Psychological Bulletin
1982, Vol. 91, No. 2, 324–348

0033-2909/82/9102-0324$00.75

Sex Differences in Math Achievement: Toward a Model of Academic Choice

Judith L. Meece

Jacquelynne Eccles Parsons, Caroline M. Kaczala, Susan B. Goff, and Robert Futterman

Psychological Bulletin
1982, Vol. 91, No. 2, 324-348

0033-2909/82/9102-0324$00.75

Sex Differences in Math Achievement: Toward a Model of Academic Choice

Judith L. Meece
Learning Research and Development Center
University of Pittsburgh

Jacquelynne Eccles Parsons, Caroline M. Kaczala, Susan B. Goff, and Robert Futterman
University of Michigan

Competence in mathematics has long been identified as a critical skill directly related to educational and occupational choices. Yet compared with men, fewer women elect to take advanced level mathematics courses and to enter mathematically oriented careers. This review first summarizes the common explanations of this problem and then integrates this research into a theoretical model first proposed by Parsons and her colleagues for studying students' academic choices and decisions. Drawing on concepts used in decision-making, in achievement, and in attribution research, this psychological model links academic choice to expectations of success and the subjective value of a particular course. In addition, the model specifies the relations among a set of other variables that are believed to mediate individual differences in both students' expectations of success and their perceptions of the relative value of various academic options. The utility of this model for increasing our understanding of course enrollment patterns and career decisions and for designing appropriate intervention strategies is discussed.

A growing concern has been expressed by policymakers over the small numbers of women pursuing careers in the scientific, mathematical, and technical fields. Despite efforts at amelioration through affirmative action and scholarship programs, employment statistics indicate that men and women are still entering these fields in disproportionate numbers (Bureau of Labor Statistics, 1980).

Although many factors contribute to this problem, one is of particular interest to educators and researchers: sex differences in the mathematical training of students. A strong mathematical background is important for admission to many college majors, for most professional occupations, and increasingly for many computerized technical occupations as well. Yet compared with male students, female students are less likely to enroll in more advanced high school and college mathematics courses (Brush, 1980; Ernest, 1976; Sells, 1980; Sherman & Fennema, 1977; Chipman & Thomas, Note 1; Armstrong & Kahl, Note 2; Sells, Note 3). Although enrollment patterns do not emerge consistently until the 12th grade and are not especially marked among undergraduate mathematics majors, strong sex differences in the proportion of men to women are evident among applied mathematics majors (e.g., engineering, computer science, physical sciences, business and finance) and in most postgraduate mathematics programs (Chipman & Thomas, Note 1).

The decision to limit one's mathematical training has serious consequences, involving both the long-range effects of restricting career options and the more immediate effects of educational inequity. Although women may receive less encouragement to continue their mathematical studies, it is not the case that they are being systematically excluded through discriminatory course availability.

The research reported in this article was supported by grants from the National Institute of Education (NIE-G-78-0022) and the National Institute of Mental Health (1 RO1 MH 31724-0) awarded to Jacquelynne Eccles Parsons while the first author was a graduate student at the University of Michigan. The opinions expressed do not reflect the position or policy of either agency, and no official endorsement should be inferred.

The authors would like to extend their sincere appreciation to Terry Adler, Susan Chipman, Carol Midgley, Lauren Resnick, and Diane Ruble for their helpful comments and suggestions on earlier drafts of this article.

Requests for reprints should be sent to Judith L. Meece, Learning Research and Development Center, University of Pittsburgh, Pittsburgh, Pennsylvania 15260.

On the contrary, all too often women *choose* not to enroll in more advanced mathematics courses or to pursue math-related college majors. Therefore, the social and psychological factors influencing the academic choices of these students appear to play a crucial role in this problem.

Many researchers have studied the math enrollment patterns of men and women. Their research, however, has been limited by a number of methodological and conceptual shortcomings. Of major importance is the lack of an integrative theoretical framework to guide the selection of a comprehensive set of variables for study. In response to this shortcoming, this review first summarizes past research on achievement and course selection in mathematics and then integrates this research into a theoretical model that has been proposed by Parsons and her colleagues for studying students' academic choices (Parsons, Adler et al., in press). Drawing on the theoretical and empirical work of decision-making, achievement, and attribution theorists, the model links academic choices to expectations of success and to the subjective value of the task. It also specifies the relation of these constructs to a number of other personal and social factors. 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.

Proposed Sources of Sex Differences in Math Achievement and Course Enrollment

Biological Factors

Sex differences in mathematics learning and course selection are sometimes attributed to innate differences in ability or aptitude. Proponents of this position argue that the different achievement and participation of men and women in mathematics result from the superior mathematical talents of men (see Benbow & Stanley, 1980; Bock & Kolakowski, 1973; Stafford, Note 4). Followed to its logical extreme, this position implies that no problem exists: Men and women simply choose activities that reflect their inherent abilities.

The conclusion that biological factors are a major determinant of sex differences in course enrollment rests on three assumptions: (a) There are consistent sex differences on measures of math ability; (b) these differences reflect a biological difference between the sexes; and (c) the sex difference in students' decisions to enroll in math courses or to enter professions requiring math skills is a consequence of these sex differences in math aptitude. Each of these assumptions is discussed and evaluated below.

Sex differences on tests of quantitative skill. Sex differences on tests of quantitative skills do not appear with any consistency prior to the 10th grade. High school boys generally perform somewhat better than high school girls on tests of mathematical reasoning (primarily word problems). Younger boys and girls perform equally well on tests of algebra and basic mathematical knowledge. Also, girls occasionally outperform boys on tests of computational skills. Support for these conclusions can be drawn from several recent studies, many of which are based on large national samples (Burnett, Lane, & Dratt, 1979; Fennema, in press; Fennema & Sherman, 1977, 1978; Schratz, 1978; Sherman, 1980, in press; Starr, 1979; Armstrong, Note 5; Connor & Serbin, Note 6; College Entrance Examination Board, Note 7; Steel & Wise, Note 8). (See Fox, Brody, & Tobin, 1980; Maccoby & Jacklin, 1974; and Wittig & Petersen, 1979, for reviews of studies prior to 1975.)

In most studies, the sex difference on tests of mathematics achievement persists, although to a lesser degree, even when one corrects for the number of mathematics courses taken (Sherman, 1980; Starr, 1979; Armstrong, Note 5; Steel & Wise, Note 8). It is important to note, however, that in all of these studies, the achievement differences favoring male students are neither very large nor universally found even among seniors in high school. For example, Fennema and Sherman (1977) found the expected sex difference in mathematical achievement in only two of four high schools they studied. Schratz (1978) found that the direction of the sex differences is dependent on ethnic group. In addition, sex differences are not evident when student grades are the criteria of achievement (College Entrance Examination Board, Note 7).

An important exception to the developmental emergence of sex differences on tests of quantitative skills was recently reported by Benbow and Stanley (1980) and by Fox and Cohn (1980). In several large samples of highly gifted seventh- and eighth-grade students, boys scored consistently higher than girls on the Scholastic Aptitude Test for Mathematics (SAT-M). The differences were especially marked at the extreme upper end of the distribution. These data suggest that sex differences in mathematics achievement may emerge earlier in gifted samples of students than in more general populations.

Sex differences in spatial skills. Although the pattern of sex differences in mathematical skills is not entirely consistent, several researchers have argued that the pattern seems consistent enough to suggest that biological factors such as genetic differences, differences in brain organization, or hormonal differences may be involved (see McGlone, 1980; Wittig & Petersen, 1979). The possibility that sex differences in innate spatial visualization abilities mediate mathematical achievement differences has become a popular hypothesis.

As was the case with tests of mathematics achievement, a fairly consistent sex difference on tests of spatial skills does not emerge prior to the 10th grade (Burnett et al., 1979; Connor, Schackman, & Serbin, 1978; Fennema & Sherman, 1977, 1978; Sherman, in press; Steel & Wise, Note 8). Recent studies, however, suggest that the magnitude of the sex effect varies depending on maturational timing (Waber, 1979; Herbst & Petersen, Note 9), body type (degree of masculinity; Petersen, 1979), personality characteristics associated with masculinity and femininity (Nash, 1979), previous experience with spatial activities (Burnett & Lane, 1980; Connor et al., 1978; Connor, Serbin, & Schackman, 1977; Sherman, Note 10), ethnic background, parental styles, socioeconomic status (Fennema & Sherman, 1977; Nash, 1979; Schratz, 1978; Gitelson, Note 11), and the particular test given (Connor & Serbin, Note 6). In fact, in a recent national survey study of 3,240 junior and senior high school students, 13-year-old girls did better on a test of spatial skill than did 13-year-old boys; 12th-grade boys and girls did equally well (Armstrong, Note 5). Thus, as Connor and Serbin (Note 6) concluded, "Junior and senior high school males . . . perform better than females on some visual–spatial measures, some of the time" (p. 36).

The relation between spatial skills and mathematical achievement. Several studies have demonstrated a strong positive correlation (*r*s ranging from .50 to .60) between spatial skills and a variety of mathematical achievement test scores (Burnett et al., 1979; Fennema & Sherman, 1977, 1978; Sherman, 1980; Armstrong, Note 5; Connor & Serbin, Note 6; Steel & Wise, Note 8). Verbal abilities, however, also correlate quite highly with mathematical performance (Fennema & Sherman, 1977, 1978; Sherman, 1980; Armstrong, Note 5; Connor & Serbin, Note 6). In the most comprehensive study available, Connor and Serbin (Note 6) found a very inconsistent pattern of relations between spatial skills, verbal skills, and mathematical achievement. Although some measures of both verbal and spatial skills emerged as significant predictors of general mathematical achievement, not all of the measures of spatial skills correlated significantly with all of the measures of mathematical achievement, and the correlations varied across grade level and sex. Further, when Connor and Serbin factor analyzed their measures, the tests of spatial skills formed one factor and were independent of the factor containing the measures of mathematical achievement. Thus, it appears that the relation between spatial skills and mathematical achievement is not yet fully understood.

Several investigators have also examined whether the relation between spatial skills and mathematical achievement varies according to sex. No consistent findings have emerged. Sherman (1980) found the relation to be stronger among girls than among boys, whereas other researchers found the relation to be the reverse (e.g., Hyde, Geiringer, & Yen, 1975; Connor & Serbin, Note 6; Steel & Wise, Note 8). In contrast, Fennema and

Sherman (1977, 1978) and Burnett et al. (1979) found no sex difference in the strength of the relation. In addition, when comparing the relative importance of spatial skills with other possible predictors of mathematical achievement, Steel and Wise (Note 8) found that attitudinal factors were stronger predictors for girls, whereas Connor and Serbin (Note 6) found verbal abilities to be the strongest predictors.

Finally, one other approach has been used to address the central question of whether or not the sex difference in spatial ability mediates the sex difference in mathematical achievement. The effects of statistically partialing out spatial skills differences from mathematical achievement scores were evaluated. By and large, sex differences in mathematical achievement scores are significantly reduced or eliminated when spatial skills are partialed out (Burnett et al., 1979; Fennema & Sherman, 1977; Hyde et al., 1975). As Burnett et al. (1979) pointed out, however, one cannot conclude from these findings that the sex differences in spatial skill cause the observed differences in mathematics achievement. One can conclude only that the data are consistent with that hypothesis. The findings reported earlier on the relations of verbal skills to girls' mathematics achievement scores makes this caveat even more critical. In addition, Fennema and Sherman (1977) found that one can also eliminate sex differences in mathematics achievement by partialing out either the number of courses taken or a set of attitudes toward math, variables that are also distinctly differentiated by sex.

