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AUTHOR Fox, Lynn H.
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ABSTRACT

The primary focus of this paper is on understanding factors related to sex differences in mathematics achievement with particular attention to course-taking. The perception of the usefulness of mathematics for future educational and career plans and the support or lack of support from significant others appear to be the major factors associated with women's decisions to elect or not elect advanced courses in mathematics. These factors are in turn influenced by the stereotype of mathematics as a male domain. Other factors associated with course-taking and achievement are attitudes towards mathematics, feelings of self-confidence, and values. Certain educational policies and practices tend to reinforce sex-role stereotypes while some practices may promote greater course-taking and achievement. The organization of the research reported in the body of this paper is as follows: (1) Perceptions of the Career Relevance of Mathematics; (2) Influences of Significant Others; (3) The Perception of Mathematics as a Male Domain; (4) Attitudes, Self-Confidence and Values; and (5) Educational Policies and Practices. The research studies were rather consistent in support of the premise that sex differences in mathematics achievement result, at least in part, from social influences. (Author/JLL)

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The Effects of Sex Role Socialization on

Mathematics Participation and Achievement

Lynn H. Fox

Assistant Professor of Education

and Project Associates of the

Intellectually Gifted Child Study Group

The Johns Hopkins University

Baltimore, Maryland 21218

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Although males and females do not appear to differ on measures of general intelligence, sex differences on tests of mathematical achievement are repeatedly found in adolescent and adult populations (Aiken, 1976; Anastasi, 1958; Astin, 1974a; Fennema, 1974a; Fox, 1975a; 1975b; Maccoby and Jacklin, 1974). Dwyer (1976) has suggested that the tests such as the Scholastic Aptitude Test - Mathematics (SAT-M) may be biased against females due to artifacts of test-item construction and selection. Alas, the question of differential aptitude is difficult to research because of the limitations of measurement tools and the overlap among measures of aptitude and achievement.

Fennema and Sherman (1976) suggest that there may be no real differences in aptitude at all and that sex differences on measures of aptitude and achievement reported in much of the literature may be the result of a failure to control for differential course-taking. Large sex differences have been found in favor of males, however, among gifted students on the Scholastic Aptitude Test-Mathematics (SAT-M) as early as grade seven (Astin, 1974a; Fox, 1975a). These sex differences can not be explained in terms of differential course-taking. It is, however, possible that differential exposure to mathematical games and activities outside of school accounts for some of the performance differences (Fox, 1975a; 1975b).

The fact that far fewer women than men pursue careers in mathematical and scientific areas and achieve lower scores on tests of aptitude and achievement in these areas has, until recently, been accepted as a natural consequence of innate sex differences in aptitude for those fields. Stafford (1972) and Page (1976) have suggested a sex-linked hereditary hypothesis. A rival hypothesis of merit is that sex differences in mathematical aptitude in adolescents and adults are a result of social factors (Aiken, 1976; Astin, 1974a; Fox, 1975b; 1976a; 1976b).

Whether or not one believes that there are sex differences in aptitude, one must accept the fact that there are great sex differences at the higher levels of achievement in mathematics that cannot be explained in terms of differential aptitude alone (Anastasi, 1974). Many females who do appear to have the aptitude do not take the advanced courses (Ernest, 1976; Fox, 1974a; 1974b; 1976c; Haven 1972; Sells, 1976). Farley (1968) has suggested that perhaps there would be no sex differences in mathematics achievement if course-taking was not optional in the high school years. Sells (1976) says that avoidance of high school mathematics courses, not ability, is the critical filter that keeps women out of many career areas including, but not only, those in pure or applied science and mathematics.

The primary focus of this paper is on understanding factors related to sex differences in mathematics achievement with particular attention to course-taking. Such a focus excludes an in-depth treatment of the process of general socialization and child-rearing practices. Some studies purporting to assess socialization influences on aptitude rather than achievement and course-taking have been included. By and large, the research has ignored social class and racial or ethnic variables. The interpretation and integration of the research literature has also been limited by problems of definitions of terms and different assumptions about the process of socialization and the meaning of sex-role identity.

The perception of the usefulness of mathematics for future educational and career plans and the support or lack of support from significant others appear to be the major factors associated with women's decisions to elect or not elect advanced courses in mathematics. These factors are in turn influenced by the stereotype of mathematics as a male domain. Other factors associated with course-taking and achievement are attitudes towards mathematics, feelings of self-confidence, and values. Certain educational policies and practices tend to reinforce sex-role stereotypes while some practices may promote greater course-taking and achievement.

Thus the organization of the research reported in the body of this paper is as follows:

I. Perceptions of the Career Relevance of Mathematics

II. The Influences of Significant Others

III. The Perception of Mathematics as a Male Domain

IV. Attitudes, Self-Confidence and Values

V. Educational Policies and Practices

Some redundancy of topics from section to section appeared unavoidable. Omissions of some relevant research has also, undoubtedly, occurred. The research reported also varies in quality and some important questions remain unanswered. For the most part, however, the research studies were rather remarkably consistent in support of the premise that sex differences in mathematics achievement result, at least in part, from social influences.

Perceptions of the Career Relevance of Mathematics

One reason why many females do not achieve their full potential in mathematics is that they simply fail to elect to take the advanced courses in the secondary school. For some this decision may occur as early as grade seven when Algebra I becomes an optional course for the eighth grade. In many school systems, two years of high school mathematics are all that is required. Even females who elect a college preparatory program in high school are not typically required to take Calculus. Several studies indicate that females, even those who are college bound, elect not to take the advanced mathematics courses because they do not perceive them as useful to their future educational and career plans.

Course-taking and Achievement

Haven (1972) found that the two most significant predictors of taking courses in mathematics in high school for above-average-ability girls were the perception of the usefulness of mathematics for future educational and career goals, and greater interest in natural sciences than the social sciences. Sherman and Fennema (1976) also found that course-taking in high school was related to the perception of the usefulness of mathematics. In a study of women mathematicians, Luchins (1976) found early career commitment among a third of the group. Almost all of the mathematicians had felt a strong interest in mathematics before entering college and a third, before age 12.

Fennema and Sherman (1976) found significant sex differences on achievement tests in two high schools where there were also significant sex differences in the perceived usefulness of mathematics, but no such differences in achievement in the two high schools where there were no differences in the perceived usefulness of mathematics. Hilton and Berglund (1971) also found significant sex differences in the perceived usefulness of mathematics in grades nine and eleven. They also reported a significant relationship between the increase in sex differences on achievement tests and perceptions of the usefulness of mathematics for earning a living. Fox (1975c) found significant sex differences in the perceived usefulness of mathematics in a study of gifted seventh and eighth graders. There were also significant sex differences on measures of aptitude and career interests in the population. Although the perceived usefulness of mathematics was not significantly related to the expressed willingness to accelerate in mathematics for the sample studied, it may be related to their future willingness to take advanced courses. Hilton and Berglund (1971) concluded that sex differences in the perception of the usefulness of mathematics resulted from the sex-typing of mathematics and careers.

The perceived usefulness of mathematics appears to be different for boys and girls for three related reasons. First, girls are less oriented to careers other than homemaker than boys. Second, girls who express career interests are more likely to be interested in fields other than mathematics and science than boys. Third, girls who are interested in careers in business, nursing, education and the social sciences, etc., are likely to be unaware of the relevance of mathematics and science to these professions. Sex differences in mathematics achievement are rarely found in elementary school populations. If courses were optional in those years, perhaps sex differences would be found sooner.

Career Orientation

Sex differences in career interests are found as early as kindergarten and first grade (Looft, 1971; Schlossberg and Goodman, 1972). In one study, girls and boys were asked to describe a typical day in their life as an adult. Even the girls who had initially indicated a career goal other than homemaking described their typical day as being spent as a wife or mother, rather than at a job outside the home (Iglitzen, 1972, 1973). In a 1976 study of national merit scholars, sex was the single best predictor of career aspirations (Ory and Helfrich, 1976).

In an article entitled "Women in Science: Why so Few", Rossi (1965a) speculated that it is the belief that marriage and careers are not really compatible for women that lies behind girls' vacillation between the pursuit of social popularity (the perceived road to a successful marriage) and excellence in scholarship (the perceived road to a successful career). Astin (1974b) concluded that if a woman anticipates a conflict between the homemaking role and a career, she is likely to forego the career. Ory and Helfrich (1976) found that females who held non-traditional sex-role stereotypes were more likely to desire professional careers than those who held traditional views of sex-roles.

Smith (1976) asked girls what they perceived as barriers to career plans; over half the respondents listed the following barriers: first, a long term commitment to a career interferes with raising a family; second, women have less geographic and thus career mobility because they must adjust their careers so as not to interfere with their husbands' success; and third, a strong career commitment would interfere with a happy marriage.

It is interesting to note that the gifted men in Terman's longitudinal study of genius who were married actually reported their greatest life satisfaction was derived from their family, followed by their career. The majority of these men were professionals, many in science areas (Oden, 1968; Sears, 1976). Perhaps we need to make this finding known and see if it is replicated in other samples. Clearly, the fact that these men gained their greatest satisfaction from the family did not inhibit their success in their careers (Sears, 1976; Oden, 1968). A follow-up study of the gifted women in Terman's sample found that the women who had careers derived great satisfaction from them, whether or not they had families (Sears and Barbe, 1975). Yet, the prevailing myth is that, while women may work outside the home, a full-fledged career will detract from their family life and, thus, their total fulfillment.

Hawley (1971; 1972) and Astin (1974b) concluded that marriage was the primary goal of most women, and if they do elect a career, it is based on what they feel men can tolerate. Astin (1974b) finds that while husbands of career women may be tolerant or even supportive of their wives, professional men in general hold negative attitudes towards women who try to fulfill the dual role of career woman and homemaker. Entwisle and Greenberger (1972) concluded that peers, especially male peers, exert considerable pressure on adolescent girls' occupational aspirations. White middle-class adolescent males were the most conservative in this respect. Although black adolescents were more liberal than whites, they are not strongly in favor of leadership positions for women. It is interesting that so many males perceive a conflict between family and career responsibilities for women, but not men.

Astin (1976b) concluded that there was little research evidence on how and why differences exist between women who decide to work and those who do not. One noteworthy difference that has been found repeatedly is that girls who persist in career interests from high school to adulthood are likely to score higher on mathematical aptitude tests than less career oriented girls (Astin, 1968; Astin, 1974a; Astin and Myint, 1971). This suggests that autonomy and independence are associated with both career interest and mathematical competence. (Additional support for this hypothesis is discussed in the sections on parental factors.).

Although Astin (1974b) concluded that there was a paucity of good research on sex role identification and early socialization as related to career choice, there are a few interesting relationships and trends suggested by the literature. Presumably, women pattern their career expectations after the women they see. Girls see their mothers staying home and their fathers going to work (Rossi, 1965b). Lack of appropriate role models for girls limits their career choices (Lipman-Blumen, 1975). Astin, Harway and McNamara (1976) speculated that many young girls may be thinking about a career, but they have no experiences to help them know what is involved in the role of the career woman, so they focus instead on the female roles of wife and mother with which they are familiar. Women who go on to graduate school are likely to have had working mothers. Astin (1969; 1974b) concluded that either identification with the father, or a working mother are factors that influence a girl's career orientation. Girls who perceive their primary future role as wife and mother are certainly not likely to see advanced mathematics courses as relevant to this goal.

Career Interest in Mathematics and Science

If role conflict and absence of models are major barriers to development of career interests in general, they are even greater barriers to the development of career interests in mathematics or scientific fields. Professional careers in the sciences and mathematics are perceived as too demanding for women who wish to combine a family and a career. Many scientific careers require long years of training and do not lend themselves to interruption during the child bearing years (Rossi, 1965a). Rossi (1965b) found that female college graduates believe that women do not select careers in medicine, science, and engineering because they believe that these fields do not offer part-time or intermittent work. Astin (1969) found that college women in general do not pursue graduate training. Thus, they avoid careers in law, medicine, and science that require advanced degrees. Prediger, McClure and Noeth (1976) found that ninth and twelfth grade girls expressed doubts about the feasibility of combining family life with a career in science. Although they lacked information about specific steps in preparing for a science career, they did believe that the preparation would be long and difficult. Even mathematically gifted seventh and eighth graders differ drastically from boys with respect to interest in careers in mathematics and science (Fox, 1974b; 1975d; Fox and Denham, 1974). Fox, Pasternak, and Peiser (1976), however, did find that gifted seventh grade girls are more likely to be interested in science and mathematics careers than are average ability female adolescents.

The absence of role models and the presence of negative stereotypes appears to contribute to the lack of interest in scientific careers. Luchins (1976) reports that the stereotype of the mathematician is a person who can only communicate with other mathematicians. Unfortunately, this stereotype is reinforced by the isolation of research mathematicians. They are not highly visible to the general public. A study by Mead and Metraux (1957) found that the composite image of the scientist held by adolescents was of a person who was intelligent and dedicated, but whose work was dull and who neglected family and other interests. Ahlgren and Walberg (1973) also found the stereotype of scientists to be remote and unsocial for high school students in physics classes. These negative stereotypes are hardly inspiring to adolescent girls who believe that marriage and family life are important.

Plost and Rosen (1974) found that eighth grade students exposed to a slide-tape presentation depicting men and women in two previously unfamiliar occupations in the computer science field preferred the one depicted by the like-sex model. The effect of like-sex model was significantly more potent for girls than boys. Males and females alike tended, however, to assign more prestigous characteristics to the occupation depicted by the male. This seems to raise the question, not analyzed by the authors, whether the girls prefer the occupation because they identified with the female role model, or because of the lower status they assigned that occupation by virtue of the female model. The students were simply asked to express a preference for one of the two occupations depicted, both of which were within the general computer area. Whether or not the students were seriously interested in the careers depicted is not known.

Lantz, West and Elliott (1976) reviewed projects funded by the National Science Foundation designed to increase the participation of girls in mathematics and science, and concluded that role models appeared to be the most effective component of some of the projects. In a project designed to recruit women to engineering careers, Leonard, Fein, Freim, and Fein (1976) found that the female role models who lived with the freshwomen in their dormitories may have helped reduce the feeling of discrimination towards females in engineering that the students felt at the beginning of the program. Thompson (1976) felt that seeing real women in these kinds of jobs made the girls more positive towards majoring in scientific areas. Levine (1976) interviewed female mathematicians and cited several instances where the women mentioned female role models as being important in their decision to continue studying mathematics. Smith (1976) reported that role models helped reduce the perceived conflict between parenthood and careers. Casserly (1975) found that girls who had an apprenticeship in a museum with a doctoral student became extremely enthusiastic about science. They reported: "We were junior partners in her quest." Luchins (1976) reported that a woman mathematician felt that encouragement from a female mathematics professor had meant a great deal to her. Luchins suggested that women are not aware of female mathematicians who have "made it", and that books on the history of mathematics should pay more attention to female mathematicians.

It is not possible to say how lasting the influence of a short-term contract with one or more salient role-models will be. Career education models which do not employ live role-models appear to be less effective than those that do. Prediger, McClure, and Noeth (1976) sent information to twelfth grade women about programs in science and technology at colleges chosen by the students. A booklet depicting women in interesting careers in science and technology was also enclosed. This program was not found to be successful in increasing the students' interest in such careers or majors. Prediger et. al. (1976) also experimented with a non-sexist interest inventory supplemented with group discussions of career planning in general, and science and technology in particular, with ninth-grade girls. This form of intervention was also not successful in changing career interests.

There is a clear need for more research on career education program models for women. Personal communications from Prediger stated that the failure of the two career intervention attempts may have been in part because ninth and twelfth grade is too late for effective intervention. The precise age at which intervention is necessary is difficult to assess. Even by kindergarten children have stereotyped perceptions of women's work (Schlossberg and Goodman, 1972). These views are continuously reinforced throughout the school years. Perhaps career awareness programs should begin in the early elementary school years, followed by more intensive programs in the middle and high school years.

Knowledge About Careers

Fennema and Sherman (1976) have suggested that girls are unaware of the relevance of mathematics to many career areas other than purely scientific ones. Anecdotal accounts support this view. More systematic study of this question seems warranted. In a pilot study of career awareness and mathematical skills, fifth and sixth grade boys and girls seemed to be relatively naive about the uses of mathematics. After exposure to a program that emphasized the applications of mathematics to art and social problems the girls became considerably more positive about school, reported liking mathematics more, and showed some increased interest in scientific careers (Fox, 1976d). A somewhat different but related mathematics program is now being tested for college students at Wellesley (Schafer, 1976). The results of this approach will be interesting.

Knowledge about the applications of mathematics to real life is sorely lacking in most mathematics curricula. Word problems in algebra, for example, that deal with rowing boats up and down streams or draining vats with different sized pipes are not very relevant to many life situations. The introduction of courses in computer science and applied statistics at earlier ages might make mathematics seem somewhat more meaningful.

