# Social Categories and Student Perceptions in High School Mathematics

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The plans that adolescent boys and girls make about participating in senior mathematics courses and mathematics-related careers are often at odds with their actual mathematics achievements. In contrast to explanations relating plans to gender differences in mathematics performance, mathematics participation can be explained by expectancy-value models of academic choice, based on gendered self-perceptions, task perceptions, and value judgments. This study with Year 10 Australian students ($N$ = 199) added to an expectancy-value model the students' current course levels that act as salient social categories. The results suggest that intervention programs need to target perceptions by girls and boys about mathematical talent, as well as making mathematics more useful and interesting to young adults. The findings raise further questions about the stratification of students into separate mathematics courses during the early years of high school.

It has long been a concern expressed by educators, policymakers, and researchers that women are underrepresented in the study of mathematics and in careers requiring mathematics (e.g., Fennema, Wolleat, Pedro, & Becker, 1981; Leder, 1992; Sherman, 1982; Willis, 1989). The present study asks about the social factors that explain women's participation in mathematics, given that mathematics is a critical filter determining access to many well-paid, high-status careers (Sells, 1973). The importance of addressing the gender imbalance in mathematics participation is informed from several perspectives. A waste-of-talnsent argument is often implied in the view that students should participate in mathematics at a level commensurate with their abilities (Willis, 1989). It also has been argued in Australia that mathematically talented and knowledgeable women as well as men are needed to aid the nation's technological advances (Willis, 1989). We may question expectations of equal proportions of men and women, ask about the relevance of higher level mathematics courses, or even suggest the overselection of men. Regardless of the perspective taken, it is

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clear that the unequal participation of men and women in mathematics is a persistent issue.

Several explanations in educational psychology have been put forward regarding the gender imbalance of participation in mathematics courses: explanations that are also applied to mathematics-related careers. In principle, the variations in course selection by girls and boys imply systematic contributing factors. Social-cognitive theories explain the phenomena in terms of self-concepts, attributions, or learned helplessness versus mastery orientations. In general, models of academic choice are based on expectations of success, and highlight subjective task values such as importance, usefulness, and enjoyment (Eccles, 1994; Eccles, Adler, & Meece, 1984). Predictions of future behavior from student aspirations (Carpenter & Fleishman, 1987) provide long-term behavioral confirmation (Snyder, Tanke, & Berscheid, 1977) of expectancy-value models of plans for future participation in mathematics. In brief, students' perceptions and interpretations of learning mathematics inform their intentions and choices about further study of mathematics, which in turn influence work and career roles (Eccles, 1987; Eccles & Hoffman, 1984; Jacobs & Eccles, 1992).

The present study builds on the expectancy-value model of contributions by self-perceptions, task-perceptions, and value judgments about mathematics to plans for mathematical participation. Social categories are added to the model that describes students' current level of mathematics course. Implications of this extended model are examined for immediate plans for the following year about participation in senior mathematics courses and for more long-term plans about mathematics-related careers.

In principle, explanations about students' plans for mathematics course participation in senior high school should account for students' previous experience of mathematics (Fennema & Sherman, 1977). The advantage of locating the study in New South Wales is that mathematics is compulsory for the first 4 years of high school (Year 7 to Year 10). In the first year of high school, it is usual for students to study a common mathematics course. In subsequent years (Year 8 to Year 10), students are streamed or stratified into basic, intermediate, or advanced mathematics courses on the basis of mathematics performance. In this way, the mathematics background of each Year 10 student is captured in the level of her or his current mathematics course. This provides a known basis from which to ask students about future plans where senior mathematics courses are optional. This Australian study is therefore an important variation of previous research in the United States using the expectancy-value theoretical framework. In settings where students elect mathematics courses from an early age, the varied course backgrounds would inform their experiences of learning mathematics, perceptions, and aspirations against a background of prior choices. The present study builds on previous Australian research examining student perceptions and participation in relation to mathematics (e.g., Bornholt, 1992; Watt & Bornholt, 1994). A follow-up study of adolescents in their next to final year of high school suggested that students make choices of subject levels in senior high school mostly with reference to themselves, rather than their parents, and in particular to perceived natural talent and interest in the subject (Watt, 1995).