Summary. In this section the assumptions underlying the argument that sex differences in math achievement and course enrollment are due to biological factors were discussed. Fairly consistent evidence was found for sex differences in tests of both mathematical and spatial skills among 11th and 12th graders. These differences appear to persist into adulthood in those limited populations studied.

The relative contribution of biological factors to the development of spatial skills is not, however, fully resolved (Vandenberg & Kuse, 1979). Some studies show that spatial skills can be trained (Burnett & Lane, 1980; Connor et al., 1977, 1978; Goldstein & Chance, 1965). In addition, the relation of spatial skills to mathematics learning is not fully understood. Further, whether or not the sex differences in either mathematical aptitudes or spatial skills contribute to the sex differences in course enrollment patterns seems to be an open question.

In the few studies that have attempted to predict math course enrollment among high school students, spatial visualization sometimes emerges as a significant predictor. Nevertheless, spatial skills are not always a significant predictor for either girls or boys. Enrollment is also predicted by scores on vocabularly tests (Sherman, in press), by past math achievements (Fennema, in press; Parsons, Adler et al., in press; Sherman & Fennema, 1977; Armstrong, Note 5; Steel & Wise, Note 8; Dunteman, Wisenbaker, & Taylor, Note 12), by interest in mathematics and career plans (e.g., Fennema, in press; Parsons, Adler et al., in press; Steel & Wise, Note 8), and by a variety of attitudinal and social factors. Thus, the magnitude of the contribution of biological factors, the inevitability of their effects, and the exact nature of these effects are still to be determined.

Socialization Factors

Several researchers propose that sex differences in math achievement and course selection can be explained by the different socialization experiences of boys and girls. The attitudes of teachers, parents, and counselors often reflect cultural stereotypes regarding not only the alleged natural superiority of boys' mathematical abilities but also the different utility of mathematical skills for boys and for girls (e.g., Fennema, 1974; Fox, Tobin, & Brody, 1979; Jacklin, 1979; Nash, 1979). By embracing these views, socializers could undermine girls' confidence, their motivation to perform well, and their actual learning in mathematics. Socializers are believed to contribute to the observed sex differences in three important ways: (a) Male and female socializers differ in their attitudes and behavior 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 male and female children that train different skills and interests.

Modeling effects. Social learning research has established the importance of adult behavior as a standard or model for children's behavior, particularly for sex role appropriate behavior. Adult models, especially parents, exhibit behavior that children imitate and later adopt as part of their own behavioral repertoire (Bandura & Walters, 1963; Maccoby & Jacklin, 1974; Parsons, Adler, & Kaczala, in press).

According to this point of view, male and female socializers can variously influence boys' and girls' behavior by simply engaging in different activities. Ernest (1976) reported that after sixth grade, fathers are more likely than mothers to help their children with their math homework. Fox (Note 13) reported a tendency for more advanced mathematics courses to be taught by men. 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 programs in increasing math participation among women through exposure to female models supports this line of reasoning (e.g., Brody & Fox, 1980; Tobin & Fox, 1980).

In addition, if male and female socializers hold different beliefs about their respective math abilities and competence, then boys and girls may develop different beliefs about their own abilities. Although 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 are their male peers. Similarly, Parsons, Adler, and Kaczala (in press) found that college-educated mothers are less interested in math and hold a more negative view of their math abilities than do college-educated fathers. If young girls model their behavior after these important adults, then this difference in self-concepts, coupled with the paucity of female role models with mathematical orientations, could lead girls to view themselves as less competent than boys in math. Tests of this hypothesis, however, are virtually nonexistent. In the one study that did assess the relevant relations within families, Parsons, Adler, and Kaczala (in press) found no significant association between parents' and children's self-concepts of mathematical abilities. Further, the relative amount of math done by mothers and fathers also appeared to have little relation to either children's math attitudes or their course enrollment plans. Parental expectations for their children's performance in math, however, were found to be important.

Socializers' expectations and related behavior. Although considerable criticism and controversy followed early studies of expectation effects (e.g., Rosenthal & Jacobson, 1968), subsequent studies have presented convincing evidence that teacher expectations are related to both teacher and student behavior in the classroom (see Brophy & Good, 1974; Cooper, 1979). These effects, however, are generally quite small and are more likely to solidify differences already in existence than to create the differences in the first place (Cooper, 1979). Throughout the achievement literature, parental expectations have also been linked to both high need-achievement motivation and behavior (e.g., Crandall, 1969; Rosen & D'Andrade, 1959; Winterbottom, 1958).

If the expectations of others mediate behavior, as these studies suggest, then the degree to which important socializers hold sex-differentiated achievement expectations is a critical factor to consider. Several studies suggest that parents and teachers have higher educational expectations for boys than for girls (Good, Sikes, & Brophy, 1973; Hilton & Berglund, 1974; Sears, Maccoby, & Levin, 1957), though these biases do not emerge with any consistency until the adolescent years. In fact, during the elementary school years, parents and teachers are more likely to expect girls to do better than boys (see Maccoby & Jacklin, 1974). Not until high school do teachers express expectations of higher academic performance for boys than for girls (Good et al., 1973; Cooper, Note 14).

Few studies have directly measured the

specific expectations that socializers hold for math achievement. Surveying a small sample of elementary and high school teachers, Ernest (1976) reported that 41% thought that boys do better than girls in mathematics; none believed that girls do better than boys. Parsons, Adler, and Kaczala (in press) reported that, in comparison with parents of sons, parents of daughters thought math was more difficult for their daughters and that they were having to work hard to do well in it.

Other results reported in these studies do not yield a consistent pattern of sex differences. For example, parents in the Parsons, Adler, and Kaczala (in press) study did not have lower expectations for their daughters' mathematical performance nor did they rate their daughters' mathematical ability as any lower than that of their sons. Similarly, Parsons, Kaczala, and Meece (in press) 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. Furthermore, in the Ernest (1976) study, 59% of the teachers did not expect boys to do better in math. Thus, it appears that sex differences in the expectations of significant others are not universally found but favor boys when they are present.

It is unclear exactly how these different expectations for boys and for girls are conveyed. There is undoubtedly a variety of direct and indirect means by which children learn what others expect of them. Patterns of reinforcement, direct instruction, and evaluative feedback for children's math performances are three means that have received recent attention.

Research on parents suggests that they may convey different expectations by offering more explicit rewards and reinforcements for learning math to their sons than to 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 (Haven, 1971; Parsons, Adler, & Kaczala, in press; Casserly, Note 15; Luchins, Note 16). For example, Haven (1971) 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, counselors admitted discouraging girls from taking these courses, citing reasons that reflected their stereotyped views 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, Parsons, Adler, and Kaczala (in press) report that parents, especially fathers, were more likely to stress to their daughters the importance of taking social science and humanities courses and to stress to their sons the importance of advanced mathematics courses.

In addition, on the basis of extensive observations in classrooms, several investigators conclude that the quantity and type of teacher instruction varies according to the sex of the student and subject matter being taught. In general, teachers tend to interact more with boys than with girls, especially in mathematics and science classes (Becker, 1981; Brophy & Good, 1974; Leinhardt, Seewald, & Engel, 1979; Stallings, Note 17; Bean, Note 18). Student–teacher interaction patterns may also vary depending on both ability and sex: High-potential boys often receive more praise for their achievements and more total interactions than do high-potential girls (Fennema, in press; Parsons, Kaczala et al., in press). Quantity of formal teaching has also been found to vary as a function of a child's sex (Becker, 1981; Leinhardt et al., 1979; Bean, Note 18), with boys getting more formal math instruction. For example, Leinhardt et al. (1979) found different treatment as early as second grade, when basic skills are taught. On the basis of multiple observations of math instruction periods, these researchers predict that over the course of an academic year, boys could receive as much as six more hours of instruction than would girls. The cumulative effect of this difference in formal education over the entire course of elementary school may be significant.

There is also some evidence to suggest that boys and girls receive different evaluative feedback for their school work. For example, Dweck, Davidson, Nelson, and Enna (1978) reported that teachers use more indiscriminate criticism with boys, addressing two thirds of the total negative evaluation for boys to intellectually irrelevant aspects of their academic performance. Thus, boys were more likely to be criticized for conduct or neatness rather than for the academic content of their work. In contrast, more than two thirds of the negative evaluation of girls was directed at the academic quality of their work; girls were criticized for correctness rather than for neatness or format. In addition, Dweck et al. found that teachers explicitly attributed academic failure to a lack of motivation or effort six times more often for boys than for girls. These researchers conclude that this different pattern of teacher feedback could help explain the sex difference in achievement expectations. They argue that because teachers use negative evaluation more indiscriminately with boys than with girls, it will lose its meaning for boys and consequently have less (if any) adverse effect on their achievement expectations and performance than it would have on those for girls.

Recent studies have not supported Dweck's findings (e.g., Fennema, in press; Heller & Parsons, 1981; Parsons, Kaczala et al., in press; Blumenfeld, Bossert, Hamilton, Wessels, & Meece, Note 19; Swarthout, Note 20). These studies suggest that teachers give very little criticism, that teacher criticism is directed almost universally to classroom conduct, and that the pattern of evaluative feedback is similar for boys and for girls, although boys receive more overall criticism.

The picture is further complicated when one considers the few studies that have actually attempted to relate teacher–student interaction patterns in math classes to student attitudes. Heller and Parsons (1981) and Parsons, Kaczala et al. (in press) tested the relation between student–teacher interaction patterns and (a) students' attitudes toward their own mathematical abilities and the difficulty of math courses and (b) students' plans to continue taking math. Although both studies found a significant relation between a teacher's reported expectations for a student and the student's own self-concept of his or her math ability (even after the effects of the student's past grades in mathematics had been partialed out), neither study found many significant relations between observed teacher behavior and the student's attitudes. Parsons, Kaczala et al. did find that when teacher praise covaried with teacher expectation, the quantity of teacher praise was weakly but significantly related to students' self-concepts of their math ability. This was true, however, only for boys and only in some classrooms. Thus, additional research is clearly needed to determine how classroom experiences might undermine girls' math achievement expectations and performances.

Different experiences. In addition to the more direct socialization effects discussed thus far, parents and teachers can influence children's achievement behavior and values by the types of general experiences they provide or encourage. A difference in toys and recreational activities has been linked to the spatial skill differences between boys and girls discussed earlier. Connor et al. (1978) argued that the spatial skill deficit shown 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, these researchers designed an intervention procedure for the preschool years that improved girls' spatial skills. On the basis of the results of their intervention study, Connor et al. 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 than for girls further support this argument (Astin, 1974; Hilton & Berglund, 1974).

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 nurturance, permissiveness, and encouragement of independence are important child-rearing practices for facilitating achievement 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 overbearing and intrusive, giving 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. Although 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 behavior by providing or encouraging sex-differentiated activities.