When girls are faced with decision about taking advanced mathematics courses, they are likely to seek guidance from significant others in their lives, such as teachers, guidance counselors, peers, and parents. Girls are also likely to be influenced by indirect, as well as direct, messages they received from these important others in their lives and the society as a whole about the relevance of careers in general, and achievement in mathematics in particular.

The Influence of Significant Others

The impact of significant others upon course-taking and achievement in mathematics and career aspirations seems worthy of special attention. Parents, peers, teachers and counselors have tremendous influence upon the child and adolescent learner. Unfortunately, very little research on child-rearing practices has focused specifically on the development of competence in mathematics. In this section, some general discussion of the child development literature will be interwoven with some studies of the specific impact of socializing agents upon mathematics achievement. The presentation of the data on the impact of significant others is given in reverse order of apparent potential for influence. Thus, counselors are perceived as the least potent influence, and parents as the most significant others.

Counselors

Harway, Astin, Suhr, and Whiteley (1976) reported that females were more likely than males to seek advice from counselors. Haven (1972) found that girls seek advice from counselors, more than any other source, regarding advanced mathematics courses. Numerous sources suggest that the girls receive little encouragement from counselors to pursue mathematics courses or "deviant" career goals (Casserly, 1975; Harway, et al., 1976; Christman, Vidulich, Dralle, and Kirk, 1976; Haven, 1972, Luchins, 1976, 1976; Perucci, 1970; Schlossberg and Pietrofisa, 1974; Friedersdorf, 1970). For example, Haven (1972) found that 42 percent of the girls who were interested in careers in mathematics or science reported being discouraged rather than encouraged to take advanced mathematics courses. Over half of the girls who did not take the courses reported no encouragement to do so from counselors. Whether or not they were actually discouraged is not clear. Casserly (1975) and Luchins (1976) reported that counselors actually admitted discouraging girls from taking the advanced courses. The reasons counselors gave reflected their stereotypes. For example, counselors said that they discouraged girls from taking the courses because a low grade would hurt the girls' otherwise excellent school records. Other reasons were that jobs in the sciences were scarce and should go to men, or that such careers were too demanding for women. Perucci (1970) noted that even in some elite women's colleges, counselors discourage women from careers such as engineering and medicine.

Casserly (1975) suggested that female counselors may be projecting their own anxieties about careers in mathematics and science onto the women they counsel. Harway, et al. (1976) suggested that counselors are either ambivalent or negative. Thomas and Stewart (1971) said that girls who are contemplating "deviant" careers may find themselves confused by the stereotypic thinking of their counselors.

One bright spot is that students may not be strongly influenced by their counselors. Harway et al. (1976) reported that the majority of students (80 percent) felt that counselors exert little or no influence. Casserly (1975) reported that in only five of thirteen high schools, students reported seeing counselors as a positive force in their lives. Haven (1972) also found that many girls ignored their counselors' advice about mathematics courses. It is also important to note that stereotyped thinking may be declining among counselors. Englehard, Jones, and Stiggins (1976) reported that counselors' attitudes in 1974 were less stereotyped than in 1968. Changes in counselor attitudes should not be left to chance, however. Perhaps "counseling" for counselors is needed.

Teachers

There is some controversy over the effect of teacher expectation upon student achievement as suggested by Rosenthal and Jacobson (1968). In some studies, large effects have been found (Dusek, 1975; Lockheed, 1975). The support or lack of support of teachers does appear to have an effect on female achievement in mathematics. A very negative attitude towards mathematics is often linked to bad experiences with a teacher (Ernest, 1976; Haven, 1972; Poffenberger and Norton, 1956, 1959). Inspirational teachers, on the other hand, were frequently cited by women mathematicians as a major factor in their choice of career (Luchins, 1976). Studies by Casserly (1975) and Anderson (1963) also showed the positive effects of non-sexist and enthusiastic teachers upon the intellectual development of girls.

Unfortunately, teachers appear to have different expectations for girls and boys in mathematics at the high school level (Ernest, 1976; Levine, 1976). Solano (1976) found that teachers have more negative perceptions of mathematically gifted girls than boys. Fox (1974b, 1976c) found that teachers can be hostile towards mathematically gifted girls. Frazier and Sedaker (1973) have referred to teachers as "hidden carriers" of society's sex-role stereotyping. Such stereotypic thinking appears to be common among both female and male teachers.

Studies of student - teacher interaction indicate that teachers interact more with males than females, especially in mathematics and science classes (Bean, 1976; Good, Sikes, and Brophy, 1973; Levy, 1972; Sanderson and Anderson, 1960; Stacey, Bereaud and Daniels, 1974). Female students appear to be more sensitive to corrections by teachers (Dweck, 1976; White and Aaron, 1967). It seems likely that most teachers are "unconscious sexists" and should be made aware of the negative outcomes of their sex-role stereotyped attitudes and behaviors.

When teachers actively recruit girls for mathematics programs and expect them to perform as well as males, the results are significantly positive (Casserly, 1975).

The impact of teachers upon students seems to be most potent at the extremes of attitudes. Thus, a very bad experience with a teacher may be influential; and when a teacher makes a very strong effort to support and encourage, it may also be influential. The overall impact of teachers may be less potent than the influence of others. Additional research on the influence of teachers will be presented in the section on attitudes.

Peers

Maccoby and Jacklin (1974) asserted that boys and girls were equally affected by social stimuli. They, like Coleman (1961), however, noted that girls gravitate towards small same-sex cliques while boys function as loners or in larger, more flexible peer groups. The pressure to conform is somewhat greater in the smaller peer group. Shapiro (1962) found that upper elementary grade girls (grades four to six) were more susceptible to peer influences than were boys.

In the elementary school years, Ernest (1976) found that students believe their own-sex peers are superior in all subjects. In early adolescence, gifted girls and boys tend to see both sexes as equally talented in mathematics (Fox, 1975c). In the high school years, however, males and females are more likely to perceive mathematics as a male domain (Ernest, 1976; Fennema and Sherman, 1976; Sherman and Fennema, 1976). Sex differences in achievement were found in schools where mathematics was labeled as a male domain, but not in schools where it was not stereotyped (Fennema and Sherman, 1976; Sherman and Fennema, 1976).

Thus, in adolescence, girls may perceive real peer pressures against achievement in mathematics. Solano (1976) found that adolescents have a more negative stereotype of mathematically gifted girls than boys. In adolescence and young adulthood, the peer pressure against achievement in mathematics may be directed more strongly from male than female peers, at least in some situations. Entwisle and Greenberger (1972) found middle-class males were less supportive of achievement for women than were the girls themselves or males from the working class. Fennema and Sherman (1976) found males more than females stereotyped mathematics as a male domain. Husbands (1972) found that female college students were more concerned about male than female perceptions of their femininity. Girls did not socialize or date the boys in their advanced placement classes in the Casserly (1975) study.

Anecdotal accounts illustrate how peer pressures can operate. One mathematically gifted girl dropped out of an accelerated mathematics program only because her best friend did so (Angel, 1975). Although many mathematically gifted males skip grades or take college courses early with little or no problem (Stanley, 1973), mathematically gifted girls are very reluctant to skip a grade or take college courses early because of fear of peer rejection. One girl was ready to abandon a grade-skip in the first week of school and return to the lower grade because she had no friend with whom to eat her lunch (Angel, 1975). Casserly (1975) found that girls who took advanced placement courses in mathematics remarked on the importance of a girlfriend's support to help deal with the disapproval of boys.

Achievement and course-taking in mathematics and science appear to be influenced by the sex-ratio of the learning situation. Efforts to recruit girls for special mixed-sex mathematics classes outside of school were not very successful when the number of girls was small. When an all-girl class was arranged, the response was considerably higher (Fox, 1974a; 1974b; 1976c). Ruehl (1975) found that girls paired with girls in a physics lab were more successful than boys paired with boys, or mixed-sex pairings. Presumably, the all-girl classes or pairings allow girls to achieve by reducing sex-role conflict. Hurley (1964; 1965) found greater gains on achievement tests for girls in all-girl classes at the fifth grade than for girls in mixed-sex classes at the end of one year. This included a significant gain in arithmetic concept scores. Boys made few gains in the first year, but did better the second year. Teachers noted a significant decline in sex-role stereotyped behavior for both sexes in the same-sex classes. Ironically, the boys, but not the girls, wished to continue the same-sex classes. Why the girls did not like the sex-segregation is not known. Husbands (1972) argues against sex-segregation, at least at the college level, because the quality of the mathematics and science offerings will become diluted in all-girl classes.

Although all-girl classes may not be totally acceptable to girls, there may be some value in having programs that track girls early for academic programs that lead to the taking of advanced courses in mathematics and science (Fox, 1975b; 1976a). Both Haven (1972) and Casserly (1975) found this to be true. Being "tracked" as early as grade 4 may instill in the student the expectation that an academic program, including advanced mathematics and science, is inevitable. Casserly (1975) found that for girls not tracked early, the placement in Algebra in the eighth grade was often traumatic. Early tracking also may lead to the development of a peer clique of girls who support and reinforce each other. Farley (1968) went even further and recommended that four years of mathematics be required for everyone. This would eliminate course options and diffuse the mystique of mathematics as a male domain. If choice is eliminated, girls would not have to defend their pursuit of such courses to male or female peers.

Attitudes of peers may be more important in reinforcing existing stereotypes and attitudes than changing attitudes and behaviors (Almquist and Angrist, 1971). Poffenberger and Norton (1956; 1959) noted that basic attitudes and beliefs about mathematics are shaped before the child enters school. It is generally believed that the prime agency of socialization is the family.

Parents

In a review of the general literature on socialization and sex-typing Maccoby and Jacklin (1974) concluded that there is "a remarkable degree of uniformity in the socialization of the two sexes". The major sex difference is that boys seem to have a more intense socialization experience than girls. They are more pressured than girls against engaging in sex-inappropriate behavior. These conclusions are based on sex-typed behavior in narrowly defined terms, such as toy preference and clothing. Parents reportedly notice children's behaviors more when they run counter to sex-role stereotypes and they punish wrong behavior more when it is seen as sex-inappropriate than sex-appropriate, while reinforcing desirable behavior more when it is seen as sex-inappropriate rather than sex-appropriate. Maccoby and Jacklin (1974) refer to this as the "perceptual adaptation level" hypothesis. They cited no studies, however, relating this to mathematics achievement.

There is some evidence that support and encouragement from parents are crucial for girls in their decisions to elect or not elect mathematics courses in high school (Haven, 1972; Luchins, 1976; Poffenberger and Norton, 1956;

1959). Fox (1975c) found that mathematically gifted boys were significantly more likely to perceive their parents as favorable towards acceleration in mathematics than were girls. Anecdotal evidence from the Study of Mathematically Precocious Youth indicates that the girls are correct in perceiving less parental support (Stanley, Keating and Fox, 1974; Keating, 1976). Fennema and Sherman (1976) also found sex differences in students' reports of parental perceptions of the child as a learner of mathematics.

The influence of fathers may be even greater than that of mothers. Haven (1972) found that girls were more likely to discuss course-taking with fathers than mothers. Ernest (1976) found that at the secondary school level, both males and females turned to the fathers rather than the mothers for help with mathematics homework. Carlsmith (1964) found that mathematics achievement was lower for both boys and girls in father-absent homes than in homes where fathers were present. Helson (1971) suggests that fathers were more salient parental figures than mothers in homes of woman mathematicians. Block (1973) concluded that fathers were more potent agents of sex-typing than mothers.

In general, parents are less likely to notice and encourage mathematical talent in female offspring. Astin (1974a) found that parents of mathematically gifted boys were more likely than parents of girls to notice their offsprings' talent in early childhood. Also parents of boys bought toys of a scientific nature for their sons more often than did parents of girls. The provision by parents of more toys, games, etc. of a scientific nature for boys than girls was also reported by Maccoby and Jacklin (1974). Casserly (1975) noted that girls in her study felt that they had received fewer such toys than their brothers. Career goals and educational plans were more likely to be discussed with children by the parents of boys than by the parents of girls.

Levine (1976) found that parents hold lower educational aspirations for daughters than for sons. Casserly (1975) also found that parents had limited aspirations for daughters. Levine (1976) found that 75 percent of the mothers of girls who earned poor grades in mathematics accepted this as inevitable because of their own lack of ability in mathematics. Parents of boys who earned poor grades in mathematics were likely to say that the boy was simply lazy. Thus, lower levels of achievement in mathematics are more easily accepted by parents of girls than parents of boys. Helson (1971) found that female mathematicians in the United States, particularly creative ones, were likely to come from all-girl families and/or were first or second generation Americans. This suggests that parental expectations for daughters are influenced by social factors. If family resources for education are limited, the presence or absence of a male child may influence the degree of support and encouragment a female child receives. Casserly (1975) found that even in working class families where the aspirations for daughters were high, the understanding of how to achieve the goal was missing.

Several studies suggest that the development of a low numerical ability pattern or its converse result from specific child-rearing practices. Bing (1963) found that discrepant verbal ability was fostered by a close relationship with a demanding and intrusive mother, while discrepant nonverbal abilities are enhanced by allowing a child a considerable degree of freedom to experiment on his or her own. A marked pattern of help seeking and help giving interferes with the development of an independent, self-reliant attitude. This, in turn, is needed for non-verbal competency. Unfortunately, Bing did not control for hereditary influences. Perhaps non-interfering mothers are themselves less verbal. Other studies have, however, found similar results. Ferguson and Maccoby (1966) found that high number ability boys and girls were detached from their parents from over-close dependency. High verbal/low number ability boys and girls were overly dependent upon their parents. Block (1973) reported that parents of boys emphasize achievement, competition, and control of feelings and expression of affection. Parents of girls emphasize interpersonal relationships, affection and protection. Although White (1973) has suggested that there is a generalized parenting style that fosters competence in children, Baumrind (1972) notes that a parental style may have differential outcomes for boys and girls. Stein and Bailey (1973) concluded that moderate but not overpowering parental nurturance, permissiveness, and encouragement of independence and achievement efforts were aspects of child-rearing practices that facilitated the development of an achievement orientation in women. The presence of an achieving maternal model was also considered to be an influential factor.

Aiken (1975; 1976) hypothesized that sex differences in mathematical ability was a partial consequence of same-sex modeling. Young girls model their behavior after their mothers who are typically more verbal than quantitative. This, combined with the general lack of salient female models who exhibit mathematical orientations, leads girls to view themselves as incompetent in mathematics. Maccoby and Jacklin (1974) conclude that same-sex models are more potent for stimulating imitative behavior. The exact process by which boys and girls learn sex-role appropriate behaviors, however, is not clearly understood; it may not result from direct modeling but rather from a more complex cognitive process. (Kolberg, 1966; Maccoby, 1966; Maccoby and Jacklin, 1974; Mischel, 1966). **The hypothesis that mathematical competence results from identification with a masculine role is discussed in the following section.**

The Perception of Mathematics as a Male Domain

The belief that mathematics is a male domain reaches the very core of the issue of sex-role socialization and mathematics achievement. Two major hypotheses often offered as social-cultural explanations for sex differences in mathematics are the masculine identification hypothesis and the cultural reinforcement hypothesis (Aiken, 1970a; 1975; 1976; Astin, 1974a). In the former achievement and interest in mathematics are assumed to result from identification with the masculine role. This is related to the issue of achievement motivation. The second hypothesis also assumes that mathematics is a masculine domain, and thus females receive less encouragement from society for achievement in this realm. The support of significant others has already been discussed. In this section the emphasis is upon the relationships between the sex-typing of mathematics and the encouragement from significant others.

The Masculine Identification Hypothesis

A major hypothesis offered as an explanation for sex-differences in mathematics achievement is the masculine identification hypothesis (Plank and Plank, 1954; Elton and Rose 1967; Aiken, 1970a; 1975; 1976). It is argued that boys and girls who identify with their fathers or a generalized masculine sex-role are either better at mathematics than those who have a feminine identification, or at least are better mathematically than verbally. Alas, the studies which attempt to deal with this issue are not in total agreement. A major source of confusion lies with the definition of masculine identification. Most studies used a score on a paper-and-pencil test of masculinity/femininity as the measure of sex-role identification. Constantinople (1973) has stressed the basic problems with bipolar scales and constructs of masculinity and femininity. Persons who score relatively low on the sex-appropriate scale may be androgynous rather than cross-sex identified.

Block (1973) reports that women who score high on the masculinity scale of the California Psychological Inventory (CPI) can be further divided into two groups based on their socialization scores. Women who are high on socialization appear to have a general feminine identification but without the "female" passivity and dependency characteristics despite their "masculine" CPI scores. Analysis of the life history of these women suggests that they did not identify specifically with either parent, but with an "androgynous" composite of the parents. Those women low on the socialization scale appeared to have identified specifically with their fathers. These women exhibited extreme deviations from traditional definitions of appropriate sex role.