Findings generally support the expectancy-value model of gendered intentions and subsequent choices of senior mathematics courses; however, the role of current course level was not explicitly examined. Students are aware of the stratified meaning of levels of mathematics courses, as evidenced by the salience of course level as a social category in student self-perceptions (Watt, 1998). In light of this, the present study evaluates the impact of Australian students' perceptions including the current course level on mathematics plans, over and above mathematics performance.

## Explanations Beyond Mathematics Performance

Although recent research suggests that girls and boys approach mathematics problems in various ways (Fennema & Carpenter, 1998), similarities in mathematics performance by boys and girls make previous actual achievement an unlikely factor responsible for differential participation rates in mathematics. Meta-analyses have established similar mathematical performance for girls and boys. Research articles from 1967 to 1987 about mathematics performance by students from primary school to undergraduate university (Hyde, Fennema, & Lamon, 1990) show negligible differences between the performance of girls and boys in overall scores ($d = -.05$), as well as understanding of mathematical concepts ($d = -.03$), computation ($d = -.14$), and complex problem-solving tasks ($d = .08$). Further, a meta-analysis of 98 studies from 1974 to mid-1987 (Friedman, 1989) found the 95% confidence interval for mathematics performance by gender included zero, implying that zero difference may exist. In the local situation, records of final mathematics examinations in New South Wales also show similar performance for boys and girls (e.g., Gagen, 1993). It would seem that explanations other than differential mathematics performance are needed for the gender imbalance in mathematics participation.

In summary, expectancy-value theory predicts that student self-perceptions, task perceptions, and value judgments about mathematics inform student plans for participation in senior mathematics courses. The present study adds the social categories defined by students' current mathematics course level to a model examining well-differentiated aspects of self-perceptions (talent and expected success), task perceptions (effort required and difficulty), and value judgments (interest and utility) about mathematics (Eccles & Wigfield, 1995). These direct and indirect contributions were examined for students' short-term plans regarding senior mathematics courses, as well as long-term plans about mathematics-related careers.



## Method

### *Participants*

Participants were from two coeducational government secondary schools in an upper-middle-class area of Sydney (Australian Bureau of Statistics, 1990). Year 10 students in their fourth year of secondary schooling were in advanced and intermediate mathematics courses (girls: Advanced $n = 51$, Intermediate $n = 27$; boys: Advanced $n = 65$, Intermediate $n = 56$). In Australia, formal schooling from kindergarten, Year 1 to Year 6 at infants and primary school, is followed by Year 7 to Year 12 at high school. The last 2 years of high school are optional. Ranking in the Year 12 final examination generally determines university entrance (e.g., the Higher School Certificate in the state of New South Wales).

### *Materials*

A pilot study with boys (Advanced $n = 13$, Intermediate $n = 9$) and girls (Advanced $n = 12$, Intermediate $n = 10$) in Year 10 at school indicated that instructions and questionnaire items were unambiguous, and the test and questionnaire could be completed in the time allowed. Consequently, no modifications were made on the basis of piloting.

*Mathematics performance.* Alternate items were used from the Progressive Achievement Test, Form 3B (Australian Council for Educational Research, 1984), so that it could be administered within a 40-min lesson. The test was found to be internally consistent (Cronbach's $\alpha = .87$), and a low chi-square to degrees-of-freedom ratio showed the test to be unidimensional, $\chi^2(23, N = 199) = 566.4$, $p = .003$. Multiple-choice test items included numeracy, computation, measurement and money, statistics and graphs, spatial relations, relations and functions, and logic and sets. Mathematics test scores summed for incorrect (scored as 0) and correct (scored as 1) responses ranged from 0 to 28.

*Student perceptions.* Measures of students' perceptions in relation to mathematics included internally consistent scales of perceived talent ($\alpha = .90$), expected success ($\alpha = .91$), effort required ($\alpha = .84$), task difficulty ($\alpha = .80$), interest ($\alpha = .95$), and usefulness ($\alpha = .79$). Each scale was measured by two or more indicators, to which students responded on a 7-point Likert scale ranging from 1 (*low*) to 7 (*high*).

*Student plans.* Students' plans for optional mathematics courses in senior high school ranged from no mathematics in senior high school (0), to low-level mathematics courses (1), to high-level mathematics courses (4). The inclusion of plans for senior mathematics courses in the regression analysis was justified on the basis that one discriminant function explained 92% of the variance in plans, and this function proceeded along an interval scale.