Summary. The studies reviewed in this section strongly support the hypothesis that socializers treat boys and girls differently in a variety of ways that might be linked to mathematics and course selecton. Only a few studies have directly assessed the causal impact of these socialization experiences on students' math achievement and course selection. In these studies, encouragement from parents (as measured from parent reports or from students' ratings of parental encouragement) has emerged as an important causal factor in girls' decisions to elect advanced mathematics courses in high school (e.g., Haven, 1971; Parsons, Adler, & Kaczala, in press; Sherman & Fennema, 1977; Armstrong, Note 5; Luchins, Note 16). Similarly, our previous research has demonstrated a strong relation between parental perceptions and expectations and their children's plans to continue taking math courses. In these studies, sex differences on the predictor variables favored boys and seemed to have a negative influence on the academic and career choices of girls (see Parsons, Adler et al., in press; Parsons, Adler, & Kaczala, in press).

It is important to note, though, that the direction of causality in these studies is difficult to ascertain. Are socializers' expectations and attitudes a reflection of actual student 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 that is just as supportive of the notion that student achievement causes expectations (cf. West & Anderson, 1976). It is likely then that both conclusions are correct. Future studies should examine more carefully the reciprocal relations between socializers' expectations and students' achievement and course selection.

Attitudinal Factors

Students' attitudes toward mathematics are another proposed source of sex differences in mathematics achievement and course selection. The major thrust of research in this area has been directed toward uncovering sex differences in students' perceptions of themselves as math learners and in the sex typing of mathematics and its usefulness. Very little research, however, has examined the causal influence of these differences on the behavior of interest.

Self-concepts of math ability. Students' perceptions of their own mathematical ability have been measured in a variety of ways. The findings are quite consistent. Few sex differences in their perceptions of their math ability are found among elementary school children; large and more consistent differences are found among adolescents. Ernest (1976) reported that during the elementary school years, members of each sex believe that children of their own sex do better in mathematics. There is, however, a great deal of evidence to suggest that by junior high school, boys perceive themselves as more able in math than do girls (e.g., Brush, 1980; Fennema, in press; Fennema & Sherman, 1977; Parsons, Adler, et al., in press; Robitaille, 1977; Sherman, 1980; Armstrong & Kahl, Note 2; Fox, Brody, & Tobin, Note 21; Heller, Futterman, Kaczala, Karabenick, & Parsons, Note 22; Kaczala, Parsons, Futterman, & Meece, Note 23; Kaminski, Erickson, Ross, & Bradfield, Note 24). These differences appear despite the fact that during the elementary and junior high school years girls typically do as well as boys in their math classes and on standardized math achievement tests (Fennema, 1974;

Sherman, 1980; Armstrong, Note 5; Wise, Steel, & MacDonald, Note 25). The prime exception to this developmental trend is the performance of gifted boys and girls discussed earlier (Benbow & Stanley, 1980).

The pattern emerging from research on self-concepts and related variables suggests that as students go through junior and senior high school, ratings of their general math ability decline; girls' ability declines earlier and to a greater extent than that of boys. Although this sex difference may not be reflected in students' expectations for performance in their current math courses, it is evident in their more general ratings of confidence and math abilities and in their expectations for future courses (Heller & Parsons, 1981; Parsons, Adler et al., in press; Heller et al., Note 22).

Only a few studies have tested the link between self-concepts of math ability and course selection. These studies show that students are more likely to enroll in optional math courses when they perceive themselves as having high math ability or feel confident of their math performance (Parsons, Adler et al., in press; Sherman, 1980; Sherman & Fennema, 1977; Armstrong Note 5; Kaminski et al., Note 24). More studies are needed to clarify the causal significance of these self-perceptions relative to the effects of past performances or socialization factors.

Sex role attitudes and math achievement values. Consistent with traditional sex role values and beliefs, numerous studies have shown that high school students view mathematics as a male achievement domain (Ernest, 1976; Fennema & Sherman, 1976, 1977; Parsons, Adler et al., in press; Stein & Smithells, 1969; Armstrong & Kahl, Note 2). Boys sex type math as masculine to a greater extent than do girls (e.g., Brush, 1980; Fennema & Sherman, 1977; Parsons, Adler et al., in press; Sherman, 1980; Sherman & Fennema, 1977). These studies, however, show that math is neither always sex typed as masculine, nor is it even one of the most likely subject areas to be sex typed; mechanical art courses and athletics are both more likely to be classified as masculine (Stein & Smithells, 1969).

Ratings of the usefulness of math also reflect sex stereotypes. Several studies indicate that boys, as early as seventh and eighth grades, tend to rate math as more useful than do girls (Brush, 1980; Fennema & Sherman, 1977; Haven, 1971; Hilton & Berglund, 1974; Parsons, Adler et al., in press; Fox et al., Note 21; Wise et al., Note 25). These results are not entirely consistent across age groups and schools. Fennema and Sherman (1977) found the sex difference in only two schools, and Sherman (1980) found that girls' perceptions of the usefulness of math declined over the high school years, whereas boys' perceptions did not.

This issue is further complicated when one looks at studies that have attempted to assess the relations between sex typing, perceived usefulness, performance, and course plans. Results differ across studies and across the sexes within studies. These variations do not follow a consistent pattern. For example, on the one hand, Fennema and Sherman (1977) found only a modest relation between sex typing math as a male domain and mathematics achievement in grades 9–11, and this relation existed only for girls. On the other hand, Sherman (1980) found that a low level of stereotyping of math as a male domain at grade 8 was one of the major attitudinal predictors of girls' math achievement at grade 11. Furthermore, Parsons, Adler et al. (in press) found that junior high school girls' plans to continue taking math were predicted by relatively high levels of stereotyping of math as a male domain. Thus, the relation between the sex typing of mathematics and students' achievements and course plans in mathematics is neither clearly understood nor likely to be simple. Nash (1979) recently suggested that one must consider the sex role of the individual as well as the sex typing of the subject matter in making predictions. This hypothesis is discussed in more detail later in the article.

The findings associated with the perceived usefulness of math are more consistent. Perceptions of the value of math or math-related careers emerge as significant predictors of both achievement and course plans in most studies (e.g., Brush, 1980; Fennema, in press; Fennema & Sherman, 1977; Fox et al., 1980; Fox & Denham, 1974; Parsons, Adler et al., in press; Sherman & Fennema, 1977; Armstrong, Note 5; Fox et al., Note 21; Wise et al., Note 25; Parsons, Note 26). The strength of its effect, however, is still unclear. Whereas Brush (1980) reported that the perceived usefulness of math was not a strong predictor of math course participation relative to other factors such as ability level, socioeconomic status, and general feelings toward math, several other investigators reported that it was an important predictor, accounting for a substantial proportion of the variance in course enrollment patterns (see Fennema, in press; Parsons, Adler et al., in press; Steel & Wise, Note 8; Parsons, Note 26).

Affective Factors

In recent years math anxiety has emerged as still another explanaton 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, some researchers argue that women and men differ in their emotional reactions to mathematics and that these differences could influence students' participation in math (Lazarus, 1974; Tobias, 1978; Tobias & Weissbrod, 1980).

Only a few empirical studies have directly assessed affective responses to mathematics learning, and the findings are not entirely consistent. In terms of general affect, expressed as a liking or preference for mathematics, few differences are evident in boys' and girls' responses during elementary and high school. Sex differences in these variables do appear after high school, with boys expressing more positive affect toward math (Aiken, 1976; Brush, 1980; Ernest, 1976; Fox, Tobin, & Brody, 1979). A few empirical studies have also assessed more extreme reactions to mathematics (e.g., anxiety, excessive worry and concern) and support the hypothesis that greater numbers of women are math anxious (Brush, 1978, 1980; Dreger & Aiken, 1957; Suinn & Richardson, 1972). These studies, however, have not controlled for the possibility that men might be less willing to admit to feelings of anxiety, especially with regard to an area of achievement that is viewed as masculine, particularly by men.

If math anxiety is to be used 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 also the conceptualization of math anxiety itself needs to be refined. Some critics suggest that math anxiety may simply reflect a strong emotional reaction to evaluation or testing, which is commonly found in most math classes. In response to this criticism, Brush (1978) compared students' ratings of questionnaire items dealing with computation with ones dealing with tests and similar evaluations. As expected, students rated tests in math as more anxiety arousing, with women reporting higher anxiety than do men. Suinn and Richardson (1972) found that a majority of the students who reported feeling anxious about math indicated that they had no similar anxieties for other academic subjects. Thus, for some students math anxiety may reflect a generalized fear of failure or test anxiety, whereas for other students math anxiety appears to reflect a very specific affective response.

Other researchers have argued that math anxiety is nothing more than a lack of confidence in one's ability to learn mathematics. In support of this conclusion, Fennema and Sherman (1976) reported strong correlations between measures assessing confidence in math and anxiety. Again it is the case that women have more negative feelings than do men. Even in studies that have controlled for the number of math courses taken, men report greater confidence in their math abilities than do women (Fennema & Sherman, 1977; Sherman, 1980; Sherman & Fennema, 1977).

Because women tend to have negative feelings toward math, several researchers argue that women are more likely than men to avoid this area of study, if given the opportunity. 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 optional course work in mathematics or to choose quantitative college majors

(Brush, 1978, 1980; Sherman & Fennema, 1977). Given that women typically score higher on these measures, this finding 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. In a recent study using causal modeling procedures, Brush (1980) reported that when other affective and attitudinal variables are considered, the relative importance of anxiety in explaining students' enrollment in physical science courses was nonsignificant. Anxiety appeared to have its effect primarily as a mediator of other variables that are more directly linked to students' course selection such as their liking of the course and their expected grades. It is interesting to note, though, that in this study women seemed to use anxiety as a stronger criterion for judgments about liking and performance than did men. In this way anxiety may play a more influential role in women's academic choices.

Summary of Past Research

In their attempt to account for sex differences in math achievement and course enrollment, researchers have advanced several explanations ranging from biologically based differences in mathematical aptitude to the sex typing of math as a male domain. Though no one explanation has emerged with unequivocal support, each of the bodies of research reviewed provides insights into the determinants of math achievement behavior. There is, however, no apparent overriding theme linking together the several important influences. Even if the specifics are not well understood, it is clear that sex differences in math achievement and enrollment patterns are determined by a complex set of causative factors.

An integrative theoretical framework that provides a more complete description of the factors influencing students' academic choices is clearly needed. Given the complexity of the cognitive skills involved and the sociocultural context in which mathematics learning takes place, such a framework should be comprehensive in its approach. To ameliorate shortcomings of past research, it should also take into account the complex interplay of the many factors contributing to students' academic choices. A framework that describes the causal effects of aptitude, socialization, attitudinal, and affective factors on subsequent academic choices from a motivational perspective would help clarify existing research and would provide the basis for future research and for intervention programs. Such a model for general achievement behavior has been developed by Parsons and her colleagues. The application of this theoretical model of academic choice to an understanding of sex-differentiated math enrollment patterns is presented in the next section.

