

# SEX DIFFERENCES IN MATHEMATICS PARTICIPATION

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## ABSTRACT

Competence in mathematics is a critical skill directly related to educational and occupational choices. Yet compared to males, females are less likely to enroll in advanced level mathematics courses and to aspire to mathematically oriented careers. The possible reasons for this sex difference are reviewed in this chapter. In addition, the evidence is integrated into the theoretical model proposed by Eccles, Adler and Kaczala (1983) for studying students' academic choices and decisions. This psychological model, based, in part, on classical expectancy-value models of task choice, links academic choice to two cognitive constructs: (a) expectations for performance in particular courses and (b) perceptions of the value or importance of the various courses from which one must choose. Further, the model specifies the relations among the set of both psychological and social experiential constructs believed to mediate individual differences in expectations for success and perceptions of the relative value of various achievement options. In particular, the following constructs are discussed: confidence in one's academic (especially mathematical) ability, perceptions of the difficulty of mathematics, attributional patterns, sex role identity, stereotypes of the sex typing of math-related careers, self-schemata or self-systems, personal goals and values, past experi-

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ences related to mathematics in both the school and the home, parental expectations and behaviors, the expectations and behaviors of teachers and other school personnel, one's mathematical aptitude, and one's performance history in mathematics. Recommendations, based on this model, for intervention strategies designed to increase the participation of females in mathematics courses and in math-related careers are discussed.

## INTRODUCTION

A growing concern has been expressed by policymakers over the small number of women pursuing careers in the scientific, mathematical, and technical fields (Sells, 1980). 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 disproportionate numbers (Bureau of Labor Statistics, 1980). Women are less likely than men to enter professions which are math-related. For example, in the academic year 1975-1976, women received only 3.2% of all undergraduate engineering degrees and only 20% of all undergraduate degrees in computer science, physical science, and business and management. In contrast, females received 73% of the undergraduate degrees in education and 79% of the undergraduate degrees for health-related professions.

Interestingly, women did receive 41% of the undergraduate degrees in mathematics. But relatively few students major in mathematics in comparison to the more applied fields associated with mathematics. For example, in 1975-1976, approximately 16,800 degrees were awarded in mathematics; in contrast, 220,000 degrees were awarded in engineering, computer science, physical science, and business and management; and 211,000 B.A. degrees were awarded in education and in health-related majors. Furthermore, the proportion of degrees in mathematics awarded to women drops at each level beyond the B.A. degree; for example, in 1976, only 34% of the masters degrees in mathematics went to women and only 15% of the doctorates in mathematics were awarded to women (Chipman & Thomas, 1980).

While these trends have remained fairly stable over the last 10-15 years, there has been a slight increase in female participation in the last 3 or 4 years, especially in business programs. A survey of 1979 college freshmen reported in *The Chronicle of Higher Education* (Magarrell, 1980) suggests that this increase may persist into the 1980s. For example, when asked their prospective major, 23% of women in 1979 (as compared to 12.5% of the women in 1969) indicated business, 2.5% (vs. 0.4% in 1969) indicated engineering, 1.8% (vs. 1.0% in 1969) indicated physical science, and 3% (vs. essentially 0% in 1969) indicated computer science and electronics. However, while these figures reflect a slight increase in participation of women in math-related fields, the percentage of men planning on majoring in these same areas still far outnumbers the percentage of women. For example, 19% of the men planned to major in engineering, 4% in physical science, and 5.5% in computer sciences and electronics.

Many researchers have expressed an interest in this problem. Findings from

a wide variety of sources indicate that although girls receive less encouragement to continue their mathematical studies or to pursue mathematical careers, it is not the case that the sex differences in career plans are the result of systematic discrimination. On the contrary, all too often girls choose to limit, or to end, their math training while still in high school or soon after entering college. This choice effectively eliminates the options of many math-related careers for these girls.

Why do girls choose to limit their options in this way? The search for an understanding of the motivational-attitudinal determinants of achievement-related behaviors is not new to psychology. Much of the relevant work in the 1950s and 1960s was stimulated by the expectancy-value theory of Atkinson and his colleagues (Atkinson, 1964). This theory focused attention on individual differences in the motive to achieve and the effects of subjective expectation on both this motive and the incentive value of success. Some investigators, using new techniques to measure achievement motives, have continued to explore the implications of motivational mediators for achievement behaviors (Spence and Helmreich, 1978). Much of the work of the last decade, however, has shifted attention away from motivational constructs to cognitive constructs such as causal attributions, subjective expectations, self-concept of ability, perceptions of task difficulty, and subjective task value. The theoretical and empirical work presented in this chapter fits into this more recent tradition.

Building on the seminal works of Atkinson (1964), Crandall (1969), Crandall, Crandall, Katkovsky, and Preston (1962), Crandall, Katkovsky, and Crandall (1965), and Weiner (1972, 1974), my colleagues and I have elaborated a model of academic choice. Drawing upon the theoretical and empirical work associated with decision making, achievement, and attribution theory, the model links academic choices to expectancies for success and to the importance or incentive value of the task. It also specifies the relation of these constructs to cultural norms, experience, aptitude, and a set of personal beliefs and attitudes associated with achievement activities (Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983). It is our contention that this model, originally proposed as a general model of achievement choices, is particularly useful in analyzing sex differences in students' course selection in mathematics and in guiding future research efforts in this domain (Meece, Eccles-Parsons, Kaczala, Goff, & Futterman, 1982). A general summary of the mediators and their relation to expectations, values, and achievement behaviors is depicted in Figure 1. As can be seen, the model is built on the assumption that it is not reality itself (i.e., past successes or failures) that most directly influences students' expectancies, values, and achievement behavior, but rather their interpretations of that reality. The influence of reality on achievement beliefs, outcomes, and future goals is assumed to be mediated by causal attributional patterns for success and failure, by the input of socializers (primarily parents and teachers), by one's needs and values, by sex role identity, and by one's perceptions of the task itself. Each of

these factors is assumed to contribute to both the expectations one holds for future success and the subjective value one attaches to any particular achievement task. Expectations and subjective value, in turn, directly influence achievement-related behaviors (including the decision to engage in a particular activity) and actual performance.

Reviewing all of the literature supporting the importance of these cognitive mediators for career choice is beyond the scope of this chapter. This literature is reviewed extensively in Eccles et al. (1983). Suffice it to conclude at this point that studies ranging from such diverse fields as mathematical modeling of decision making to career counseling and guidance have consistently pointed to the importance of these constructs in task or career choice.

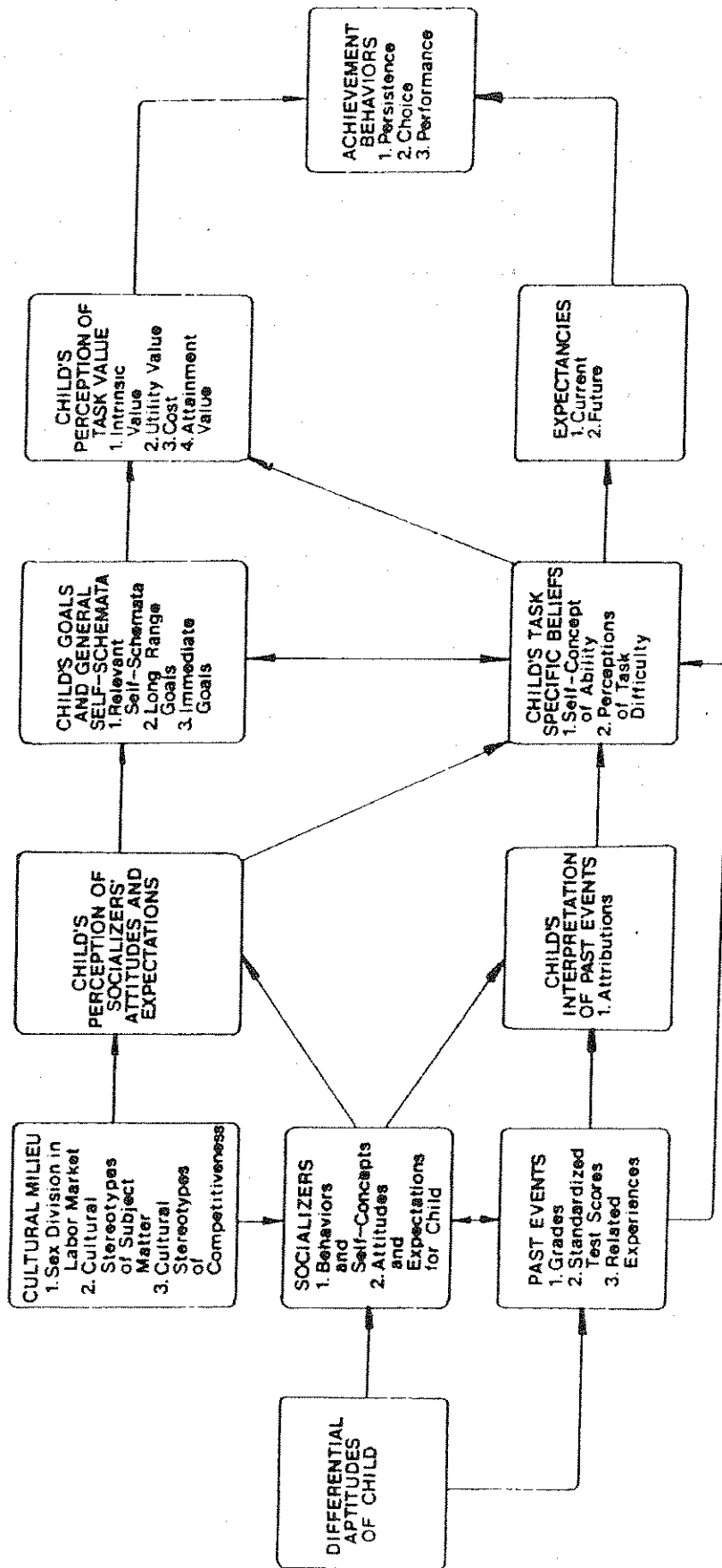
In this chapter I apply this model to mathematics course enrollment and career choice. The role of each of the major psychological components in shaping mathematics-related expectations, values, and academic choices is discussed. Particular attention is focused on assessing the contribution of these constructs to our understanding of sex differences in decisions regarding math-related careers. My review focuses on two issues. First, I summarize the existing literature regarding sex differences on these constructs. Second, I discuss in more detail those studies which tested the relationship between these constructs and either mathematics course or math-related career choices (henceforth referred to as math participation).

