

Sex Differences in Math Achievement  
and Course Enrollment

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A growing concern has been expressed by policy makers over the small numbers of women pursuing careers in the scientific, mathematical, and technical fields. Despite efforts to ameliorate this through affirmative action and scholarship programs, employment statistics indicate that men and women are still entering these career fields in unequal numbers (Bureau of Labor Statistics, 1980). The problem begins in late high school when girls start dropping out of advanced level math courses at a higher rate than boys. Why this sex difference exists is the subject of this chapter.

### Biological Factors

Some scientists attribute the sex difference to innate ability or aptitude differences. Proponents argue that there are consistent sex differences on tests of both quantitative and spatial skills, and that these differences account for sex differences in both math performance and math participation. Each of these conclusions are reviewed below.

Sex differences on tests of quantitative skills. The following results are fairly consistent across studies using a variety of achievement tests: (a) High school boys perform a little better than high school girls on tests of mathematical reasoning (primarily solving word problems); (b) Boys and girls perform similarly on tests of algebra and basic mathematical knowledge; and (c) Girls occasionally outperform boys on tests of computational skills (Armstrong, 1980; Burnett, Lane, & Dratt, 1979; Connor & Serbin, 1980; E.T.S., 1979; Fennema, in press; Fennema & Sherman, 1977, 1978; Hyde, 1981; Schratz, 1978; Sherman, 1980, 1981; Starr, 1979; Steel & Wise, 1979; Wittig & Petersen, 1979). Among normal populations

achievement differences favoring boys do not emerge with any consistency prior to the 10th grade, are typically not very large and are not universally found even in advanced high school populations. There is some recent evidence, however, that the general pattern of sex differences may emerge somewhat earlier among gifted and talented students (Benbow & Stanley, 1980; ETS, 1979).

Sex differences in spatial skills. The findings regarding sex differences in spatial skills are also fairly consistent, though not universal, and do not emerge prior to the 10th grade. Among these older adolescents, boys outperform girls on some measures of spatial skills but the magnitude of the sex difference varies depending on body type (Petersen, 1979), on personality characteristics associated with masculinity and femininity (Nash, 1979), on previous experience with spatial activities (Burnett & Lane, 1980; Connor, Serbin, & Schackman, 1977; Connor et al., 1978), on ethnic background, parental styles, and socioeconomic status (Fennema & Sherman, 1977; Nash, 1979; Schratz, 1978), on maturational rate (Waber, 1979), and on the particular test given (Connor & Serbin, 1980). In fact, in a recent national survey study of 3240 junior and senior high school students, 13-year-old girls did better on a test of spatial skill than 13-year-old boys; twelfth grade boys and girls did equally well (Armstrong, 1980). Thus as Connor and Serbin conclude "junior and senior high school males...perform better than females on some visual-spatial measures, some of the time" (Connor & Serbin, 1980, p.36).

Relation of spatial skills to mathematics achievement. Several studies have demonstrated a strong positive correlation between spatial skills and a variety of mathematical achievement test scores

(Burnett et al., 1979; Fennema & Sherman, 1977, 1978; Sherman, 1980a,b; Armstrong, 1980; Connor & Serbin, 1980; Steel & Wise, 1979). But verbal abilities also correlate quite highly with mathematical performance; not all measures of spatial skills correlate significantly with all measures of mathematical achievement; and that the patterns of these relations varies across grade level, sex, and study (Armstrong, 1980; Burnett et al., 1979; Connor & Serbin, 1980; Fennema & Sherman, 1977, 1978; Hyde et al., 1975; Sherman, 1980; Steel & Wise, 1979'). Further, in a recent factor analytic study Connor & Serbin (1980) found that the tests of spatial skills factor together and independent of measures of mathematical achievement. Thus the relation between spatial skills and mathematical achievement is not clear. Furthermore, whether or not the sex difference in spatial skills is contributing to the sex difference in mathematical achievement is even less clear. While some findings are consistent with this hypothesis (e.g., Burnett et al., 1979; Fennema & Sherman, 1977; and Hyde et al., 1975); others are not (e.g., Connor & Serbin, 1980; Steel & Wise, 1979).