Students' future career plans were nominated in response to an open-ended question. In order to characterize student career plans relating to mathematics, a coding schedule for student career plans was derived from ratings by six experienced university teacher educators. Students' careers were judged according to the degree that knowledge and skill in mathematics is required (Watt & Bornholt, 1994). The derived coding used a Likert scale ranging from 0 (*no mathematics required*) to 10 (*extremely high degree of mathematics required*).

### Procedure

The study was conducted with the approval of the two school principals and informed consent of parents and students. Testing was carried out in the regular mathematics classroom to maximize ecological validity. The students completed the questionnaire before the achievement test, so that responses reflected internalized attitudes to school mathematics rather than their short-term reaction to the particular mathematics test.

### Analyses

Preliminary analyses indicated that results for the two schools were similar and were subsequently combined (independent $t$ tests with unequal variances, $p > .05$ for student perceptions and planned level of senior mathematics, $p > .01$ for mathematics performance). Means and standard deviations describe students' test scores, perceptions, and plans. Cronbach's alpha coefficients of about .70 confirmed the reliability of self-perceptions and task perceptions in relation to mathematics. Plans for mathematics course participation and careers by gender are also described by percentages for each category. Multiple regressions estimate the direct and indirect contributions of gender, actual performance, current course level, and student perceptions on plans for senior mathematics course participation and career plans involving mathematics.

## Results

Results confirm that student performance on the mathematics test was similar for boys and girls, and a gender imbalance existed in plans for participation in senior mathematics courses as well as mathematics-related careers. The results describe the contributions of gender, actual performance, current mathematics course level, and students' self-perceptions, task perceptions, and value perceptions to students' plans for participation in senior mathematics courses and mathematics-related careers.



Table 1

*Plans for Senior Mathematics Courses by Girls and Boys*

| | Senior mathematics courses | Boys (%) | Girls (%) |
|---|---|---|---|
| 0 | None | 0.8 | 0.0 |
| 1 | Maths in Society | 6.7 | 15.8 |
| 2 | 2-Unit Maths | 49.6 | 39.5 |
| 3 | 3-Unit Maths | 26.1 | 34.2 |
| 4 | 4-Unit Maths | 16.8 | 10.5 |

*Note.* In New South Wales, Maths in Society is a basic senior mathematics course, and other courses are named according the units that contribute toward the final Higher School Certificate examination, in increasing order of difficulty.

### Mathematical Performance

Student performance on the achievement test was similar for boys ($M$ = 65.9%, $SD$ = 22.6%) and girls ($M$ = 70.3%, $SD$ = 18.9%), $t(184) = -1.45$, $p = .149$. Test scores differentiated well between the two levels of current mathematics courses. Advanced students scored, on average, 30% higher than did intermediate students (Advanced $M$ = 80.0%, $SD$ = 13.9%; Intermediate $M$ = 50.3%, $SD$ = 17.4%), $t(152) = -12.85$, $p < .001$.

### Mathematics Participation

The gender imbalance in students' plans for senior mathematics courses is shown in Table 1. Approximately 9% more girls than boys plan to study the basic senior mathematics course, and 6% more boys than girls plan to study mathematics at the highest level. It is important to note here that these sample proportions are roughly representative of general participation rates.

Students' plans to pursue careers that require mathematics are shown in Table 2 for boys and girls. It is clear that more girls than boys plan to pursue careers involving a relatively low level of mathematics. More boys than girls intend to pursue careers requiring a high level of mathematics.

### Influences on Participation in Mathematics

Multiple regression estimates in Table 3 describe the relative influences of gender, actual performance, current course level, and student perceptions on plans for mathematics courses in senior high school and mathematics-related

Table 2

*Extent to Which Mathematics Is Required for Intended Careers Nominated by Boys and Girls*

| Maths required[a] | | Boys (%) | Girls (%) |
|---|---|---|---|
| None | 0 | — | — |
| Low | 1 | — | — |
| | 2 | — | — |
| | 3 | — | — |
| | 4 | 4.8 | 14.7 |
| | 5 | 11.9 | 30.9 |
| | 6 | 16.7 | 20.6 |
| | 7 | 16.7 | 4.4 |
| | 8 | 20.2 | 7.4 |
| High | 10 | 4.8 | 1.5 |

[a]The derived coding used a Likert scale ranging from 0 (*no mathematics required*) to 10 (*extremely high degree of mathematics required*).

careers. The main contributions to planned participation in mathematics-related careers were gender ($\beta$ = -0.33), current course level ($\beta$ = 0.30), and perceived usefulness of mathematics ($\beta$ = 0.33). These three variables alone explained 28% of the variance in career plans involving mathematics. Plans for participation in senior mathematics courses were substantially explained (64% of the variance) by contributions from gender ($\beta$ = -0.10), current course level ($\beta$ = 0.33), perception of talent ($\beta$ = 0.22), perceived effort ($\beta$ = -0.15), and interest ($\beta$ = 0.29).