Model of Academic Choice

Parsons and her colleagues have developed a general model of academic choice that builds on earlier Expectation × Value models of achievement behavior (e.g., Atkinson, 1964; Crandall, 1969; Kukla, 1972, 1978; Lewin, 1938; Weiner, 1972, 1974). The proposed model links academic choice to two specific constructs: expectation of success on a task and the subjective value of the task for the individual. Figure 1 displays an overview of this model. In line with cognitive approaches to achievement motivation, the model assumes that the effects of past achievement and socialization experiences are mediated by one's interpretations of those events in light of cultural influences and a fairly stable perception of oneself. Therefore, as shown in Figure 1, achievement expectations and values are hypothesized to be influenced by students' perceptions of their own ability, personal needs, and future goals and by their perceptions of task characteristics. Individual differences on these variables are further assumed to result from variations in perceptions of socializers' beliefs and behavior, causal attribution patterns for success and failure, perceptions of appropriate behavior and goals, and previous achievements.

Each of the model's major psychological components is described in the subsequent sections. Relevant research from the general achievement motivation literature is integrated with previous findings from the math achievement literature to provide a more complete picture of students' academic choices.

Expectations

Expectation or probability of success has long been recognized by decision and achievement theorists as an important variable in determining behavioral choice (e.g., Atkinson, 1964; Edwards, 1954; Kukla, 1972, 1978; Lewin, 1938). Numerous studies have demonstrated the importance of expectations for a variety of achievement behavior including academic performance, task persistence, and task choice (e.g., Crandall, 1969; Diggory, 1966; Feather, 1966; Veroff, 1969). Studies using measures of confidence in learning math, a conceptually related variable, have demonstrated a similar link between confidence and performance (Parsons, Adler et al., in press; Sherman, 1980; Sherman & Fennema, 1977; Armstrong & Kahl, Note 2; Sherman, Note 10). On the basis of this research, achievement expectations are included in our model as key determinants of academic choices in mathematics.

Several studies have reported sex differences in achievement expectations. Laboratory studies, using somewhat novel tasks, generally find that girls who are 8 or more years old have lower initial expectations than do boys (Crandall, 1969; Dweck & Bush, 1976; Dweck & Gilliard, 1975; Montanelli & Hill, 1969; Parsons & Ruble, 1977). When familiar tasks or actual school subjects are used, however, the findings are less consistent. For example, although Parsons and Ruble (1977) found an initial sex difference in the 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. Whereas few sex differences are typically found in students' expectations for current performance, sex differences are evident in students' expectations for unfamiliar tasks

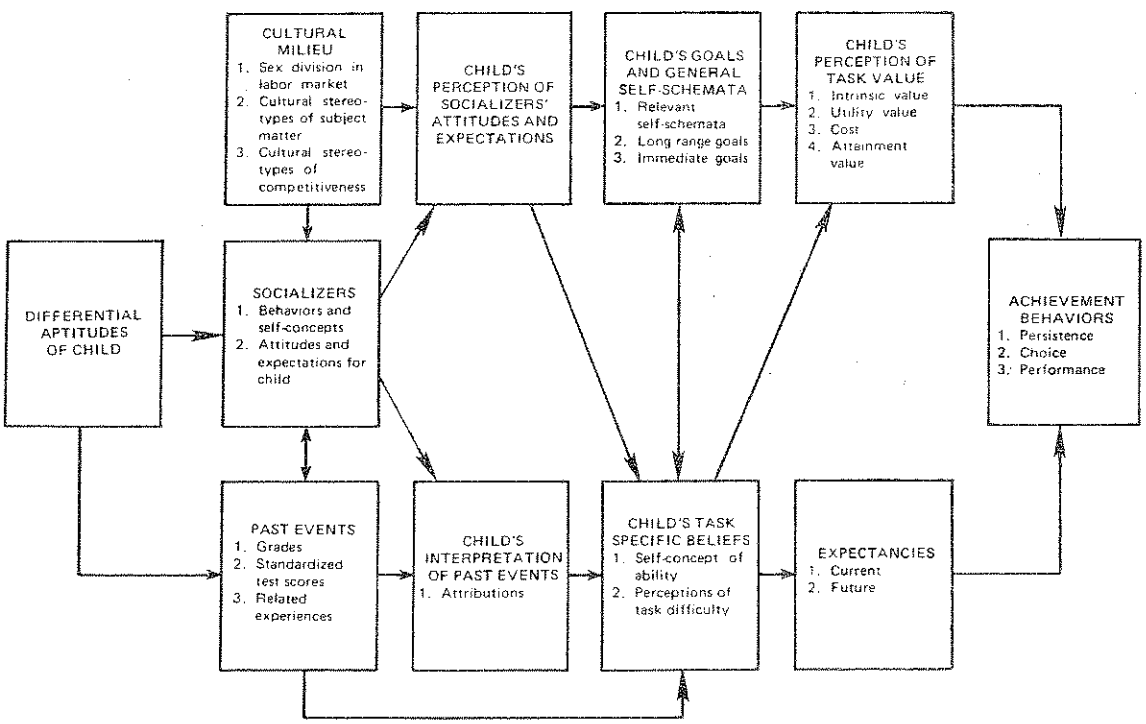

Figure 1. General model of academic choice. [Adapted from "Expectancies, Values, and Academic Behaviors" by J. E. Parsons, T. F. Adler, R. Futterman, S. B. Goff, C. M. Kaczala, J. L. Meece, & C. Midgley. In J. T. Spence (Ed.), *Perspectives on Achievement and Achievement Motivation* (in press). Copyright forthcoming by W. H. Freeman. Reprinted by permission.]

such as future math courses or math contests (Heller & Parsons, 1981; Parsons, Adler et al., in press; Fox, Note 13; Heller et al., Note 22).

Frieze, Fisher, Hanusa, McHugh, and Valle (1978) interpreted this pattern of results as reflecting the difference between specific and generalized expectations. They argued that girls' generalized expectations are lower than those of boys, but 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, one can expect their expectations to rise. It is their generalized expectations, rather than specific expectations, however, that should be the more powerful influence on decisions regarding future achievements, and generalized expectations appear to be especially detrimental to girls' academic choices and achievements. In particular, because advanced mathematics differs from earlier math courses and students perceive advanced math courses as more difficult than their current math course (Brush, 1980; Parsons, Adler et al., in press), future expectations would be the more salient factor. Furthermore, because girls generally have lower future expectations than do boys, girls would, therefore, be less likely to enroll in advanced math courses.

Given that achievement expectations play a significant role in students' academic choices, it is important to identify the factors that might account for different expectations. Within our model, expectations are most directly influenced by self-concepts of ability and by estimates of task difficulty. In addition, these variables and expectations are all assumed to be influenced indirectly by past achievement and cultural factors through students' interpretations of previous achievements, perceptions of the expectations of others, and identification with the goals and values of existing cultural roles.

Self-concept of ability. The importance of self-concepts of ability in the achievement process has been discussed extensively in the achievement literature. Research documenting a positive relation between self-perception of ability and task choice is of particular importance to our model (e.g., Brookover & Erickson, 1975; Kukla, 1972, 1978; Meyer, Folkes, & Weiner, 1976). Brookover and Erickson (1975) suggested that self-concepts of ability in regard to various academic areas function as "threshold variables" to set limits on the kinds of subjects a person chooses to study. On the basis of an assessment of one's own competence to perform a given task, one must assume a minimal level of success before undertaking the task.

The relation of self-concepts of math ability to students' decisions to enroll in optional math courses has also been amply demonstrated (e.g., Parsons, Adler et al., in press; Sherman, in press; Armstrong & Kahl, Note 2; Steel & Wise, Note 8; Sherman, Note 10; Fox, Note 13; Kaczala et al., Note 23; Kaminski et al., Note 24; Parsons, Note 26). These studies report that sex differences in students' self-perceptions of math ability, favoring boys, are evident by junior high school. In view of this evidence, self-concepts of math ability are included in our model as an important source of individual differences in academic choices.

The causal role of these sex differences in accounting for differences in math course selection and other achievement behavior, however, is less clear. Studies by Parsons and her colleagues, which addressed this issue using path analysis procedures, found self-concept of ability to have only a small direct effect on math course enrollment plans (Parsons, Adler et al., in press; Kaczala et al., Note 23). In line with the predictions of our model, however, self-concept of math ability did have a significant effect on expectations, which in turn had a significant effect on enrollment plans. Thus, self-concepts of ability are assumed to influence students' academic choices indirectly through raising or lowering their achievement expectations.

Perceived task difficulty. Intuitively, it seems that expectations of success should be inversely related to the perceived difficulty of the task. Although little research has addressed this prediction directly, there is strong evidence indicating that task choice is related to perceived task difficulty (e.g., Atkinson & Birch, 1970; Meyer et al., 1976; Weiner, 1972, 1974). Nevertheless, the relation is not straightforward. Several investigators (e.g., Atkinson, 1964; Kukla, 1978;

Meyer et al., 1976; Weiner, 1972) have suggested a curvilinear relation between perceived task difficulty and task choice. Maehr (Note 27) has suggested that this analysis applies only to a limited set of achievement circumstances, namely, those that might be labeled recreational. For inherently difficult tasks with important future implications, such as achievement in one's math courses, our model predicts that perceived task difficulty is negatively correlated with task choice.

The few studies testing this prediction in the area of math achievement have 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 (Husen, 1967). Stallings and Robertson (Note 28), 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.

A few studies have also tested for sex differences in perceived task difficulty. Brush (1980) found that junior and senior high school girls rate mathematics as more difficult than do their male peers. In our own studies, girls also rated future courses as more difficult than did boys, suggesting that girls' perceptions of task difficulty might work in conjunction with their low self-concepts of math ability to lower their expectations of success in those future courses (see Parsons, Adler et al., in press; Heller et al., Note 22; Kaczala et al., Note 23). In support of this hypothesis, Parsons, Adler et al. (in press) found that the perceived difficulty of mathematics courses has a causal effect on expectations of future success, on self-concepts of math ability, on perceptions of the utility of future math courses, and on liking of mathematics. In each case the belief that math is very difficult is associated with a more negative view of one's math abilities and of mathematics itself 1 year later.

Because girls think mathematics is more difficult than do boys, these findings suggest that girls will be less likely to enroll in mathematics courses if given an option. Although there is very little research directly testing this hypothesis, there is some evidence indicating that girls more frequently than do boys avoid tasks that have been designated as difficult (Stein & Bailey, 1973; Veroff, 1969). In a direct test of this hypothesis, however, we found that the enrollment plans of either boys or girls were not influenced directly by the students' estimates of the difficulty of their current or future mathematics courses. Instead, estimates of task difficulty appear to have their influence through the direct effects they have on students' expectations of success and students' perceptions of the value of mathematics (see Futterman, 1980; Parsons, Adler et al., in press).

Perceptions of beliefs and expectations of significant others. The achievement literature has documented the importance of socializers' expectations and attitudes in shaping children's self-concepts and general expectations of success (Brookover & Erickson, 1975; Brophy & Good, 1974; Crano & Mellon, 1978; Parsons, Frieze, & Ruble, 1976; Rosenthal & Jacobson, 1968). Research has also clearly shown that boys and girls have very different socialization experiences. Of particular relevance to our model is the growing body of literature indicating that parents and teachers hold different achievement expectations for boys and for girls, which may in part reflect cultural views of the inferior competence of women and girls. Given that math is sometimes sex typed as a masculine subject area, this issue becomes especially significant for our understanding of the origins of sex-differentiated course enrollment patterns in mathematics. If girls infer that parents and teachers hold lower expectations for their mathematics performance, then girls may develop lower expectations for their own potential achievement in mathematics courses and choose not to enroll in optional courses.