Heilbrun (1974) in a lengthy review of the literature on parent identification and filial sex-role behavior concludes that the biological and psychological sex of the parent with whom the child identifies is related to sex-role identification of boys, but not girls. Girls who have identified primarily with either a masculine father or a feminine mother can be equally feminine in their own identification. Both Block and Heilbrun concluded that measures of either a masculine or feminine identification for women are independent of sex of parent with whom the child identified. It is argued that what is even more important is that sex-role identification relates to healthy psychological adjustment for boys, but not girls (Heilbrun, 1974; Broverman, Broverman, Clarkson, Rosenkrantz, and Vogel, 1970).

Thus, for females, identification with the father does not necessarily lead to a masculine rather than feminine identification and, conversely, high scores on masculinity scales do not necessarily mean identification with the father. This complicates the interpretation of studies on masculine identification and mathematics achievement.

The masculine identification hypothesis appears to have originated from a report by Plank and Plank (1954) on case histories of women who were eminent in scientific and mathematical fields. Clinical evaluations of women mathematicians rated as creative by their peers revealed that many of these women had identified with their fathers rather than their mothers. They did not, however, score extremely high on the masculinity scale of the CPI (Helson, 1971). It is difficult to draw conclusions on such small select samples. Perhaps the identification with father for these women is related more to their pursuit of atypical careers than the development of their mathematical ability per se.

Another study often cited as support for the masculine identification hypothesis is one by Carlsmith (1964) who found that boys and girls whose fathers were absent from the home during the early childhood years had higher verbal aptitude than mathematical aptitude. Carlsmith assumes the high verbal, low mathematical pattern is a feminine style while the reverse pattern is masculine. Thus, the absence of the father lessened the availability of the masculine model for identification. Landy, Rosenberg and Sutton-Smith (1969) also found decreased quantitative scores in father absent homes for girls as well as boys. Landy et al. suggest that it is decreased opportunity for interaction with the father that accounts for the lower scores.

Ferguson and Maccoby (1966) offered a different interpretation of the causes of discrepant ability patterns. They hypothesized that stress and tension interfere differentially with functions underlying mathematical and verbal performance. Parental absence causes tension and thus a high verbal and low mathematical profile for both sexes.

In a test of the two hypotheses (Carlsmith's sex-typing and Ferguson and Maccoby's tension hypothesis) Nelson and Maccoby (1966) did not get clear results and support of either hypothesis. They concluded that perhaps the hypotheses combined had some explanatory merit, for example, boys who had a cross-sex identification were experiencing mo tension and the identification with the mother combined with the tension produced the high verbal pattern. Lynn (1972) suggests that boys are more analytical than girls because the very process of identifying with the abstract, culturally defined masculine role requires a more analytical method of learning sex-role than does the learning of the female role through direct identification with the mother. Presumably, girls who identify with the masculine role are also developing the more analytical cognitive style.

Kolberg's (1966) model of sex-role identification, however, implies that both sexes employ cognitive processes in the act of developing their sex-role identifications. A study by Brown (1957) suggests that girls know the masculine role and prefer it to the female role in the early grades. By grade 5, girls begin to switch to a preference for the feminine role. If girls know the masculine role, they must, like the boys, learn about it in an analytical way.

Thus, there is no overwhelming evidence that identification with the father is a necessary condition for the development of mathematical competence. When masculine identification is defined in terms of psychological test scores, the results are also somewhat contradictory with respect to mathematical achievement.

In a study by Elton and Rose (1967), women with high mathematical aptitude and average verbal aptitude scored higher on the masculinity scale of the Omnibus Personality Inventory (OPI) than did women with average mathematical aptitude and high verbal aptitude. Women who were either high or average on both abilities did not score high at the extremes of the scale. The Masculinity/Femininity dimension used in this study was a measure of a theoretical versus aesthetic orientation. Milton (1959) found males and females who had masculine orientations were better problem-solvers than males and females who had less masculine orientations.

Somewhat opposite results are suggested, however, by other studies. Lambert (1960) found that female mathematics majors in college scored higher on the femininity scale of the Minnesota Multiphasic Personality Inventory (MMPI) than did female education majors. (The number of female mathematics majors, however, was very small.) No differences were found between male mathematics and education majors on this scale. A study of eleventh-grade girls found that the higher achievers in mathematics were significantly more accepting of the female sex-role stereotype than were lower achieving females (Jacobs, 1974).

Research on the masculine identification hypothesis is difficult to interpret due to the measurement problems involved. Bem (1974) and others (Constantinople, 1973; Spence, Helmreich and Stapp, 1975) have suggested that masculinity and femininity should be treated as two dimensions rather than a bipolar scale. It may well be that psychological androgyny rather than a strong masculine identification is associated with mathematical competence in women. Thus, females who do not sex-type mathematics as masculine are able to achieve in mathematics without a conflict with their acceptance of a general feminine sex-role, whereas females who sex-type mathematics as masculine, and have a feminine sex-role identification experience conflicts and achieve less. For example, Bem and Lenny (1976) found that cross-sex behavior is motivationally problematic for individuals who are strongly sex-typed. Discomfort was greatest when the subject had to perform a cross-sex activity in front of a member of the opposite sex. This was not true of androgynous subjects.

At present the evidence that identification with the father or a masculine identification as measured by tests is a necessary condition for achievement in mathematics is not overwhelmingly impressive. The hypothesis that sex-typing of mathematics as a male domain inhibits female achievement seems to be a more logically consistent argument.

Achievement Motivation and the Male Domain

The sex typing of mathematics as a male domain is related, indirectly at least, to the literature on achievement motivation and women. Several researchers have noted the potential conflict for girls between academic achievement and popularity (Coleman, 1961; Hawley, 1971; 1972; Komarovsky, 1946). Lavach and Lanier (1975) found that success in a domain labeled "feminine" was less threatening for females than success in a domain labeled "masculine". As long as mathematics is considered to be a masculine domain, achievement conflicts are likely to exist for girls.

The construct "fear of success" proposed by Horner (1972) has been sharply criticized (Zuckerman and Wheeler, 1973). While it is true that attempts to replicate Horner's original studies and to expand the concept have met with problems, the theory does seem to fit well with anecdotal data on women and achievement in mathematics. For example, gifted girls have often been reluctant to accelerate their progress in mathematics because of fear of negative social consequences, primarily peer rejection (Fox, 1974b; 1975b; 1976c). Fennema and Sherman (1976) reported that girls said they did not pursue the advanced mathematics courses because taking such courses might hamper their social relationships with boys and/or make them appear masculine. Levine (1976) also reported that girls believed that boys do not like "smart" girls, especially "math whizzes". Sherman and Fenneman (1976), however, did not find a "fear of success" effect in their study when they attempted a paper-and-pencil assessment in relationship to mathematics.

While not all women fear success Horner (1972) said those who have high fear of success were the least likely to develop their intellectual potential, especially in situations requiring competition with men. Romer (1975) found similar results for girls in high school. If this is true, perhaps these women should feel less threatened in all female classes for mathematics than in mixed-sex groups. Fox (1974b; 1976c) found that it was easier to recruit seventh grade girls for all girl accelerated summer mathematics classes than for co-educational ones.

There appears to be a need to test the relationships of fear of success and failure motives more directly within real and observable, rather than imaginary settings. The rejection of advanced mathematics classes by girls may be a result of complex motives. Some may fear the consequences of success in a situation they consider to be a male domain. Others may fear failure partly because they are conditioned to believe they are less capable than the males in this domain. Some may fear both success and failure. They will appear "stupid" if they fail or ask a silly question but appear "masculine" if they are too successful. Another possibility is that girls do not fear either success or failure but simply see no value in achieving in a domain labeled as masculine by society.

Sex-typing of Mathematics

There is little doubt that the perception of mathematics as a male domain is common. As Casserly (1975) points out, traditionally the physical sciences and mathematics have been male provinces, and relatively few women have crossed the borders to seek eminence in these domains. Lambert (1960) hypothesizes that even at an early age, boys are expected to be interested in mathematics. Girls, on the other hand, though they may have equal ability, may be discouraged from learning by the prevailing idea that mathematics is a masculine field. Ernest (1976) cites a professor at Columbia University, who said, "Why didn't I study Mathematics at age 21? I felt it was not a 'feminine' thing to do. I'm afraid that it seems to me that this is a continuing problem for many young women." Another professor said, "Many people, on hearing the words 'female mathematician' conjure up an image of a six-foot, grey-haired, tweed-suited oxford-clad woman. This image, of course, doesn't attract the young woman who is continually being bombarded with messages, direct and indirect, to be beautiful, 'feminine', and to catch a man."

While investigating high school students' attitudes toward mathematics, Sherman and Fennema (1976) addressed the issue of mathematics as a male domain. They reported that the boys, more than the girls, rated mathematics as a male domain. Sherman and Fennema (1976) hypothesized, however, that these girls live in a community where the women's movement receives much publicity. When the females in this study were asked to respond to such an item as "Studying mathematics is just as appropriate for women as for men" they agreed. They behaved, however, in a more stereotypic way when it came to course selection. The boys, on the other hand, may have felt freer to express the view that mathematics is a male domain. Sherman and Fennema (1976) suggested that this masculine view is undoubtedly communicated to the girls. Thus, while the study did not document that girls more then boys believe mathematics is a male domain, it did find that the girls' actions contradicted their words. The stereotyping of mathematics as a male domain did relate to both female achievement and course-taking (Fennema and Sherman, 1976).

Sherman and Fennema also point to the fact that mathematics teachers tend to be male (69 percent in the city studied in 1974-75) and this contributes to the impression that mathematics is a male domain. There is also a tendency for the more advanced mathematics courses to be taught by males, lending additional support to the overall impression that mathematical thinking is a male province.

In a study by Farley (1974) students were asked to rank in order six reasons for girls' lack of interest in mathematics oriented work. The second choice for girls was that men do not want girls in the mathematical occupations. Boys ranked this reason fourth. Thus, this study suggests that girls feel more strongly than boys that there is male prejudice against the girls' engaging in mathematics-related work. Neither group put much stress on the idea that it is not ladylike for girls to enter these occupations. Both groups ranked this reason fifth. Farley suggests that this is a departure from the popular opinion of previous decades. She cites the case of a high school senior in a girls' school, who had done outstanding work in mathematics and science. When the student sought information about the procedure for applying for admission to M.I.T., she was referred to the school's consulting psychologist, who was charged with the duty of redirecting her interests into more ladylike channels.

Thus, the Farley study and the Sherman and Fenneman study suggest that the concept of mathematics as unfeminine is not as prevalent as it once was, and that girls on the verbal level attest to their right to enter any field. The evidence, however, shows that male prejudice against girls'entering mathematics either still exists (as the Fenneman-Sherman study suggests) or, at least, the girls believe it exists (as the Farley study suggests). The end result is the same. If male prejudice is inhibiting to a girl, that girl will probably choose to study something other than mathematics when given the choice.

Hawley (1971; 1972) found a definite relationship between women's career choices and their perceptions of significant men's views of the feminine ideal. She found that women preparing for traditionally feminine careers(e.g., teaching) believe significant men in their lives dichotomize attitudes and behaviors into male-female categories. They thought men viewed behavior as appropriately male or female. Those preparing for nontraditional careers (e.g., mathematics/science majors) believe men do not see sex as a determinant of attitudes and behavior. The math/science women indicated that their men feel women should be free to compete with men in all areas, even those that have been traditionally considered male domains.

Casserly (1975) found that many guidance counselors still believe that careers in mathematics and mathematics courses are male domains. The fact that teachers perceive boys as better at mathematics than girls (Ernest, 1976) is also suggestive of their sex-typing of mathematics.

Parental Socialization

Since teachers, counselors and peers tend to reinforce the belief in mathematics as a male domain, it seems likely that this belief has early roots. Yet there is little research on parental sex-typing and socialization practices as they affect attitudes and/or achievement in mathematics. In a review of the general literature on socialization and sex-typing Maccoby and Jacklin (1974) concluded that there is "a remarkable degree of uniformity in the socialization of the two sexes". The major sex difference is that boys seem to have a more intense socialization experience than girls. They are more pressured than girls against engaging in sex-inappropriate behavior. These conclusions are based on sex-typed behavior in narrowly defined terms, such as toy-preference and clothing. Parents reportedly notice children's behaviors more when they run counter to sex-role stereotypes and they punish wrong behavior more when it is seen as sex-inappropriate than sex-appropriate, while reinforcing desirable behavior more when it is seen as sex-inappropriate rather than sex-appropriate. Maccoby and Jacklin (1974) refer to this as the "perceptual adaptation level" hypothesis. They cite no studies, however, relating this to mathematics achievement.

The evidence that parents sex-type mathematics comes largely from indirect rather than direct measures. For example, Ernest (1976) found that after grade six, both males and females tended to seek homework help in mathematics from fathers rather than mothers. Parents of mathematically gifted boys were more likely to report having bought scientific and mathematical games and toys for their sons than were the parents of girls (Astin, 1974a). Block (1973) found fathers to be more crucial than mothers as the agent for directing the sex-typing of the child. (Although parental ideas about mathematics per se were not investigated, Block found that parents of boys emphasize achievement, competition and control of feelings and expression of affection, while parents of girls emphasize interpersonal relationships, affection and protection.) This suggests that changing the sex-role stereotypes of fathers is even more important than changing those of mothers.

If parents do sex-type mathematics as a male domain, this should lead to differential expectations of behavior for sons versus daughters. There is some evidence to this effect. Fathers who regard mathematics as a more masculine than feminine pursuit had higher expectations for their sons in mathematics than did fathers who sex-typed mathematics less (Hill, 1967). A similar relationship was not found for mothers. The effect of sex-typing of parents on expectations for daughters was not studied. Perhaps mothers and fathers who sex-type mathematics have lower expectations for daughters than parents who do not sex-type this domain. In general, perceptions of parents' expectations of the child's mathematical ability is lower for girls than boys. This perception leads to differential self-conceptions and course-taking (Kaminski, Erickson, Ross, and Bradfield, 1976). The relationship of this to sex-typing by parents is assumed, but not systematically shown.

Parents who sex-type mathematics as masculine are probably more likely to notice and reward success in mathematics and less likely to punish failure for girls than boys. There appears to be no study which effectively supports or reflects this hypothesis. A study by Astin(1974a) found that parents of mathematically gifted boys were more likely than parents of mathematically gifted girls to notice and reinforce their child's early interest in mathematics. The degree to which the parents sex-typed mathematics is not known. There is however, a general belief that parents are more tolerant of failure in mathematics for girls than boys. This is supported by anecdotal reports more than direct research (Levine, 1976). In a study of pre-schoolers, Block (1973) found parents to be much more concerned with task-oriented achievement for boys than for girls. Block (1973) concluded that parents expect far less achievement from girls than boys in general.

Although there is a large body of literature on sex-role socialization and modeling, none of the theories are adequately proven (Maccoby and Jacklin, 1974). It appears that children learn by employing both direct modeling of same-and opposite-sex models and by generalizing, from observational learning, the behavior of both sexes. Unfortunately, there is little research evidence to suggest how attitudes and competence or lack of competence in mathematics results from the socialization practices of parents. We can only speculate. For example, if Kolberg's (1966) theory of sex-role development is correct, the observation of the sex-typing of mathematics as a masculine domain by parents should lead to the internalization of different self-expectations for girls and boys. If more direct modeling theories are correct, the fact that more fathers than mothers are likely to be the models for mathematical activities, as suggested by Ernest (1976) and Aiken (1976) will also lead to sex differences. (As noted earlier, Lynn's (1972) speculations on the development of analytical competence as a result of modeling on abstract rather than concrete role models is not supported by evidence.) The problem is that regardless of the dynamics, the message most girls are likely to hear is that competence in mathematics is a masculine rather than feminine trait.

Media and Texbooks

Whether or not the female child has access to mathematically competent female role models in the home, the general communication from the larger society is sex-biased. Television, children's literature, textbooks, and tests typically reinforce traditional sex-role stereotypes (Harway et. al., 1976), some of them conveying some distinct messages about women and mathematics.

In a study on role models presented to children in children's TV shows, Sternglanz and Serbin (1974) pointed out that the role models for children on TV depict women in a derogatory manner, rarely having jobs, and usually in romantic and/or family roles. Moreover, commercial TV shows aimed primarily at children show males as aggressive and constructive. Females are shown as being second-rate and punished when they engage in a high level of activity. TV shows carry a different message for girls than boys, and they postulate that girls learn from their TV watching that it is inappropriate to make plans and carry them out or to be aggressive. Girls will be punished if they abandon the sedate female style. The most successful route for females on TV shows seemed to be magic. Even Sesame Street, one of the most popular television shows for little children, reflects sex role stereotyping. Bergman (1974) states that a little girl watching Sesame Street "was like taking lessons in invisibility." Live females are underrepresented and generally appear in stereotyped roles and there are few female puppet characters who aren't mommys or sisters. Cartoons used in the program are narrated by males and almost all were about males. Documentaries rarely show girls doing anything except standard stereotyped play activities. Although Bergman believes the program has changed somewhat from being incredibly sexist to being slightly sexist, she feels it has not yet gone beyond tokenism.

