mathematics and mathematics-related careers was tested for the effects of student gender, mathematics performance, course level, gendered self-perceptions, task perceptions, interest and perceived usefulness. The participants were Advanced and Intermediate year 10 students (N=199) from two co-educational government schools in an upper middle-class metropolitan area of Sydney. A standardised mathematics test measured students' performance, and a questionnaire asked about self-perceptions, task-perceptions, interest, perceived usefulness and plans for participation in mathematics for both the HSC, and intended career.

The results support a persistent gender imbalance in mathematics participation. Males more than females intended to participate in the higher levels of HSC mathematics. Gender, task performance, level, perception of talent, perceived effort and interest were significant predictors of this imbalance. There was also a gender imbalance in plans for participation in mathematics-related careers. The predictors of participation in mathematics-related careers were student gender, level and perceived usefulness.

The implications are that in order to increase female participation in the higher levels of HSC mathematics, intervention programmes would need to focus on students' self-perceptions in relation to mathematics, in particular effort and interest, and gendered perceptions of talent. Effective interventions regarding participation in mathematics-related careers would focus on students' perceptions of the usefulness of mathematics. Results also raise questions about the meaning of socially categorising students into separate levels of mathematics, with implications for teacher training.

The participation of females in high school mathematics and mathematics-related careers has been recognised as an important issue for many years. Two main perspectives have informed this gender imbalance. The first is based on a 'waste of talent' notion, implying that students should participate in mathematics at a level proportional to their ability. The second argues that mathematically gifted people are needed to aid the nation's technological advance, and hence females should provide a mathematical 'yield' equivalent to that of males' (Willis, 1989). Regardless of the view taken, the gender imbalance in mathematics is clearly a robust phenomenon.

## Mathematics Participation

Gender differences in mathematics participation are difficult to identify in NSW school years 7 to 10, since mathematics is a compulsory subject and streaming is based entirely on assessment. However, clear gender differences emerge in enrolment trends for the senior years 11 and 12, when students elect the level of mathematics they wish to study. Females dominate the lower Maths in Society (MIS) and 2-unit courses, while more males elect the 3-unit and highest 4-unit courses. The recently introduced lowest level Maths in Practice (MIP) course is also chosen by more females than males. Table 1 shows the percentages of males and females studying each HSC mathematics level from 1985 to 1993, revealing persistent gender imbalances at each level. Participation rates in 3-unit mathematics and MIS appear to be converging over time, while the difference in 2-unit mathematics is very small and it is too early to identify any trends in MIP. However, the gender imbalance for 4-unit mathematics has remained remarkably constant. The persistence of this difference implies that there are strong operative factors inhibiting female participation at this highest level.

Table 1
Male and Female Higher School Certificate Participation Rates

Year:1985 19861987198819891990199119921993
M.I.P.% Males1.32.64.6
% Females2.23.75.7
M.I.S.% Males26.328.329.229.129.028.530.533.932.8
% Females34.738.340.039.837.737.337.138.437.2
2-unit% Males41.640.740.340.038.438.135.434.736.3
% Females46.644.942.441.541.239.838.137.237.9
3-unit% Males24.924.322.420.821.121.021.819.117.3
% Females15.914.614.413.815.016.317.215.414.3
4-unit% Males7.26.78.110.111.512.411.19.79.0
% Females2.82.23.24.96.16.65.45.34.9

## Mathematical Performance

It has been suggested that differences in male and female mathematical performance may be responsible for differential participation rates in mathematics. It is difficult to find a more controversial topic in recent educational research than gender differences in mathematics performance. Despite the view of females achieving less well than males in mathematics having been challenged, and the focus having shifted from achievement to the under-participation of females in mathematics and careers requiring mathematics, some doubt as to the relative performance of males and females appears to remain.

Two recent meta-analyses utilising approximately 100 research articles each (Hyde, Fennema, & Lamon, 1990; Friedman, 1989) found that in samples from the general population, male and female mathematical performance is equivalent. In the first meta-analysis, females were actually found to outperform males by a negligible amount on overall scores (d=-.05), understanding of mathematical concepts (d=-.03) and computation (d=-.14). Males outperformed females by a negligible amount on problem solving tasks (d=.08). The second meta-analysis found that a 95% confidence interval for the relative superior mathematical performance of males to females covered zero. It seems clear that overall, males and females perform similarly in mathematics.

Australian data from the 1992 Higher School Certificate (HSC) which is a state-wide externally moderated examination for all final year high school students, providing them with a ranking that determines university entrance, reveals similar performance for males and females at each level of difficulty. Table 2 represents mean scores and participation rates from the lowest Maths in Practice to the highest 4-unit level. It seems indisputable that there are no mean gender differences in mathematics performance. Explanations other than differential performance for female under-participation in mathematics must be sought.