Whether the sex differences in either mathematical ability or spatial skills contribute to the sex differences in course participation rates is even more debatable. The pattern of results is quite mixed. For example, in Sherman (1981) spatial skills predicted girls' but not boys' participation. In contrast, in Steel and Wise's study (1979) spatial skills predicted for boys only. Participation is also predicted by scores on vocabulary tests (Sherman, 1981), by past math achievements (Armstrong, 1980; Dunteman et al., 1979; Fennema in press; Parsons et al., in press-a, Steel & Wise, 1979), by interest

in mathematics and career plans (e.g., Fennema, in press; Parsons et al., in press-a, Steel & Wise, 1979) and by a variety of attitudinal and social factors which will be reviewed in the next section.

In addition, it must be noted that spatial visualization skills can be trained (Burnett & Lane, 1980; Connor et al., 1977 1978; Goldstein & Chance, 1965). Thus the magnitude of the contribution of biological factors, the inevitability of their effects, and the exact nature of these effects are still to be determined.

### Socialization Factors

Modeling effects. Several studies have found that adult females are both less likely to be engaged in math activities and more likely to express doubts about their math abilities than are adult males. For example after sixth grade fathers are more likely to help their children with their math homework than are mothers (Ernest, 1976); advanced math courses are more likely to be taught by men (Fox, 1977); female student teachers have lower estimates of their math ability and openly admit they are less comfortable teaching math than their male peers (Aiken, 1970); and finally mothers hold a more negative view of their math abilities and interest than do fathers (Parsons et al., 1982). This under-representation of appropriate female role-models could discourage some girls from engaging in activities involving mathematics during the high school years. The success of several recent intervention programs designed to increase female math participation through exposure to female models supports this line of reasoning (e.g., Brody & Fox, 1980; Tobin & Fox, 1980).

Socializer's expectations and related behaviors. The expectations parents and teachers hold for children are another

possible source of influence on children's math involvement. Several studies indicate that parents and teachers have higher educational expectancies for high school and college age males than for comparable females (Good, Sikes, & Brophy, 1973; Hilton & Berglund, 1974; Sears, Maccoby, & Levin, 1957). Only a few studies have directly measured the expectancies that parents and teachers hold for math achievement. While these studies have yielded a mixed pattern of results, when differences emerge, they favor boys. For example, in some studies both parents and teachers believe boys are better at math than girls (Casserly, 1975; Ernest; 1976; Haven, 1971; Luchins, 1976). Similarly, parents rate math as more difficult for daughters than for sons and feel that daughters have to work harder than boys in order to do well in math courses (Parsons et al., 1982). Other studies, however, yield either inconsistent or non-significant sex effects (e.g. Ernest, 1976, Parsons, et al., 1982a,b). For example, in the Parsons, et al., (1982) study, neither parents nor teachers had lower expectations for their girls' math performance than for their boys'. Thus it appears that the sex stereotypes held by parents and teachers are small but favor boys when they are present.

But do these stereotypes affect students' attitudes and if so how? Parents, teachers and counselors have all been found to provide boys more explicit rewards, encouragement and reinforcements for learning math and for considering math related careers than girls (Astin, 1974; Haven, 1971; Casserly, 1975; Luchins, 1976; Parsons, et al., 1982b). In one study the counselors openly admitted discouraging girls from taking these courses, citing reasons that reflected their stereotyped views of appropriate adult roles and math

abilities. In addition, based on extensive observations in classrooms, several investigators have concluded that the quantity and type of teacher instruction sometimes varies according to the sex of the student and the subject matter being taught. Some, but not all, teachers interact more with, provide more praise to and provide more formal instruction to boys than girls, especially in mathematics and science classes (Bean, 1976; Becker, 1981; Brophy & Good, 1974; Fennema, 1982; Leinhardt, Seewald, & Engel, 1979; Parsons et al., 1982; Stallings, 1979). These differences in teacher behavior, when found, are most extreme among high math ability children.

While the pattern of results associated with differential treatment is fairly consistent, studies which have attempted to assess the causal influence of these difference on course enrollment or career aspirations have yielded a much less definitive picture. Both Heller and Parsons (1981) and Parsons et al. (1982) tested the relation of student-teacher interaction patterns to both students' attitudes toward math and their plans to continue taking math. While both studies found a significant relation between teachers' expectations for a student (as provided by the teacher on a written questionnaire) and student attitudes even after the effects of the students' past grades in mathematics had been partialled out, both studies found very few significant relations between actual teacher behaviors and student attitudes. And those which did emerge were quite small. Other studies, focusing more on the impact of a single, salient teacher, suggest that teachers can have a big impact on girls' attitudes. But the teachers must provide active encouragement to the girls in the form of (a) exposure to role models, (b) sincere praise

for high ability and high performance and (c) explicit advice regarding the value of math and its potential utility for high paying, prestigious jobs (Casserly, 1975, 1979).