The fact that males and females differ on some variable (for example, self-confidence in their math ability) does not, in and of itself, support the inference that sex differences in math career plans are a consequence of the sex difference on that variable. At a minimum, the relationship between the variable and math participation must be assessed. Furthermore, while a significant correlational relationship would provide support for a hypothesized link between a variable and math participation, it does not demonstrate a causal effect. Longitudinal and/or causal modeling procedures are necessary to evaluate the causal relationship between two variables. Longitudinal and causal modeling procedures have been used in only a few studies of math course enrollment patterns and continuing motivation for mathematics study. Since these methods provide the best available evidence regarding the impact of attitudes and beliefs on students' academic and career decisions, extra attention is devoted to these studies.

## EXPECTATIONS FOR SUCCESS

Expectations for success have long been recognized by decision and achievement theorists as important mediators of behavioral choice (Atkinson, 1964; Edwards, 1954; Lewin, 1938). There have been numerous studies demonstrating the importance of expectations for a variety of achievement behaviors including academic performance, task persistence, and task choice.

Similarly, studies using measures of confidence in learning math have dem-



**Figure 1. General model of academic choice.**

Note: Adapted from Eccles, J. et al., 1983 and Meece et al., 1982. We have not included a box for innate aptitudes variations. We assume that innate aptitudes influence this system of beliefs, attitudes, and achievement behaviors primarily through their impact on one's unique historical experiences with various achievement tasks. And given that we have not yet devised adequate measures of innate capabilities, we have chosen not to include this construct as an independent box. We are not suggesting that innate capacities are unimportant. Rather we are suggesting that their impact is primarily a function of their contribution to variations in observable behavior.

onstrated a consistent link between expectations for one's future math performance and decisions regarding mathematics involvement (Armstrong & Kahl, 1980; Eccles et al., 1983; Sherman, 1979, 1980a,b, 1981; Sherman & Fennema, 1977). Thus, expectations for math achievement, like more general achievement expectations, appear to be a critical component of decisions regarding mathematics course enrollment and career development.

But are there consistent sex differences in either expectations in general or in math expectations in particular? Several studies have reported sex differences in general achievement expectations. Laboratory studies, using somewhat novel tasks, generally find girls 8 years and older to have lower initial expectations than boys (Crandall, 1969; Dweck & Bush, 1976; Dweck & Gilliard, 1975; Montanelli & Hill, 1969; Parsons & Ruble, 1977). But when familiar tasks or actual school subjects are used, the findings are less consistent. For example, while Parsons and Ruble (1977) found an initial sex difference in children's expectations, the sex difference disappeared after a series of successes at the task. A similar pattern of findings has been reported in studies of students' math achievement expectations. While few sex differences are typically found in students' expectations for current performance, sex differences are evident in students' expectations for more unfamiliar tasks such as future math courses or math contests (Eccles et al., 1983; Heller & Parsons, 1981; Heller, Futterman, Kaczala, Karabenick, & Parsons, 1978; Parsons et al., 1980).

Frieze, Fisher, Hanusa, McHugh, and Valle (1978) attributed this pattern of results to the difference between specific and generalized expectations. They argued that while girls' generalized expectations are lower than boys', their specific expectations, like those of boys', are largely determined by performance history. Consequently, if girls are required to participate in a given achievement activity, it is probable that their expectations will rise.

However, generalized expectations may have more influence on decisions regarding future achievements than specific expectations, and it is on measures of generalized or future math expectations that the most consistent sex differences emerge. Consequently, it is probable that the sex difference in generalized expectations is having a detrimental effect on girls' math-related choices and achievements. Since advanced math courses differ from earlier math courses and since both boys and girls think that advanced math courses are more difficult than their current math courses (Brush, 1980; Eccles et al., 1983; Parsons, et al., 1980), future expectations, or more generalized math expectations, are likely to have a more salient influence than current expectations on enrollment plans. Since girls have lower future expectations than boys, it can be predicted that girls will be less likely to enroll in advanced math courses than boys.

Given that achievement expectations play such a significant role in students' academic choices, it is important to identify the factors that influence expectations. Eccles et al. (1983) suggested the following attitudes and beliefs as critical mediators of expectations for future math performance: (a) self-concept of ability;

(b) estimates of task difficulty; (c) interpretations of previous achievement experiences; (d) identification with masculine and feminine sex roles; and (e) actual performance in mathematics. Each of these sources of influence is described briefly below.

### Self-Concept of Ability

The influence of self-concept of ability on achievement behaviors has been discussed extensively (Brookover & Erickson, 1975; Covington & Beery, 1976; Covington & Omelich, 1979a,b; Kukla, 1972, 1978; Meyer, Folkes, & Weiner, 1976; Nicholls, 1976; Eccles et al., 1983; Purkey, 1970). These authors believe that self-concepts of ability are critical predictors of achievement behavior. Research assessing this view has yielded somewhat mixed results. Although several studies have demonstrated that students with higher estimates of their ability to master a task in fact do better on the task, few have actually tested the causal direction of this relation. In a recent field study, Calsyn and Kenny (1977) found that academic achievement determines self-concept of ability rather than the reverse. In contrast, intervention procedures designed to raise children's confidence in their intellectual abilities do produce gains in subsequent achievement (deCharms, 1976; Dweck, 1975). These intervention studies suggest that for some children, at least, increases in self-confidence can produce increases in achievement.

Research specific to math achievement has yielded a consistent positive relation between perceptions of mathematical ability and plans to enroll in advanced mathematics courses. For example, both Kaminski, Erickson, Ross, and Bradfield (1976) and Armstrong and Kahl (1980) demonstrated that students' ratings of their mathematical ability predicted the amount of math they planned to take in high school. Furthermore, when sex differences emerge in measures of self-concept of math ability, girls report lower estimates of their ability than boys. While these differences do not emerge with any consistency prior to junior high school, they are found frequently in and beyond junior high despite the fact that during the elementary and junior high school years girls perform just as well in math as boys (Eccles et al., 1983; Ernest, 1976; Fennema, 1974; Fennema & Sherman, 1977; Fox, 1977; Heller et al., 1978; Kaminski et al., 1976; Robitaille, 1977).

While these studies suggest that self-concept of math ability is related to course plans and actual performance, its causal significance in explaining variations in math participation is not clear. One study, which addressed this issue with path analytic techniques, found self-concept of math ability to have only a small direct effect on course enrollment plans (Kaminski et al., 1976).

However, according to our model, self-concept of ability should exert its effect on math participation indirectly through its effect on expectations for success in future math courses. To test this prediction, my colleagues and I had

approximately 350 junior and senior high school students complete an extensive questionnaire designed to tap all of the components specified by the model. The questionnaire was readministered to the same students 1 year later to provide data for longitudinal tests of the relationships predicted in the model. Consistent with the finding of Kaminski et al. (1976) our path analyses also indicated that self-concept of ability has only a small direct effect on math course enrollment plans (Eccles et al., 1983; Kaczala, Parsons, Futterman, & Meece, 1979). However, in line with the predictions of our model, self-concept of math ability had a significant direct effect on expectations, which in turn had a direct effect on enrollment plans. In addition, using cross-lagged panel analyses on the longitudinal data, we found further support for the hypothesized causal influence of self-concept of math ability on expectations of future success in mathematics. Students with the highest self-concepts of math ability in 1978 had the highest expectations for success in future math courses in 1979. Thus, it appears that self-concept of ability is an important mediator of students' decisions regarding participation in mathematics. Furthermore, since high school girls have lower estimates of their math ability, it is also probable that individual differences in confidence in one's math ability contribute to the sex differences we find in students' decisions regarding math participation.

### Perceived Task Difficulty

Intuitively, it seems that expectations for success should be inversely related to the perceived difficulty of the task. While little research has addressed this prediction directly, there is ample evidence indicating that task choice is related to perceived task difficulty (Atkinson & Birch, 1970; Meyer et al., 1976; Weiner, 1972, 1974). However, the relation between these two variables is not straightforward. Several investigators (Atkinson, 1964; Kukla, 1978; Meyer et al., 1976; Weiner, 1972) have suggested a curvilinear relationship between perceived task difficulty and task choice. Maehr has suggested that this analysis applies only to a limited set of achievement circumstances, namely, those that might be labeled recreational (Maehr, 1978). For inherently difficult tasks with important future implications, such as achievement in math courses, our model predicts that perceived task difficulty will be negatively related to participation plans.

The few studies testing this prediction in the area of math achievement have not shed much light on this debate and have, in fact, yielded conflicting results. For example, a cross-cultural study of math achievement did not find any relation between the perceived difficulty of math and actual achievement (Husén, 1967). Stallings and Robertson (1979), in contrast, found perceived difficulty to be the most important variable in discriminating between girls who planned to continue in math and those who did not.

While few studies have tested for sex differences in perceived task difficulty, those that have find that junior and senior high school girls rate mathematics as



more difficult than their male peers. (Brush, 1980; Eccles et al., 1983; Heller et al., 1978). The consistency of this pattern suggests that girls' perceptions of task difficulty may be interfering with their participation in mathematics. Few studies have tested this hypothesis directly. But there are data in the general field of achievement suggesting that girls are more likely than boys to avoid tasks which have been designated as difficult (Stein & Bailey, 1973; Veroff, 1969). In a test of the hypothesis, however, we did not find a direct relationship between students' math enrollment plans and their estimates of the difficulty of either their current or possible future mathematics courses. Instead, estimates of task difficulty had their major influence on math participation through their influence on students' expectations for success and the subjective value they attached to mathematics (Eccles et al., 1983; Futterman, 1980; Parsons, et al., 1980). Since girls think mathematics is more difficult than boys, these findings suggest that girls' perceptions of the difficulty of mathematics work in conjunction with their low self-concepts of math ability to lower their expectations for success in those future courses.

### Attributions

According to several theorists, it is not success or failure per se, but the causal attributions made for these outcomes that influence future expectations (Frieze, Fisher, Hanusa, McHugh, & Valle, 1978; Heider, 1958; Weiner, Frieze, Kukla, Reed, Rest, & Rosenbaum, 1971). Several studies have provided indirect support for this general hypothesis (Dweck, 1975; Dweck & Reppucci, 1973). The causal nature of this relation, however, has come under recent scrutiny (Covington & Omelich, 1979a). Based on their findings, Covington and Omelich propose that expectancy shifts are caused by students' initial self-concepts of ability rather than by their attributions. While in basic agreement with Covington and Omelich on the importance of self-concept of ability, our model maintains that attributions do have a causal role in determining achievement expectations. Extending the argument originally advanced by Weiner et al. (1971) into a developmental time frame, we hypothesize that attributions, particularly attributions to ability, play a critical role in the formation of self-concept of ability. To test this hypothesis, Futterman (1980) used causal modeling procedures to estimate the relations among self-concept of math ability, expectations for success in mathematics, and attributions of success and failure to one's math ability. In support of our hypothesis, he found that the attributions of success and failure to one's math ability had a direct effect on self-concept of math ability and not on expectations. Thus, it seems probable that attributions play a mediating role between actual math performances and the confidence individuals develop in their math ability.