Table 2
Male and Female Mathematical Performance and Participation in the 1992 HSC

| | | Performance | Participation | |
|---|---|---|---|---|
| Maths course | | mean score | N | (%) |
| Maths in Practice | males | 60.5 | 690 | ( 2.5) |
| | females | 57.4 | 1067 | ( 3.6) |
| Maths in Society | males | 66.2 | 8935 | (33.1) |
| | females | 66.0 | 11225 | (38.1) |
| 2-unit maths | males | 52.7 | 9154 | (33.8) |
| | females | 55.7 | 11016 | (37.4) |
| 3-unit maths | males | 35.9 | 5496 | (20.3) |
| | females | 37.2 | 4591 | (15.6) |
| 4-unit maths | males | 52.6 | 2792 | (10.3) |
| | females | 50.1 | 1591 | ( 5.3) |

(Source: adapted from Gagen, 1993, p. 58).

Possible Explanations for Female Participation Rates in Mathematics

Self-concept of one's ability in mathematics has been identified by Eccles and Jacobs as a significant factor affecting both achievement and participation in mathematics (1986). They have also suggested that if females have less favourable views than males about their abilities in mathematics this may limit their choices in studying mathematics, which in turn may confine females to 'traditional' jobs and roles (Jacobs & Eccles, 1992). This could preclude their entry to higher paying jobs that require mathematics (Eccles, 1987; Eccles & Hoffman, 1984). So far, such ideas of long-term 'behavioural confirmation' (Snyder, Tanke, & Berscheid, 1977) have been merely speculation. The present study aims to confirm such ideas through both ascertaining students' self-concept of ability in mathematics and also determining their plans regarding future participation in mathematics, since it has been found that student aspirations are a good predictor of future student outcomes (cited in Hossler & Stage, 1992, p. 433).

Within the self-concept theoretical perspective, recent Australian studies have looked at aspects of students' perceptions of achievement. These have included examination of perceived current and future performance, talent, effort and task difficulty (Bornholt, Goodnow, & Cooney, 1994). Other explanations for female under-participation in mathematics suggested by the literature include differential mathematics performance by males and females, motivational variables such as interest, and utility judgements about mathematics. The present study draws together the relative contributions of performance, self-perceptions (perceived talent and expected success), task-perceptions (effort and difficulty), interest and perceived usefulness. Other factors are taken into account by sampling students from coeducational schools, who are of the same age and socio-economic status, and by using current course level as an indicator of prior mathematics courses.

# METHOD

## Design

The present study was designed to investigate the influence of gender on students' perceptions of talent, expectation of success, perceived difficulty, required effort, interest and perceived usefulness in relation to mathematics, which may be at odds with their actual test performance. The direct and indirect effects of gender, mathematical performance and course level on students' plans for the HSC and further plans for intended careers requiring mathematics were measured, along with the effects of students' perceptions on these plans.

## Participants

The participants were Year 10 students 1. (N=199) from two co-educational government secondary schools in an upper middle-class northern metropolitan region of Sydney (based on Socio-economic index for areas, Australian Bureau of Statistics, 1990). Of the participating students, 78 were female (51 Advanced, 27 Intermediate), and 121 were male (65 Advanced, 56 Intermediate). The proportions of males and females are due to the existing class composition.

## Materials

Mathematics Achievement. Students' academic performance in mathematics was measured on a standardised Progressive Achievement Test, Form 3B (ACER, 1984). Alternate items (i=28) were selected so that the test could be administered in a 50 minute lesson. Internal consistency for the test as a whole was Cronbach alpha .70 (Bornholt, 1991, p. 41), indicating that the mathematics test was reliable.

1. Year 10 students were selected for participation in the study (N=199), because students up to Year 10 have no choice in the level of mathematics they study. That is, the students have not yet self-selected into their chosen levels of HSC mathematics. Students were selected from both the Advanced and Intermediate streams, but not the lowest stream. It was decided not to include students from this General course for two reasons. First, it was considered unethical to subject these low-achieving students to the stress of the test section of the study, since they would find the test very difficult. Second, it was decided that these students' performance would preclude their participation in the higher levels of mathematics in Years 11 and 12, and careers related to these, in any case.

Student Perceptions and Planned Participation. A questionnaire asked about students' perceptions of talent, expected success, effort, subject difficulty, interest and usefulness, as well as planned mathematics course for senior high school and intended career. This comprised part of a larger study which also measured possible influential factors on these perceptions such as parents and the media (Watt, 1993). A pilot test of the questionnaire showed the items were unambiguous, and established the length of time needed to complete the questionnaire and mathematics test.