Carney (1974) reports that racism and sexism are still the rule in children's books and textbooks. A National Organization for Women (N.O.W.) group read 135 books and children's readers in an effort to find a reading series for children that portrayed males and females in non-stereotyped roles. They could not find any series that was acceptable (Jacobs and Eaton, 1972). These findings are confirmed in studies by the National Foundation for Improvement in Education, in which images of boys and girls are examined. Girls are shown in domestic roles, caring for pets and little brothers; they are encouraged to make themselves look attractive, while success for boys is pictured in terms of independence (Weitzman and Rizzo, 1974). Images of adult women reflect the roles of housewife and mother, presented in an artificial way, but indicating this as the ideal role for women. Similarly, in a study on preschool picture books, it was found that they present an over-simplified and stereotyped image which presents a very narrow view of society (Weitzman and Rizzo, 1974). Graebner (1972) reports some changes in newer books, showing more women in careers (but stereotyped ones), but men still appear overwhelmingly in biographical stories and they dominate the illustrations and the story texts.

Secondary school textbooks are no better. Trecker (1973) reports that so far as the secondary school curriculum is concerned, humanity is masculine.

U. S. History textbooks constantly refer to men, and biographies and stories read by children are all based on the assumption that men lead more interesting lives.

Much time and attention has been given to sex typing in reading books for children, but relatively little to their mathematics texts. This is probably due to the fact that it is assumed that numbers cannot be sex-typed. It is interesting, therefore, that the few studies that have been done show that the mathematics textbooks used by both elementary and high school students do support a stereotyped view of women's role in society. In a study of 2nd, 4th and 6th grade mathematics texts, Jay (1973) found evidence that the mathematics texts used by the children were stereotyped. In a follow-up study it was reported that in elementary mathematics texts, twice as many items were identified as masculine than feminine. Even more striking were the activities in which the boys engaged, as opposed to the girls. Boys are shown to be active, earning money, participating in sports, engaging in inquisitive and exploratory play. Girls play with dolls, read books, and practice the piano. Men are fathers who earn money by working and engage in leisure activities like fishing, camping and hunting. Women are mothers who sew, make fudge, and seem to spend much of their leisure time shopping or marketing and spending the money fathers earn. Jay and Smenke (1975) suggest some problems could be rewritten with a deliberate attempt to contradict the stereotype, e.g., show boys cooking, girls working, and so forth.

Similarly, Federbush (1974) reports that mathematics textbooks portray boys as active, girls as passive. Where girls are shown to be active, they are doing typically feminine things like jumping rope or going to the store.

The "New Math" textbooks are no better. People are always being put into sets by sex. Groups of boys are divided by activities (football players vs. baseball players) while girls are grouped by the color of their eyes and the length of their hair. Female mathematicians are not included when the texts give biographies of famous people.

Even algebra textbooks are not immune to stereotyping. Rogers (1975) examined eight algebra textbooks widely used. Women and their activities were pictured as dull and insignificant; they rarely appeared in career situations. Men, on the other hand, are pictured as alert, active, and more scientific. Women were shown as social. Rogers points out that women excel in "sitting", an activity around which a great many problems are constructed. Some mathematics texts even show females as mathematically incompetent. Standardized tests show these biases as well; the Scholastic Aptitude Test-Mathematics (SAT-M) pictured men with power and influence and referred to girls in connection with mothers and children.

Science texts show similar stereotypes. Even science texts that purport to be non-biased are accompanied by illustrations of only boys using the lab equipment (Trecker, 1973). Boys control the action (a boy rides his bike); girls watch action (a girl watches a balloon float). Adult women are almost never shown in scientific roles. Gaetano (1966) reported that in the upper grades, where tentative vocational orientation begins, males predominate in 16 of 18 texts.

Although it certainly appears that females get little reinforcement for mathematical or scientific interests from texts, unfortunately, one cannot readily assess the impact of these cultural messages upon individuals. A study by Plost and Rosen (1974) does suggest that the same-sex model in media presentations may be a very salient factor for the development of career preference. It would certainly be valuable to study the impact of non-sexist texts upon the achievement of girls in mathematics.

Tests

Most Mathematics tests contain more biases in favor of males. In a study of the items on the Scholastic Aptitude Test-Mathematics (SAT-M), Donlon (1971) reported that the items heavily favored males. Only two of the items favored females. Analysis of items by content led to the conclusion that the approximate 40 point difference between the sexes on this test is a function of the content formula.

In a study, "Women and Educational Testing", Tittle (1974) found that tests were biased for males. She points out that there are two ways in which discrimination in testing can occur: first, reinforcement of sex role stereotypes and, second, restriction of individual choice in selective bias of test content and user materials.

Strassberg-Rosenberg and Donlon (1975) report that the tests reflect more items relating to things rather than people and that the SAT-M Geometry and regular Mathematics are most biased in favor of boys. Ekstrom, Donlon, and Lockheed (1976) analyzed the California Achievement Test (Level 5, Form A), Iowa Tests of Basic Skills (Levels 11 and 14, Form 6) Metropolitan Achievement Test (Grade level 12, Form F) and Sequential Tests of Educational Progress (Grade 10, Series II). Male nouns and pronouns outnumber female ones in the language of these tests. Ekstrom et al. did not find, however, that items dealing with people were significantly easier for girls than neutral items. Similarly, Donlon, Ekstrom and Lockheed (1976) affirmed the masculine bias in content in four standardized tests.

There is some controversy over whether the wording of mathematics problems affects girls' ability to do those problems. Mullis (1975) suggested that girls have difficulty with word problems in general, not especially related to the sexist content or wording of the problems. In a study of 6th graders King and Blount (1975) found that there was an interaction effect operating in favor of problems appropriate to opposite sex rather than the subject's own sex, but other studies show that girls relate better to problems more related to their own experiences.

Leder (1974) suggests that both boys and girls prefer doing mathematics problems which are more related to their experiences, although no attempt was made to relate this to performance on those problems. Milton (1959) found that when the characteristics of a problem are altered to make them less masculine, sex differences in problem solving ability were reduced. When the content is very feminine, males no longer outperform females.

In a study using college students, Graf and Riddell (1972) found that it takes females longer to do a problem with a stock market setting than the identical problem in the context of buying yard goods at a fabric store. Graf and Riddel suggest that sex-role stereotypes lead girls to perceive problems in a masculine context to be more difficult, and this perception affects the speed with which problems are solved. They suggest girls may do better on a power test rather than a timed test.

Studies are needed that manipulate various features of the item content, context, and the factors to determine the degree to which test performance is affected by such factors. Test performance is, however, a less crucial issue than course-taking.

Attitudes, Self-Confidence, and Values

Behavior is influenced by many factors. Although behaviors may be specific to situations, the attitudes and values a person holds are believed to be relatively constant and are the forces that motivate behavior. To understand why a person behaves a certain way in a given situation, one must first understand the person's attitude toward the situation, the person's self-concept as it relates to the situation, and the values the person holds. In the case of mathematics achievement and women one must strive to understand the attitudes women have towards mathematics, towards themselves as learners of mathematics, and the values which help shape these attitudes.

Attitudes

In college populations sex differences in attitudes towards mathematics have been found (Aiken, 1972; Aiken and Dreger, 1961; Dreger and Aiken, 1957). Males and females, however, do not appear to differ significantly with respect to expressed liking for mathematics or preference for mathematics as compared with other school subjects in the elementary or secondary school years (Aiken, 1970b; 1976; Ernest, 1976; Fox, 1974b; 1975c). In one study, elementary school girls actually reported liking mathematics more than boys did (Stright, 1960). Callahan (1971) found no sex differences on a composite questionnaire of attitudes towards mathematics, but did find sex differences on a few specific items. Girls had a stronger dislike of word problems than boys, but were more likely to report that they enjoyed the challenge presented by a mathematical problem.

Why sex differences are found at the college level, but not before, is unclear. Anttonen (1969) found a rather low correlation between attitudes in elementary school years with those in the high school years. The stability of attitudes is difficult to assess due to problems in the measurement of attitudes, as well as changes in the content of mathematics (Aiken, 1970b).

Whether or not sex differences in attitudes towards mathematics are found at the pre-college level is a function of the definition and measure of attitude. Numerous studies have found sex differences in the expressed usefulness of mathematics as early as grade seven, even in the presence of no sex differences on a general statement of liking for mathematics (Fennema and Sherman, 1976; Fox, 1975c; Hilton and Berglund, 1974; Sherman and Fennema, 1976). Thus, in the area of attitudes, perceived usefulness more than the expressed liking for mathematics differentiates between the sexes.

A slightly different measure of attitude is the attitude towards self as a learner of mathematics or self-confidence. Erlick and Le Bold (1975) found striking sex differences in college students' self-ratings of mathematical, scientific, mechanical and general problem-solving abilities. Fennema and Sherman (1976) found sex differences in self-confidence as a learner of mathematics in high school populations, and Kaminski, Erickson, Ross and Bradfield (1976) found sex differences in self-concept as early as grade eight.

Ernest (1976) reported that elementary school students were likely to believe that their own sex were best at all subjects, but in high school both sexes perceived boys as superior. Fennema (1974b) noted that girls' self-concepts tend to decrease with age and that even when girls are achieving better than boys in mathematics they tend to rank themselves lower in ability. Levine (1976) reports that guidance counselors notice that even when girls earn good grades in mathematics classes they do not perceive themselves as competent.

The finding of sex differences in self-confidence in mathematics is consistent with general findings on sex differences in self-confidence. Although Maccoby and Jacklin (1974) concluded that there were no significant sex differences in self-confidence, numerous studies do find sex differences with respect to particular tasks. Astin, Harway, and McNamara (1976) said that men rate themselves higher than women on academic achievement tasks while women rate themselves higher than men on measures of social competence. In general men and women tend to value men's efforts above those of women, especially in fields that are considered male domains (Etaugh and Rose, 1975; Goldberg, 1968; Mischel, 1974; Henken, Unger and Aronow, 1976; Pheterson, Kusler, and Goldberg, 1971). Deaux (1976) has found that when men suceed they attribute their success to skill whereas women assume they were lucky, not skillful. Women are more likely to seek out activities they perceive as requiring luck rather than skills. Thus, it is not surprising that self-confidence with respect to mathematics differs for males and females.

Attitudes and Achievement

Attitudes towards mathematics, as measured by expressed liking or more complex questionnaires are generally found to have a low, but significant, correlation with achievement in mathematics at the elementary, secondary, college, and post-graduate levels (Aiken, 1963; 1970a; 1970b 1976; Aiken and Dreger, 1961; Anttonen, 1969). An interaction between sex, and attitude towards mathematics, with achievement has been suggested by Aiken (1970b; 1976). Crestantrello (1962) found this to be true for college sophomores.

Behr (1973) found that mathematics grades were more predictable from attitudes for girls than boys. Jackson (1968) concluded that very positive or very negative attitudes affect achievement, whereas in the middle ranges of attitudes, aptitude is more potent than attitude for predicting achievement.

Studies using expressed liking of mathematics as the attitude measure do not show the clear relationship of attitude to achievement that is found in studies using other measures of attitude. The importance of the perceived usefulness of mathematics was discussed in a previous section. Self-confidence as a learner of mathematics also appears to be directly related to course-taking and achievement for girls.

Sherman and Fennema (1976) found a strong relationship between self-confidence as a learner of mathematics and intent to take advanced courses in high school. In a longitudinal study of 500 students in the junior and senior high school, Kaminski, et al. (1976) found that males and females who had high self-confidence with respect to mathematics did take twelfth grade mathematics courses. Boys with moderate self-concepts with respect to mathematics also took the course. Girls with medium self-concepts tended to follow the pattern of girls who had low self-concepts and not take courses beyond the required level.

It seems likely that a sense of general well-being or self-confidence is necessary but not sufficient for achievement in most academic endeavors (Adams and Fitts, 1972). The exact relationship of self-image to behavior and attitudes is not well known (Harway, et al., 1976).

A general measure of self-esteem appears to be less clearly related to achievement in mathematics than do measures of self-confidence with respect specifically to mathematics. Farley (1968) found no relationship between general self-concepts and girls' decisions to elect or not to elect a tenth grade mathematics course. Cleveland and Bosworth (1967) found sixth grade girls who achieved well in mathematics scored lower on a measure of personal worth than those who achieved less well in arithmetic. Solano (1976), however, found no sex differences in general self-concepts of mathematically gifted adolescent boys and girls. The gifted students had a somewhat more positive self-image than did a random group of adolescents. Helson (1971) found that women mathematicians had high self-esteem.

With respect to attitudes towards mathematics, we can conclude that the perceived usefulness of mathematics and self-confidence as a learner of mathematics are attitudes which reflect strong sex differences, and appear to be related to the differential achievement of the sexes as well as to the labeling of mathematics as a male domain. In terms of expressed liking for mathematics only the very extremes of feeling seem to be related to mathematics achievement and sex differences.

Math-anxiety

The extreme of very negative attitude towards mathematics has been called math-anxiety or mathemaphobia. Gough (1954) says the concept is self-defining and Tobias (1976) has described it as an "I can't" syndrome applied to all situations involving mathematics. The concept is intriguing, but at present research evidence about the nature and extent of the problem is meager.

The construct of a specific anxiety about numbers has been validated. Dreger and Aiken (1957) developed a measure of number anxiety that had a low correlation with total scale scores for the Taylor Manifest Anxiety Scale. A second instrument, the Mathematics Anxiety Rating Scale (MARS), has been developed and appears to be a measure of anxiety with respect to mathematics that is independent of measures of general anxiety (Richardson and Suinn, 1972; Suinn, Edic, Nicoletti, and Spinelli, 1972).

The evidence for sex differences with respect to math-anxiety is unclear. Maccoby and Jacklin (1974) noted that general anxiety appears to be more common among females, but Sarason and Winkel (1966) suggest that girls score higher on measures of anxiety because they are more willing to admit their fears. Carey (1958) noted that men are less likely to admit a dislike of problem-solving because they equate it with a denial of masculinity.

Dreger and Aiken (1957) reported no sex differences on a measure of math-anxiety among college students in basic mathematics courses. They found 35 percent of these students were math-anxious. Since they did not comment on the proportion of males and females in basic versus advanced courses, their findings are not totally convincing. Tobias (1976) reports more females than males enrolling in the math-anxiety clinic at Wesleyan. Again, there is the question of whether or not females are more afflicted with the problem, or simply more willing to admit it.

The fact that more women than men avoid mathematics courses in high school and college might be taken as indirect evidence of greater math-anxiety among females than males. Tobias says course avoidance is a classic symptom of anxiety. A rival hypothesis is that math-anxious males are more likely to pursue the courses than math-anxious females, because they perceive the courses as more useful or even unavoidable. Perhaps math-anxious males are more willing to pursue careers and majors that require some mathematical training than are math-anxious females. The relationship of perceived usefulness and career choice to math-anxiety is not known. A study is needed to establish the base rates and developmental history of this phobia.

Anecdotal accounts suggest that the onset of anxiety can occur as early as third grade and as late as graduate school levels. It is logical to suppose that the early adolescent years are particularly critical, as that is the time when sex differences seem to begin to be found on tests and the point at which mathematics becomes more abstract. It would be relatively simple to test this hypothesis.

Math-anxiety can apparently be reduced or alleviated by therapy (Aiken, 1970b, 1976; Hyman, 1973; Tobias, 1976). It may, however, be possible to reduce the instances of math-anxiety by preventive techniques, such as the elimination of the sex-role stereotyping of mathematics as a male domain. The extent to which math-anxiety is fostered by the perception of conflict between competence in mathematics and femininity is not documented. Although anxiety about mathematics may not in every case be a direct result of sex-role socialization conflicts, it is likely that the sex-typing of mathematics as a male domain by parents, teachers, and peers results in the acceptance of math-anxiety in females as inevitable or irrelevant to their development. As long as competence in mathematics is not perceived as useful or necessary by society, girls are likely to get little help to overcome their fears.

Dweck and Bush (1976) have used the term "learned helplessness" to describe the state in which girls may become conditioned to failure. Although they do not cite specific research with respect to mathematics, the parallel is clear. Girls learn to attribute their failure to their lack of ability, while boys attribute failure to factors beyond their control. Thus, girls learn to avoid situations in which they might fail, while boys learn to strive harder.

Unfortunately much of the research in sex-role socialization does not specifically follow the development of mathematical competence; and conversely, much of the research on sex differences in mathematics has not used a longitudinal and developmental approach. Therefore, the data on the influences of significant others upon attitudes towards mathematics, perceived usefulness of mathematics, and self-confidence as a learner of mathematics are sketchy.

Parental Influences on Attitudes.

Since attitudes, particularly very negative attitudes, do appear to be related to achievement and course-taking, it is important to understand how attitudes are influenced by others.