Studies demonstrating the causal influence of parents in shaping sex differences in math participation are virtually non-existent. While Parsons and her colleagues have demonstrated that parents' sex stereotyped beliefs are related to girls' more negative attitudes toward math, the direction of influence is still open to question (Parsons et al., 1982).

Differential experiences. In addition to the more direct socialization effects discussed thus far, parents and teachers also influence children's achievement behaviors and values through the experiences they provide or encourage. Exposure to different toys and recreational activities has been linked to the sex differences in both spatial skill and attitudes toward math and science (Connor et al., 1978; Austin, 1974; Hilton & Berglund, 1974).

Early independence training has also be suggested as a cause of sex differences in math involvement (Ferguson & Maccoby, 1966; Hoffman, 1972; Stein & Bailey, 1973). Since independence training facilitates math achievement (Bing, 1963; Ferguson & Maccoby, 1966) and since girls may get less independence training than boys, the sex difference in math involvement may result from these differential socialization practices. This hypothesis has yet to be tested directly.

Summary. The studies reviewed in this section provide strong support for the hypothesis that socializers treat boys and girls differently in a variety of ways that might be linked to math



achievement and course selection. But only a few studies have assessed the causal impact of these socialization experiences on students' math attitudes, math achievement, and course selection. The results of these few studies suggest that sex differences in math behaviors and course selection may result from the differential treatment accorded girls and boys. For example, encouragement from parents, has emerged in several studies as an important factor in girls' decisions to elect advanced mathematics courses in high school (e.g., Armstrong, 1980; Fennema & Sherman, 1977, 1978; Haven, 1971; Luchins, 1976; Parsons et al., in press-b; Sherman & Fennema, 1977). The effects hold up longitudinally and are significant even when the effects of the children's past performance in mathematics are partialled out (Parsons, et al., in press-a). Thus it seems likely that parents and teachers are having a negative impact on girls' math course-taking.

#### Attitudinal Factors

Confidence in one's math ability. The pattern of findings regarding confidence in one's math ability and related attitudes are quite consistent. While sex differences are typically not present among elementary school children, by junior high school boys are more confident of their math abilities than girls (e.g., Armstrong & Kahl, 1980; Brush, 1980; Ernest, 1976; Fennema & Sherman, 1977; Fennema, in press; Fox, Brody, & Tobin, 1980; Kaminski, Erickson, Ross, & Bradfield, 1976; Parsons et al., in press-a; Robitaille, 1977; Sherman, 1980) This sex difference, however, is not reflected in students' expectations for their performance in the courses in which they are currently enrolled (Heller & Parsons, in press; Parsons et

al., in press-a). Rather the sex difference emerges on measures reflecting students' more general rating of confidence in their math abilities and their expectations for future courses.

Although sex differences in confidence have been established, only a few studies have tested the link between confidence in one's math ability and course selection. These studies have yielded a consistent pattern of positive relation between confidence and enrollment patterns (Armstrong, 1980; Kaminski et al., 1976; Parsons et al., in press-a; Sherman, 1980; Sherman & Fennema, 1977). More studies, however, are needed to clarify the casual significance of this relationship .

Sex typing of mathematics. While numerous studies have shown that when high school students sex-type mathematics they classify it as a male achievement domain (Armstrong & Kahl, 1980; Ernest, 1976; Fennema & Sherman, 1976, 1977; Parsons et al., in press-a; Stein & Smithells, 1969), the implication of this fact for math enrollment is not clear for several reasons. First, math is neither always stereotyped as masculine (e.g., Fennema & Sherman, 1977; Parsons et al., in press-a; Stein & Smithells, 1969), nor is it even one of the most likely subject areas to be stereotyped; mechanical arts courses and athletics are both more likely to be classified as masculine (Stein & Smithells, 1969). Second boys are more likely to stereotype math as masculine than are girls (e.g., Brush, 1980; Fennema & Sherman, 1977; Parsons et al., in press-a; Sherman, 1980). Third, studies which have attempted to assess the relation of sex-typing, of math to actual math achievement, and course plans have yielded mixed results. Futhermore, the variations in results do not follow a

consistent pattern (Boswell, 1979; Dwyer, 1974; Fennema & Sherman, 1977; Nash, 1975, 1979; Parsons et al., 1982; Sherman, 1980). Thus the relation between the sex-typing of mathematics and students' achievements and course plans in mathematics is not clear at present.