Procedure

Two weeks before the survey was due to be conducted, information and consent forms were sent to each of the schools. Parents of students in the participating classes were requested to complete these and return them to the school two days before the survey date. The researcher briefed all the regular teachers of the classes being surveyed immediately beforehand, and was present for most of the time during the survey, to clarify and explain any questions.

Students were asked to complete the questionnaire before being given the Achievement Test, in order that their internalised beliefs be reflected, rather than their short-term reaction to the test. Students were not permitted to talk while completing questionnaires, so that they would feel free to write their own private responses.

After fifteen minutes the questionnaires were collected, so that students would not change any of their responses on the basis of their feelings after the test, and the test with its accompanying answer sheet was distributed. Students had 30 minutes to complete the 28-item multiple choice test. Tests and answer sheets were then collected, and students were invited to ask any questions they might have about the study in the remaining lesson time.

## Analyses

The study was designed for comparison of males and females. Descriptive characteristics such as means, standard deviations, range and distribution statistics were derived from the statistical package SPSS/PC for students' test scores and questionnaire item ratings. Cronbach alpha coefficients of internal consistency confirmed the reliability of the factors measuring student perceptions in relation to mathematics. Multiple regressions estimated the direct and indirect effects of gender, actual performance, course level and student perceptions on students' plans for the HSC, and further plans for intended careers requiring mathematics 2.

Students' future participation rates in HSC mathematics are the percentages of males and females intending to study each of the courses. Students' participation in mathematics in their future careers was assessed by comparing the percentages of males and females planning to choose careers involving varying degrees of mathematics, as rated by six senior teacher educators from two universities in Sydney.

## RESULTS

The first section of the results shows that the mathematical performance of males and females is similar. Second, it is found that more males than females intend to participate in the higher levels of HSC mathematics. Also, the gender imbalance in planned mathematics participation evident for the HSC is reflected in the extent to which males and females intend to participate in mathematics-related careers. Finally, a model showing the effects of gender, actual performance, course level and student perceptions on planned participation in both HSC mathematics and mathematics-related careers is presented. Results were similar at the two schools, so are not reported separately.

2. Multiple discriminant analyses revealed that 92% of the variance in students' intended level of HSC mathematics was explained by one discriminant function, and that this proceeded along an interval scale.

Mathematical Performance

Students' performance was measured by their marks on the Achievement Test (male mean 65.9%, s.d. 22.6%; female mean 70.3%, s.d. 18.9%). There was no difference between male and female scores (t(184)=-1.45, p=.149). In order to ensure similar performance by males and females, test results were also compared for males and females in each of the Advanced and Intermediate streams, in case the mean female performance were inflated due to its predominance of Advanced students. However, no differences were found in comparisons of male and female performance within the Advanced and Intermediate streams. This means that males and females are performing equally well in mathematics.

Mathematics Participation

HSC Mathematics. The levels of mathematics males and females plan to study for the HSC are illustrated in Table 3. Approximately 11% more females than males plan to study the lowest Maths in Society option, and 7% more males than females plan to participate in mathematics at the highest 4-unit level. These proportions are roughly representative of the NSW participation rates.

Table 3

Male and Female Intended Levels of HSC Mathematics

| | % Males | % Females |
|---|---|---|
| No maths | 1.5 | 0 |
| MIS | 6.5 | 17.1 |
| 2-unit | 43.1 | 36.9 |
| 3-unit | 31.2 | 35.5 |
| 4-unit | 17.7 | 10.5 |

Mathematics Required for Intended Career. Students' intended careers were grouped into those requiring no mathematics (0), up to careers requiring an extremely high level of mathematics (10). Mean ratings for the degree of mathematics required in each of the careers being considered by the students are shown in Table 4.

Table 4

Teacher Educator Ratings of Mathematics in Career Plans

| Career: | Mean | Std Dev |
|---|---|---|
| Hair-dressing | 3.50 | 1.26 |
| Drama | 3.67 | 1.49 |
| Journalism | 4.00 | 1.53 |
| Music | 4.67 | 1.60 |
| Fashion | 4.67 | 1.97 |
| Youth Worker | 4.67 | 2.69 |

Working with Animals4.671.97
The Arts4.672.21
Secretary5.001.29
Photography5.001.73
Housewife5.201.33
Hospitality5.331.25
Police5.500.96
Horticulture5.502.06
Customer Service5.671.37
Teacher of Handicapped5.672.56
Law5.832.54
Armed Forces6.171.21
Nursing6.331.70
Pre-school Teacher6.331.70
Sport Industry6.331.11
Graphic Design6.502.36
Trade6.671.37
'Business'7.671.80
Medical-related7.831.57

Primary Teacher7.830.90
Bank Clerk7.831.34
Architecture8.670.75
Accounting8.831.07
Pilot9.001.00
Computer-related9.421.10
Engineering9.670.75
Maths Teacher10.000.00

The extent to which males and females plan to pursue careers involving a degree of mathematics ranging from 0 to 10 is illustrated in Table 5. It is clear that more females than males plan to choose careers involving a relatively low level of mathematics, whereas more males than females intend pursuing a career that demands quite a high level of mathematics.