Throughout the attribution literature, sex differences in response to success and failure are noted. But these differences are neither very large nor are they consistent across various tasks and attributional measures (see Eccles et al.,

1983, for review). To the extent, however, that girls and boys differ in their attributional pattern, girls are more likely to exhibit what has been labeled the low expectancy pattern, and their achievement behaviors have been found to suffer as a consequence (Crandall, Katkovsky, & Crandall, 1965; Dweck, 1975; Dweck & Reppucci, 1973; Feather & Simon, 1973; McMahan, 1973; Nicholls, 1975). In particular, girls are more likely than boys to take personal responsibility for their achievement-related failures and, consequently, to lower their expectations when faced with failure (Crandall, 1969; Dweck & Bush, 1976; Dweck & Goetz, 1978; Parsons, Ruble, Hodges, & Small, 1976).

A similar pattern has emerged in studies focusing on mathematics. Girls rate the importance of lack of ability as a cause of their poor performances higher than boys. Moreover, they are less likely than boys to credit their math successes to their ability (Dornbusch, 1974; Eccles et al., 1983; Fennema, in press; Heller et al., 1978; Parsons, Meece, Adler, & Kaczala, 1982). Again, it should be noted that these differences are quite small and that lack of ability is not rated as the most important causal attribution for math failures by either boys or girls. Lack of ability is typically ranked quite low in relation to other possible causal attributions (Parsons, et al. 1982). Thus sex differences in use of the ability attribution seem a likely mediator of the sex differences in math-related expectations. In a study using path analytic procedures, Parsons (1980) reported a pattern of results consistent with this hypothesis. Additional studies directly assessing the causal role of ability attributions are badly needed.

Another interesting sex difference has emerged in studies of math attributions (Wolleat, Pedro, Becker, & Fennema, 1980; Parsons et al., 1982). Girls rank skill, diligence, and/or effort as more important causes of math success than boys. This difference may have important implications for students' decisions regarding future involvement with mathematics. Girls who view consistent effort (or skill and knowledge generally acquired through consistent effort) as an important determinant of success in mathematics may have lower expectations for their future success precisely because they think future courses will be even more difficult, demanding additional effort for continued success. The amount of effort a student can or is willing to expend has limits and if a student already thinks she is working very hard to do well in math, she may conclude (a) that her performance will deteriorate in these more difficult math courses because she is trying as hard as she can at present or (b) that the amount of effort necessary to continue performing well is just not worth it. For some students, either of these beliefs would be sufficient justification to avoid both future advanced math courses and math-related careers. The same limits would not apply to students who view ability rather than effort as the relatively more important determinant of success in math. High levels of math ability should guarantee continued success with little or no increment in one's efforts. If this analysis is valid, then girls' expectations for success in future courses should be lower than boys' even though their expectations for performance in their current courses

are equivalent. In support of this hypothesis, girls in our studies have lower future expectations than boys, but have equivalent expectations for success in their current math courses (Eccles et al., 1983; Heller & Parsons, 1981).

Closely related to attribution theory is the work on locus of control and learned helplessness. Drawing on the work of Crandall (1969), Crandall et al. (1965) and Seligman (1975), Dweck (1975) introduced the concept of academic learned helplessness to describe children who assume they cannot control their successes and failures and who give up when confronted with failure. Recently, Dweck and Licht (1980) have extended this work to the domain of mathematics, suggesting that the sex differences in the occurrence of learned helpless behavior may be responsible for sex differences in math achievement behaviors. While the attributional results described above provide some support for this position (girls do rate the importance of lack of ability higher than boys as the cause of their mathematical failures), other measures of learned helplessness do not yield the sex difference suggested by Dweck and her colleagues. For example, Fenema (in press), Parsons, et al. (1982), and Kaczala et al. (1979) found that girls are more, rather than less, likely than boys to attribute their math successes and failures to effort. Employing this criterion, girls appear to be less learned helpless in math than boys. Similarly, in a recent study, using a measure of behavioral response to mathematical failure that included a drop in both persistence and accuracy as the criterion for classifying children as learned helpless or mastery oriented, over 90% of the children classified as learned helpless were boys; only 4 girls out of a sample of 120 children exhibited what could be considered a learned helpless response to failure feedback on mathematical problems (Parsons, 1980). These results do not seem surprising, given that girls do just as well, if not better, than boys in their mathematics courses. Thus, while attributional differences may be a critical mediator of sex differences in attitudes toward mathematics, these effects do not appear to be associated directly with the phenomenon of learned helplessness. More research, however, is needed before this issue is fully resolved.

### Gender Role Stereotypes

Cognitive-developmental theorists suggest that children's self-concepts are derived in part from their interpretations of the attitudes and behaviors of those around them. Gender role structure and gender stereotypes are two particularly salient components of children's social world. Consequently, gender role beliefs and stereotypes may influence the development of children's self-concepts and their perceptions of the value of various activities and expectations for success. Research has provided some support of this hypothesis. First, by age 5, children have developed clearly defined gender role stereotypes regarding appropriate behaviors, traits, and even expectations (Williams, Bennett, & Best, 1975). Second, children do appear to monitor their behavior in terms of gender role

labels. For example, in one study (Montemayor, 1974), the performance levels of first and second grade children were directly influenced by the gender role labeling of the task.

Unfortunately stereotypes, especially gender role stereotypes, are not value-free. Ample evidence indicates that women are stereotyped as less competent than men, especially in intellectual domains (Broverman, Vogel, Broverman, Clarkson, & Rosenkrantz, 1972; Deaux & Emswiller, 1974; Feldman-Summers & Kiesler, 1974). In addition to their beliefs regarding the gender role appropriateness of a variety of more neutral traits, children also incorporate these sexist cultural stereotypes (Kohlberg, 1966). If, as cognitive-developmentalists argue, stereotypes influence children's developing self-concepts, then incorporation of the cultural gender role stereotypes could well result in girls having lower self-concepts of their intellectual abilities than boys. In support of this prediction, elementary school-aged girls rated both their abilities and their outcomes lower than boys on a concept learning task even though they had actually performed better on the task than boys (Parsons, Ruble, Hodges, & Small, 1976).

But what about mathematics? Adults stereotype boys as having more math ability than girls (see later discussion). By junior high school boys also rate themselves as having more ability in mathematics than girls despite the fact that girls and boys perform equally well in their mathematics classes during both the elementary and the junior high school years. While these findings provide initial support for the hypothesis that gender role stereotypes have a debilitating effect on girls' expectations for success in mathematics, the hypothesis actually predicts a relationship between individuals' identification with the stereotype of masculinity and femininity and their expectations for success in mathematics. According to the androgyny models (Bem, 1978; Spence & Helmreich, 1978), people who see themselves as masculine or androgynous should have higher expectations for success than people who see themselves as feminine or undifferentiated.

To test this hypothesis, we correlated students' responses to a questionnaire designed to measure self-concept of math ability and expectations for success in mathematics with their responses to a simplified version of the Personal Attributes Questionnaire (PAQ) (Spence, Helmreich, & Stapp, 1975). First, we used the expressive cluster of characteristics (commonly stereotyped as feminine) and the instrumentality cluster of characteristics (commonly stereotyped as masculine) as separate measures of gender role identification. Consistent with the findings reported by Spence and Helmreich (1978), expressiveness, or femininity, was not related to students' expectations. Instrumentality, on the other hand, was related positively to both self-concept of math ability and expectations for success in mathematics.

To test more directly for the combined effects of masculinity and femininity, we classified students on their joint scores on the two PAQ scales using the median split method outlined by Spence et al. (1975). Students' classifications

as masculine, feminine, androgynous, or undifferentiated had no effect (over and above the effect of instrumentality noted previously) on either their expectations or their estimates of their math ability.

These results suggest that the incorporation of stereotypic feminine personality characteristics is not necessarily detrimental to girls' confidence in their math abilities. In contrast, incorporation of stereotypic masculine personality characteristics may have a beneficial effect on girls' math expectations. A careful inspection of the items in the instrumentality scale suggests that a more general orientation to achievement rather than gender role identification might underlie this relationship. Five of the six instrumentality items tap either confidence in one's abilities, persistence in the face of difficulty, or an independent orientation to work. All of these characteristics have been linked to general achievement motivation in previous work and, consequently, ought to relate to confidence in one's ability to master a difficult subject like mathematics.

### Actual Performance

The final variable proposed in our model as a possible mediator of individual differences in expectations is actual performance on relevant activities. While actual performance in mathematics is predictive of both expectations and related attitudes, the mediating role of performance differences in accounting for sex differences in expectations and related attitudes is still an open question.

While the sex differences in tests of quantitative skills are fairly consistent, they do not arise until quite late in high school. Among these older adolescents, boys generally perform somewhat better than girls on tests of mathematical reasoning (primarily solving word problems). These boys and girls, however, perform equally well on tests of algebra and basic mathematical knowledge and girls occasionally outperform boys on tests of computational skills (Armstrong, 1980; Burnett, Lane, & Dratt, 1979; Connor & Serbin, 1980; Educational Testing Service, 1979; Fennema & Sherman, 1977, 1978; Schratz, 1978; Sherman, 1980a, Starr, 1979; Steel & Wise, 1979). It is important to note, however, that in all of these studies achievement differences favoring boys do *not* emerge with any consistency prior to the tenth grade, are typically not very large, are not found universally even in advanced high school populations, and are not evident in course grades. For example, Fennema and Sherman (1977) found a sex difference in mathematical achievement in only two of the four high schools they studied; similarly, Schratz (1978) found that the direction of the sex differences in math achievement varied across ethnic groups.

One important exception to the general developmental pattern associated with the emergence of sex differences on tests of quantitative skills was recently reported by Benbow and Stanley (1980) and Fox and Cohn (1980). In a large sample of highly gifted seventh and eighth graders, these researchers found that boys scored better than girls on the Scholastic Aptitude Test for Mathematics

(SAT-M). Furthermore, this difference was especially marked at the extreme upper end of the distribution.

In summary, then, high school age boys typically outperform their female peers on *tests* of mathematical achievement. In most studies these differences persist, although to a lesser degree, even when one corrects for the number of mathematics courses taken (Armstrong, 1980; Sherman, 1979, 1980a; Starr 1979; Steel & Wise, 1979). Although the pattern of sex differences seems fairly consistent, it is important to bear in mind that the magnitude of the observed differences is usually not apparent in general populations of students prior to the tenth grade and is not evident in course grades. Consequently, since the sex differences in future expectations for math performance emerge early in junior high school, it seems unlikely that sex differences in future expectations are a direct consequence of sex differences in math performance.