The few studies that have actually examined this possibility have found that when sex differences are evident, women perceive their parents as having lower estimates of their math ability (Fennema & Sherman, 1977; Parsons, Adler et al., in press; Fox, Note 13; Kaminski et al., Note 24). Our own studies show that children's self-concepts of ability are more directly related to their parents' beliefs about their math aptitude and potential than to their own past achievement in math (Parsons, Adler, & Kaczala, in press; Parsons, Note 26). Although the causal significance of these different perceptions has yet to be assessed, these studies also show that students' perceptions of their parental expectations are related indirectly to their intentions to take advanced mathematics courses.

Clearly, more research is needed to ascertain the origins of students' perceptions of the expectations of their parents and teachers. It is unclear at this point (a) whether these perceptions are veridical or a reflection of cultural stereotypes and (b) whether these perceptions are an epiphenomenon or a direct consequence of parental attitudes and behavior. With regard to this latter issue, Parsons, Adler, and Kaczala (in press) found that children's perceptions of their parents' expectations of them are more strongly related to the children's own self-concept than to parents' actual beliefs.

The relation of parental expectations and children's perceptions is undoubtedly very complex and subject to change over time. In part, our model attempts to incorporate this complexity by suggesting that children's self-concepts of ability and socializers' attitudes mutually influence one another. It is quite conceivable that early socialization experiences influence the development of different spatial and math abilities. These observed differences could in turn shape the emerging attitudes and beliefs of socializers toward children's performance in math. Their subsequent interactions with boys and girls would reflect these expectation differences, and children's self-concepts of ability would be influenced accordingly. Consequently, real or expected math ability differences are not only sustained by the attitudes and behavior of important socializers but also reinforced by the children's expressed attitudes about their own abilities.

Attributions. According to several theorists, it is not success or failure per se but the causal attributions one makes for these outcomes that influence one's future expectations (Frieze et al., 1978; Heider, 1958; Weiner et al., 1971). The causal nature of this relation, however, has come under recent scrutiny (Covington & Omelich, 1979a). On the basis of their findings, Covington and Omelich (1979a) proposed that shifts in expectation are caused by students' initial self-concepts of ability rather than by their attributions. Although our model is in basic agreement with Covington and Omelich on the importance of self-concepts of ability, it maintains that attributions have an early causal role in determining achievement expectations. Extending the argument originally advanced by Weiner et al. (1971) into a developmental time frame, we propose that attributions, particularly attributions to ability, play a critical role in the formation of one's self-concept of ability and one's perceptions of task difficulty.

Throughout the attribution literature, sex differences in response to failure are noted consistently. Girls are more likely to exhibit what has been labeled the low-expectancy pattern, and their achievement behavior has been found to suffer as a consequence (Crandall, Katkovsky, & Crandall, 1965; Dweck, 1975; Dweck & Licht, 1980; Dweck & Reppucci, 1973; Feather & Simon, 1973; McMahan, 1973; Nicholls, 1975). Many studies report that girls are more likely than boys to take personal responsibility for their achievement-related failures and, consequently, to lower their expectations and persistence when faced with failure or a difficult task (Crandall, 1969; Dweck & Bush, 1976; Dweck & Goetz, 1978; Parsons, Ruble, Hodges, & Small, 1976).

A similar pattern has emerged in studies focusing on mathematics. Compared with boys, girls more frequently give lack of ability as the reason for their poor performances. Moreover, they are less likely than boys to take credit for math achievements (Dornbusch, 1974; Fennema, in press; Parsons, in press; Parsons, Adler et al., in press; Parsons, Meece, Adler, & Kaczala, in press; Heller et al., Note 22). These differences, however, are quite small, and the attribution of one's failure to lack of ability is not a common initial response for either boys or girls. In making attributions for math failures, lack of ability is typically ranked quite low in relation to other possible causes (see Parsons, in press; Parsons, Meece et al., in press). Nonetheless, girls do give a higher rank to the importance of lack of ability as a causal attribution for math failure than do boys. The opposite is true in the case of math success: Girls rank the importance of ability lower than do boys. Therefore, causal attributional patterns are included in our model as potential mediators of the sex differences in self-concepts of ability and achievement expectations. In a study using path analysis procedures, Parsons (Note 29) reported a pattern of results that is consistent with this hypothesis. Additional studies directly assessing the causal role of attributions are badly needed.

Task Value

As first conceptualized by Atkinson (1964), the value of engaging in a task was directly related to the degree of difficulty or challenge it was assumed to have. Research on math achievement has shown, however, that other dimensions of task value affect achievement behavior in school settings. Several researchers, for example, report that students' perceptions of the usefulness of mathematics are strongly related to their intentions to continue or to discontinue their mathematical studies (e.g., Brush, 1980; Fennema & Sherman, 1977; Parsons, Adler et al., in press; Armstrong & Kahl, Note 2). 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; Hilton & Berglund, 1974; Parsons, Adler et al., in press; Sherman, 1980; Wise et al., Note 25). High school boys also place greater importance on their grades in mathematics than do girls (Dornbusch, 1974).

In response to a growing dissatisfaction with Atkinson's original conceptualization of incentive values, several theorists have suggested a broader, more individualistic concept of task value (Crandall, Katkovsky, & Preston, 1962; Parsons & Goff, 1978, 1980; Raynor, 1974; Spenner & Featherman, 1978; Veroff, 1977). According to these theorists, the value of a task is determined both by the characteristics of the task and by a person's needs, goals, and values. The degree to which a particular task is able to fulfill needs, to facilitate attainment of goals, or to affirm personal values determines the importance a person attaches to engaging in that task. Elaborating on the work of these theorists, our model suggests that task value can be conceptualized in terms of three major components: attainment value, intrinsic value or interest, and utility value.

In its more basic form, attainment value represents the importance of doing well on a task and coincides with the conceptualization of attainment value first advanced by the Crandalls (e.g., Crandall, 1969; Crandall et al., 1962). In its broader form, it includes a variety of task perceptions such as the likelihood that success on the task will confirm salient and valued characteristics of the self (e.g., masculinity, femininity, power, competence, popularity) and the likelihood that the activity will provide a challenge. 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 himself or herself as "smart" and defines a certain course (e.g., calculus) 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 his or her self-concept.

Intrinsic or interest value, the second component of task value, is the inherent enjoyment one gets from engaging in an activity. The distinction between this component and utility value, the third component, coincides most closely with the distinction made between intrinsic and extrinsic motivation (Deci, 1975; Kruglanski, 1975; Lepper & Greene, 1978; Nicholls, 1979). Some tasks are undertaken because enjoyment or satisfaction is derived from simply engaging in those tasks; performing the tasks is seen as an important end in itself.

Finally, apart from any feelings of interest or enjoyment, academic tasks also have utility value and are undertaken as a means of reaching a variety of goals. For example, a female student who wants to be a veterinarian knows she must take advanced high school mathematics courses 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 summary, we propose that task value is a function of both the perceived qualities of a task and the individual's needs, goals, and self-perceptions. Individual differences on these variables could be created by different past experiences with that task or similar tasks, by cultural stereotypes, and by different information from parents, teachers, or peers about the importance or difficulty of the task. Our model specifies three clusters of variables as particularly important mediators of these individual differences: personal needs, values, and self-schemata; perceptions of the cost of success; and previous affective experiences with similar tasks.

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 the form of an individual's achievement behavior (Mortimer & Simmons, 1978; Parsons & Goff, 1980; Spenner & Featherman, 1978; Stein & Bailey, 1973; Veroff, 1969, 1977). The degree of influence wielded by values and needs is determined by their centrality to an individual's self-definition. Specifically, personal needs and values operate in ways that both reduce the probability of engaging in roles perceived as inconsistent with these central values and increase the probability of engaging in roles perceived as consistent with one's definition of self.

Within this set of values and needs, one particular need emerges as having a strong influence on behavior: the need to act according to socially prescribed expectations for how each sex should behave. Sex roles could potentially influence achievement behavior through their impact on perceived value of a task. Specific tasks are identified as either consistent or inconsistent with one's sex role identity, and the degree of perceived consistency affects the value or attractiveness of that task.

Central to this line of argument is the assumption that sex role identity and the sex typing of particular achievement activities interact to influence task value. That is, the sex typing of the task should affect perceived task value only to the extent that one's sex role identity is a *critical* and *salient* component of one's self-image. Conversely, sex role identity should influence task value only to the extent that the task is sex typed by the individual. For example, the value of math should be low for a girl who views math as a masculine activity and wants to avoid it as a way of affirming her "femininity." It is clear from this example that the effects of sex typing on task value are complex, depending not only on the subjective sex typing of the activity but also on the salience of sex role identity to one's self-image.

The implications of sex typing on achievement behavior have received considerable attention in the area of math achievement. Several researchers have reported that when math is sex typed, it is perceived as a male achievement domain (e.g., Dwyer, 1974; Ernest, 1976; Fennema & Sherman, 1977; Nash, 1979; Parsons, Adler et al., in press; Sherman, 1980; Stein & Smithells, 1969; Armstrong & Kahl, Note 2; Fox et al., Note 21; Boswell, Note 30). Girls in these studies, however, sex typed math to a lesser extent than did boys. In addition, when asked, the girls did not show great concern about success in mathematics (Fennema & Sherman, 1977; Parsons, Adler et al., in press; Sherman, 1980). Thus, it is not clear that girls view math as inappropriate for them and even less clear that sex typing math lowers its attainment value for girls (Parsons, Note 31).

Although women may not sex type mathematics as a male domain, they may perceive math-related careers as masculine. Were this the case, then women not aspiring to masculine-typed occupations would view advanced math courses as having low utility. A number of studies have reported distinct differences in the career interests of men and women, with women preferring occupations that require little, if any, math (Fox et al. 1980; Fox & Denham, 1974; Hawley, 1971, 1972; Lipman-Blumen & Tickameyer, 1975; Parsons & Goff, 1980; Dunteman et al., Note 12; Astin, Harway, & McNamara, Note 32). Further, in a reanalysis of the Project Talent data, Wise et al. (Note 25) found that a large proportion of the sex differences in participation could be accounted for by career interests in the ninth grade. Thus, it is probable that sex differences in career goals affect the perceived utility of advanced math courses.

Sex differences in the perceived value of math could also result from differences in personal values and life goals. Personal values could influence the importance attached to various activities such that activities that are consistent with one's beliefs are seen as more valuable than activities that are perceived as inconsistent or unrelated. In support of this argument, several recent studies have documented a relation between mathematics or science involvement and personal values. For example, Dunteman et al. (Note 12) found that an orientation to things rather than an orientation to people influences the election of 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. Furthermore, in both of these studies, the girls were less likely than the boys to hold math- and science-related values. Thus, sex differences in the perceived value of math may be related in part to personal value orientations. The strength and causal direction of this prediction has yet to be tested.

Cost of success and failure. The value of an activity can also be conceptualized 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 personal needs and goals were discussed earlier. 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 was suggested by Parsons and her colleagues as one particularly important influence on the perceived cost of various achievement activities. Given that in making course enrollment decisions students must frequently choose among several equally attractive alternatives, we suggest that the perception of the amount of effort needed to do well in a course will have a significant effect on such decisions. To the extent that the amount of effort needed to do well in advanced mathematics courses exceeds the perceived worth of the outcome, the value of enrolling in advanced math courses should decrease.