Table 5
Mathematics Required in Intended Careers by Males and Females
Level of0-345678910
Mathematics
% Males-3.5114.1111.7923.5427.0716.483.52
% Females-11.5927.5411.5914.4921.7411.591.46

Predictors of Participation in HSC Mathematics and Mathematics-Related Careers
The relative contributions of gender, actual performance, course level and student perceptions towards planned participation in HSC mathematics and mathematics-related careers are shown in Figure 1.

__________ b > .25
_ _ _ _ _ _ _ _ b < .25

Figure 1. Predictors of participation in HSC mathematics and mathematics-related careers.

The significant predictors of level of participation in HSC mathematics are gender (b=-.12), actual task performance (b=.18), level (b=.28), perception of talent (b=.22), perceived effort (b=-.17) and interest (b=.24). There are also slight indirect effects of gender mediated by perceived talent (b=-.04), and performance mediated by effort (b=.06) and interest (b=.06). Together these predictors explain 69% of the variance. The predictors of participation in mathematics-related careers are gender (b=-.29), level (b=.22) and perceived usefulness of mathematics (b=.30), explaining 33% of the variance. The perceptions in relation to mathematics are of course interrelated (mean lrl=.5). There is also an association between planned level of HSC mathematics and participation in mathematics-related careers (r=.27) which accounts for some of the variance explained in each regression.

DISCUSSION

The hypotheses that females would perform similarly to males in mathematics and intend to participate to a lesser extent in both the higher levels of mathematics and mathematics-related careers were supported by the data. It is clear that students do not make their plans regarding mathematics solely on the basis of their actual performance. As Eccles and Jacobs suggested (1986), students' perceptions in relation to mathematics indeed influence their course choices in senior high school, through which these influences flow on to limit females' participation in mathematics-related careers. With regard to the HSC, gender and perceived effort as well as performance contributed to students' plans, with course level, perception of talent and interest predicting participation over and above performance. Students' plans for participation in mathematics-related careers were not influenced by their mathematical performance directly, but were predicted by gender, course level and perception of the usefulness of mathematics.

Clearly, female under-participation in mathematics-related careers is the major issue here, but HSC mathematics participation determines access to these to a large extent. This is why we need also be concerned with students HSC plans. It is unclear however whether females are not participating in mathematics at levels commensurate with their performance resulting in their under-participation, or whether in fact males are participating in mathematics at a level greater than their performance warrants resulting in their over-participation.

Should we decide that the most practical and politically viable way forward is to increase female participation in both HSC mathematics and mathematics-related careers (rather than pull males out of higher level mathematics courses and careers), then this study raises clear implications in terms of designing intervention programmes. In order to increase female participation in the higher levels of HSC mathematics, programmes should focus on perceptions of effort and interest in relation to mathematics, as well as gendered perceptions of talent. Effective intervention programmes regarding participation in mathematics-related careers should target students' perceptions of the usefulness of mathematics, demonstrating the ways in which mathematics applies to various career options. This lends support to current views of the need for practical applications of mathematics to the real world.

The study also raises interesting theoretical questions about the nature of the social categorisations of course levels. Recall that course level predicted participation in HSC mathematics over and above actual performance, and was a strong predictor of participation in mathematics-related careers over performance. Clearly, the categorisation of students into these levels is adding something to their experience with mathematics, over and above what they learn in these different courses. This seems surprising, since students are streamed into these levels solely on the basis of their performance from junior high school, and so we would expect a strong relation between mathematical performance and course level. However, these social categories contribute to mathematics plans over and above the accumulated mathematical performance from the first four years of high school.

Perhaps students ought not to be streamed into levels labelled 'Advanced', 'Intermediate' and 'General' for mathematics, but should all study a common course with extension and enrichment work where appropriate. This raises vast implications in terms of teacher training. Teachers would need to be able to cater for a range of abilities in the classroom, and to be creative and resourceful in their instruction. They would also need to guard against implying that the mathematical experience of any one student was less valuable than that of another.

Future research should explore the mathematical experiences of males and females in different course levels. A better understanding of the nature and sources of students' perceptions in relation to mathematics should lead to the design of appropriate intervention strategies. The aim of such strategies should be for students to participate in mathematics to a degree proportional to their ability.

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