In a study of college students, Poffenberger and Norton (1959) found that liking for mathematics was significantly related to students' perceptions of fathers' liking for mathematics and fathers' expectations for the students' earning a grade of A for males and females combined. There was no separate analysis by sex. (The positive attitude group, however, was 48 percent female, whereas the negative attitude group was 64 percent female.)

A study by Aiken (1972) found that perceptions of the fathers' liking of mathematics, having been good mathematics students, using mathematics in their jobs, and their professional occupation status were significantly related to positive attitudes of boys, but not girls. For both boys and girls the perception of the entire family as liking mathematics was related to positive student attitudes.

Burbank (1968), however, found no significant correlation between fathers' attitudes and attitudes of either sons or daughters. Hill (1967) also found no relationship for fathers and sons. In the Hill study, one very significant effect was found. Fathers who sex-typed mathematics as masculine rather than feminine had higher expectations of their sons' performances than did fathers who sex-typed mathematics less. In general, the fathers who had masculine expectations for their sons had higher expectations for mathematics performance. Alas, Hill did not study girls, and no similar study of the effect of sex-typing and expectations for daughters was found.

Fennema and Sherman (1976) found sex differences in students' reports of fathers' perceptions of their offspring as a learner of mathematics in schools where there were also sex differences in achievement and in perception of the usefulness of mathematics. Perceptions of parental attitudes were also significantly related to the intent to take advanced mathematics courses in high school (Sherman and Fennema, 1976).

It appears that perceptions of fathers' expectations, but not fathers' attitudes or professions are related to achievement and course-taking for girls. Presumably, fathers who sex-type mathematics as a male domain are less likely to hold and convey high expectations for their daughters.

The research on the relationship of maternal attitudes and expectations to the attitudes of sons and daughters yields a slightly different picture. Poffenberger and Norton (1956; 1959) found that college students' perception of mothers' expectations for a high grade in mathematics, but not perception of the mothers' liking for mathematics, was significantly related to positive attitudes for males and females. Aiken (1972), however, found the perceptions of the mothers' liking for mathematics and mothers' level of education (having graduated from high school) were related to positive attitudes in girls, but not boys. For boys, however, the perception of mothers' earning high grades in mathematics was related to positive attitudes. Burbank (1968) found a relationship between maternal attitudes and attitudes of both sons and daughters.

Fennema and Sherman (1976) found sex differences in perceptions of mothers' perceptions of student as a learner of mathematics in schools where there were also sex differences in achievement and perceived usefulness of mathematics. Intent to take advanced course-work was also related to students' perceptions of maternal perceptions (Sherman and Fennema, 1976).

Thus, for girls, perceptions of parental expectations and maternal attitudes towards mathematics appear to be important. It would be interesting to know to what extent the sex-typing of mathematics as a male domain influences maternal expectations for girls. Perhaps mothers who had a favorable attitude towards mathematics themselves are less likely to sex-type mathematics and, thus, more likely to have high expectations for daughters.

There appears to be no single study which has measured all the relevant dimensions to unravel the relationship of parental sex-typing, expectations, encouragement and child behavior. It would be helpful to have a study which measured all of the following variables.

1. Attitudes towards mathematics for both parents (including perceived usefulness of mathematics for daughter)
2. Parental expectations for child's performance
3. Parental sex-typing of mathematics

4. Parental estimate of own ability, and report of parent achievement
5. Education and occupation of parents
6. Student's attitudes towards mathematics (including perceived usefulness of mathematics)
7. Students' self-expectations
8. Students' self-rating of ability
9. Students' sex-typing of mathematics
10. Students' career aspirations
11. Students' actual achievement
12. Students' aptitude
13. Students' perceptions of parents' attitudes
14. Students' perceptions of parents' expectations
15. Students' perceptions of parents' ability
16. Students' expected and actual course taking grades 9 - 12.

If all of these variables were assessed, it would provide some interesting insight into the impact of parents upon the mathematics achievement of their children. In too many studies the child's perceptions of parental views have been interpreted as though they are the actual views of the parents or the construct attitude is not clearly defined, and measures of achievement vary. The interplay of all these variables needs to be explained more carefully.

Teacher Influences on Attitudes

It is generally believed that the child's most formative years in terms of cognitive abilities, personality, values, and sex-role identification are spent in the home, not in the school. As the child moves into adolescence, the peer group begins to take on a stronger socializing influence than even the family (Coleman, 1961). Thus, teachers and the school system, by themselves, may have only moderate influence upon the child. Their power to influence may be strengthened or weakened in accordance with the degree to which they work with or against these other more primary socializers.

Thus, it is not surprising that Poffenberger and Norton (1959) concluded that teachers have relatively little influence on the development of students' attitudes towards mathematics and that self-concepts with regard to mathematics are well established by the influences of the parents in the pre- and early school years. Their own data, however, do not seem to fully warrant this conclusion. Retrospective reports of students did indicate some influence of previous year teachers on attitudes.

In a review of the literature in 1970, Aiken (1970b) noted the problem of inferring causal relationships between teacher attitudes or behaviors and student attitudes and achievement. In a study in 1972, Aiken concluded that teacher attitudes do influence student attitudes. Student perceptions of mathematics teachers as negative and demanding were significantly related to negative attitudes in both sexes. Positive feelings towards mathematics were associated with positive feelings towards the teacher for boys more often than for girls. Girls appear to be able to like their mathematics teachers while simultaneously rejecting the subject (Aiken, 1972; Poffenberger and Norton, 1959).

In a review article on attitudes and mathematics in 1976, Aiken concluded that the belief that teachers' attitudes affect student attitudes towards mathematics has been difficult to confirm. Starkey (1971) concluded that the effect of teacher attitude and behavior on student attitudes and behaviors vary greatly from teacher to teacher, and student to student.

Although there is little evidence, it does seem that teacher beliefs about sex differences in mathematics, and their supportive or non-supportive behaviors, can affect girls' achievements and attitudes in mathematics. (Additional evidence on the importance of teachers is discussed in the section on significant others.) Ernest (1976) reported that 41 percent of a small sample of teachers (primarily female), believed that boys do better in mathematics than girls, while no teacher felt that girls did better than boys. Clearly, this type of attitude, which is different from the teacher attitudes typically studied, is likely to influence behavior. In the Wisconsin study, the perceptions of teachers' views of the students as learners of mathematics were significantly related to intent to take additional courses, but were not obviously related to sex-differences of the achievement tests (Fennema and Sherman, 1976; Sherman and Fennema, 1976).

A study by Bean (1976) reported differential interactions between teachers and male and female students in high school mathematics classrooms. Teachers initiated fewer interactions with females than males. Females also initiated fewer contacts with the teacher than males. Perhaps some of this differential interaction is related to teachers' and pupils' perceptions. In a study of twelve schools that had twice the natural percentage of girls enrolled in advanced placement calculus and physics courses, Casserly (1975) found that teachers of these courses had actively recruited girls for the courses. They also expected and encouraged high levels of achievement. Self-reports of women mathematicians emphasize the impact of an encouraging teacher (Luchins, 1976). Fox (1974b, 1976b) found that some teachers actually ridiculed girls who tried to accelerate their progress in school. Solano (1976) found that teacher stereotypes of mathematically gifted girls were considerably less favorable than teacher stereotypes of mathematically gifted boys.

Although the general literature on attitudes and expectations of teachers has failed to show conclusive results (Aiken, 1976; Rosenthal and Jacobson, 1968), it seems that much more research is needed, particularly research relating specifically to sex-role stereotyping by teachers. Even women mathematics teachers may not be providing girls with the same encouragement as they do boys. Elementary school teachers who are anxious about mathematics themselves may be more potent negative models for girls than for boys.

Peer Influences on Attitudes

Teachers' attitudes may be less potent than those of peers. Unfortunately, there are relatively little data. Shapiro (1962) found that peer attitudes in elementary school are determiners of attitudes toward mathematics, especially for girls. In a study of adolescents, Poffenberger and Norton (1959) argued that peer-group influence helped to reinforce already developed attitudes. No discussion of sex differences was provided. Anecdotal accounts of gifted girls suggest that girls fear rejection by peers if they appear too bright in mathematics. Solano (1976) found that student stereotypes of mathematically gifted girls were more negative than those of gifted boys.

It seems likely that social class may also relate to peer perceptions. Entwisle and Greenberger (1972) found blue-collar adolescent males to be the most liberal towards career achievement of women. In Fennema and Sherman's study of Wisconsin youth (1976), sex differences in mathematics achievement seemed greater in the upper socio-economic levels. On the other hand, the taking of advanced mathematics courses may be more normative for boys and girls in schools that have high percentages of college bound populations. An analysis of already existing data banks on high school students who apply to colleges and take examinations, such as the Scholastic Aptitude Tests, might provide some clarification of this issue.

Other School-Related Influences on Attitudes

Clearly, the stereotype of mathematics as a male domain is prevalent in media, textbooks, and tests. There is no research, however, which shows how these factors influence girls' attitudes towards mathematics as a male domain, or their actual achievement and course-taking. Continual exposure to jokes about women's poor mathematical skills, and the portrayal of mathematics as a male domain do shape girls' attitudes. Girls who do like mathematics must feel some sense of conflict in expressing such unfeminine interests.

In general, the reports suggest that neither curriculum nor specific teaching strategies have significant effects on attitudes. Aiken (1970, 1976) reviewed the literature on attitude change as a result of specific curriculum, such as SMSG, UICSM, Ball State, etc., specific teaching strategies, or the use of motivational devices, such as calculators and computers. Many of the studies do not analyze the attitude change separately for girls and boys. Lack of significant findings in some studies may be due in part to failure to control for other relevant factors. For example, Devine (1967) found that teacher experience interacted with instructional approach. When the teacher of a programmed course was inexperienced, achievement was equal to a teacher-directed comparison class, but negative attitudes towards mathematics developed. When the teacher was experienced, achievement was lower, but attitudes were not affected.

Aiken's (1970b) review of the literature on attitudes towards mathematics reported that studies of ability-grouping had not found this practice to have significant effect on attitudes or achievement. More recent studies (Brody, 1976; Casserly, 1975; Fox, 1975b; 1975e; 1976a) suggest that ability-grouping may affect course-taking behavior of girls. It seems likely from these studies that ability-grouping alone is not enough. Other factors that may interact with ability-grouping for girls are:

1. pace of instruction and level of content
2. duration of the tracking, and some social aspects of the situation
3. number of girls in the program
4. teacher characteristics and behaviors
5. parental and peer support
6. attitudes, interests, and values of the student

What is needed are studies which identify teaching strategies or curricula that affect girls' attitudes towards the usefulness of mathematics and their willingness to take advanced courses. A study at Wellesley (Schaefer, 1976) is experimenting with a special mathematics curriculum for freshmen that is radically different from typical mathematics programs. In this study, the importance of social and aesthetic interests of women has been considered. The evaluation is not completed. If this proves successful, similar studies with younger populations would seem warranted.

Changing Attitudes and Behaviors

In a small pilot study of a career education and skills course in mathematics, Fox (1976d) found that girls' attitudes towards mathematics became more positive after the program. In this program, emphasis was placed upon the application of mathematics to social problems and art. Farley (1968) found that girls who were not given a choice with respect to tenth grade mathematics became more favorable towards mathematics than girls who had the opportunity to elect or not elect the course. In general, however, it may be more efficient and effective to modify behavior directly rather than attitudes (McGuire, 1969).

Mathematically gifted seventh-grade girls who participated in an accelerated algebra program were significantly more accelerated in their mathematics progress by the end of the tenth grade than were the girls in a control group. The experimental girls were not, however, more favorable towards mathematics or mathematical careers after the special class, or three years later (Fox, 1976e; 1976f). Thus, changing the behavior had little effect upon the expressed liking for mathematics, but still accomplished the more important goal of modifying course-taking behavior.

Carey (1957) found significant sex differences in attitudes towards problem-solving as well as performance on problem-solving tasks. After intervention, a discussion session to improve attitudes, problem-solving behavior improved for the women but not the men. Attitudes, however, did not change for either sex.

A limitation of the studies of attitude change is that they have in general not focused on specific attitudes of perceived usefulness of mathematics and perception of self as a learner of mathematics. Perhaps when behavior is changed, it is these attitudes, not expressed liking for mathematics, problem-solving, or specific career choices, that are affected. More research is needed.

Values

On the basis of a review of the literature on several measures of social orientation such as empathy, response to social reinforcements, proficiency in imitating models, and amount of time spent in interactive social play, Maccoby and Jacklin (1974) concluded that the belief that girls are more "social" than boys was unfounded. They did not cite, however, the studies of social (altruistic) value orientation versus theoretical (intellectual) value orientation among adolescents and adults.

Numerous studies report sex differences on the value scales of the Allport-Vernon-Lindzey Study of Values. Indeed, in most studies women score higher than men on the social, aesthetic, and religious scales and lower on the theoretical, economic, and political scales (Allport, Vernon, Lindzey, 1970). Differential value profiles are related to educational and occupational choice. For example, the profiles for female medical students are distinctly different from female graduate students in business or nursing, or art students.

High scores on the theoretical scale are associated with interests in science and mathematics. MacKinnon (1962) found high scores on both theoretical and aesthetic scales to be typical of creative mathematicians. Studies at the Johns Hopkins University have found high theoretical scale scores to be characteristic of mathematically precocious adolescent males (Fox, 1976g; Fox and Denham, 1974). Mathematically gifted girls were less likely than the boys to have high social or aesthetic scale scores. Differential values seemed to account for some of the observed sex differences in interest in mathematical acceleration and careers among academically talented youth.

Although it is possible to measure values of gifted students as early as grade seven (Linsenmeier, 1976), there are no studies of the development of value orientations as measured by the Study of Values from early adolescence to adulthood. One study of stability of values for college students between the freshman year and graduation found the following: First, values appeared to be very stable over the college years, although there was some tendency for aesthetic value scores to increase and religious value scores to decrease; second, values of students in specific majors were similar; and third, individual values shifted slightly to become even more like the major group profile (Feldman and Newcomb, 1970). These results are consistent with other studies of personality which suggest that personality formation occurs early and is not highly flexible and fluid. Value orientations are not likely to be as amenable to change as are attitudes.

Influences Upon the Development of Values

Few studies have examined the relationship between parents and children on the Study of Values. Fisher (1948) studied college students and their parents and found that students' value profiles were more similar to their same-sex than opposite-sex parent. Gray and Klaus (1956) found that both college males and females had profiles more like their mothers than their fathers. Females were more like both parents than were males. In a study of mathematically gifted adolescents Pyryt (1976) found that profiles of boys were more like their parents' profiles than were the profiles of girls. Although boys' profiles were more like their fathers than were girls, girls were not significantly more like their mothers than the boys. A very small number of girls and boys had become accelerated in mathematics. These students had profiles like their opposite-sex parent.

It is interesting that the profiles of mathematically gifted females in the Pyryt study were less like those of either parent than were females in the college samples. The small number of students in the study makes generalization difficult.

It is surprising that there is so little research on the development of values and the relationship of values to learning environments. Perhaps values have seemed to be too personal or too political to be explored. It seems logical to assume that values are developed as a result of learning rather than by purely biological maturation. The fact that males and females tend to develop rather different value profiles suggests the impact of strong but subtle conditioning. It would seem important to understand more about the process of value development and its reinforcement by family, schools, and peers.

Values and Educational Strategies

The social value scale of the Study of Values is a measure of altruistic concern for people rather than a measure of sociability. Persons who score high on this value scale may find mathematics classes that emphasize the theoretical and abstract nature of mathematics less interesting than courses which emphasize the application of mathematics.

To date, there are no reports of programs that have studied value-treatment interaction in science and mathematics instruction. Sex differences in mathematics are even more likely to be directly related to value/interest correlates of sex-identity than to innate biological/cognitive correlates. Research of this type is sorely needed. Perhaps boys who have low theoretical values also under-achieve in mathematics programs that have theoretical orientations. Instructional strategies that recognize and adapt to differing values and interests might foster greater achievement for both boys and girls.

Knowledge of the value orientations of students and their parents might be useful information for identifying girls and boys who may not enjoy traditional mathematics classes, or who will receive little parental support. Three program implications come to mind. Girls who have low theoretical value orientations may respond differentially from girls with high theoretical orientation to various kinds of mathematical experiences. The former might be more interested in learning mathematics if it were taught in ways to emphasize social or aesthetic applications, as the program at Wellesley does. Second, girls who have moderate or high theoretical orientations may be those who are most predisposed to respond to career education efforts and encouragement to develop within more traditionally scientific areas. Third, parents whose values are not highly theoretical, but who have mathematically talented children, might benefit from family counseling programs aimed at increasing their recognition, acceptance and nurturance of mathematical or scientific talent and interests of their children.