One factor considered in determining how much effort is worthwhile is the amount of time lost for 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 well in math, she assumes she will have to do math homework every night. She also believes that she can optimize her chance of getting a leading role by staying after school with some friends to practice for the audition. Despite its high incentive value, doing well in math poses an obstacle to the achievement of other goals. Consequently, the value of math for this girl would be decreased by its high cost in terms of realizing other important goals.

Our own work has provided some initial support for the importance of this component of task value. Using cross-lagged panel analyses, we found that students' estimates of the relative worth of the effort needed to do well in math influenced students' expectations of their future success in mathematics, their confidence in their mathematical ability, their perceptions of the utility of mathematics, and their interest in mathematics (Parsons, Adler et al., in press). As predicted, the relative worth of the effort needed to do well in mathematics had an important influence on students' course enrollment decisions.

Another factor influencing the value of a task is the psychological costs of failure to one's self-esteem when maximum effort is expended on the task. Consider, for example, those students who view themselves as competent, who have strong achievement needs, yet who are unsure of their mathematical abilities and feel as though they will have to try exceptionally hard to do well in their next math course. For these students, the cost of failure is high because failing to do well would mean a lack of ability and would have detrimental implications for their self-concept (Covington & Beery, 1976; Covington & Omelich, 1979b; Nicholls, 1976). Consequently, the perceived value of math should be lower for these students than for students who are either certain of success or do not find threatening the prospect of poor performance. If the option is available, the first group of students would probably want to avoid the activity altogether, choosing to engage in less psychologically costly tasks.

Previous or anticipated affective experiences. A final set of variables assumed to influence the value of achievement activities involves previous or anticipated affective experiences. Achievement activities elicit a wide range of emotional responses. If one had a bad experience with a math teacher at some point, the negative feelings aroused by that teacher can condition one's perception of math such that it takes on a negative value or comes to elicit negative feelings.

Support for this hypothesis can be drawn from three recent studies reporting a developmental decrease in the perceived value and enjoyment of math (Brush, 1980; Parsons, Adler et al., in press; Heller et al., Note 22). Brush (1980) interviewed students to assess the possible causes of this decline. Her students reported that advanced math courses are especially anxiety provoking because students are called on and tested a great deal. Brush concluded that this teaching style invokes negative affect toward math and thus lowers the perceived value of these courses for older students. Girls reported these teaching practices to be more anxiety provoking than did boys, which could reduce the value of math even more dramatically for girls.

Why are evaluative situations more painful for some students than for others? Attribution research has shown that individuals differ markedly in their interpretations of various achievement experiences. The extent to which students attribute their poor performance in mathematics to factors not under their control, such as a bad teacher or a poor teaching style, should make these experiences less emotionally painful than if students accept full responsibility for their performance (Weiner, Russell, & Lerman, 1978). Individual differences in attributional patterns for mathematics outcomes, consequently, should produce individual differences in the affect associated with mathematics activities. Therefore, all of the variables discussed earlier as influencing students' interpretations of achievement outcomes would also help account for different affective reactions to math achievement activities.

This analysis could in part explain the previously reported sex differences in math anxiety. We propose that this reaction is primarily a joint function of low expectations of success and the high psychological cost associated with doing poorly in mathematics. If students believe that they have low mathematical skills and perceive poor achievement in math as undesirable, then a reasonable emotional response would be to feel uneasy or anxious about math. Because girls have lower estimates of their math ability and are more likely to attribute their poor math achievement to a lack of ability, it is not surprising that girls report math to be more anxiety provoking than do boys. This difference could, in turn, lead girls to lower the value of math and to avoid mathematics as a means of reducing their anxiety (Meece, Note 33).

Summary. Our model proposes that task value interacts with expectations to influence achievement-related behavior. Several factors were also proposed as critical mediators of achievement expectations and the subjective value attached to mathematics. Unfortunately, little systematic research has been done on the origins of individual differences in the subjective value of various achievement activities. Consequently, the section on task value has been more speculative than the preceding one on expectations. This review suggests the importance of investigating more systematically the influence of task value on math achievement behavior, and it provides several recommendations for future research.

Conclusions

The theoretical model described in this review was originally developed as a general model of academic choices. In this article the model has been used to organize and analyze the existing research on mathematics achievement and course enrollment. This approach has several advantages over previous approaches to the problem of sex-differentiated enrollment in mathematics courses.

The model stresses the necessity of placing the decision to enroll in math courses in the context of a variety of choices. It further assumes that this decision is guided by a set of core values such as achievement needs, competency needs, sex role values, and long-range plans and goals. Thus, if a girl likes math but feels that the amount of effort it will take to do well is not worthwhile because it decreases the time she will have available for more preferred activities (i.e., activities that are more consistent with her personal values), she will be less likely to continue taking math. Similarly, if a girl sex types mathematics or careers involving mathematics as masculine and not in line with her own sex role values, she will be less likely to value mathematics learning and less likely to continue her mathematical studies, especially if she does not expect to do well.

We have also clearly taken the position that it is important to study modifiable determinants of course selection and achievement in math. Although our model does not rule out the possibility of biological explanations for sex differences in math achievement, it does emphasize social and motivational factors. We believe that in making decisions to pursue a particular course of study, natural ability is just one among many factors weighed, and that the final decision is more likely to be a consequence of the students' interpretation of reality than of reality itself. Analyzing the problem from this broad perspective helps to 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 different information they receive from their social environment could in part account for this apparent paradox.

Although many of the theoretical predictions generated in this review have not been fully examined, existing research on the role of expectations, task value, and their mediators provides a good basis for developing intervention strategies to encourage more girls and women in mathematics. This research underscores the need for a comprehensive approach to the problem and for early intervention while children's personal value orientations and occupational interests are developing.

One course of action might involve helping students overcome their own self-defeating attitudes. As this review has advocated, feelings of competence are psychological events, depending far more on the subjective meaning given to achievement experiences than on actual levels of attainment. In that regard, research strongly suggests that adults function primarily as interpreters of reality. It is critical then that teachers and parents become more sensitive to their own attitudes toward mathematics and avoid perpetuating stereotypic views of math achievement or careers in the quantitative fields as inappropriate for girls and women. Also, steps could be taken to increase students' awareness of the usefulness and importance of mathematics for a variety of careers. Several innovative programs are available that offer information to counselors and educators on math-related career opportunities and how to encourage girls to enter them (e.g., Project Equals, University of California at Berkeley; Project Multiplying Options and Subtracting Bias, University of Wisconsin-Madison; Women in Technology and Sciences, Massachusetts Institute of Technology). Research is needed to test the effectiveness of these and other programs in reducing the likelihood that students will either unknowingly or unnecessarily restrict their career options by choosing to limit their background in mathematics.

Reference Notes

1. Chipman, S. F., & Thomas, V. G. *Women's participation in mathematics: Outlining the problem.* Washington, D.C.: Report to the National Institute of Education, Teaching and Learning Division, 1980.
2. Armstrong, J., & Kahl, S. *A national assessment of performance and participation of women in mathematics.* Washington, D.C.: Final report to the

National Institute of Education, Teaching and Learning Division, 1980.

3. Sells, L. *The mathematics filter and the education of women and minorities.* Paper presented at the meeting of the American Association for the Advancement of Science, Boston, February 1976.
4. Stafford, R. E. *An investigation of similarities in parent–child test scores for evidence of hereditary components* (ETS RB 63-11). Princeton, N.J.: Educational Testing Service, 1963.
5. Armstrong, J. *Achievement and participation of women in mathematics.* Washington, D.C.: Final report to the National Institute of Education, Teaching and Learning Division, 1980.
6. Connor, J. M., & Serbin, L. *Mathematics, visual–spatial ability and sex-roles.* Washington, D.C.: Final report to the National Institute of Education, Teaching and Learning Division, 1980.
7. College Entrance Examination Board. *National college-bound seniors, 1979.* Princeton, N.J.: Educational Testing Service, 1979.
8. Steel, L., & Wise, L. *Origins of sex differences in high school math achievement and participation.* Paper presented at the meeting of the American Educational Research Association, San Francisco, April 1979.
9. Herbst, L., & Petersen, A. *Timing of maturation, brain lateralization and cognitive performance.* Paper presented at the meeting of the American Psychological Association, Montreal, September 1980.
10. Sherman, J. *Women and mathematics: Summary of research from 1977–1979.* Washington D.C.: Final report to the National Institute of Education, Teaching and Learning Division, 1980.
11. Gitelson, I. B. *The relationship of parenting behavior to adolescents' sex and spatial ability.* Paper presented at the meeting of the American Psychological Association, Montreal, September 1980.
12. Dunteman, G. H., Wisenbaker, J., & Taylor, M. E. *Race and sex differences in college science program participation* (Rep. RTI 22U-1570). Research Triangle Park, N.C.: Research Triangle Institute, May 1979.
13. Fox, L. The effects of sex-role socialization on mathematics participation and achievement. *Women and mathematics: Research perspectives for change* (NIE Papers in Education and Work, No. 8). Washington, D.C.: National Institute of Education, 1977.
14. Cooper, H. *Teacher–student interaction.* Paper presented at the meeting of the Eastern Psychological Association, New York, April 1976.
15. Casserly, P. *An assessment of factors affecting female participation in advanced placement programs in mathematics, chemistry, and physics.* Washington, D.C.: Report to the National Science Foundation, 1975.
16. Luchins, E. *Women mathematicians: A contemporary appraisal.* Paper presented at the meeting of the American Association for the Advancement of Science, Boston, February 1976.
17. Stallings, J. A. *Comparison of men's and women's behaviors in high school math classes.* Paper presented at the meeting of the American Psychological Association, New York, September 1979.
18. Bean, J. P. *What's happening in mathematics and science classrooms: Student–teacher interactions.* Paper presented at the meeting of the American Educational Research Association, San Francisco, April 1976.
19. Blumenfeld, P., Bossert, S., Hamilton, V. L., Wessels, C., & Meece, J. *Teacher talk and student thought: Socialization into the student role.* Paper presented at the Conference on Teacher and Student Perceptions of Success and Failure: Implications for Learning, Learning Research and Development Center, University of Pittsburgh, October 1979.
20. Swarthout, D. *Applying four social–cognitive perspectives to the study of classroom life.* Paper presented at the meeting of the American Educational Research Association, Boston, April 1980.
21. Fox, L., Brody, L., & Tobin, D. *Sex differences in attitudes and course taking in mathematics among the gifted: Implications for counseling and career education.* Paper presented at the meeting of the American Educational Research Association, San Francisco, April 1979.
22. Heller, K., Futterman, R., Kaczala, C., Karabenick, J. D., & Parsons, J. *Expectancies, utility values, and attributions for performance in mathematics.* Paper presented at the meeting of the American Educational Research Association, Toronto, March 1978.
23. Kaczala, C., Parsons, J., Futterman, R., & Meece, J. *Developmental shifts in expectancies and attributions for performance in mathematics.* Paper presented at the meeting of the American Educational Research Association, San Francisco, April 1979.
24. Kaminski, D., Erickson, E., Ross, M., & Bradfield, L. *Why females don't like mathematics: The effect of parental expectations.* Paper presented at the meeting of the American Sociological Association, New York, August 1976.
25. Wise, L., Steel, L., & MacDonald, C. *Origins and career consequences of sex differences in high school mathematics achievement.* Washington, D.C.: Final report to the National Institute of Education, Teaching and Learning Division, 1979.
26. Parsons, J. *Social forces shape math attitudes and performance.* Manuscript submitted for publication, 1981.
27. Maehr, M. Personal communication, 1978.
28. Stallings, J., & Robertson, A. *Factors influencing women's decisions to enroll in advanced mathematics courses.* Washington, D.C.: Report prepared for the National Institute of Education, 1979.
29. Parsons, J. *Attributions as mediators of attitudes toward mathematics.* Paper presented at the meeting of the American Educational Research Association, Boston, April 1980.
30. Boswell, S. *Nice girls don't study mathematics: The perspective from elementary school.* Paper presented at the meeting of the American Educational Research Association, San Francisco, April 1979.
31. Parsons, J. E. *Sex-stereotyping and school achieve-*

ment-related attitudes and behavior. Paper presented at the meeting of the Society for Research in Child Development, Boston, April 1981.