Perceived Value of Math. Ratings of the utility value of math also vary by sex. Several studies indicate that boys, as early as 7th and 8th grades, rate math as more useful than girls (Brush, 1980; Fennema & Sherman, 1977; Fox et al., 1979; Haven, 1971; Hilton & Berglund, 1974; Parsons et al., in press-a; Wise et al., 1979). These results, however, are not entirely consistent across age groups and schools (Fennema & Sherman, 1977; Sherman, 1980).

Perceived value of math and math-related career plans emerge as significant predictors of both achievement and course plans in most studies (e.g., Armstrong, 1980; Brush, 1980; Fennema, in press; Fennema & Sherman, 1977; Fox et al., 1980; Fox & Denham, 1974; Lantz & Smith, 1982; Parsons et al., in press-a; Wise et al., 1979). Furthermore, while Brush (1980) found that the perceived usefulness of math was a relatively weak predictor of course participation in comparison to other predictors such as ability level, socioeconomic status, and general feelings toward math, other investigators have found interest in math and perceived utility value are two of the most important mediators of the sex differences in math involvement.

#### Affective Factors

In recent years math anxiety has emerged as yet another explanation for the sex difference in math involvement (Lazarus, 1974; Tobias, 1978; Tobias & Weissbrod, 1980). Although there are only a few empirical studies which test for sex differences in "math anxiety"

and these are not entirely consistent, there is some support for the hypothesis that in high school and beyond girls have more negative affective response to math than boys (Brush, 1978, 1980; Dreger & Aiken, 1957; Meece, 1981; Suinn & Richardson, 1972). These studies, however, have not controlled for the possibility that boys may be less willing to admit to feelings of anxiety, especially since they regard mathematics as a male domain.

The few studies that have tested for the causal impact of anxiety on course taking suggest that anxiety does not have a large direct effect on course plans. Instead it appears to have its most important effect on other variables related to students' course selection such as how much they expect to like the course and how well they expect to do (Brush, 1980; Meece, 1981; Parsons, 1982). In two of these studies, girls attitudes' were affected more by their anxiety levels than boys. Thus, it is likely that anxiety is having a more negative effect on girls math involvement than on boy's.

#### Summary of Past Research

We have reviewed several explanations for the sex difference in math involvement. Not surprisingly, no one cause has emerged with unequivocal support. Because aptitude differences appear to be quite small and difficult to assess and because the majority of the researchers have been interested in identifying modifiable determinants of the sex differences in participation, much of the recent research has focused on social and experiential factors. Evidence from these studies suggests that socializers have a powerful influence on students' academic choices. There is also fairly strong evidence suggesting that students themselves, through their attitudes,

self-perceptions, and feelings about mathematics are a major source of the sex differences in both math achievement and course enrollment patterns. Of these variables, confidence ability and the perceived value of math appear to play the most critical role. Finally, there is some support for the possibility that biological factors may be involved, but the exact nature of these factors and their susceptibility to training are still unknown.

#### Model of Student's Enrollment Decisions

Each of the bodies of research reviewed in the previous section provides insights into the determinants of math achievement behaviors. It is clear from these findings that many factors influence sex differences in math participation. What is missing, however, in this research tradition is a theoretical system specifying the links between all of these factors. Given the variety of psychological processes that influence students decisions and the sociocultural context in which mathematics learning takes place, a theoretical system with the following characteristics would be particularly useful. First and foremost the system should be comprehensive. It should specify the interrelations among the various components presumed to contribute to students' academic decisions and outline the developmental origins of the individual differences in these components. Such a framework examining the causal impact of aptitude, socialization, attitudes, and affect on student's academic decisions would help clarify existing research, would provide direction for future research, and would provide the basis for sound intervention programs. Parsons and her colleagues (in press, a) have developed such a model and have used it in designing a large scale longitudinal

study of sex differences in math attitudes. (Figure 1 displays an overview of this model.)