This is not to say that expectations and related attitudes are unrelated to one's performance. Indeed math expectations are strongly related to actual performance (Eccles et al., 1983). But a link between actual math performance differences and sex differences in math expectations has yet to be demonstrated. In fact, using path analytic techniques, we have found that sex remains a significant predictor of future expectations even when the effects of past performance in math are partialled out (Eccles et al., 1983).

## TASK VALUE

As first conceptualized by Atkinson (1964), the value of engaging in a task is directly related to the degree of difficulty or challenge inherent in the task. Success at harder tasks was assumed to have greater value than success at easier tasks. Research on math achievement has shown, however, that other dimensions of task value affect achievement behaviors in school settings. Several researchers, for example, report that students' perceptions of the usefulness of mathematics are strongly related to students' decisions regarding enrollment in mathematics courses (Armstrong & Kahl, 1980; Brush, 1980; Eccles et al., 1983; Fennema & Sherman, 1977; Fennema, Wolleat, Pedro, & Becker, 1981; Lantz & Smith, 1980). There is also evidence suggesting that boys and girls may not value math in the same way. Boys, as early as seventh and eighth grade, are more likely than girls to perceive math as important to future career goals (Brush, 1980; Dornbusch, 1974; Eccles et al., 1983; Fennema & Sherman, 1977; Fox, Brody, & Tobin, 1979; Fox & Denham, 1974; Hilton & Berglund, 1974; Parsons, et al., 1980; Sherman, 1980a,b; Wise, Steel, & McDonald, 1979). High school boys also place greater importance on their grades in mathematics than girls (Dornbusch, 1974). These results point to the importance of a broader definition of task value and suggest the importance of a fuller exploration of the determinants of task value.

Recently, several theorists have been elaborating a broader, more individu-

alistic concept of task value (Crandall et al., 1962; Parsons & Goff, 1978, 1980; Raynor, 1974; Spenner & Featherman, 1978). According to these theorists, the value of a task is determined both by the characteristics of the task and by the needs, goals, and values of the person. The degree to which a particular task is able to fulfill needs, facilitate reaching goals, or affirm personal values influences the value a person attaches to engaging in that task. Elaborating on the work of these theorists, Eccles et al., (1983) suggested that task value can be conceptualized in terms of three major components: attainment value, intrinsic value or interest, and utility value.

In its most basic form, attainment value represents the importance of doing well on a task and coincides with the conceptualization of attainment value advanced by the Crandalls (see, e.g., Crandall, 1969; Crandall et al., 1962). In its broader form, attainment value is related to a variety of dimensions, including: the perceived challenge of the activity and the likelihood that success on the task will confirm salient and valued characteristics of the self such as masculinity, femininity, affiliation, power, intellectual competence, and popularity. The perceived qualities of the task determine its value through their interaction with an individual's needs and self-perceptions. Consider, for example, a student who thinks of herself as "smart" and defines a certain course (e.g., advanced math) as an intellectually challenging course that "smart" students should take. For this particular student, the attainment value of math would be high because enrolling and doing well in it will affirm a critical component of her self-concept.

Intrinsic or interest value, the second component of task value, is the inherent enjoyment one gets from engaging in an activity. Some people just like mathematics. They enjoy solving mathematical problems. They find mathematics an aesthetically pleasant or intellectually challenging academic domain. For these people, the subjective value of math is high and they are intrinsically motivated to continue their involvement with mathematical activities (Deci, 1975; Kruglanski, 1975; Lepper & Greene, 1978; Nicholls, 1979).

Finally, apart from any feelings of interest or enjoyment, tasks also have utility value and are undertaken as a means of reaching a variety of long- and short-range goals. For example, a high school student may want to be a veterinarian and may need to take a particular course (e.g., calculus or advanced algebra) in order to gain entry into the appropriate college program. Consequently, she may take advanced mathematics classes, even though she has little or no interest in math itself. In this case, the desirability of her career goal and the instrumentality of mathematics in helping her to achieve that goal outweigh her negative or neutral attitude toward the subject matter itself. The utility value of math in this case is high because of its long-range usefulness.

In sum, task value can be conceptualized as a function of both the perceived qualities of the task and an individual's needs, goals, and self-perceptions. Individual differences on these variables are created by differential past experiences, by social stereotypes (e.g., the perception of math as a male domain),

and by differential information from parents, teachers, and peers about the importance of and/or the difficulty involved in doing well at math. Three clusters of variables are particularly important mediators of individual differences in subjective value: (a) personal needs, global values, and self-schemata; (b) perceptions of the cost of success; and (c) previous affective experiences with similar tasks. The role of each of these as a potential mediator of mathematics enrollment is discussed below.

### Personal Needs, Values, and Self-schemata

A sizable portion of the literature related to the processes of socialization suggests that a variety of needs and values influence achievement behavior (Mortimer & Simmons, 1978; Parsons & Goff, 1980; Spenner & Featherman, 1978; Stein & Bailey, 1973; Veroff, 1969, 1977). For example, Parsons and Goff (1980) argue that individuals develop an image of who and what they are as they grow up. This image is made up of many component parts including (a) conceptions of one's personality; (b) long-range goals and plans related to anticipated adult roles; (c) schemata regarding the proper roles of mothers and fathers; (d) instrumental and terminal values (Rokeach, 1973); (e) motivational sets; and (f) social scripts regarding proper behavior in a variety of situations.

Some parts of an individual's image are very central or critical to his or her self-definition. According to Markus (1980), these are the parts of one's self-image that exert the most influence on behavior. For example, if being a good athlete is a central part of an individual's self-image, then it is to be expected that this individual will work at continuing to be a good athlete and at projecting an image to others of being a good athlete. Parsons and Goff (1980) argue that the degree of influence wielded by values and needs is determined by their centrality to an individual's self-definition. Specifically, they suggest that personal needs and values operate in ways which both reduce the probability of engaging in those roles or activities that are perceived as being inconsistent with one's central values and increase the probability of engaging in roles or activities perceived as being consistent with one's definition of self.

### Gender Role Schemata

#### *Overview*

Among the set of all possible values and needs, one need is particularly relevant to the issue of sex differences in mathematical participation: the need to fulfill a set of behavioral prescriptions associated with one's gender role. Both Eccles et al. (1983) and Tittle (1981) have suggested that gender roles influence behavior primarily through their impact on perceived task value. According to these theorists, individuals for whom gender role identity is a salient part of their self-definition stereotype specific tasks as being either consistent or inconsistent



with their gender role. The extent to which a task is either compatible or incompatible with one's gender role is assumed to influence the subjective value and attractiveness of the task.

Central to this argument is the assumption that gender role identity and the gender stereotyping of particular achievement activities interact in influencing task value. That is, the gender typing of the task should affect perceived task value only to the extent that gender role identity is a *critical* and *salient* component of one's self definition or self-schemata (Markus, 1980; Nash, 1979). Conversely, gender role identity should influence task value only to the extent that the task is gender-typed by the individual. Given both of these considerations, it is clear that effects of gender typing on task value are complex, depending not only on an individual's gender typing of the activity but also on the salience of gender role identity to the individual's self-image. To assess the impact of gender roles on the value of mathematics, then, we need to consider not only gender role identity and the gender stereotyping of mathematics, but also the interaction of these two constructs.

*Stereotyping of math.* The influence of gender stereotyping of achievement behaviors has received considerable attention in the area of math achievement. The results of these studies are mixed but when math is stereotyped, it is seen as a male achievement domain by both male and female students. Males, however, typically consider math to be more of a male achievement domain than females; females, when asked, do not characterize participation in mathematics courses or competence in mathematics as unfeminine (Armstrong & Kahl, 1980; Boswell, 1979; Dwyer, 1974; Ernest, 1976; Fennema & Sherman, 1977; Fox, Brody, & Tobin, 1979; Nash, 1979; Stein, 1971; Stein & Smithells, 1969). Thus, it is not clear that females stereotype math as inappropriate for them. It is even less clear that the gender stereotyping of math is lowering its attainment value for females. For example, while Fennema and Sherman (1977) found only a modest relation between stereotyping math as a male domain and mathematics achievement in grades 9-11, and then only for girls, Sherman (1980b) found that stereotyping of math as a male domain at grade 8 was not one of the major attitudinal predictors of girls' math achievement at grade 11. In contrast, we have found that stereotyping of math as a male domain increases its subjective value for both boys and girls in junior and senior high school (Eccles et al., 1983). Thus the relation between the gender typing of mathematics and students' achievements and course plans in mathematics is neither clearly understood nor is it likely to be simple.

*Self-schemata by task stereotypes.* Congruent with the more complex hypothesis outlined earlier, Nash (1979) has argued that the gender typing of mathematics will have an effect on a girl's participation only to the extent that maintaining gender role congruence is a central concern to her. In support of

this. Nash (1975) found that individuals with high levels of masculine gender identity performed better on a spatial visualization task typically stereotyped as masculine than individuals with lower levels of masculine identity. The results however, were not consistent across different measures of gender role identity furthermore, Nash did not assess each individual's stereotype of the spatial visualization task. Thus, Nash (1979) concluded that a more definitive study of the interactive effects of gender role identity and the stereotyping of mathematical skills on the perceived value of math was needed.

In a study addressing this important issue, my colleagues and I measured both the gender stereotyping of mathematics and gender identity and tested the relation of individual differences on these two measures to variations in the subjective value attached to mathematics. Gender typing of mathematics is fairly easy to measure. Gender role identity, on the other hand, turned out to be very difficult to conceptualize, much less to measure. After much deliberation, we decided to focus on two types of measures of gender role identity; a measure based on the endorsement of gender-related personality characteristics and a measure based on the endorsement of gender-stereotyped activities.

We selected the measure of gender-related personality characteristics for two reasons. First, several theoreticians have suggested the importance of personality characteristics for achievement choices. For example, Hoffman (1972) has suggested that females' lower goal orientation, lower achievement orientation, greater affiliative needs, and greater expressive orientation lead women to have weaker achievement strivings and to be less self-confident about certain academic tasks than men. Second, many previous studies in the field of gender role identity have used one of two personality measures as the criterion measure for gender role identity. We chose the PAQ as our measure. The results based on this measure will be discussed first. Results associated with the second measure will be discussed in a later section.

To evaluate both gender-typed personality characteristics and the effects of the stereotyping of math as a male domain on attitudes toward math and course enrollment plans, we correlated students' stereotyping of math as a male domain and their ratings of themselves on a simplified version of the PAQ (Spence et al., 1975) with a battery of measures designed to assess attitudes toward mathematics. The battery included measures of expectations for success, self-concept of one's math ability, intrinsic interest in math, perceived utility value of math, and plans to continue taking math courses (a measure of continuing motivation in math). As discussed earlier, instrumentality (the masculine-stereotyped personality dimension) related to measures of both expectations for success and self-concept of math ability for both boys and girls. Neither instrumentality nor expressiveness (the feminine sex-typed personality dimension) were related to the student's ratings of the value of mathematics. In contrast, the stereotype of math as masculine was very predictive of its subjective value for both boys and

girls; stereotyping math as masculine increased its value for *both* boys ( $r = .50$ ,  $p \leq .001$ ) and girls ( $r = .58$ ,  $p < .001$ ).