32. Astin, H., Harway, M., & McNamara, P. *Sex discrimination in education: Access to post-secondary education.* Washington, D.C.: National Center for Education Statistics, Department of Health, Education, and Welfare, February 1976.
33. Meece, J. L. *Sex differences in achievement-related affect.* Paper presented at the meeting of the American Educational Research Association, Los Angeles, April 1981.

References

Aiken, L. Attitudes toward mathematics. *Review of Educational Research,* 1970, *40,* 551–596.

Aiken, L. Update on attitudes and other affective variables in learning mathematics. *Review of Educational Research,* 1976, *46,* 293–311.

Astin, H. *The woman doctorate in America: Origins, career, and family.* New York: Russell Sage Foundation, 1967.

Astin, H. S. Sex differences in mathematical and scientific precocity. In J. C. Stanley, D. P. Keating, & L. Fox (Eds.), *Mathematical talent: Discovery, description, and development.* Baltimore, Md.: Johns Hopkins University Press, 1974.

Atkinson, J. W. *An introduction to motivation.* Princeton, N.J.: Van Nostrand, 1964.

Atkinson, J. W., & Birch, D. *A dynamic theory of action.* New York: Wiley, 1970.

Bandura, A., & Walters, R. H. *Social learning and personality development.* New York: Holt, Rinehart & Winston, 1963.

Becker, J. R. Differential treatment of females and males in mathematics classes. *Journal for Research in Mathematics,* 1981, *12,* 40–53.

Benbow, C. P., & Stanley, J. C. Sex differences in mathematical ability: Fact or artifact? *Science,* 1980, *210,* 1262–1264.

Bing, E. Effect of childrearing practices on development of differential cognitive abilities. *Child Development,* 1963, *34,* 631–648.

Bock, R. D., & Kolakowski, D. Further evidence of sex-linked major gene influence on human spatial visualizing ability. *American Journal of Human Genetics,* 1973, *25,* 1–14.

Brody, L., & Fox, L. H. An accelerated intervention program for mathematically gifted girls. In L. H. Fox, L. Brody, & D. Tobin (Eds.), *Women and the mathematical mystique.* Baltimore, Md.: Johns Hopkins University Press, 1980.

Brookover, W. B., & Erickson, E. L. *Sociology of education.* Homewood, Ill.: Dorsey Press, 1975.

Brophy, J. E., & Good, T. *Teacher–student relationships: Causes and consequences.* New York: Holt, Rinehart & Winston, 1974.

Brush, L. A validation study of the mathematics anxiety rating scale (MARS). *Educational and Psychological Measurement,* 1978, *38,* 485–490.

Brush, L. R. *Encouraging girls in mathematics: The problem and the solution.* Cambridge, Mass.: Abt Associates, 1980.

Bureau of Labor Statistics. *Monthly employment and earnings* (Vol. 27). Washington, D.C.: U.S. Department of Labor, 1980.

Burnett, S. A., & Lane, D. A. Effects of academic instruction on spatial visualization. *Intelligence,* 1980, *4,* 233–242.

Burnett, S. A., Lane, D. M., & Dratt, L. M. Spatial visualization and sex differences in quantitative ability. *Intelligence,* 1979, *3,* 345–354.

Connor, J. M., Schackman, M. E., & Serbin, L. A. Sex-related differences in response to practice on a visual–spatial test and generalization to a related test. *Child Development,* 1978, *49,* 24–29.

Connor, J. M., Serbin, L. A., & Schackman, M. Sex differences in children's response to training on a visual–spatial test. *Developmental Psychology,* 1977, *3,* 293–294.

Cooper, H. Pygmalion grows up: A model for teacher expectation communication and performance influences. *Review of Educational Research,* 1979, *49,* 389–410.

Covington, M., & Beery, R. *Self-worth and school learning.* New York: Holt, Rinehart & Winston, 1976.

Covington, M., & Omelich, C. Are causal attributions causal? A path analysis of the cognitive model of achievement motivation. *Journal of Personality and Social Psychology,* 1979, *37,* 1487–1504. (a)

Covington, M., & Omelich, C. Effort: The double-edged sword in school achievement. *Journal of Educational Psychology,* 1979, *71,* 169–182. (b)

Crandall, V. C. Sex differences in expectancy of intellectual and academic reinforcement. In C. P. Smith (Ed.), *Achievement-related behaviors in children.* New York: Russell Sage Foundation, 1969.

Crandall, V. C., Katkovsky, W., & Crandall, V. J. Children's belief in their own control of reinforcement in intellectual-academic achievement situations. *Child Development,* 1965, *36,* 91–109.

Crandall, V. J., Katkovsky, W., & Preston, A. Motivational and ability determinants of young children's intellectual achievement behavior. *Child Development,* 1962, *33,* 643–661.

Crano, W. T., & Mellon, P. Causal influence of teachers' expectations on children's academic performance: A cross-lagged panel analysis. *Journal of Educational Psychology,* 1978, *70,* 39–49.

Deci, E. S. *Intrinsic motivation.* New York: Plenum Press, 1975.

Diggory, J. *Self-evaluation: Concepts and studies.* New York: Wiley, 1966.

Dornbusch, S. M. To try or not to try. *Stanford Magazine,* 1974, *2,* 51–54.

Dreger, R. M., & Aiken, L. R. Identification of number anxiety. *Journal of Educational Psychology,* 1957, *47,* 344–351.

Dweck, C. S. The role of expectations and attributions in the alleviation of learned helplessness. *Journal of Personality and Social Psychology,* 1975, *31,* 674–685.

Dweck, C. S., & Bush, E. Sex differences in learned helplessness: I. Differential debilitation with peer and adult evaluations. *Developmental Psychology,* 1976, *12,* 147–156.

Dweck, C. S., Davidson, W., Nelson, S., & Enna, B.

Sex differences in learned helplessness: II. The contingencies of evaluative feedback in the classroom, and III. An experimental analysis. *Developmental Psychology*, 1978, *14*, 168–276.

Dweck, C. S., & Gilliard, D. Expectancy statements as determinants of reactions to failure: Sex difference in persistence and expectancy change. *Journal of Personality and Social Psychology*, 1975, *32*, 1077–1084.

Dweck, C. S., & Goetz, T. E. Attributions and learned helplessness. In J. H. Harvey, W. Ickes, & R. F. Kidd (Eds.), *New directions in attribution research* (Vol. 2). Hillsdale, N.J.; Erlbaum, 1978.

Dweck, C. S., & Licht, B. G. Learned helplessness and intellectual achievement. In J. Garber & M. E. P. Seligman (Eds.), *Human helplessness: Theory and application*. New York: Academic Press, 1980.

Dweck, C. S., & Reppucci, N. D. Learned helplessness and reinforcement responsibility in children. *Journal of Personality and Social Psychology*, 1973, *25*, 109–116.

Dwyer, C. A. Influence of children's sex-role standards on reading and arithmetic. *Journal of Educational Psychology*, 1974, *66*, 811–816.

Edwards, W. The theory of decision-making. *Psychological Bulletin*, 1954, *51*, 380–417.

Ernest, J. *Mathematics and sex*. Santa Barbara: University of California Press, 1976.

Feather, N. T. Effects of prior success and failure on expectations of success and subsequent performance. *Journal of Personality and Social Psychology*, 1966, *3*, 287–298.

Feather, N. T., & Simon, J. G. Fear of success and causal attributions for outcome. *Journal of Personality*, 1973, *41*, 525–542.

Fennema, E. Mathematics learning and the sexes: A review. *Journal for Research in Mathematics Education*, 1974, *5*, 126–139.

Fennema, E. Attribution theory and achievement in mathematics. In S. R. Yussen (Ed.), *The development of reflection*. New York: Academic Press, in press.

Fennema, E., & Sherman, J. Fennema-Sherman Mathematics Attitudes Scales. JSAS *Catalog of Selected Documents in Psychology*, 1976, *6*, 1–39. (Ms. No. 1225)

Fennema, E., & Sherman, J. Sex-related differences in mathematics achievement, spatial visualization and affective factors. *American Educational Research Journal*, 1977, *14*, 51–71.

Fennema, E., & Sherman, J. Sex-related differences in mathematical achievement and related factors: A further study. *Journal for Research in Mathematics Education*, 1978, *9*, 189–203.

Ferguson, L., & Maccoby, E. Interpersonal correlates of differential abilities. *Child Development*, 1966, *37*, 549–571.

Fox, L. H., Brody, L., & Tobin, D. *Women and the mathematical mystique*. Baltimore, Md.: Johns Hopkins University Press, 1980.

Fox, L. H., & Cohn, S. J. Sex differences in the development of precocious mathematical talent. In L. H. Fox, L. Brody, & D. Tobin (Eds.), *Women and the mathematical mystique*. Baltimore, Md.: Johns Hopkins University Press, 1980.

Fox, L. H., & Denham, S. A. Values and career interests of mathematically and scientifically precocious youth. In J. C. Stanley, D. P. Keating, & L. H. Fox (Eds.), *Mathematical talent: Discovery, description and development*. Baltimore, Md.: Johns Hopkins University Press, 1974.

Fox, L. H., Tobin, D., & Brody, L. Sex-role socialization and achievement in mathematics. In M. A. Wittig & A. C. Petersen (Eds.), *Sex-related differences in cognitive functioning: Developmental issues*. New York: Academic Press, 1979.

Frieze, I. H., Fisher, J., Hanusa, B., McHugh, M., & Valle, V. Attributing the causes of success and failure: Internal and external barriers to achievement in women. In J. Sherman & F. Denmark (Eds.), *Psychology of women: Future directions of research*. New York: Psychological Dimensions, 1978.

Futterman, R. *A causal analysis of expectancies and values concerning mathematics*. Unpublished doctoral dissertation, University of Michigan, 1980.

Goldstein, A. G., & Chance, J. E. Effects of practice on sex-related differences in performance on embedded figures. *Psychonomic Science*, 1965, *3*, 361–362.

Good, T., Sikes, J. N., & Brophy, J. E. Effects of teacher sex and student sex on classroom interaction. *Journal of Educational Psychology*, 1973, *65*, 74–87.