Building upon general expectancy/value theories of achievement (Atkinson, 1964; Crandall, 1969; Kukla, 1972, 1978; Lewin, 1938; Weiner, 1972, 1974), the framework proposed by Parsons et al. (in press-a) links academic choice to two specific cognitive constructs: expectancy for success on a task and subjective value of the task for the individual. Individual differences on these two cognitive constructs are attributed to variations in aptitude, and performance, on socialization experiences, and on students' current and future goals. In line with cognitive approaches to achievement motivation, the effects of achievement and experience are assumed to be mediated by a student's interpretations of these events in light of cultural influences and a fairly stable perception of oneself. Therefore, as shown in Figure 1, achievement expectancies and values are hypothesized to be influenced by students' perceptions of their own abilities, personal needs, and future goals, and by their perceptions of a set of task characteristics inherent in various achievement tasks. Individual differences on these variables are assumed to result from students' perceptions of socializers' beliefs and behaviors, students' causal attributions for their own successes and failures, students' perceptions of role-appropriate behaviors and goals, and previous experiences with similar achievement situations.

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The model stresses the interactive qualities of expectancy for success and subjective task value. Work within the general

expectancy/value framework has tended, over the last decade, to focus primarily on variables that are presumed to be related to students' expectations for success. Individual variations in achievement have been attributed to differences in such constructs as confidence in one's abilities. Much of the research on sex differences in math participation has embraced this same orientation. Too little attention has been paid to the impact of the subjective value of math to the individual on students' decisions. This model clearly focuses attention on the importance of subjective value. Furthermore, it specifies the range of factors that can influence subjective value.

The model also places the decision to enroll in math courses in the context of a complex social environment which confronts students with a wide variety of choices. These decisions are assumed to be guided by a set of core values such as achievement needs, competency needs, and sex role values, and by more utilitarian values such as the importance of mathematics courses for future goals. Thus if a girl likes math but feels that the amount of effort it will take to do well is not worthwhile because it decreases the time she will have available for more preferred activities (i.e., activities more consistent with her personal values), she will be less likely to continue taking math. Similarly if a girl stereotypes mathematics or careers involving competency in mathematics as masculine and not consistent with her own sex role values, she will be less likely to value mathematics learning and less likely to continue her mathematical studies, especially if she does not expect to do well.

Finally, the model clearly stresses the importance of modifiable determinants of course selection and achievement in math. While the

model does not rule out the possibility of biological explanations for sex differences in math achievements, it does emphasize social and psychological factors. While inherited ability is acknowledged as one important determinant of math achievement and attitudes, it is assumed that a students' ultimate decision regarding pursuit of math training is more likely to be a consequence of the students' interpretation of reality rather than reality itself. Analyzing the problem from this perspective helps clarify some of the inconsistencies found in the math achievement literature. For example, past research has shown that girls do as well as boys in math throughout their formative years, yet they do not expect to do as well and are less likely to go on in math. The extent to which boys and girls differ in their interpretation of achievement outcomes because of the differential information they receive from their social environment could, in fact, account for this apparent paradox. The subjective meaning individuals attach to math is mediated by a variety of psychological and social factors such as the causal attribution made for their math performance, the input of socializers, perceptions of the demands inherent in math as a subject area, and perceptions of their own needs, values, and role identity. Each of these factors is assumed to play a role in shaping students' confidence in their math abilities, their expectations regarding future success, the subjective value they attach to math, and ultimately students' decisions regarding enrollment in math courses.

Many of the theoretical predictions generated by this model have not been examined. However, much of the research reviewed early clearly points out the importance of several of the constructs. The



importance of other constructs and the causal relations specified by the model have not been tested. In an effort to test some of these predictions, Parsons and her colleagues conducted a large scale, multi-faceted longitudinal study of sex differences in math participation. The results of this study are reviewed briefly in the next section.

### Empirical Test of Model

To assess the relevance of this model for explaining sex differences in math enrollment, approximately 600 children in grades 5-9, their parents, and their math teachers were recruited to participate in a longitudinal study. Measures were designed to assess the psychology constructs specified in the model. Data collection has involved 1) administering a lengthy questionnaire to all of the students in each of the first two years of the study (year 1 and year 2), 2) administering a somewhat shorter questionnaire to the students' parents in year 1, 3) administering a very short questionnaire to each students' math teacher in year 1, 4) observing in the students' math classroom in year 1, 5) gathering standardized test scores and courses grades from the students' school records in years 1, 2, 3, 4, 5. In the initial analysis the data were separated into in two sets. One set was composed of the student measures; the other set was composed of the parental, classroom, and teacher measures. Before discussing the test of the model, the findings from each of these data sets will be summarized.