To test more directly for the combined effects of "masculine" instrumentality and "feminine" expressiveness, we next classified students as masculine, feminine, androgynous, or undifferentiated, using the median split method outlined by Spence et al. (1975). In addition, we classified students according to the degree of their stereotyping of math as a masculine domain. Three levels of stereotyping were created: neutral, moderately masculine, and highly masculine. We used the students' gender role classification, the students' stereotyping classification, and their gender as predictor variables in a series of multivariate contingency table analyses. Self-concept of math ability, perceived difficulty of mathematics, subjective value of math, estimates of the utility of math for future goals, and expectations for success were the dependent measures in these analyses. Neither personality classification nor degree of stereotyping of math as a masculine domain had any significant effect on these dependent measures. These results suggest that one's conception of oneself in terms of gender-stereotyped personality traits is not related to the subjective value one attaches to mathematics. In addition, these results suggest that one's attitudes toward mathematics are not a joint function of one's gender typing of math and one's conception of oneself in terms of gender-stereotyped personality traits.

These findings do not, however, invalidate the significance of a student's gender role identity as an influence in course or career selection. As Spence and Helmreich (1978) have repeatedly argued, the PAQ was not designed as a measure of gender role identity. What the results do suggest, however, is that the link between gender-typed personality structures and achievement-related behaviors is weak at best.

*Career goals and task value.* These data also do not support the popular notion that stereotyping of mathematics as masculine acts as a deterrent to female math achievement. Yet, the hypothesized impact of the stereotyping of math continues to be a favored explanation of sex-differentiated math course taking. If it is not the stereotyping of high school math courses per se that is responsible for this hypothesized link, how else might gender roles influence student decisions regarding mathematics? While girls may not be stereotyping mathematics as exclusively masculine, they may stereotype math-related careers as either masculine or unfeminine. In support of this suggestion, Boswell (1979) found that career mathematicians are perceived by both boys and girls as being decidedly unfeminine and unmasculine. Given this stereotype, it is not likely that girls who are seeking out a "feminine" career would aspire to math-related occupations. Consequently these girls should rate the utility value of math courses low. A number of articles have either reported or summarized distinct differences in the career interests of males and females, with females preferring occupations

which require little math (Astin, 1967, 1974; Astin, Harway, & McNamara, 1976; Fox & Denham, 1974; Goff 1978; Hawley, 1971, 1972; Lipman-Blumen & Tickameyer, 1975; Parsons, 1977; Parsons & Goff, 1980). Further, in a recent reanalysis of the Project Talent data, Wise (1979) found that a large proportion of the sex difference in math course enrollment was accounted for by career interests in the ninth grade.

To the extent, then, that one's future career goals influence the value one attaches to any given subject area, these studies suggest that it is the utility value of math rather than its gender typing that is mediating sex differences in enrollment patterns. In support of this suggestion, perceptions of the utility value of math and math-related career plans emerge as significant predictors of both achievement and course plans in many studies (Armstrong, 1980; Brush, 1980; Eccles et al., 1983; Fennema, in press; Fennema & Sherman, 1977; Fox, Brody, & Tobin 1979, 1980; Fox, Tobin & Brody 1979; Fox & Denham, 1974; Parsons, 1981; Wise et al., 1979). The strength of the relationship, however, is still unclear. 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, Eccles et al. (1983), Fennema (1981), Steel and Wise (1979), and Parsons (1981) all found that interest in math and its perceived utility value were the major mediators of sex differentiated participation.

Results from our second measure of gender role identity provide additional support for the suggestion that it is the range of students' activity interests rather than the gender stereotyping of mathematics that influences the subjective value of mathematics. As a second measure of gender role identity we asked students to rate how important it is for boys and girls to engage in a variety of gender-typed activities (e.g., taking care of an infant, shoveling snow, going fishing, and being interested in makeup). Kaczala (1981) scored a child (a) *androgynous* if he or she felt it was important for the same sex peers to engage in female-typed tasks, (b) *feminine* if he or she felt it was only important for the same sex peers to engage in female-typed tasks, (c) *masculine* if he or she felt it was only important for the same sex peer to engage in male-typed tasks, and (d) *undifferentiated* if he or she felt it was not important whether a same sex peer engaged in either type task. Girls whose ideal female was androgynous rated math both more valuable and more important and rated their math abilities higher than girls whose ideal female was either gender-typed or undifferentiated. Similarly, boys whose ideal male was androgynous rated math both more valuable and important than boys whose ideal male was either sex-typed or undifferentiated. Apparently, for both boys and girls positive attitudes toward math are associated with an androgynous ideal for members of their own gender.

We next had the children estimate the frequency with which they themselves engaged in these same activities. Using a median split procedure similar to that outlined above, Kaczala (1981) classified the children as androgynous, mascu-

line, feminine, or undifferentiated based on the frequency with which they engaged in masculine and feminine activities. Once again, androgynous girls had more positive attitudes toward the value of math than feminine girls. In addition, androgynous and masculine girls were the least likely to stereotype math as a masculine domain. Similarly, androgynous and masculine boys had the most positive views of their own math ability while feminine boys had the most negative views of both their own math ability and the difficulty of math. In addition, masculine boys were the most likely to stereotype boys as having more math ability than girls while androgynous boys were the least likely to hold such a stereotype.

In summary, then, for both boys and girls a positive attitude toward the value of math and toward one's own math abilities was associated either with preferring an androgynous activity pattern for one's own gender or with having an androgynous activity pattern oneself. Being classified as feminine by either of these criteria was associated with a more negative view of math. For boys only, being classified as masculine based on one's own activity patterns was associated both with holding stereotypic beliefs regarding which gender has more math aptitude and with the beliefs that math is easy and that one is good in math.

These results suggest that having an androgynous, rather than gender-typed, orientation toward the activities of childhood facilitates girls' attitudes toward the value of mathematics as a subject area. It could be argued that it is precisely these androgynous girls who will consider technical, more scientific, and less traditionally feminine careers among the various career options open to them. They will come to the career decision points in their lives with a past history of engaging in both masculine- and feminine-typed activities, will hold an androgynous activity ideal for their own gender, and will see mathematics as both interesting and important. This cluster of attitudes should facilitate nontraditional career choices. These relationships, however, remain to be tested.

### Personal Values and Life Goals

Sex differences in the subjective value of mathematics could also result from more general personal values and life goals. Several theoreticians have argued that one's values and life goals influence the value one attaches to various activities; activities which are consistent with one's beliefs will be perceived as more valuable than those activities which are perceived as being inconsistent with or unrelated to one's personal value structure. In support of this argument, several recent studies have documented a relation between involvement in both mathematics and science and personal values. For example, Dunteman, Wisenbaker, and Taylor (1978) have found that being thing-oriented rather than person-oriented predicted becoming a math or science major. Similarly, Fox and Denham (1974) found that mathematically talented children are relatively low on social values and high on theoretical, political, and economic values. In both of these studies, females were less likely to hold the math- and science-related values than were males. Thus it seems quite plausible that the sex difference in

the perceived value of math is a function, in part, of the sex difference in persons value structure. The strength and causal direction of this prediction has yet to be tested.

### Cost of Success and Failure

The value of a task to an individual is also affected by a set of variables which can be conceptualized best as the cost of engaging in the activity. In our model my colleagues and I conceptualize the influence of cost on the value of an activity in terms of a cost-benefit ratio. Assuming that individuals have a conception of both the costs and benefits of engaging in a variety of activities, then the value of each activity ought to be inversely related to this cost-benefit ratio. The benefits of engaging in an activity in terms of fulfilling the need to achieve were discussed in previous sections. For some individuals, however, the benefits of an activity may be outweighed by what a person perceives as the psychological "costs" associated with engaging in that activity.

A person's perception of the amount of effort needed for success is one particularly important influence on the perceived cost of various achievement activities. Given that career decisions are not made in a vacuum and that in many cases students must choose among several equally attractive alternatives, we have suggested that the perception of the amount of effort needed to do well in any given career will have a significant impact on career decisions (see Eccles et al., 1983). To the extent that the amount of effort needed to do well in advanced mathematics courses exceeds, for example, the perceived worth of the outcome, the value of enrolling in the advanced math courses should decrease. Similarly, to the extent the amount of effort needed to succeed in a math-related career is perceived to interfere with other salient adult roles (e.g., parenting) the perceived cost of pursuing such a career should increase.

One factor considered in determining how much effort is worthwhile is the amount of time lost from other valued activities. For example, imagine a girl who likes math, thinks that it is quite difficult, and wants to be chosen for a leading role in an upcoming school play. To do as well in math as she feels she should, she thinks she'll have to do math homework every night. She also believes that she can optimize her chance of getting a leading role in the play by staying after school with some friends to practice for the audition. Her parents, however, will not allow her to engage in extracurricular activities until her homework is finished. For this girl, math, despite its high incentive value, poses an obstacle to the achievement of other important goals. Consequently, the value of math for this girl should be decreased by its high cost in terms of realizing other important goals. Little research has assessed either the importance of this component of task value on students' decisions or the potential of this component of task value for explaining sex differences in the choice of math-related courses. Our own work has provided initial support for its importance. Using cross-lagged panel analyses, we found that variations in students' estimates of the relative

worth of the effort needed to do well in math in 1978 predict students' expectations for their future success in mathematics, their confidence in their mathematical ability, their perceptions of the utility value of mathematics, and their interest in mathematics in 1979 (Eccles et al., 1983; Parsons et al., 1980). Clearly, variations in the subjective value of the effort needed to do well in mathematics are important mediators of the subjective relative value attached to mathematics. Additional research, however, is needed before we will understand more fully both how this variable affects students' attitudes and its developmental origins.

With regard to sex effects, we did not find any differences in the perceived worth of the effort needed to do well in mathematics. However, we were asking about the worth of doing well in a mathematics course. Girls are noted for the importance they attach to school achievement, especially in the courses in which they are enrolled. They work very hard and often make better grades than boys, even in mathematics. Perceptions of the relative worth of the amount of effort needed to succeed in various careers, including math-related careers, might yield different results. Unfortunately, few studies have investigated this hypothesis directly. Two recent studies indicate that many high school- and college-age women weigh the impact of potential careers on their role as mothers and wives in making career decisions (Parsons & Goff, 1980; Tittle, 1981). These women do not aspire to careers, and in some cases actively avoid careers, which they perceive as being too costly in terms of time away from their future families. Whether the majority of math-related careers are stereotyped as too costly has yet to be tested.