Educational Policies and Practices

The very fact that fewer mathematics courses are required in high school than are courses in English, or even sometimes social studies or physical education, reflects the belief that mathematical competence may not be necessary for everyone. Although it does seem true that not all students are capable of mastering advanced courses, such as calculus, perhaps girls who are capable of learning it should not be allowed to omit it from their programs. If four years of high school mathematics were required, perhaps more girls would take the advanced courses. In a comparison of girls in schools that required a third year mathematics course with those in a school that did not, Farley (1968) found that the girls who were forced to take the course showed improved attitudes towards mathematics, whereas girls who elected the course did not. A seventh grade intervention program for gifted girls also had significant results (Fox, 1976e). Girls who became accelerated in mathematics by one year as a result of a special summer program continued to accelerate by the end of the tenth grade. A control group of girls was not equally accelerated. Yet the control boys had become accelerated, presumably by virtue of their own initiative and encouragement from parents and teachers.

Although it may be difficult to mandate the advanced courses, current teacher and counselor practices should clearly be changed. Teachers and counselors should make a concerted effort to identify and encourage girls who have the ability to take the courses. Perhaps the implementation of accelerated mathematics programs in the elementary and junior high school would foster greater course-taking in the high school and college years.

Programs for the gifted, especially the mathematically gifted, do appear to make a difference. Casserly (1975) noted that many of the girls enrolled in the advanced calculus and science courses felt that their induction into special gifted or academic tracks as early as grade four had been a major determiner in their taking the advanced courses. Special accelerated mathematics programs initiated in several school systems in Maryland appear to be highly successful in accelerating the mathematics progress of girls, particularly when the program is integrated into the basic school program (Brody, 1976; Fox, 1975e; 1976f).

The acceptance of programs for the gifted at all school levels would also be useful for identifying girls for whom career education programs that emphasize professional career areas would be most appropriate. Once girls are identified as gifted and tracked into advanced and accelerated programs, they may be likely to raise their self-expectations, and expectations of their parents, teachers, and counselors may be modified. Such programs may relieve girls of the pressure to defend a choice to pursue the advanced courses.

Special programs and advanced courses are likely to be most beneficial to girls if the number of girls does not become too small. This has been noted by both Casserly (1975) and Fox (1974a; 1976a). The exact number of girls needed to form a "critical mass" is not known. Nor do all girls shy away from being the only girl in an otherwise all-male class in school. The inclusion of a sizeable number of girls, however, does seem to make a difference. Fox (1974b; 1976c) found that girls were far more eager to participate in all-girl accelerated classes than in ones where there were very few girls. In mixed-sex classes, if one girl drops out, others may soon follow

(Angel, 1975). Casserly (1975) noted that girls in advanced placement courses cited the need for a female peer cohort for moral support.

Whether or not all-girl schools or classes promote greater achievement among girls than mixed-sex groups is not clear. Hurley (1964, 1965) found that scores on several achievement measures, including arithmetical concepts, improved for fifth grade girls after one year of a same-sex class, but no increases were found after the second year. The reverse was true of males in all-boy classes. Although teachers felt there had been significant changes in behavior of both boys and girls in same-sex classes as compared with mixed-sex ones, especially in terms of less sex role stereotypic behavior, the boys, but not the girls, liked the sex-segregation. Although Fox (1974b; 1976c) found girls more willing to participate in all-girl accelerated mathematics classes than in mixed-sex ones, achievement was not notably better. This may have been, in part, because of the different selection procedures used. The girls in the all-girl class were less highly selected than in mixed-sex comparison groups. Husbands (1972) has argued against sex segregation on the grounds that separate rarely can be separate and equal. There is a danger that science and mathematics courses in all-girl schools will be of lower caliber than in all-male schools. The data are not strong enough to warrant mandating all-girl classes as part of a regular program. It may be, however, that for career education purposes and special accelerative or remedial programs, all-girl classes will be more successful than mixed-sex ones. For example, remedial mathematics programs at the college level may be more successful when all-female groups are employed (MacDonald, 1976). Further research is indicated, but the restraints of Title IX may be a problem.

Although Title IX may inhibit some research efforts, by and large it will probably reduce some sexist practices, such as all-male schools that emphasize science and mathematics.

The sex of the teacher is probably totally irrelevant to the success of girls in regular or special programs. The attitudes of the teacher may however, by very important as found by Casserly (1975). The continued use of textbooks and tests that reflect sexist bias, however, should not be tolerated. Even though there is a lack of direct research evidence to support the negative consequences of the use of such materials, the implications of the bulk of the research is that the prevailing stereotype of mathematics as a male domain inhibits achievement of females and must be discouraged.

A final educational practice that works against the achievement of women in mathematics is the failure of many, if not most, educational institutions to provide career education programs and counseling services that seriously consider the special needs of women. Some general insight into the problems of sex discrimination of schools and counseling is provided in a series of reports.

Conclusions and Recommendations

There are typically three general hypotheses offered as explanations for male superiority in mathematics (Aiken, 1976). The first is that biology is destiny and genetics not interests, effort, and cultural expectations and conditioning account for sex differences. The second is that psychological masculinity is required for excellence in mathematics. The third is that the sex-typing of mathematics as masculine results in differential expectations and socialization practices for boys and girls with respect to achievement in mathematics. The first hypothesis was not addressed in this review of the literature. The second hypothesis was not strongly supported by the literature. The third hypothesis does appear to be strongly supported by the existing research.

Conclusions

Despite the lack of longitudinal studies, particularly ones that assess the multi-factor nature of the issue, and the confusion of terms, the bulk of the evidence on sex role socialization and mathematics achievement points in the same general direction. Women achieve less in mathematics and science than men in terms of careers and on tests partly, if not totally, because that is what society expects and encourages. Subtle and not so subtle messages that mathematics is a male domain are given to girls and women by parents, peers, educators, and society at large. Although the penalties for trespassing into the male domain are not so severe as to threaten life or limb, they are harsh enough to deter all but the most intrepid souls. Society encourages girls to believe that there is a conflict between the ideal feminine role and adult achievement in careers, particularly in mathematics and the sciences.

Sex differences in adolescence and adulthood on mathematics tests and career choices appear to result, at least in part, from the differential pursuit of mathematical experiences, notably course-taking in the secondary and post-secondary school years. Differences in course-taking for the sexes is both cause and effect. Although sex differences in course-taking may not explain all the observed sex differences on tests of achievement and aptitude, it is by itself a major achievement difference and contributes heavily to differences in adult career options. The reduction or elimination of sex differences in course-taking should lead to decreases in sex differences on other measures of achievement. Even if course-taking could be made constant, some sex differences might still exist as long as the underlying causes of differential course-taking are left unchanged. To reduce or eliminate sex differences in achievement in mathematics we must first understand the social conditions that foster differential interest in the pursuit of mathematics education.

Two factors that have been found to relate directly to sex differences in course-taking are the perception of the usefulness of mathematics for careers and the support and encouragement from significant others. A third factor that also appears relevant but for which there is less direct research evidence is educational policy and practice. Underlying these three factors and a factor in itself is the perception of mathematics as a male domain.

Perceived Usefulness of Mathematics

Sex differences in the perception of the usefulness of mathematics for adult life has been reported as early as grade seven, the age at which sex differences on achievement measures are typically first found. It is quite likely that these differences actually develop far earlier than grade seven.

This does not appear to have been researched. It may be, however, that the perception of the usefulness of mathematics is also influenced by the fact that the nature of mathematics appears to change from arithmetic skills and concepts to more abstract algebraic and geometric concepts at the middle-school years. The pre- and early adolescent years are also those in which the awareness of the social and biological differences between the sexes becomes a crucial force in the development of the child. It is at this point that awareness of sex-role appropriate behavior is likely to become quite potent in influencing behavior. It is then perhaps not coincidental that in adolescence many girls begin to perceive themselves as less competent than boys in mathematics. The perception of the usefulness of mathematics appears to be related to the perception of mathematics as a male domain and to some general beliefs about appropriate careers for women.

Sex differences in career interests and aspirations are found as early as kindergarten. In general girls are less oriented to careers other than homemaker than boys and those who are career-oriented are less likely than boys to be interested in professional careers in mathematics and science. It is not too surprising that girls perceive mathematics as less important for their future than do boys. Some girls who are career oriented may be prematurely self-selecting themselves out of mathematics courses because they are unaware of the true relevance of these courses for the careers in which they are interested. Ignorance about the importance of mathematics for many career areas is perhaps a result of the lack of adequate career education programs in the schools as well as ignorance or sexism on the part of counselors, teachers and parents. Lack of interest in careers in general seems to be a result of the complex socialization process during which girls learn to perceive a conflict between achievement (careers) and the feminine role of wife and mother despite the fact that the great majority of today's women do indeed spend some time in the labor force. The avoidance of professional and technical careers, particularly in mathematics, is also a result of the lack of available women role models and the stereotype of these career areas as unsocial. Why women appear to be more oriented towards social and aesthetic than theoretical and economic values and careers is not totally clear. Society, particularly the significant others in the child's life, appears to reinforce if not cause these differences.

Support from Significant Others

Girls' decisions to take or not to take advanced courses in mathematics are directly influenced by the advice of significant others. School counselors, alas, are likely to discourage rather than encourage girls to take the courses or to pursue careers in mathematics and science. Although the impact of a non-sexist and inspirational teacher may be greater than the influence of a counselor upon a girl's perception of self relative to mathematics, teachers are by-and-large likely to believe and reinforce sex-role stereotypes. Girls may be even more sensitive to peer pressure than to the influences of educators. Whether or not their perceptions are accurate, girls seem to believe that excellence in mathematics is socially undesirable. Adolescents do appear to have a more negative image of mathematically talented girls than boys, and males, particularly white middle-class males, do not appear to be supportive of achievement for girls. Girls tend to orient their career aspirations in keeping with their perceptions of what males will tolerate. On the other hand, support from a strong female peer group may enable girls to deal with male peer pressure when selecting courses and careers. Although all-girl classes may be unacceptable under Title IX and not totally acceptable to many girls, the sex-ratio of a mathematics class may be an important factor in girls' willingness to take advanced or accelerated mathematics and science courses. Peers, teachers and counselors may be less potent as changers of attitudes than as reinforcers of attitudes already shaped by the home and society at large. Parents, particularly fathers, play a crucial role, directly and indirectly, in the development of attitudes, career interests and decisions to elect or not elect courses in mathematics.

Although there may be a great deal of similarity in the early socialization experiences of boys and girls, parents often have lower educational expectations for daughters than for sons. Parents have the earliest influence upon the child's concept of self and upon the child's perceptions of sex roles and sex-appropriate behavior. If parents sex-type mathematics and related activities as masculine this view is communicated to the child. Parents do tend to reinforce sex-role stereotypes in their choice of toys and in their greater acceptance of low levels of achievement in mathematics for daughters than sons. The attitudes and expectations of the father may be more important than those of the mother since the father is more likely to be the parent who exhibits interest in mathematics and science and to whom the daughter turns for help with mathematics homework and advice about course-taking. Mathematical competence appears to be adversely affected by the absence of the father for both sexes. If mothers, however, are strong models for career aspiration and competence in mathematics, they may have a potent effect upon their daughters' attitudes and career orientations. The fact that little girls often perceive women only as homemakers appears to shape their expectations for their own future roles.

Identification with the mother or father does not necessarily exclude or foster competency in mathematics. The nature and importance of a female child's identification with either the father or the mother or the generalized masculine or feminine role with respect to achievement in mathematics are not clear. What seems to be a most promising explanation is that females who have very feminine orientations can succeed in mathematics or pursue a mathematical career if these activities are not perceived by them as incompatible with the feminine role. If the females perceive these activities as masculine then they will succeed less well in them than males unless the females have a masculine or at least androgynous role orientation. The argument that identification with an abstract masculine role by boys promotes an analytical cognitive style does not seem to be supported by evidence. Clearly more research is needed to untangle the issue of masculinity-feminity dimensions of psychological identification and mathematical competence.

There is also surprisingly little direct research on the impact of specific child-rearing practices upon the development of mathematical competence or career orientations in girls. The research suggests that those practices which foster independence and self-reliance also foster competence in mathematics whereas children who are over dependent or who have interfering and demanding mothers may develop discrepant verbal and mathematical abilities. Many of these are based on samples of children selected for their discrepant ability patterns without studying the ability patterns of the parents to control for possible hereditary factors. Studies do indicate, however, that parents of boys are more likely to emphasize achievement, competition and control of feelings while parents of girls stress interpersonal relationships, affection and protection. While it seems logical that these parenting practices will eventually lead to less intellectual risk-taking on the part of girls than boys, there is no direct evidence as to the impact of these practices upon the development of mathematical ability.

Thus while there is some indication that parents are the most important influence upon the development of the child's view of self and the world, the exact dynamics by which the child learns sex-role appropriate behavior from the parents is unclear. Nor is it entirely clear exactly how parents foster or inhibit their child's achievement in mathematics and careers. It does appear, however, that many girls do receive some direct messages from their parents which indicate low expectations for success in mathematics and the pursuit of professional careers. Girls who take the advanced mathematics courses are likely to report encouragement from parents. In general, however, parents may be less supportive of daughters than sons because of their own stereotypes of appropriate feminine activities.

Educational Policies and Practices

Although the perception of the usefulness of mathematics for future careers and the support of significant others are the most directly obvious factors associated with course-taking, educational policies and practices also have some influence. If mathematics course-taking was not optional in the secondary school years, perhaps there would be more girls enrolled in the advanced courses. When the courses are optional more boys than girls take them because the boys are encouraged to see these courses as necessary while the girls are not.

Programs for the academically able student that begin in the elementary school years also appear to promote greater course-taking in mathematics and science at the secondary level. Although "tracking" has become unpopular and only a few states have active programs for the intellectually gifted child, boys who have ability tend to move ahead in mathematics at a more rapid pace than their gifted female cohorts. Perhaps if programs for the academically gifted were wider-spread more girls would be encouraged to take the advanced courses in mathematics and science.

Until recently some classes were segregated by sex, such as home economics, shop and mechanical drawing. Such practices helped institutionalize sex-role stereotypes. It is perhaps unfortunate that efforts to eliminate these sexist practices may also eliminate sex-segregation for purposes which might ultimately benefit both boys and girls. For example, special classes in mathematics or science just for girls might be useful for attracting girls who would otherwise avoid these courses for fear of competition with males.

Although there is no evidence that the sex of the teacher is an important factor for achievement or attitudes in regular classes, the fact that teachers of science and mathematics at the secondary level are typically male helps reinforce the image of mathematics as a male domain. The problem is of course circular. It will be difficult to recruit more females for these jobs as long as many women avoid the courses at the high school and college level.

Perhaps the major institutional practice that poses a barrier to women's entry into courses and career areas in mathematics and science is the lack of career education and counseling programs at the elementary, secondary and post-secondary school levels. Even schools which have such programs may upon closer scrutiny discover that these programs still perpetuate the stereotypes of limited career opportunities for women. Also, these programs often do not include female role-models for atypical careers which appear to be a necessary component of an effective career education program.

Mathematics as a Male Domain

The view of mathematics as a male domain is wide-spread and portrayed in the media, textbooks and tests. Parents, teachers and students all appear, at least for secondary students, to believe that this is true. This belief undoubtedly underlies the foregoing correlates to sex differences in course-taking and achievement in mathematics. Although there is some question as to whether or not females fear success, there is ample evidence that females who wish to appear "feminine" are more comfortable in task-situations that are labeled <u>feminine</u> or at least <u>neutral</u> than in those labeled <u>masculine</u>. The sex-typing of mathematics as a male domain leads to different expectations for boys and girls with respect to success in mathematics classes. These self-perceptions are reinforced by behaviors and expectations of teachers, peers and parents. It is little wonder that girls have less self-confidence than boys as learners of mathematics. This presumably accounts for differences in course-taking when courses become optional.

It has been hypothesized that in some cases the conflict between femininity and competence in mathematics becomes so great that an actual phobia or anxiety about mathematics develops. At present there is little information as to the causes of math-anxiety, but it does appear to exist. Even females who on tests appear to have well-above average aptitude for mathematics are not apparently immune to the phobia. For some adolescent girls this fear may result from an approach-avoidance conflict. They may be attracted to mathematics and related careers by virtue of their abilities and interests yet be too insecure in their own feminine identity to trespass upon male territory or be drawn by conflicting interests to more aesthetic or social pursuits.

The stereotype of the mathematician or scientist as cold and asocial is likely to contribute to this conflict. It does appear that females have more social than theoretical values. It is unfortunate that mathematics is so often taught in such a way as to deemphasize its relationship to the arts and the social sciences. Mathematics classrooms, particularly at the advanced course level, do indeed appear to be male domains taught by men to largely male classes.

As long as mathematics classes and careers in related areas maintain their masculine mystique the problem is somewhat circular. Girls avoid mathematics classes and careers because they perceive them as male domains; they receive little encouragement to pursue courses and careers in these areas by significant others who also appear to perceive these activities as male. As long as women avoid these courses and careers there will be few role models and the image will remain unchanged. The question of interest is how to break the chain and to reduce the sex-typing of mathematics as a male domain and increase girls' participation in mathematics classes and careers.