Students' Beliefs and Attitudes. Few sex differences in the students' beliefs and attitudes toward math emerged; but those which did confirmed previous findings. Compared to girls, boys rated math as

easier and more useful, felt math required less effort, had higher expectations for their performance in future math courses and reported lower levels of math anxiety, even though the boys and girls had done equally well in their previous math courses and on standardized math aptitude/achievement tests.

Boys and girls also differed in the attributions they made for success and failure in math. Boys ranked lack of ability as a less important reason for their math failure than did girls and ranked high ability as a more important reason for their math success than did girls. Girls, in contrast, ranked consistent effort as a more important reason for their math success than did the boys.

These differences in attribution patterns reflect very different perceptions of the task demands of math which may affect both students' expectation for future success in math and their decision to enroll in advanced math courses. The girl who thinks consistent effort is a more important cause of her successes than ability may be unsure about how well she will do in future math courses precisely ] because she thinks these courses will be more difficult than her current math course. Further, she may conclude that success in these courses will require even more effort than she is expending in her current math course. The amount of effort she can (or is willing to) expend has limits. Consequently, perceptions of the need for even greater effort may predispose her against continuing to take math, especially if she doesn't think math is all that useful for her long range goals. The same dynamics would not apply to a boy who views his ability as an important cause of his success in math. He can assume that his ability will allow him to continue performing well in future

courses with little or no additional effort.

We also asked the older children two sets of questions specifically related to their math enrollment decisions. First, we asked them to rate how much encouragement to continue taking math they had received from various individuals. Contrary to the popular belief that peer pressure prevents some girls from enrolling in math, peers were not rated as having had any negative effect on students' enrollment plans by either boys or girls. Boys, however did feel that guidance counselors had provided them with more encouragement to continue than did the girls.

We also asked the students to rate the importance of various reasons for taking advanced math courses. Three reasons emerged as the most influential: preparation for either a college major or career, gaining admission to a prestigious college and the importance of math in a well-rounded education. Intrinsic properties of math, such as its challenge, ease, or interest were rated as much less important. One sex difference emerged: boys rated the importance of future plans (college or career) in their decision higher than did girls ( $p < .01$ ).

The final set of attitudes we assessed were related to sex-role stereotypes and sex-role identity. It has been suggested that girls avoid math because it is perceived to be masculine. To test this hypothesis we had our students rate the usefulness of math for males and females and judge whether boys or girls have more math ability. While the students did rate math as more useful for males than for females, they did not stereotype males as having more math ability. Furthermore, the degree to which a girl stereotyped math as especially

useful to males enhanced the subjective value of math for her. Thus we found no support for the idea that stereotyping math as useful for males is a deterrent to girls enrollment in math.

In summary, boys and girls do differ in their attitudes toward math. Additional analyses indicate, as predicted by the model, that confidence in one's math ability and subjective value are significantly related to math grades, enrollment plans and actual course enrollment. These analyses are discussed in more detail later.

#### Socialization Variables.

By and large, we found very little evidence of differential treatment of boys and girls in their math classrooms. Therefore we will limit this review to our parent data.

A student's sex had a definite effect on parents' perceptions of the student's ability and on parents' perceptions of the relative importance of various high school courses. While parents did not rate their daughters' math abilities significantly lower than they rated their sons', they did think that math was more difficult for their daughters. Furthermore, like the girls themselves, parents think daughters have to work harder than their sons in order to do well in math (see Parsons et al., in press for full details). In fact, boys and girls reported doing the same amount of homework. Therefore it seems that this belief that girls are having to work harder to do well in math is a myth. Whether parents initiate the bias or merely echo it is not clear in our data. But, at the very least, parents are not providing their daughters with a counter-interpretation.

But are parental beliefs about their children's abilities and plans predictive of future math expectancies and future course plans?

To answer this question we correlated the major parent and child variables. (Since the patterns of correlations were essentially the same for boys and girls, only the results from the entire sample will be discussed.) Children's course plans, future expectancies, current expectancies, and perceptions of the importance and value of math were all related consistently in the predicted direction to measures of their perceptions of their parents' beliefs and expectancies, and to the parents' actual estimates of their children's abilities (see Parsons et al., in press for full details).