Haven, E. W. Factors associated with the selection of advanced academic mathematics courses by girls in high school (Doctoral dissertation, University of Pennsylvania, 1971). *Dissertation Abstracts International*, 1971, *32*, 1747A. (University Microfilms No. 71-26027)

Hawley, P. What women think men think: Does it affect their career choice? *Journal of Counseling Psychology*, 1971, *18*, 193–199.

Hawley, P. Perceptions of male models of femininity related to career choice. *Journal of Counseling Psychology*, 1972, *19*, 308–313.

Heider, F. *The psychology of interpersonal relations*. New York: Wiley, 1958.

Heller, K. A., & Parsons, J. E. Sex differences in teachers' evaluative feedback and students' expectancies for success in mathematics. *Child Development*, 1981, *52*, 1015–1019.

Hilton, T. L., & Berglund, G. W. Sex differences in mathematics achievement: A longitudinal study. *Journal of Educational Research*, 1974, *67*, 231–237.

Hoffman, L. W. Early childhood experiences and women's achievement motives. *Journal of Social Issues*, 1972, *28*, 129–155.

Husen, T. (Ed.). *International study of achievement in mathematics* (Vols. 1 & 2). New York: Wiley, 1967.

Hyde, J. S., Geiringer, E. P., & Yen, W. M. On the empirical relation between spatial ability and sex differences in other aspects of cognitive performance. *Multivariate Behavioral Research*, 1975, *10*, 289–309.

Jacklin, C. Epilogue. In M. Wittig & A. Petersen (Eds.), *Sex-related differences in cognitive functioning: Developmental issues*. New York: Academic Press, 1979.

Kruglanski, A. W. The endogenous–exogenous partition in attribution theory. *Psychological Review*, 1975, *82*, 387–406.

Kukla, A. Foundations of an attributional theory of performance. *Psychological Review*, 1972, *79*, 454–470.

Kukla, A. An attributional theory of choice. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 2). New York: Academic Press, 1978.

Lazarus, M. Mathophobia: Some personal speculations. *The Principal*, 1974, *53*, 16–22.

Leinhardt, G., Seewald, A. M., & Engel, M. Learning what's taught: Sex differences in instruction. *Journal of Educational Psychology*, 1979, *71*, 432–439.

Lepper, M. R., & Greene, D. (Eds.). *The hidden costs of reward: New perspectives on the psychology of human motivation*. Hillsdale, N.J.: Erlbaum, 1978.

Lewin, K. *The conceptual representation and the measurement of psychological forces*. Durham, N.C.: Duke University Press, 1938.

Lipman-Blumen, J., & Tickameyer, A. R. Sex-roles in transition: A ten-year perspective. In A. Inheles (Ed.), *Annual review of sociology* (Vol. 1). Palo Alto, Calif.: Annual Reviews, 1975.

Maccoby, E. E., & Jacklin, C. N. *Psychology of sex differences*. Palo Alto, Calif.: Stanford University Press, 1974.

McGlone, J. Sex differences in human brain asymmetry: A critical survey. *Behavioral and Brain Sciences*, 1980, *3*, 215–227.

McMahan, I. Relationships between causal attributions and expectancy for success. *Journal of Personality and Social Psychology*, 1973, *28*, 108–114.

Meyer, W. U., Folkes, V., & Weiner, B. The perceived informational value and affective consequences of choice behavior and intermediate difficulty task selection. *Journal of Research in Personality*, 1976, *10*, 410–423.

Montanelli, D. S., & Hill, K. T. Children's achievement expectations and performance as a function of two consecutive reinforcement experiences, sex of subject, sex of experimenter. *Journal of Personality and Social Psychology*, 1969, *13*, 115–128.

Mortimer, J. T., & Simmons, R. G. Adult socialization. *Annual review of sociology* (Vol. 4). Palo Alto, Calif.: Annual Reviews, 1978.

Nash, S. C. Sex role as a mediator of intellectual functioning. In M. A. Wittig & A. C. Petersen (Eds.), *Sex-related differences in cognitive functioning: Developmental issues*. New York: Academic Press, 1979.

Nicholls, J. G. Causal attributions and other achievement-related cognitions: Effects of task outcomes, attainment value, and sex. *Journal of Personality and Social Psychology*, 1975, *31*, 379–389.

Nicholls, J. G. Effort is virtuous, but it's better to have ability: Evaluative responses to perceptions of effort and ability. *Journal of Research in Personality*, 1976, *10*, 306–315.

Nicholls, J. G. Quality and equality in intellectual development: The role of motivation in education. *American Psychologist*, 1979, *34*, 1071–1084.

Parsons, J. E. Attributions, learned helplessness, and sex differences in achievement. In S. R. Yussen (Ed.), *The development of reflection*. New York: Academic Press, in press.

Parsons, J. E., Adler, T. F. et al. Expectancies, values and academic behaviors. In J. T. Spence (Ed.), *Perspectives on Achievement and Achievement Motivation*. San Francisco, Calif.: Freeman, in press.

Parsons, J. E., Adler, T. F., & Kaczala, C. M. Socialization of achievement attitudes and beliefs: Parental influences. *Child Development*, in press.

Parsons, J. E., Frieze, I. H., & Ruble, D. N. Introduction. *Journal of Social Issues*, 1976, *32*, 1–5.

Parsons, J. E., & Goff, S. B. Achievement and motivation: Dual modalities. *Journal of Educational Psychology*, 1978, *13*, 93–96.

Parsons, J. E., & Goff, S. Achievement motivation: A dual modality. In L . J. Fyans (Ed.), *Recent trends in achievement motivation: Theory and research*. Englewood Cliffs, N.J.: Plenum Press, 1980.

Parsons, J. E., Kaczala, C. M., & Meece, J. L. Socialization of achievement attitudes and beliefs: Classroom influences. *Child Development*, in press.

Parsons, J. E., Meece, J. L., Adler, T. F., & Kaczala, C. M., Sex differences in attributional patterns are learned helplessness? *Sex Roles*, in press.

Parsons, J. E., & Ruble, D. N. The development of achievement-related expectancies. *Child Development*, 1977, *48*, 1075–1079.

Parsons, J. E., Ruble, D. N., Hodges, K. L., & Small, A. W. Cognitive-developmental factors in emerging sex differences in achievement-related expectancies. *Journal of Social Issues*, 1976, *32*, 47–61.

Petersen, A. G. Hormones and cognitive functioning in normal development. In M. A. Wittig & A. C. Petersen (Eds.), *Sex-related differences in cognitive functioning*. New York: Academic Press, 1979.

Raynor, J. O. Future orientation in the study of achievement motivation. In J. W. Atkinson & J. O. Raynor (Eds.), *Motivation and achievement*. Washington, D.C.: V. H. Winston, 1974.

Robitaille, D. A comparison of boys' and girls' feelings of self-confidence in arithmetic computation. *Canadian Journal of Education*, 1977, *2*, 15–22.

Rosen, B., & D'Andrade, R. C. T. The psychosocial origins of achievement motivation. *Sociometry*, 1959, *22*, 185–218.

Rosenthal, R., & Jacobson, L. *Pygmalion in the classroom*. New York: Holt, Rinehart & Winston, 1968.

Sears, R. R., Maccoby, E. E., & Levin, H. *Patterns of child rearing*. Evanston, Ill.: Row & Peterson, 1957.

Sells, L. W. The mathematical filter and the education of women and minorities. In L. H. Fox, L. Brody, & D. Tobin (Eds.), *Women and the mathematical mystique*. Baltimore, Md.: Johns Hopkins University Press, 1980.

Schratz, M. A developmental investigation of sex differences in spatial (visual–analytic) and mathematical skills in three ethnic groups. *Developmental Psychology*, 1978, *14*, 263–267.

Sherman, J. Mathematics, spatial visualization, and related factors: Changes in girls and boys, grades 8–11. *Journal of Educational Psychology*, 1980, *72*, 476–482.

Sherman, J. Girls' and boys' enrollment in theoretical math courses: A longitudinal study. *Psychology of Women Quarterly*, in press.

Sherman, J., & Fennema, E. The study of mathematics by high school girls and boys: Related variables.

American Educational Research Journal, 1977, *14,* 159–168.

Spenner, K., & Featherman, D. L. Achievement ambitions. *Annual review of sociology,* (Vol. 4). Palo Alto, Calif.: Annual Reviews, 1978.

Starr, B. S. Sex differences among personality correlates of mathematical ability in high school seniors. *Psychology of Women Quarterly,* 1979, *4,* 212–220.

Stein, A. H., & Bailey, M. M. The socialization of achievement orientation in females. *Psychological Bulletin,* 1973, *80,* 345–366.

Stein, A. H., & Smithells, T. Age and sex differences in children's sex-role standards about achievement. *Developmental Psychology,* 1969, *1,* 252–259.

Suinn, R., & Richardson, F. The mathematics anxiety scale: Psychometric data. *Journal of Counseling Psychology,* 1972, *19,* 551–554.

Tobias, S. *Overcoming math anxiety.* New York: Norton, 1978.

Tobias, S., & Weissbrod, C. Anxiety and mathematics: An update. *Harvard Educational Review,* 1980, *50,* 63–70.

Tobin, D., & Fox, L. H. Career interests and career education: A key to change. In L. H. Fox, L. Brody, & D. Tobin (Eds.), *Women and the mathematical mystique.* Baltimore, Md.: Johns Hopkins University Press, 1980.

Vandenberg, S., & Kuse, A. Spatial ability: A critical review of the sex-linked major gene hypothesis. In M. A. Wittig & A. C. Petersen (Eds.), *Sex-related differences in cognitive functioning: Developmental issues.* New York: Academic Press, 1979.

Veroff, J. Social comparison and the development of achievement motivation. In C. P. Smith (Ed.), *Achievement-related behaviors in children.* New York: Russell Sage Foundation, 1969.

Veroff, J. Process vs. impact in men's and women's motivation. *Psychology of Women Quarterly,* 1977, *1,* 283–292.

Waber, D. P. Cognitive abilities and sex-related variations in the maturation of cerebral cortical functions. In M. S. Wittig & A. C. Petersen (Eds.), *Sex-related differences in cognitive functioning: Developmental issues.* New York: Academic Press, 1979.

Weiner, B. *Theories of motivation: From mechanism to cognition.* Chicago: Markham, 1972.

Weiner, B. *Achievement motivation and attribution theory.* Morristown, N.J.: General Learning Press, 1974.

Weiner, B. et al. *Perceiving the causes of success and failure.* Morristown, N.J.: General Learning Press, 1971.

Weiner, B., Russell, D., & Lerman, D. Affective consequences of causal ascriptions. In J. H. Harvey, W. Ickes, & R. F. Kidd (Eds.), *New directions in attribution research* (Vol. 2). Hillsdale, N.J.: Erlbaum, 1978.

West, C. K., & Anderson, T. H. The question of preponderant causation in teacher expectancy research. *Review of Educational Research,* 1976, *46,* 613–630.

Winterbottom, M. R. The relation of childhood training in independence to achievement motivation. In J. Atkinson (Ed.), *Motives in fantasy, action, and society.* Princeton, N.J.: Van Nostrand, 1958.

Wittig, M. A., & Petersen, A. C. (Eds.). *Sex-related differences in cognitive functioning: Developmental issues.* New York: Academic Press, 1979.

Received June 15, 1981 ■