Recommendations for Educational Policies and Practices

To increase girls' participation and achievement in mathematics classes at the secondary and post-secondary school levels, it will be necessary to increase girls' awareness of career opportunities for women and the importance of mathematics to many career areas including homemaker. Girls should also be made aware of the wide variety of careers in business, government, and industry that require mathematical competence and yet have social service components. Appreciation of many avocational activities in art, music, and games might be heightened also by an awareness of their relationships to mathematical concepts.

The most obvious and direct method for fostering an understanding of the relevance of mathematics to careers and life would seem to be through career awareness and education programs at the elementary through post-secondary level. Such programs could be widely varied in nature; they should probably include, however, some exposure to women who have full- or part-time careers related to mathematics and the sciences. Career education programs need not be costly. Many community resources exist for little or no charge and retired persons might serve as volunteers. Such programs should be constructed with a concern for eliminating sexist portrayals for women. Some existing programs should also be carefully evaluated to eliminate "unconscious" sexism. Some standards or guidelines for career education programs need to be developed and disseminated to schools. Some preliminary research and pilot-testing of model programs may be needed before such guidelines can be developed.

Non-sexist career counseling is also needed. In order to provide this some special in-service training for guidance counselors may be needed. It might also be valuable to generate a list of non-sexist vocational interest inventories or guidelines for improving the interpretation of existing instruments for women. Some research is already in progress and should be continued.

The provision of non-sexist career awareness, education, and counseling programs should help dispel some of the negative peer pressure against girls' pursuit of "atypical" careers. The attack on sexism and racism should not be left to chance. Program materials should be designed to directly confront and dispel myths and prejudices. It might also be wise to design such programs, particularly those at the elementary and junior high school levels, in such a way as to elicit parent and classroom teacher involvement so that they will be aware of the purposes and merits of such programs. Parents might be encouraged to serve as volunteer workers in some aspects of career and community education.

Parent-effectiveness training has recently become popular in some areas of the country. Such programs are not typically offered by the public school system. Perhaps public education should offer courses for parents that encompass a wide range of topics including agism, sexism, racism, and the importance of career education and guidance. Many parents may not realize that their attitudes and behaviors, such as the choice of toys and games for their offspring, could influence later learning.

In-service programs for teachers should also be developed. Many teachers may be totally unaware of their own sexist practices or beliefs. Mathematics and science teachers might be encouraged to develop special units that depict the importance of these subjects to broad areas of human endeavor including social service and aesthetic careers and activities. In some cases the practical applications should receive greater emphasis. Courses on statistics, computers and other areas of applied science and mathematics might be developed and offered at the upper elementary and lower secondary level. Teachers should be encouraged to take a critical look at the textbooks they use and the activities and tests they develop. Some general guidelines might be developed and disseminated through teacher organizations such as the Nation l Council of Teachers of Mathematics. Teachers should be advised to specifically identify the boys and girls who appear to have very high aptitude for mathematics and to encourage both girls and boys to pursue courses and careers in this area. If teachers, counselors, and school administrators seek out these students at an early age they may be able to increase the participation of girls in the more advanced courses.

Programs for the gifted and talented child that recognize and facilitate the developments of special talents, such as mathematical ability, may have a positive effect on the course-taking behavior and attitudes of above-average ability girls. Early identification programs would enable schools to identify those girls who have great academic potential at an age where special intervention in the form of career education and special encouragement in mathematics might be most beneficial. The early tracking of these girls into college bound programs that emphasize the importance of mathematics and science could have a potent positive effect on later achievement and career choice. Concomitant counseling for the parents of such students would also be desirable. For such talented students sp ial after-school or summer courses that combine career education with mathematical skills might be valuable.

Early screening programs to identify gifted students might be integrated with existing programs to identify students who need special remediation in basic subjects. Early and continued identification programs might also seek to locate students who are developing anxieties about their abilities in mathematics. To some extent such programs now exist to identify students who show potential for difficulty in reading. Such efforts should be expanded to include those who show high verbal or reading competency but poor arithmetical skills development. The concept of literacy should be expanded to include quantitative literacy as well. The Right to Read program might be broadened to include the right to learn basic computational skills, arithmetic concepts, and the applications of these to everyday life. At present most school systems require only one or two years of mathematics at the high school level for graduation. Increased requirements and more varied course offerings would also seem desirable for all ability groups.

There has been some concern with the sexism present in media, tests, and textbooks. This concern has by-and-large not been as directed towards mathematics texts and tests as it has been towards basic readers and children's literature. The image of mathematics as a male domain might be greatly reduced if textbooks, tests, and media were less sexist with respect to mathematics. Textbook adoption committees at State and local school system levels should be encouraged to scrutinize the offerings for their sexism as well as racism. Publishers of educational materials should be made aware of the negative aspects of sex-role stereotyping and urged to develop materials that portray women in a variety of roles and as capable and active rather than incompetent and passive and avoid equating mathematical and scientific interests with masculinity. Although it may be impossible to mandate standards for publishers or textbook committees, lists of recommended books and materials as well as informal guidelines might be generated and widely disseminated. Some federal grants might be given for the creation of non-sexist educational materials as models. It is difficult to know how to best influence the media. Federal and private foundations that give grants to public broadcasting efforts could at least be urged to demand non-sexist and non-racist programming. Professional women's organizations might also be encouraged to become more vocal advocates of non-sexist practices.

Professional women's groups such as the Society of Women Engineers or the Association of Women Mathematicians might also be encouraged to expand their activities to include more direct involvement with schools and school systems in career education efforts. Perhaps federal and private monies might be provided for furthering their efforts to recruit students and disseminate positive images of career opportunities for women.

There is one additional barrier to women's full development in mathematics, particularly careers in this area, that cannot be directly removed by educational program efforts. There still exists ambivalence and conflict about appropriate roles for women. The combining of family life and careers is still more problematic for females than males. Career education programs and career counseling for women must somehow deal with the realities of this problem. The world of work outside the family is accessible to women but may carry some extra burdens or costs that are not present for men. As long as this situation exists, some females may remain aloof to attempts to increase their interests in careers and thus their achievements in mathematics.

Time and systematic efforts to educate society as a whole may eventually bring about some desired changes. Closer federal scrutiny of sexist hiring and promotion practices, the provision of better jobsite day care facilities for children of working mothers, wider acceptance of the contribution of women to the labor force, better health insurance provisions for working mothers, and other labor and health measures may in combination with better educational opportunities lead to changes in society's acceptance of women's potential for contributions to all areas of endeavor.

The foregoing suggestions for educational values and practices do not begin to exhaust the possible strategies that might be employed to increase women's participation in mathematics courses and careers and thus hopefully reduce sex differences. In summary, there appear to be five important goals related to education that could be affected directly by program efforts at the national level. First, greater awareness among females of the value and usefulness of mathematical competency for adult life, particularly in careers. This can be approached through the development of career programs, curriculum development, and public education. Second, a reduction of harmful stereotyping of mathematics as a male domain and the feminine role as incompatible with achievement and competency in mathematics. This goal can be approached through a variety of means. Third, the fostering of greater awareness and sensitivity on the part of educators, parents, and the general public of their role in promoting the full development of all talent areas in young children and the value of the first two goals. Fourth, the promotion of a truly flexible and democratic educational system that can deal with individuals and not stereotypes. Fifth, the support of educational research on the causes and correlates of sex differences in achievement in mathematics and the development of intervention and remediation strategies including career education efforts. Elaboration of research needs are in the following section.

Recommendations for Research

Until very recently there has been little research on factors inhibiting the intellectual and career development of women. Two types of research efforts seem indicated. First, more basic research is needed to understand the nature, extent, and causes of sex differences in mathematics achievement on tests, in course-taking, and in career choices and success. Second, it is not too soon to conduct experimental and quasi-experimental studies of intervention and remediation programs for students, educators, parents, and combinations of the three groups.

The design and implementation of both types of studies should include two considerations. There is a real need for longitudinal studies. Interpretation of future studies would also be greatly enhanced by the observance of some uniform standards for measurement and evaluation.

Too few existing studies of sex differences have been developmental and longitudinal developmental studies of child-rearing practices have rarely collected the types of information necessary to understand the dynamics of sex differences in mathematical competence and self-confidence. Some on-going longitudinal studies might be modified to include the collection of such data s parental sex-typing of activities and expectations for sons and daughters in careers and mathematics achievement. There is clearly much we do not know about the development of competence in mathematics, career aspirations and interests, values, and sex-typed or androgynous personalities. Longitudinal studies that assess a multitude of variables are needed to provide meaningful answers to the many questions that exist. A single national study of the problem may be too difficult and costly to tackle. A comprehensive plan might be developed, however, and various parts of the research divided among many different research groups.

The need for a complex but congruent research design is also true of studies of intervention and remediation programs. Lantz, et al. (1976), for example, found it extremely difficult to evaluate and compare intervention strategies funded by the National Science Foundation which varied in criteria for selection of subjects and measurement of outcomes. The interpretation of findings would be considerably enhanced by the application of uniform selection and outcome measures across studies. For example, studies that attempt career education or counseling in different ways could be compared more readily if they used the same pre- and post-test measures.

Let us consider the following questions: At what age should career education programs begin? Are female role-models essential to career education programs? Is it more efficient to have programs for teachers or parents or counselors than programs for students? If numerous separate proposals are sought and funded which attack these questions as separate entities and employ different populations and evaluation measures there may be only non-comparable fragments of the puzzle at the end. If, on the other hand, one large research design is developed and appropriate sampling techniques employed as well as uniform pre- and post-measures, the results may prove most enlightening. We could have X number of treatment models, some designed for students, with and without role-model components, some designed for teachers, some for parents, some for counselors, and perhaps some which have components for more than one group. Each of the X number of models could be tried for Y number of age groups. Social class and mathematical aptitude of students could be controlled for by various methods. Pre- and post-test measures could be designed to encompass the goals of all the programs. Out-come measures of increased course-taking at a given age, career interests, knowledge of career opportunities, etc. could all be assessed for each sample of students to determine the relative effectiveness of each strategy. If sample populations are large, other variables such as value orientation, etc. could also be assessed. If all data were collected at uniform times and recorded in the same format, a single computer analysis could be programmed and conducted. Perhaps one institution could design and perform all the analysis while a large number of different research groups conducted the actual program aspects. Such an approach might indeed revolutionize and revitalize the educational research community.

Such an approach might also be employed on longtudinal developmental studies and thus alleviate the burden placed on one research group or one set of respondents. Thus five or ten or even hundreds of small manageable longitudinal studies could be conducted simultaneously on matched or random samples. Such an approach would make it possible to assess the full range of possible correlates without studying each factor in every sample.

Let us consider some of the research questions that might be addressed by non-intervention studies, particularly those of a longitudinal or case study nature. Studies of the development of career interests and aspirations, values, and specific interest in course-taking,and achievement in mathematics should be funded. Ideally these studies should collect information on parental child-rearing practices or styles, expectations for the child in mathematics and careers, and degree of parental sex-typing of mathematics as masculine and concern for sex-appropriate behavior of offspring. Within such a study or as a separate study, data should be collected to determine the onset of sex differences in the perception of the usefulness of mathematics and the relationship of this to other variables such as the child and parent view of mathematics as a male domain, the child's primary sex role identification, the child's apparent mathematical aptitude, and so forth. Although it would be a mammoth task to study all these variables, a single research design could be developed and somewhat different pieces of the puzzle parceled out to different investigators for samples matched on relevant variables such as social class and working status of mother. (It is difficult to know what variables should be controlled; for example, the number and sex of siblings may also be important.)

Such a design would encompass many specific testable hypotheses while also allowing for more complex analysis of the relative importance of the various factors. From this research we might learn how potent are the effects of role-models in the home, the importance of parental expectations versus child-rearing practices, the home factors that lead to the development of sex-typed rather than androgynous views of self and the world, and so on.

In time we might be able to develop prediction equations for career interests and achievement. Thus, we could know which girls have the greatest likelihood of success in mathematics without special intervention efforts and which girls need the most encouragement from sources outside the home.

It would also seem desirable to approach the study of the development of math-anxiety and low self-confidence in such a way. Some preliminary research such as case studies of identified cases is needed, however, before such an ambitious project can be launched. The relationship of spatial visualization abilities to mathematics achievement and math-anxiety should also be attacked.

Some additional non-intervention studies which would not need to be longitudinal are also indicated. In some cases re-analysis of existing data banks might provide some answers. For example, we need to know more about the relationship of social-class and ethnic or racial identity to career interests, the perceptions of the usefulness of mathematics, course-taking and achievement, and so forth. We also need to understand more about school and school systems' administrative practices that foster female course-taking and achievement in mathematics.

Some additional studies of the effect of differential course-taking upon sex differences on achievement and aptitude tests might also be done in ways as to control for the effects of attitudes or even sex-typing of mathematics, and/or androgynous rather than sex-typed views of self and the world. For example, do female high school or college students who have an androgynous view of self and/or a neutral rather than masculine view of mathematics score as well as their male cohorts on tests such as the SAT-M or GRE-Q when course-taking is controlled? Another related question would be, do females who have a strong feminine identity and a view of mathematics as a male domain take fewer advanced courses and score lower on achievement tests than would be predicted for females of similar aptitude but different perceptions of self and mathematics? Basic research on the whole issue of psychological gender identification is also needed.

Studies of the impact of peer pressure on course-taking and achievement would also be interesting. Consider these questions: Do girls who are very talented in mathematics who have friends who have strong social values and a strong perception of the importance of being feminine avoid the full development of their talents more than girls who have friends who have less sex-stereotyped values and views? Are mathematically gifted girls who pursue the development of their talents less sensitive to peer pressure; are they socially more like loners than other girls? Do adolescent girls form peer groups on the basis of their acceptance or rejection of the stereotyped feminine role?

All of the above questions are interesting to researchers. They do not exhaust the rich source of hypotheses to be studies for the advancement of the science of individual differences. They are not all equally valuable, however, for the purposes of the design of intervention programs and the development of educational policy. Perhaps some of these questions could be studied within the framework of research that simultaneously study intervention strategies.

In planning and implementing intervention and/or remediation programs, we are confronted with the question of goals. There are at least four different goals we might adopt or some combinations of them. First, we might aim at the reduction or elimination of sex differences on test performance. Second, we might attempt to reduce sex differences in course-taking at the secondary and post-secondary levels. Third, we might wish to increase women's interest and participation in a variety of career areas that require mathematical competence. Fourth, we might wish to reduce or eliminate sex-role stereotyping, particularly with respect to mathematics. This fourth goal also implies the reduction of conflict between femininity and achievement in mathematics and thus the increase in females' self-confidence in selves as learners of mathematics.

Of the four goals, the first three lend themselves most directly to attack and evaluation. The first and second goals overlap as do the second and third, while the fourth goal overlaps the first three. Therefore, in the ensuing discussion of research on intervention we will assume that all four goals are desirable.

Intervention efforts can be roughly classified in four types of strategies although a particular program might use more than one strategy. The first strategy is to create programs directly for students that aim to alter their attitudes and behaviors with respect to mathematics and careers. The second is to influence the attitudes and behaviors of signigicant others in the students' lives at home and school. The third is to manipulate instructional and administrative educational practices. The fourth is to try to change the image of mathematics as a male domain by manipulating the language and messages of media, textbooks, and tests and perhaps increasing the visability of positive female role-models.

The first type of strategy would include career awareness and education programs and career counseling efforts. This could also include counseling programs for math-anxiety and accelerative programs for gifted students. The specifics of the programs might be quite varied. The literature suggests, however, that exposure to female role-models should be incorporated in the design. The exact nature of the program may be far less important than the interaction of the age of the subject and the duration and intensity of the program with the nature of the program. For example, a short-term intensive Algebra program for gifted seventh-grade girls appeared to have an effect that lasted for about three years but may fade without further intervention. Some of the dependent measures that might be assessed in evaluating the impact of career education, counseling and other intervention programs are the perceptions of the usefulness of mathematics, the perception of mathematics as a male domain, course-taking, and expressed career interests and aspirations.

It might be worthwhile to consider the development of a video-tape career education program with workbook and teacher guide that could be widely disseminated. Existing commercial products of this type should be evaluated.

Ideally, career education units should be integrated with the regular curriculum so that the relationship of the skills required for a particular job could be related to the skills being learned in classes. Careers in many business areas can require a wide range of mathematical skills from basic percent and decimals to calculus and computers. Students in general mathematics courses as well as calculus might simultaneously study applications of mathematics to careers in accounting, tax-law, marketing, and so forth.

Programs that are developed for and offered to different populations should not be compared with one another. At least two levels of the population should be targeted. First, we should develop and evaluate programs for increasing women's participation in careers in mathematics and science at the professional level, that are piloted on high ability students. Second, we should develop and evaluate programs for increasing women's participation in career areas that require competence in mathematics but not the more advanced levels of abstract mathematics.