In conclusion, the parents in this study had sex-differentiated perceptions of their children's math ability despite the similarity of the actual performance of their boys and girls. This difference was most marked for the parents' estimates of how hard their children have to try in order to do well in math. Parents also thought advanced math was more important for their sons than for their daughters. Most importantly, parents' perception of, and expectations for, their children were predictive of the children's self-concept of math ability, future expectations, and course plans.

More central to the issue of sex differences in math participation, however, is the question of whether or not these differences in parental attitudes and in student attitudes mediate sex differences in students' motivation to seek out advanced training in mathematics. To answer this question, we entered our subjects' responses into a path analysis. The results of this analysis are depicted in Figure 2. As predicated by our model

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students' motivation to continue taking math is predicted most directly by their estimate of the value of mathematics courses and by their math anxiety. Students' grades, on the other hand, are most directly predicted by self-concept of ability.

The path analytic results also point out the importance of parents as critical socializers of sex differences in children's math attitudes and achievement. Parents' estimates of the difficulty of math for their children have a stronger impact on students' attitudes than the attitudes of teachers. Furthermore, parents believe that math is harder for their daughters than for their sons. In contrast, while teacher beliefs are also predictive of student beliefs, the teachers' attitudes are not sex differentiated. These results suggest that exposure to parents' sex stereotyped beliefs has an especially debilitating effect on girls' orientation toward mathematics.

Although it could be argued that the parents' beliefs reflect a true difference between boys and girls in math aptitude, the following additional results suggest that this is not the case. First, the girls and boys in this sample had equivalent math grades and standardized math test scores at the start of the study. Second, when asked how much math homework they did, the boys and girls reported equivalent amounts. Third, the teachers' estimates of these students' mathematical ability were equivalent for boys and girls. Thus it appears that the sex difference in parental beliefs is not grounded in reality but reflects instead the cultural sex-stereotype that math is more difficult for girls.

Comparing the zero-order correlations between boys' and girls' estimates of the value of mathematics and objective indicators of their mathematical ability yielded another set of interesting differences. Boys' estimates of the value of math are significantly related to their past math performance ( $\underline{r}=.33$ ,  $\underline{p}<.01$ ) and to both their teachers' ( $\underline{r}=.33$ ,  $\underline{p}<.01$ ) and parents' ( $\underline{r}=.28$ ,  $\underline{p}<.01$ ) estimates of their math ability. In contrast, girls' estimates of the value of math are not significantly related to any of these three measures but are related to a set of more subjective variables. In particular the girls' estimates of the value of math are related to their stereotypes of math as masculine, ( $\underline{r}=.58$ ,  $\underline{p}<.01$ ), to their career plans ( $\underline{r}=.42$ ,  $\underline{p}<.01$ ), and to their parents' beliefs regarding both the importance of math courses ( $\underline{r}=.24$ ,  $\underline{p}<.01$ ) and the difficulty of mathematics ( $\underline{r}=-.27$ ,  $\underline{p}<.01$ ). Interestingly, as noted earlier, stereotyping math as a male subject area increased its value for the girls. Otherwise, the pattern of relations is as one would expect; girls who are planning careers in science, and whose parents think math is both not too difficult and very important rate math as more valuable than girls who are planning careers in non-scientific and non-technical fields and whose parents think math is both very difficult and not very important.

Thus, it appears that social factors, independent of real math aptitudes, have a greater impact on girls' perceptions of the value of math than on boys' perceptions. These data suggest (1) that gender roles may be shaping the value girls attach to various career-related activities such that they are less likely than boys to pursue both mathematical training and mathematical careers and (2) that neither

parents nor teacher's are doing very much to counter this process.