### Previous or Anticipated Affective Experiences

A final set of variables suggested by Eccles et al. (1983) as influencing the value of achievement activities involves previous or anticipated affective experiences. Achievement activities elicit a wide range of emotional responses (Hill, 1977). If one had a bad experience with a math teacher at some point, the negative feelings aroused by the teacher can condition one's perception of math such that it takes on a negative value or comes to elicit negative feelings. For example, Tobias (1978) reports several cases in which students' first occasion of feeling frustrated with math occurred when a busy teacher answered a seemingly legitimate question with, "We haven't got time for that now," or with an even more devastating response, "That's a dumb question."

In recent years math anxiety has emerged as still another explanation for sex differences in students' mathematics learning and course selection. Citing anecdotal evidence that more women than men openly admit feeling anxious about mathematics and enroll in math anxiety clinics, advocates of this perspective argue that women and men differ in their emotional reactions to mathematics and that these differences could differentially influence students' course enroll-

ment in mathematics (Lazarus, 1974; Meece, 1981; Tobias, 1978; Tobias Weissbrod, 1980).

Although there are only a few empirical studies which directly address affective outcomes of mathematics learning, and these are not entirely consistent, some support for this proposal is found in the literature. In terms of general affective responses to mathematics, expressed as a liking or preference for the subject matter, few differences are evident in boys' and girls' responses during elementary and junior high school years. Sex differences in these variables appear after junior high school, with males expressing more positive affective responses toward math (Aiken, 1976; Ernest, 1976; Fox, Tobin, & Brody, 1979). Turning to more extreme affective responses to mathematics (e.g., anxiety, excessive worry and concern), the view that greater numbers of females are math-anxious is supported by the few empirical studies which have addressed the issue (Brush, 1978, 1980; Dreger & Aiken, 1957; Meece, 1981; Suinn & Richardson, 1972). But the differences are generally quite small. For example, Meece (1981) found that gender accounted for less than 1% of the variance in students' math anxiety.

These studies have not controlled for the possibility that males might be less willing to admit to feelings of anxiety, especially with regard to an area of achievement which has been viewed as masculine, particularly by males. To be of use as a causal explanation, not only does the problem of social desirability and defensiveness in assessing math anxiety need to be taken into account, but the conceptualization of math anxiety itself needs to be refined. Some critics suggest that math anxiety may simply reflect a strong emotional reaction to evaluative situations, which are common in most math classes. In response to this criticism, Brush (1978) compared students' ratings of items dealing with computational situations with ones dealing with tests and similar evaluative situations. As expected, students rated situations in math involving tests as more anxiety arousing, with females reporting higher anxiety about these situations than males. Suinn and Richardson (1972) found that many students reporting feelings of anxiety about math did not indicate that they had similar anxieties for other learning situations. Thus for some children math anxiety may reflect a generalized fear of failure or test anxiety while for other children math anxiety appears to reflect a very specific affective response.

Taking the methodological and theoretical limitations into consideration, it does appear that females have more negative feelings toward math than do males. This has led several researchers to argue that females avoid mathematical courses because they feel uneasy or anxious about math. A few studies have examined this hypothesis and have shown that students who score high on math anxiety measures are less likely than students with lower scores to take advanced or optional course work in mathematics or to choose quantitative college majors, such as those in the physical sciences (Brush, 1978, 1980; Sherman & Fennema,



1977). Given that women typically score higher on these measures, this would lend support to the argument underlying research in this area.

Additional research is needed to assess the relative predictive value of anxiety in students' course selection. Using causal modeling procedures, Brush (1980) found that when other affective and attitudinal variables are controlled, anxiety does not predict students' enrollment in physical science courses. Anxiety appeared to have its effect primarily as a mediator of other variables more directly linked to students' course selection, such as how much they expect to like the course and how well they expect to do. It is interesting to note, though, that anxiety had a stronger impact on girls' judgments about liking and performance than on boys'. Consequently, anxiety may play a more influential role in women's academic choices. In support of this conclusion, Parsons (1981) found math anxiety to be a major mediator of sex differences in both mathematics achievement and course plans. Clearly, the impact of math anxiety on students' course enrollment decisions needs further clarification.

### Summary

My colleagues and I have proposed that task value is a critical mediator of achievement-related behaviors which, in the final analysis, interacts with expectations to influence achievement behaviors. In this section I have discussed the numerous factors which might influence the value attached to mathematics by individual students. In an earlier section I discussed the factors which might influence students' expectations of success in mathematics. In both sections I argued that there is evidence to suggest that sex differences in the pursuit of mathematical studies and careers are mediated by sex differences in the variables associated with expectations and subjective task value.

More central to the issue of sex differences in math participation, however, is the question of whether or not these differences mediate sex differences in students' motivation to seek out advanced training in mathematics. To answer this question, we gave approximately 350 junior and senior high school students and their parents and teachers a battery of attitudinal questions designed to assess most of the concepts discussed thus far. The battery was readministered to the students 1 year later. We then entered our subjects' responses into a path analysis. The results of this analysis are depicted in Figure 2. As can be seen, students' motivation to continue taking math is predicted most directly by their estimate of the value of mathematics courses and their math anxiety. Students' grades, on the other hand, are most directly predicted by self-concept of ability. (Factor analysis of our items indicated that current expectations and students' estimates of their math ability loaded on the same construct. Consequently, for this path analysis current expectations and estimates of math ability were combined to form the self-concept of ability measure.)

The path analytic results also point out the importance of mothers as critical socializers of sex differences in children's math attitudes and achievement. Mothers' estimates of the difficulty of math for their children have a stronger impact on students' attitudes than the attitudes of either teachers or fathers. Furthermore mothers 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 mothers' gender-stereotyped beliefs has a debilitating effect on girls' orientation toward mathematics.

Although it could be argued that mothers' beliefs reflect a true difference between boys and girls in math aptitude, the following additional results suggest that this is not the case. First, 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 do, the boys and girls reported equivalent amounts. Third, the teachers' estimates of these students' mathematical ability did not differ for boys and girls. This pattern of results suggests that the sex difference in mothers' beliefs is not grounded in reality but rather reflects the cultural gender stereotype that math is more difficult for girls.

When the zero-order correlations between boys' and girls' estimates of the value of mathematics and objective indicators of their mathematical ability are compared, another set of interesting differences emerges (see Table 1). Boys' estimates of the value of math are significantly related to their past math performance ( $r = .33, p < .01$ ) and to both their teachers' and parents' estimates of their math ability ( $r = .33, p < .01$ ;  $r = .28, p < .01$ ). In contrast, girls' estimates of the value of math are not significantly related to any of these three measures ( $r = .06, r = .03, \text{ and } r = .06$ , respectively) but are significantly related to both their plans to continue enrolling in math courses and their math grades 1 year later. In addition, girls' estimates of the value of math are related to their stereotypes of math as masculine, ( $r = .58, p < .01$ ), to their career plans ( $r = .42, p < .01$ ), and to their parents' beliefs regarding both the importance of math courses ( $r = .24, p < .01$ ) and the difficulty of mathematics ( $r = -.27, p < .01$ ). 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 nonscientific and nontechnical fields and whose parents think math is both very difficult and not very important.

Thus, it appears that social factors, independent of real math aptitude, are more likely to influence girls' perceptions of the value of math than they are to influence boys' perceptions. These data suggest 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. What might these social forces be? It is to this issue that I now turn.

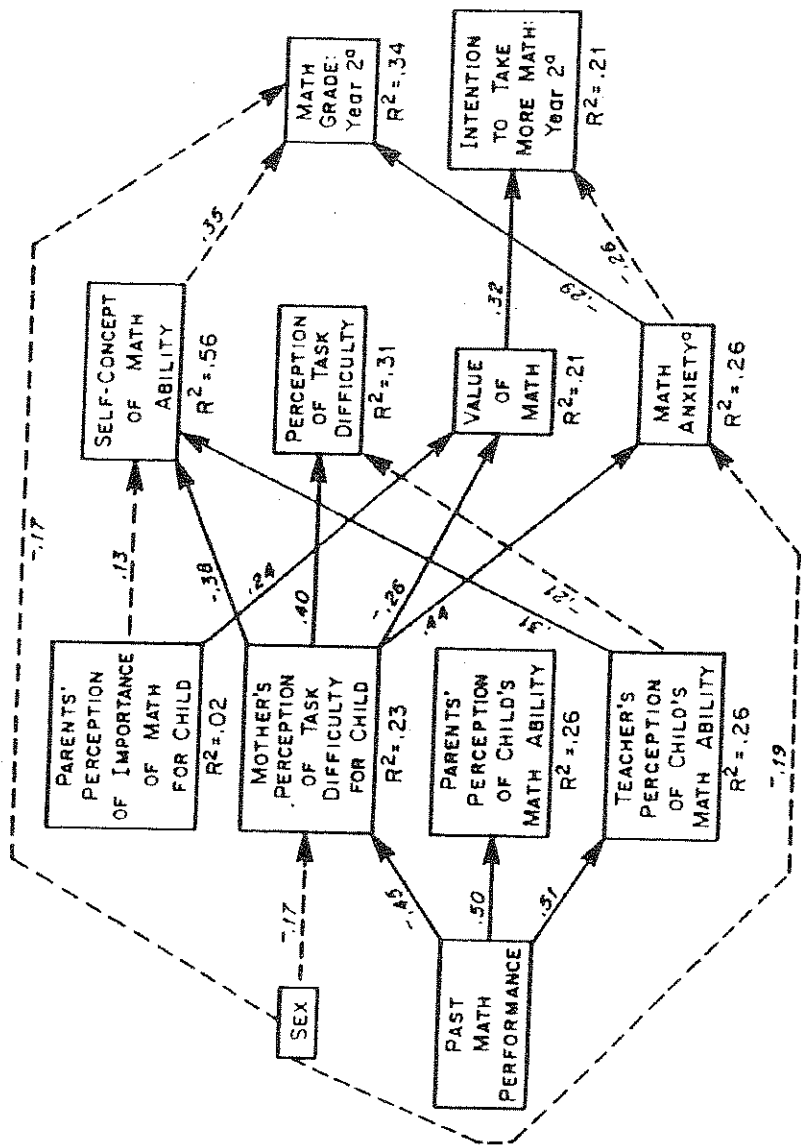


Figure 2. Reduced path analytic diagram: Longitudinal determinants of grade in mathematics course and enrollment plans.

Note: Column-wise multiple regression equation procedures were used to estimate the path coefficients. At each step, each endogenous 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 Eccles et al. (1983). 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 percentage of variance of each endogenous measure accounted for by the model; <sup>a</sup> $R^2$  is listed under each variable. <sup>b</sup>Based on year-one data.