It is interesting to note that there was no direct effect of mathematical task performance on plans for senior mathematics courses. There were indirect effects of gender through perceived talent ($\beta$ = -0.04), performance through talent ($\beta$ = 0.05), effort ($\beta$ = 0.05), and also interest ($\beta$ = 0.06). Other links are the effect of gender on perceived talent ($\beta$ = -0.18) and expected success ($\beta$ = -0.20), indicating that perceived talent and expectations of success in mathematics were higher for boys than for girls. Actual mathematics performance was linked to some extent to perceived talent ($\beta$ = 0.23), expected success ($\beta$ = 0.27), and perceived effort required in mathematics ($\beta$ = -0.34). Students' plans for senior mathematics courses and career plans were moderately associated ($r$ = .37).

A second regression analysis determined contributions to mathematics plans other than actual performance. Effects of actual performance were removed by



Table 3

*Summary of Regression Analyses Predicting Student Perceptions and Plans*

| Outcome | Predictor | $\beta$ | Partial $r$ |
|---|---|---|---|
| Perceived talent | Current course level | 0.15 | .12 |
| (Adj. $R^2$ = .13) | Gender | -0.18* | -.19 |
| | Performance | 0.24* | .18 |
| Expected success | Current course level | -0.05 | -.04 |
| (Adj. $R^2$ = .07) | Gender | -0.20* | -.20 |
| | Performance | 0.27* | .20 |
| Perceived difficulty | Current course level | -0.01 | -.01 |
| (Adj. $R^2$ = .01) | Gender | 0.09 | .09 |
| | Performance | -0.14 | -.10 |
| Effort required | Current course level | 0.08 | .06 |
| (Adj. $R^2$ = .07) | Gender | 0.01 | .01 |
| | Performance | -0.34* | -.25 |
| Interest | Current course level | 0.03 | .02 |
| (Adj. $R^2$ = .03) | Gender | -0.03 | -.03 |
| | Performance | 0.20* | .15 |
| Perceived usefulness | Current course level | 0.05 | .03 |
| (Adj. $R^2$ = .01) | Gender | -0.11 | -.11 |
| | Performance | 0.06 | .04 |
| Planned senior maths course | Current course level | 0.33* | .37 |
| (Adj. $R^2$ = .64) | Gender | -0.10* | -.17 |
| | Performance | 0.11 | .12 |
| | Perceived talent | 0.22* | .21 |
| | Expected success | 0.02 | .02 |
| | Perceived difficulty | -0.04 | -.04 |
| | Effort required | -0.15* | -.19 |
| | Interest | 0.29* | .32 |
| | Perceived usefulness | 0.04 | .06 |

(*table continues*)

Table 3 (Continued)

| Outcome | Predictor | β | Partial $r$ |
|---|---|---|---|
| Maths-related career plans | Current course level | 0.30* | .23 |
| (Adj. $R^2$ = .28) | Gender | -0.33* | -.35 |
| | Performance | -0.08 | -.07 |
| | Perceived talent | -0.08 | -.05 |
| | Expected success | 0.10 | .07 |
| | Perceived difficulty | 0.08 | .05 |
| | Effort required | -0.04 | -.04 |
| | Interest | 0.10 | .09 |
| | Perceived usefulness | 0.33* | .30 |

*Statistically significant nonzero standardized beta coefficients ($p < .05$).

regressing plans for further study on performance and saving the standardized residual. The main contributions were perceived talent ($\beta = 0.20$) and interest in mathematics ($\beta = 0.27$). These two variables alone explained 42% of the variance in plans for senior mathematics courses.