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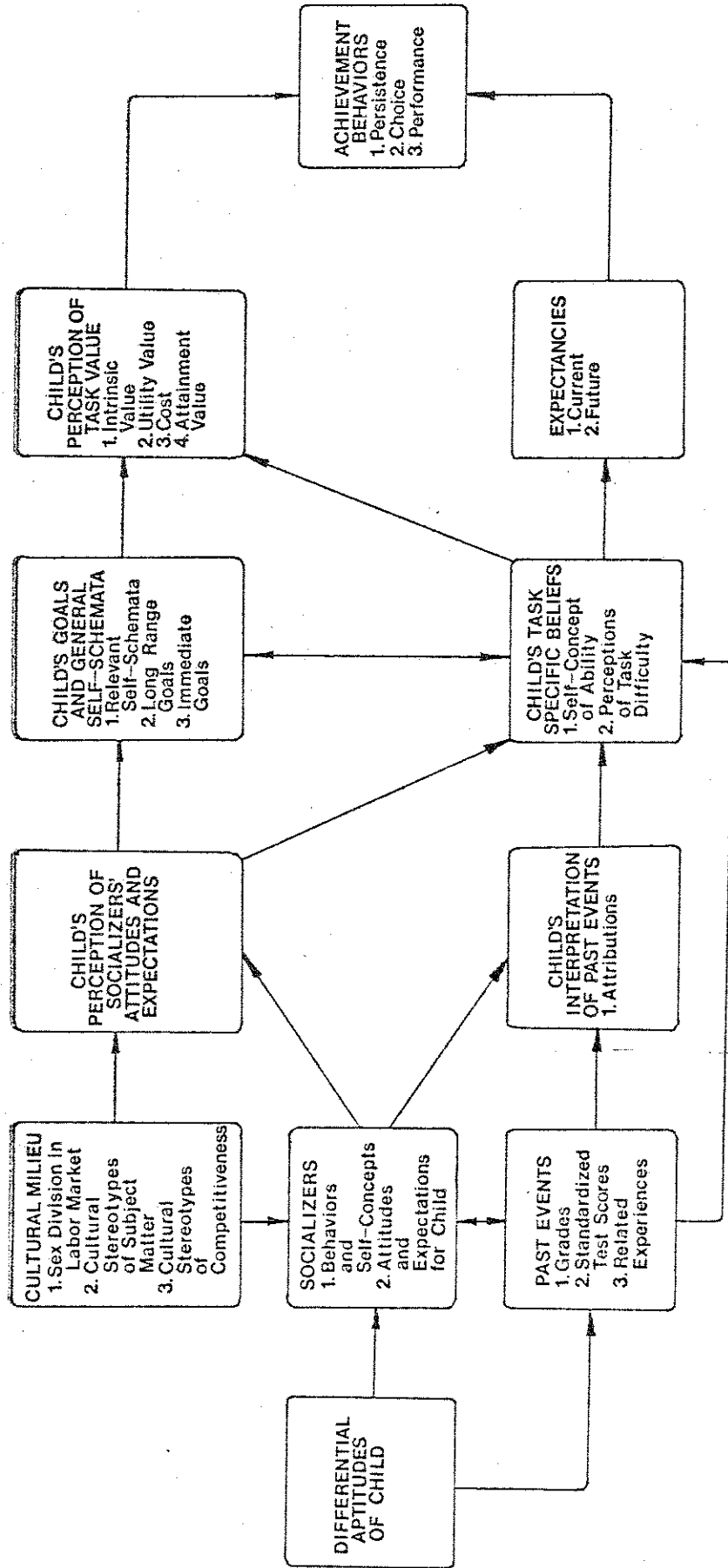
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## Figure Caption

Figure 1. General model of academic choice. (Adapted from Parsons, J.E., Adler, T.F., Futterman, R., Goff, S.B., Kaczala, C.M., Meece, J.L., & Midgley, C. Expectancies, values, and academic behaviors. In J.T. Spence (Ed.), Perspective on achievement and achievement motivation. San Francisco: W.H. Freeman, in press.





### Figure Caption

Figure 2. Reduced path analytic diagram: longitudinal determinants of grade in mathematics course and enrollment plans. (Column-wise multiple regression equation procedures were used to estimate the path coefficients. At each step, each endogeneous variable was regressed on the set of all predictor variables to the left of the column to which it belongs. Shared explanatory variance is divided among the relevant predictor variables. The standardized path coefficients, which are standardized regression coefficients, reflect the relative predictive power of the predictor variables in comparison to one another. Specification of the path model, i.e., assignment of variables to particular columns, was based on the theoretical model laid out by Parsons et al. (20). All possible paths across columns were estimated by regression procedures. No paths were specified within columns. A t-test was used to test for the significance of each path coefficient. Only paths significant at  $p < .02$  are presented in the figure. Dashed lines are significant at  $p < .02$ ; solid lines at  $p < .001$ ;  $N=164$ .  $R^2$ =the percent of variance of each endogeneous measure accounted for by the model, a  $R^2$  is listed under each variable).

<sup>a</sup>Based on year two data. All other scores based on year one data.