Table 1  
Zero-order Correlation Matrix of All Variables Used in the Path Analysis<sup>a</sup>

Past math performance <sup>b</sup>	1.00	-.06	-.33 <sup>**</sup>	.51 <sup>**</sup>	.56 <sup>**</sup>	.31 <sup>**</sup>	-.21 <sup>*</sup>	.06 <sup>d</sup>	-.19 <sup>*</sup>	.28 <sup>**d</sup>	.19 <sup>*</sup>
Parents' perception of importance of math for child <sup>b</sup>	.05	1.00	-.10	.14	-.04	.09	.00	.24 <sup>**</sup>	-.07	.07	.03
Mother's perception of task difficulty for child <sup>b</sup>	-.50 <sup>**</sup>	-.06	1.00	-.40 <sup>**</sup>	-.47 <sup>**</sup>	-.59 <sup>**</sup>	.52 <sup>**</sup>	-.27 <sup>**</sup>	.26 <sup>**d</sup>	-.22 <sup>**d</sup>	-.10
Parents' perception of child's math ability <sup>b</sup>	.42 <sup>**</sup>	.23 <sup>*</sup>	-.35 <sup>**</sup>	1.00	.52 <sup>**</sup>	.31 <sup>**</sup>	-.21 <sup>*</sup>	-.06 <sup>d</sup>	-.21 <sup>*</sup>	.36 <sup>**</sup>	.13
Teacher's perception of child's math ability <sup>b</sup>	.49 <sup>**</sup>	.16	-.51 <sup>**</sup>	.39 <sup>**</sup>	1.00	.47 <sup>**</sup>	-.34 <sup>**</sup>	-.03 <sup>d</sup>	-.20 <sup>*</sup>	.37 <sup>**</sup>	.01
Child's self-concept of math ability <sup>b</sup>	.51 <sup>**d</sup>	.14	-.60 <sup>**</sup>	.35 <sup>**</sup>	.62 <sup>**</sup>	1.00	-.67 <sup>**</sup>	.49 <sup>**</sup>	-.46 <sup>**</sup>	.29 <sup>**d</sup>	.20 <sup>*</sup>
Child's perception of task difficulty <sup>b</sup>	-.34 <sup>**</sup>	-.00	.46 <sup>**</sup>	-.16	-.40 <sup>**</sup>	-.59 <sup>**</sup>	1.00	-.05	.40 <sup>**</sup>	-.10 <sup>d</sup>	-.05

Child's rating of the value of math <sup>b</sup>	.33 <sup>xxd</sup>	.09	-.33 <sup>xx</sup>	.28 <sup>xxd</sup>	.33 <sup>xxd</sup>	.59 <sup>xx</sup>	-.12	1.00	-.27 <sup>xx</sup>	.07	.32 <sup>xx</sup>
Child's math anxiety <sup>c</sup>	-.19 <sup>*</sup>	-.10	.49 <sup>xxd</sup>	-.20	-.11	-.56 <sup>xx</sup>	.46 <sup>xx</sup>	-.36 <sup>xx</sup>	1.00	-.27 <sup>xx</sup>	-.30 <sup>xx</sup>
Math grade <sup>d</sup>	.52 <sup>xxd</sup>	.10	-.42 <sup>xxd</sup>	.38 <sup>xx</sup>	.47 <sup>xx</sup>	.50 <sup>xxd</sup>	-.34 <sup>xxd</sup>	-.18 <sup>*</sup>	-.39 <sup>xx</sup>	1.00	.12
Child's intention to take more math <sup>e</sup>	.14	.12	-.15	.08	-.09	.21 <sup>*</sup>	-.03	.39 <sup>xx</sup>	-.39 <sup>xx</sup>	.06	1.00
Past math performance		Parents' perception of importance of math for child	Mother's perception of task difficulty for child	Parents' perception of child's math ability	Teacher's perception of child's math ability	Child's self-concept of math ability	Child's perception of task difficulty	Child's rating of the value of math	Child's math anxiety	Math grade	Child's intention to take more math

<sup>a</sup> Correlations for females are presented in the upper right triangle

Correlations for males are presented in the lower left triangle

<sup>b</sup> Based on year one data

<sup>c</sup> Based on year two data

<sup>d</sup> There is a significant sex difference in the zero-order correlations

<sup>e</sup>  $p < .05$

<sup>f</sup>  $p < .01$

## SOCIALIZATION

Several researchers have proposed that sex differences in math achievement and course selection can be explained by differential socialization experiences of boys and girls. Specifically, these researchers have proposed that the behavior and attitudes of teachers, parents, and counselors determine, to a large extent the sex differences in mathematics. Attitudes held by these socializers, it is argued, reflect cultural stereotypes regarding not only the natural superiority of males' mathematical abilities, but also the differential utility of mathematical skills for boys and girls (Casserly, 1975; Eccles et al., 1983; Fennema, 1974; Fox, Tobin & Brody, 1979; Jacklin, 1979; Nash, 1979). These stereotypes are assumed to influence socializers' behaviors and attitudes which, in turn, are assumed to undermine girls' confidence in their math ability, girls' motivation to perform well, girls' acquisition of appropriate math-related skills, and girls' motivation to seek out a math-related career. The following three sets of hypotheses have guided most of the research on the effects of socialization on girls' math attitudes and behaviors: (a) male and female socializers differ in their attitudes and behaviors toward math and thus create differences through their power as role models; (b) socializers have different expectations and goals for boys and girls which are conveyed through a variety of direct and indirect means; and (c) socializers provide or encourage different activities for their children that, in turn, train differing skills and interests.

### Modeling Effects

Experimental research has established the importance of adults' behavior as a standard or model for children's behavior. The process of "observational learning" has been suggested as one mechanism by which children absorb a variety of social norms, particularly those associated with gender roles (Bandura & Walters, 1963; Maccoby & Jacklin, 1974; Parsons, Adler & Kaczala, 1982).

There are several ways in which models could be influencing children's attitudes toward mathematics. Since parents and teachers are themselves males or females, they might influence students' behavior by simply engaging in different activities. Ernest (1976) reported that after sixth grade fathers are more likely to help their children with their math homework than mothers; similarly, Fox (1977) has reported a tendency for more advanced mathematics courses to be taught by males. This underrepresentation 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 in increasing female math participation through exposure to female models supports this line of reasoning (Brody & Fox, 1980; Tobin & Fox, 1980). Additional evidence is provided by the reports of female mathematicians, engineers, and girls aspiring to these math-related careers. With great regularity these women

stress the impact of salient, supportive models in the development of their career plans (Boswell, 1979; Casserly, 1975).

Parents and teachers might also influence children's beliefs through the messages they provide regarding their beliefs about their own abilities. If men and women differ in their estimates of their own math abilities and competence, then boys and girls may incorporate these differences into their beliefs about their own abilities. While relevant research is sparse, Aiken (1970) cited data indicating that female student teachers have lower estimates of their math ability and openly admit they are less comfortable teaching math than their male peers. Similarly, we (Parsons, Adler, & Kaczala, 1982) have found that college-educated mothers are less interested in math and hold a more negative view of their math abilities than college-educated fathers.

If young girls model their behaviors after these important socializers, then this difference, coupled with the general lack of salient female role models with mathematical orientations, could lead girls to have more negative views of both their own math competence and the value of math than boys. Tests of this hypothesis, however, are virtually nonexistent. In a study designed to assess the impact of parents' self-perceptions on children's attitudes toward math, we (Parsons, Adler, & Kaczala, 1983) found no significant association between parents' related self-concepts and either children's confidence in their math ability or the value they attached to math. Further, the relative amount of math done by mothers and fathers also appeared to have little effect on either children's math attitudes or their career plans. Parent expectations for their children, however, were found to be important.

### Socializers' Expectations and Related Behaviors

The expectations parents and teachers hold for specific children are another possible source of influence on children's performance on a variety of situations. Although considerable criticism and controversy followed early studies of expectation effects (Rosenthal & Jacobson, 1968), subsequent studies have presented convincing evidence that teacher expectations are related to both teacher and student behaviors in the classroom (Brophy & Good, 1974; Cooper, 1979). It should be noted, however, that these effects are generally quite small and are more likely to solidify differences already in existence than create the differences in the first place (Cooper, 1979). Nonetheless, teacher expectancy effects exist. Similarly, throughout the achievement literature, parental expectations have been linked to both the achievement motivation and behavior of their children (Crandall, 1969; Rosen & D'Andrade, 1959; Winterbottom, 1958).

If the expectations of parents and teachers can influence children's attitudes and behaviors as these studies suggest, then the degree to which parents and teachers hold different expectations for boys' and girls' performance in mathematics is an important factor to consider. Several studies suggest that parents

and teachers have higher educational expectations for boys than girls (Good Sikes, & Brophy, 1973; Hilton & Berglund, 1974; Sears, Maccoby, & Levitt, 1957). However, these biases do not emerge with any consistency until the adolescent years. In fact, when differences are reported for elementary school samples, parents and teachers generally expect girls to do better than boys (Cooper, 1976; Maccoby & Jacklin, 1974).

Few studies have directly measured the actual expectations that parents and teachers hold for math achievement in particular. Surveying a small sample of elementary and high school teachers, Ernest (1976) reported that 41% of the teachers felt that boys do better in mathematics and none believed that girls outperform boys. Furthermore, several researchers have found that parents and teachers hold different expectations of the potential adult math-related achievement of boys and girls (Casserly, 1975; Haven, 1971; Luchins, 1976). Similarly we have found that, in comparison to parents of sons, parents of daughters think that math is more difficult for their children and that their daughters have to work harder to do well in their mathematics courses (Parsons, Adler, & Kaczala, 1982). However, the parents in our study neither had lower expectations for their daughters' mathematical performance nor rated their daughters' mathematical ability as any lower than their sons'. Similarly, in another study we found that math teachers in the fifth through ninth grades had equally high or higher expectations for their female students than for their male students (Parsons, Kaczala, & Meece, 1982). Finally, in the Ernest study noted above, 59% of the teachers did not expect boys to do better in math. Thus it appears that the gender stereotypes held by parents and teachers are small, are not universal, but tend to favor boys when they are present.

While there is some support for the suggestion that parents and teachers have different math-related expectations for boys and girls, the mechanisms by which these expectations are conveyed to children are not well understood. Research designed to assess the mechanisms of transmission have not yet provided any definitive answers. There is undoubtedly a variety of direct and indirect means by which children learn what others expect of them. Patterns of reinforcement, evaluative feedback for children's math performances, and direct mathematical instructions are three means that have been studied in recent years.