## Discussion

As expected, performance on the mathematics test was similar for girls and for boys, yet a gender imbalance was evident in plans for senior mathematics courses and mathematics-related careers. Explanations for the gender imbalances generally supported expectancy-value models of academic choice in terms of self-perceptions and task perceptions in relation to mathematics (e.g., Bornholt, 1992; Eccles, 1994), with an important addition of the social categories defined by students' current mathematics courses. The main contribution of this study was to suggest a different set of explanations for the plans that these Year 10 students expressed for senior school mathematics courses and their plans for mathematics-related careers. The accumulation of gender, mathematical performance, current level of mathematics course, self-perceptions of talent and effort, and interest in mathematics contributed to students' plans for senior mathematics courses. Career plans involving more mathematics were also more likely for boys than for girls. However, career plans depend mainly on current mathematics course level, as well as students' perceptions of the usefulness of mathematics.

These findings support a wealth of research that gives clear indication that other factors in addition to performance in mathematics contribute to students' plans for senior school mathematics courses (Eccles, 1987, 1994). After removing the effects of mathematical performance, senior mathematics plans can be largely explained by students' gendered self-perceptions regarding mathematical talent in addition to level of interest in mathematics. This implies that in order to address the gender imbalance in senior mathematics course participation, the social basis of students' gendered perceptions of talent must be targeted. A focus on the nature of school mathematics itself that heightens student interest would also contribute to students electing higher levels of senior school mathematics. In order to address students' plans for participation in mathematics-related careers, intervention programs would need to focus on students' perceptions of the usefulness of mathematics. The main focus would be on the knowledge that students, teachers, and career advisors have of the extensive use of mathematics in diverse careers.

The present study raises interesting questions about the social meanings of students' streamed mathematics courses. The contribution to students' plans suggests that student awareness of the stratified mathematics courses acts as a salient social category, such that current course level has an impact over and above that of an objective performance indicator. This interpretation is strengthened by qualitative research into the bases of students' self-perceptions related to mathematics (Watt, 1998), which found that course levels have social meaning to students. For example, in response to an open-ended question asking why students felt talented (or not talented) at mathematics, 25% of students with high self-perceptions spontaneously cited their current high course level as the reason, with 10% of students having low self-perceptions conversely citing their low course level as the reason. This implies that social categorization adds to students' mathematical experiences from earlier years in high school. Future studies are needed to investigate these self-perceptions regarding mathematics for boys and girls in earlier years of high school. One possible implication from the present study warns against stratification of students in mathematics classes in the early years of high school. Grading students may facilitate effective teaching, although this may be achieved better by a common course, with extension and enrichment work where appropriate. The consequences for teacher training require catering to a range of abilities in the classroom and guarding against implications that the mathematical experience of any one student is any less valuable than that of another.

Implications for policy and practice are more speculative. One possibility is that some Year 10 girls should or could choose higher level senior mathematics courses but do not because of gendered perceptions regarding mathematical talent, over and above their mathematics performance. The results may alternatively suggest that some boys who study higher level mathematics should not do so. In either case, only a small proportion of students take this option. The practical implications prompt us to ask about the longer term consequences. Boys are more likely than girls to pursue strongly mathematics-related careers, and social categories of current mathematics courses contribute to the imbalance in a manner quite unrelated to actual mathematical performance. If the under-representation of women in mathematical domains is of concern—and both the waste-of-talent notion and the utilization-of-national-resources perspectives imply that it is—then we need to investigate sources of gendered perceptions of mathematical talent and social categories of current mathematics courses. It is clear that students, teachers, and career advisors must be more aware of emotional and attitudinal aspects related to mathematics, as well as mathematical performance.

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## ERRATUM

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*Social Categories and Student Perceptions in High School Mathematics*

Helen M. G. Watt and Laurel J. Bornholt .......... 1492

Page 1492, 1st paragraph, lines 8-9 appeared as follows:
"A waste-of-talnsent argument . . . ."

This sentence should read:
"A waste-of-talent argument . . ."

Page 1498, Table 2 appeared as follows:

| Maths required[a] | | Boys (%) | Girls (%) |
|---|---|---|---|
| | . . . | | |
| | 8 | 20.2 | 7.4 |
| High | 10 | 4.8 | 1.5 |

These lines should read:

| Maths required[a] | | Boys (%) | Girls (%) |
|---|---|---|---|
| | . . . | | |
| | 8 | 20.2 | 20.5 |
| | 9 | 24.9 | 7.4 |
| High | 10 | 4.8 | 1.5 |

Sincerely,

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