Research suggests that parents may convey differential expectations by offering more explicit rewards and reinforcements for learning math to their sons than their daughters (Astin, 1974). Other studies show that girls are less likely than boys to be encouraged by parents and counselors to pursue math-related careers and to enroll in advanced level math courses (Casserly, 1975; Haven, 1971; Luchins, 1976; Parsons, Adler, & Kaczala, 1982). For example, Haven reported that 42% of the girls who were interested in math-related careers indicated that they had received no encouragement from their counselors to take advanced mathematics courses. Furthermore, in the Haven study counselors openly admitted discouraging girls from taking these courses, citing reasons that reflected



their stereotyped view of appropriate adult roles and math abilities. They believed, for example, that a low grade in math would hurt a girl's otherwise excellent school record or that careers in the sciences were too demanding for women. Similarly, we found that parents, especially fathers, were more likely to stress the importance of taking social science and humanities courses to their *daughters* and to stress the importance of advanced mathematics courses to their *sons* (Parsons, Adler, & Kaczala, 1982).

Parsons, Ruble, Hodges, and Small (1976) also suggested that parents and teachers may convey differential expectations by the attributions they make for their sons' and daughters' math performance. While Dweck, Davidson, Nelson, and Enna (1978) found that teachers are more likely to attribute fourth and fifth grade boys' failures to lack of effort, the frequency of these attributions was very low and the attributions were not assessed in math classrooms. We did not find any studies which assessed parental attributions for math performance. But, if the parental beliefs uncovered in our study translate into attributional statements, then our findings suggest that parents will be more likely to attribute their daughters' success in mathematics to hard work and effort than their sons'. This result certainly matches well with our finding that the girls themselves are more likely to attribute their math success to effort than are the boys. But the causal link between parental attributions and the gender differences in the students' attributions has not been tested.

Extensive observations in classrooms have led several investigators to conclude that the quantity and type of teacher instruction differs for boys and girls. In general, teachers tend to interact more with boys than girls, especially in mathematics and science classes (Bean, 1976; Becker, 1981; Brophy & Good, 1974; Leinhardt, Seewald, & Engel, 1979; Stallings, 1979). Both Fennema (1981) and Parsons, Kaczala, & Meece (1982) found that the student-teacher interaction patterns are affected by both students' ability level and gender; high math ability boys often receive more praise for their achievements and more total interaction than high math ability females. The actual quantity of formal teaching is also influenced by the students' gender (Bean, 1976; Becker, 1981; Leinhardt et al., 1979). For example, Leinhardt et al. found that as early as second grade, when basic skills are being taught, boys get more math instruction than girls. Based on multiple observations of math instruction periods, they concluded that over the course of an academic year, boys could receive as much as 6 more hours of instruction than girls. Although seemingly inconsequential, it is quite possible that the cumulative effect of this difference in formal education over the course of the elementary school years is very significant.

Some evidence suggests that boys and girls receive different types of evaluative feedback in response to their achievement efforts. For example, Dweck et al. (1978) compared the frequency with which boys and girls received either praise or criticism for three types of behavior: their conduct, the quality of their academic work, and the form of their academic work (e.g., its neatness). Boys

were more likely to be criticized for their conduct or neatness than for the academic content of their work; in contrast, girls were more likely to be criticized for incorrectness of their academic work than for its neatness or for their conduct. In addition, boys were most likely to be praised for the academic work whereas girls were most likely to be praised for their conduct or the neatness of their work. Finally, as noted above, these teachers explicitly attributed academic failures to a lack of motivation or effort six times more often for boys than for girls. Dweck et al. (1978) suggested that this pattern of differences in evaluative feedback to boys and girls should increase boys' confidence in their ability to master intellectual tasks. Girls, on the other hand, should be less certain of their intellectual abilities precisely because they have been praised for their conduct and neatness rather than for their academic performance.

To support their suggestion, Dweck et al. (1978) demonstrated that the male pattern of feedback does produce greater confidence. Thus, if such a difference in the patterns of teacher feedback exists in math classes, then it could be argued that teacher feedback contributes to the sex differences in attitudes toward mathematics. Recent studies, however, have not supported Dweck's findings in either math classes or general elementary school classes (Blumenfeld, Bossert, Hamilton, Wessels, & Meece, 1979; Fennema, 1981; Heller & Parsons, 1981; Parsons, Kaczala, & Meece, 1982; Swarthout, 1980). These new studies suggest (a) that teachers give very little work criticism, (b) that teacher criticism is directed almost universally to classroom conduct, (c) that the pattern of evaluative feedback is similar for boys and girls, although boys receive more overall criticism, and (d) that attributional statements are given so rarely that it is difficult to interpret what their psychological meaning to the students might be.

The picture is further complicated when one considers the few studies that have actually attempted to relate teacher-student interaction patterns in math classrooms to student attitudes toward math. Both Heller and Parsons (1981) and Parsons, Kaczala, & Meece (1982) tested the relation between student-teacher interaction patterns and students' estimates of their own mathematical abilities, the difficulty of math courses, 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 the student's estimates of his or her own math ability (even after the effects of the student's past grades in mathematics had been partialled out), neither study found many significant relations between teacher-student interaction patterns as observed in the classroom and the student's attitudes or plans. Parsons, Kaczala, and Meece (1982) did find that when teacher praise covaried with teacher expectations, the quantity of teacher praise was very weakly but significantly related to students' estimates of their math ability. However, this was true only for boys and only in some classrooms. Thus additional research is clearly needed to determine how classroom experiences might be undermining girls' math achievement expectations and performance.

### Differential Experiences

In addition to the more direct socialization effects discussed thus far, parents and teachers can influence children's achievement behaviors and values by the types of general experiences they provide or encourage. The provision of different toys and recreational activities has been linked to the spatial skill differences between boys and girls discussed earlier. Connor, Shackman, and Serbin (1978) argued that the spatial skill deficit evidenced by girls is a consequence of their lack of experience with activities requiring spatial problem solving (e.g., large-block play, mechanical toy manipulation, and team sports). To support their hypothesis, they designed an intervention procedure for the preschool years which produced an improvement in girls' spatial skills. Based on the results of their intervention study, these researchers contend that socializers, especially parents, do not provide girls with the experiences necessary for spatial skill acquisition. Studies documenting that parents purchase more mathematical and spatial games for boys provide further support for this argument (Astin, 1974; Hilton & Berglund, 1974). Training studies provide additional support for the importance of experience in developing good spatial skills (Burnett & Lane, 1980; Connor, Serbin, & Schackman, 1977; Goldstein & Chance, 1965).

Several researchers have argued that early independence training may foster sex-differentiated achievement patterns (Astin, 1967; Ferguson & Maccoby, 1966; Hoffman, 1972; Stein & Bailey, 1973). Specifically, these researchers emphasize that moderate but not overbearing nurturance, permissiveness, and encouragement of independence are important child-rearing practices for facilitating the development of achievement striving in girls. With regard to math achievement in particular, a study of mother-daughter interactions in a problem-solving situation showed that mothers of girls with high math ability allowed their daughters to solve the tasks by themselves. In contrast, mothers of girls with low math ability were more intrusive, offering help, suggestions, and criticism (Bing, 1963). Similarly, Ferguson and Maccoby (1966) reported that both boys and girls with low math ability were dependent on their parents. While further research is needed to substantiate these findings, these studies suggest that parents and teachers may have a subtle influence on children's math achievement behaviors by providing or encouraging sex-differentiated socialization experiences.

### Summary

To summarize, 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 indicate that math behaviors and course selection may be

influenced by the differential treatment accorded girls and boys. For example, encouragement from parents (as measured from parent reports or student ratings of parental encouragement) has emerged in several studies as an important factor in girls' decisions to elect advanced mathematics courses in high school (Armstrong, 1980; Fennema & Sherman, 1977, 1978; Haven, 1971; Luchins, 1970; Parsons, Adler, & Kaczala, 1982). Similarly, Parsons, Adler, and Kaczala (1982) have demonstrated a strong relation of parents', especially mothers', judgments of their children's math ability and the difficulty of math for their child to the children's estimates of their own math ability, their plans to continue taking math courses, and their actual math grades. These effects hold up longitudinally and are significant even when the effects of the children's past performance in mathematics are partialled out. And finally, Sherman and Fennema (1977) found that students' beliefs regarding their parents' perceptions of them as learners of mathematics predicted the students' intent to take advanced mathematics courses. In many of the studies examining the influence of parents and teachers, sex differences on the predictor variables favor males. Thus it seems likely that parents and teachers are having a negative impact on girls' math course taking.

It is important to note, however, that the direction of causality in these studies is difficult to ascertain. Are socializers' expectations a reflection of actual achievement differences or do they cause them? Using a series of cross-lagged panel correlational analyses, Crano and Mellon (1978) found that the prevailing causal direction for teachers was from expectations to academic performance. Other studies present evidence just as supportive of the notion that student achievement causes teacher expectations (West & Anderson, 1976). It is likely, then, that both conclusions are correct. Future studies should examine more carefully the recursive relation between expectations and achievement.

## CONCLUSION

Throughout this chapter and in other chapters, my colleagues and I have clearly taken the position that it is important to study modifiable determinants of course selection and achievement in math. While the model used to guide this review does not rule out the possibility of biological explanations for sex differences in math achievement, it does emphasize experiential factors. We believe that in making decisions to pursue a particular course of study, aptitude is just one among many influential factors and that the final decision is more likely to be a consequence of students' interpretation of reality than of 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 give an achievement experience is mediated by causal attributional patterns for success and failure, the input of socializers, perceptions of the task's characteristics, and perceptions of their own needs, values, and role identity. Each of these factors plays a role in determining the expectations for success and the subjective value associated with any particular task and, consequently, with the decisions regarding that task.

Given the importance of the perceptions of the value of mathematics in shaping both boys' and girls' course and career decisions, socializers should do all they can to point out both the real possibility of a career in a math-related field and the importance of mathematics for a variety of adult careers. High school students think about their future roles and make very important decisions, often in the absence of good information regarding these future roles. Counselors, teachers, and parents could play a much more active role in encouraging girls to consider scientific or technical occupations. They could make sure that math-able girls are aware of their options and of the wide variety of occupations and careers that would allow them to make use of their math skills. Information regarding occupations such as psychology, education, medicine and related human services, environmental engineering, and/or hospital administration which combine women's social orientation with their math skills should be made available to high school girls. Practices such as these would alert more girls to potential technical and/or scientific occupations that might be of interest to them.

The possibilities of integrating these careers with their family plans should also be discussed. Too often girls may drop their math courses because they assume that math-related careers are too demanding or because they assume they will not have to work as adults. Counselors and teachers could do more both to allay the girls' fears regarding career and family incompatibility and to alert girls to the necessity of developing skills which will maximize their earning potential and work possibilities in future years. Efforts in this direction should increase the subjective value of math training and, as a consequence, increase the likelihood that girls will continue their math training as long as boys do.

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