A simple caution seems indicated. Career education efforts should consider different ability levels of students. All students cannot realistically aspire to professional level jobs in science and mathematics. Programs for the student who has high mathematical aptitude should be different from programs for the student of average ability. Internship programs that place students in situations with college professors, graduate students, and research scientists, for example, are most likely to impact students who have the aptitude and necessary skills to benefit from such exposure. College professors, lawyers, and doctors are not realistic role-models for all students. A program designed to expose students to professional career possibilities in mathematics and science will be far more effective it is directed toward the top 10 percent of the female populations with respect to mathematical aptitude than if it is aimed at those who score below the average. Programs that ignore this factor are not likely to be effective.

The same caution applies to career counseling efforts. In our zest to increase women's participation in mathematics and the sciences, we must not overlook real individual differences and limitations. A student who scores high on a scale of mathematical or computational interest in a vocational preference inventory but has average scores on measures of mathematical and verbal aptitude should not be told to consider careers such as a professor of mathematics or an electrical engineer.

Initial research efforts aimed at improving career counseling for women might be aimed at studying the effects of non-sexist counseling. Research on the non-sexist use of existing vocational interest inventories and the development of better instruments for women should be encouraged.

The second intervention strategy would be to attempt to influence the attitudes and behaviors of significant others in the child's life. For educators, in-service courses could be developed. They might take a variety of forms. It may be more difficult to have programs for parents unless they are integrated with programs for students. In other words, it may be easier to get parents to attend meetings to explain a "new" program for students than to get parents to attend general sessions on the negative effects of sex-role stereotyping or on non-sexist child-rearing, etc.

The impact of programs for educators or parents could be compared with that of those for students by selecting teachers and parents of samples of students matched in relevant variables to those who receive more direct intervention programs. One methodological problem will be that parents and teachers of students involved in a direct program may become affected by the program in indirect ways. Ideally, we should compare the effects of programs for students with those for students and their teachers and parents and with those for teachers or parents only. In the latter cases the dependent variables could be the same as for the direct intervention studies with some additions. We would need to know the pre- and post-attitudes and behaviors of the teachers and parents. This latter type of research could become more complicated. We would need to learn whether or not the teacher program affected their attitudes and behaviors and then if this in turn led to changes in course-taking, etc. of the girls.

From a cost-effectiveness viewpoint programs for educators would be the easiest and least expensive to undertake. Current research, alas, does not suggest that changing teacher, counselor, or school administrator attitudes and behaviors would be a highly potent program in itself. A true experimental test of this hypothesis seems crucial in terms of long-range planning and program costs.

It is difficult to envision a research design to impact peer attitudes that would not be encompassed under the general provision of career education programs. The peer group at times is an elusive concept. A possible research issue is the determination of the "critical number" of girls required in an advanced or accelerated mathematics class to ensure the success of the girls involved.

The third strategy is to focus on research on changes in instructional modes, curriculum, and administrative practices. We might compare the effects of programs that require more mathematics courses at the high school or college level with those that maintain an optional policy. More systematic study of the effects of accelerative and non-accelerative programs for the gifted with those of programs that do not provide for the identification and facilitation of the academically able student seems warranted. A study of grouping by values and interests along with appropriate curriculum modifications would also be interesting. Do students who have social and aesthetic values benefit more from mathematics courses that emphasize the application of mathematics to the arts and social service programs than they do from courses that do not emphasize the applications of mathematics? Are self-paced mathematics classes less effective for girls who have social interests and values than for girls who are more theoretical in orientation?

Research efforts on the interaction of verbal and spatial abilities of students with instructional strategies and curricula are also needed. Perhaps students who have poor spatial abilities and high verbal abilities learn mathematical concepts in a different way from those who are less verbal and more spatial in orientation.

For the fourth strategy we must consider the ways in which society communicates sex-role stereotypes in relationship to mathematics. It is possible that girls would be more interested in learning mathematics if textbooks were less sexist. Performance on tests might be improved if the wording and context of tests were less sexist. Experimental research on the effects of textbooks and test items would seem desirable. It is difficult to envision an experiment or quasi-experiment that could assess the influence of sexism in general media.

In order to research the four strategies at minimum cost, it might be possible to capitalize upon naturally occurring experiments so that the cost of the research would not have to include the cost of treatment. For example, schools or school systems that have existing career awareness programs or mathematics programs for the gifted could be compared with schools or systems that do not offer such programs on measures of course-taking and achievement. The control schools or systems could be matched with the "treatment" schools on relevant variables such as size, available course-taking, and socio-economic levels of students. Base-rate figures for the treatment school system prior to the implementation of their special programs, if available, could also be compared with current rates of course-taking and achievement among females.

Research efforts that include the actual development and conduct of treatments should probably focus on strong rather than weak treatments. Short-term interventions such as a one-day career education program with exposure to female role-models that aim at hundreds of girls are probably far less effective than more intensive efforts that work with smaller groups of students over longer periods of time. This hypothesis can be readily tested. A somewhat more complicated question is whether or not small but stable changes in teacher behaviors and school policies and practices will eventually impact a larger number of students over time than intensive programs for a specific sample of girls that is too complicated or expensive to ever become integrated into the basic school curriculum. Some technical questions need to be answered. For example, are live role-models significantly more effective than video-taped programs or written materials that include many female role-models? For the short-run it would be easier to use live models than to create films and video-tapes. The films or tapes, however, could be used year after year. It is probably more difficult to continually recruit live models on a yearly basis. It may be less costly to conduct an in-service course for teachers than to buy new textbooks and tests. One in-service experience for a teacher may not have, however, as lasting an effect as the continued use of non-sexist curricula materials and tests.

Thus, initial efforts to fund research should be expansive and not assume too quickly that one approach in more promising. Existing research simply does not allow us to make these decisions. It is too soon to say which type of intervention strategy will have the greatest impact. Although it will not be possible to fund every conceivable variation and combination of intervention strategies, it would seem desirable to select projects for funding that provide some balance among the types of strategies, the characteristics of the target populations, the costs, scopes, and durations of the projects.

References

Adams, Jennie L. and Fitts, William H. "The development of the self concept". In William H. Fitts, The self concept and self actualization, 1972, Nashville, Tenn.: Counselor Recordings and Tests, 27-38.

Ahlgren, Andrew and Walberg, Herbert J. Changing attitudes towards science among adolescents. Nature, 1973, 245, 187-190.

Aiken, Lewis R. Jr. Personality correlates of attitude toward mathematics. The Journal of Educational Research, 1963, 56 (9), 476-480.

Aiken, Lewis R. Jr. Non-intellective variables and mathematics achievement: Directions for research. Journal of School Psychology, 1970a, 8 (1), 28-36.

Aiken, Lewis R. Jr. Attitudes toward mathematics. Review of Educational Research, 1970b, 40 (4), 551-596.

Aiken, Lewis R. Jr. Research on attitudes toward mathematics. The Arithmetic Teacher, 1972, 19 (3), 229-234.

Aiken, Lewis R. Jr. Some speculations and findings concerning sex differences in mathematical abilities and attitudes. In Fennema, Elizabeth (Ed.), Mathematics learning: What research says about sex differences, December 1975, Columbus, Ohio: ERIC Mathematics, Science and Environmental Education Clearinghouse, 13-20.

Aiken, Lewis R. Jr. Update on attitudes and other affective variables in learning mathematics. Review of Educational Research, 1976, 46 (2), 293-311.

Aiken, Lewis R. Jr. and Dreger, Ralph Mason. The effect of attitudes on performance in mathematics. Journal of Educational Psychology, 1961, 52 (1), 19-24.

Allport, G. W., Vernon, P. E. and Lindzey, G. Manual for the study of values: A scale for measuring the dominant interests in personality. Boston: Houghton Mifflin Company, 1970.

Almquist, Elizabeth M., and Angrist, Shirley S. Role model influence on college women's career aspirations, Merrill-Palmer Quarterly, 1971, 17 (3), 263-279.

Anastasi, Anne. Differential psychology: Individual and group differences in behavior. New York: The MacMillan Company, 1958, 664 pp.

Anastasi, Anne. Commentary on the precocity project. In J. C. Stanley, D. P. Keating and L. H. Fox (Eds.), Mathematical talent: Discovery, description and development. Baltimore: The Johns Hopkins University Press, 1974, 87-100.

Anderson, Kenneth E. A comparative study of student self ratings on the influence of inspirational teachers in science and mathematics in the development of intellectual curiosity, persistence and a questioning attitude. Science Education, 1963, 47 (5), 429-437.

Angel, Michael F. Wolfson I: A study in precocious mathematical ability and education. Master's Thesis at The Johns Hopkins University, November, 1974, 38 pp.

Anttonen, Ralph G. A longitudinal study in mathematics attitude. Journal of Educational Research, 1969, 62 (10), 467-471.

Astin, Helen S. Career development of girls during the high school years. Journal of Counseling Psychology, 1968, 15 (6), 536-540.

Astin, Helen S. The woman doctorate in America: Origins, career, and family. New York: Russell Sage Foundation, 1969, 196 pp.

Astin, Helen S. Sex differences in mathematical and scientific precocity. In J. C. Stanley, D. P. Keating and L. H. Fox (Eds.), Mathematical talent: Discovery, description and development. Baltimore: The Johns Hopkins University Press, 1974a, 70-86.

Astin, Helen S. Overview of the findings. In H. Astin, H. Suniewick and S. Dweck, Women: A Bibliography on Their Education and Careers. New York: Behavioral Publications Incorporated, 1974 (b), 1-10.

Astin, Helen S., Harway, Michele and McNamara, Patricia. Sex discrimination in education: Access to post secondary education. National Center for Education Statistics, Education Division, Department of Health, Education and Welfare, February 1976, 284 pp.

Astin, Helen S. and Myint, Thelma. Career development of young women during the post-high school years. Journal of Counseling Psychology Monograph, 1971, 18 (4), 369-393.

Astin, Helen S., Suniewick, Nancy and Dweck, Susan. Women: A bibliography on their education and careers. New York: Behaviorial Publications, 1974, 232 pp.

Baumrind, Diana. From each according to her ability. School Review, 1972, 80 (2), 161-197.

Bean, Joan 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, California, 1976.

Behr, A. N. Achievement, aptitude and attitude in mathematics. Two Year College Mathematics Journal, 1973, 4, 72-74.

Bem, Sandra L. The measurement of psychological androgyny. Journal of Consulting and Clinical Psychology, 1974, 42 (2), 155-162.

Bem, Sandra L. and Lenney, Ellen. Sex typing and the avoidance of cross sex behavior. Journal of Personality and Social Psychology, 1976, 33 (1), 48-54.

Bergman, Jane. Are little girls being harmed by 'Sesame Street'? In Judith Stacey, Susan Bereand and Joan Daniels (Eds.), And Jill came tumbling after: Sexism in American education, New York: Dell Publishing Company, Inc., 1974, 110-115.

Bing, Elizabeth. Effect of childrearing practices on development of differential cognitive abilities. Child Development, 1963, 34, 631-648.

Block, Jeanne Humphrey. Conceptions of sex role: Some cross-cultural and longitudinal perspectives. American Psychologist, 1973, 28 (6), 512-526.

Brody, Linda. Follow-up of Falstaff fast-paced mathematics classes. Unpublished paper included in the annual report to the Spencer Foundation by the Intellectually Gifted Child Study Group, The Johns Hopkins University, 1976.

Broverman, I. K., Broverman, D. M., Clarkson, F. E., Rosenkrantz, P. S. and Vogel, S. R. Sex-role stereotypes and clinical judgments of mental health. Journal of Consulting and Clinical Psychology, 1970, 34 (1), 1-7.

Brown, Daniel G. Masculinity-femininity development in children. Journal of Consulting Psychology, 1957, 21 (3), 197-202.

Burbank, Irvin Kimball. Relationships between parental attitude toward mathematics and student attitude toward mathematics and between student attitude toward mathematics and student achievement in mathematics (Doctoral dissertation, Utah State University, 1968). Dissertation Abstracts International, 1970, 30, 3359A-3360A. (University Microfilms No. 70-2427)

Callahan, Walter J. Adolescent attitudes toward mathematics. Mathematics Teacher, December 1971, 64, 751-755.

Carey, Gloria L. Sex differences in problem solving performance as a function of attitude differences. Journal of Abnormal and Social Psychology, 1958, 56, 256-260.

Carlsmith, Lyn. Effect of early father absence on scholastic aptitude. Harvard Educational Review. 1964, 34 (1), 3-21.

Carney, Julia A. Fletcher. Racism and sexism in children's books. Carnegie Quarterly, 1974, 22 (4), 1-4.

Casserly, Patricia Lund. An assessment of factors affecting female participation in advanced placement programs in mathematics chemistry and physics. Report to the National Science Foundation, July 1975, 42 pp.

Christman, John F., Vidulich, Robert N., Dralle, Penelope and Kirk, M. Ann. Factors influencing the selection of science careers by women. Paper presented at the symposium of the committee on women in physics, 1976 spring meeting of the American Physical Society, Washington, D. C.

Cleveland, Gerald Arthur and Bosworth, Dorothy. A study of certain psychological and sociological characteristics as related to arithmetic achievement. The Arithmetic Teacher, 1967, 14, 383-387.

Coleman, James S. The adolescent society, the social life of the teenager and its impact on education. New York: The Free Press of Glencoe, 1961, 368 pp.

Constantinople, Anne. Masculinity-femininity: An exception to a famous dictum? Psychological Bulletin, 1973, 80 (5), 389-407.

Cristantiello, Philip D. Attitude toward mathematics and the predictive validity of a measure of quantitative aptitude. Journal of Educational Research, 1962, 55 (4), 184-186.

Deaux, Kay. Ahhh, she was just lucky. Psychology Today, 1976, 10 (6), 70-75.

Devine, Donald F. Student attitudes and achievement: A comparison between the effects of programmed instruction and conventional classroom approach in teaching algebra I in Rich Township high school (Doctoral dissertation, Colorado State College, 1967). Dissertation Abstracts International, 1967, 28, 535A. (University Microfilms No. 67-9621)

Donlon, Thomas F. Content factors in sex differences on test questions. Paper presented at the meeting of the New England Educational Research Organization, Boston, June 1971.

Donlon, Thomas F., Ekstrom, Ruth B. and Lockheed, Marlaine. Comparing the sexes on achievement items of varying content. Paper presented at the annual meeting of the American Psychological Association, Washington, D. C., September 1976.

Dreger, Ralph Mason and Aiken, Lewis R., Jr. The identification of number anxiety in a college population. The Journal of Educational Psychology, 1957, 48, 344-351.

Dusek, Jerome B. Do teachers bias children's learning? Review of Educational Research, 1975, 45 (4), 661-684.

Dweck, Carol S. Children's interpretation of evaluative feedback: The effect of social cues on learned helplessness. Merrill-Palmer Quarterly, 1976, 22 (2), 105-109.

Dweck, Carol S. and Bush, Ellen S. Sex differences in learned helplessness: I. differential debilitation with peer and adult evaluators. Developmental Psychology, 1976, 12 (2), 147-156.

Dwyer, Carol. Probing curriculum and test construction in math and science. Paper presented at the 1976 meeting of the American Educational Research Association, San Francisco, California, April 1976.

Ekstrom, Ruth B., Donlon, Thomas F. and Lockheed, Marlaine E. The effect of sex biased content on achievement test performance. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, California, April 1976.

Elton, Charles F. and Rose, Harriett A. Traditional sex attitudes and discrepant ability measures in college women. Journal of Counseling Psychology, 1967, 14 (6), 538-543.

Engelhard, Patricia Auer, Jones, Kathryn Otts and Stiggens, Richard J. Trends in counselor attitudes about women's roles. Journal of Counseling Psychology, 1976, 23 (4), 365-372.

Entwisle, Doris R. and Greenberger, Ellen. Adolescents' views of women's work role. American Journal of Orthopsychiatry, 1972, 42 (4), 648-656.

Erlick, Arline C. and LeBold, William K. Factors influencing the science career plans of high school students. Measurement and Research Center, Purdue University, West Lafayette, Indiana, June 1975, 26 pp.

Ernest, John. Mathematics and Sex. Santa Barbara: University of California, April 1976, 30 pp.

Etaugh, Claire, and Rose, Suzanne. Adolescents' sex bias in the evaluation of performance. Developmental Psychology, 1975, 11 (5), 663-664

Farley, Sister Mary de Chantal. A study of the mathematical interests, attitude and achievement of tenth and eleventh grade students (Doctoral dissertation, University of Michigan, 1968). Dissertation Abstracts International, 1969, 29, 3039A. (University Microfilms No. 69-2312)

Federbush, Marsha. The sex problems of school math books. In Judith Stacey, Susan Bereand and Joan Daniels (Eds.), And Jill came tumbling after: Sexism in American education, New York: Dell Publishing Company, Inc., 1974, 178-184.

Feldman, Kenneth A. and Newcomb, Theodore M. The Impact of College on Students. San Francisco: Jossey-Bass, Inc., 1970, 8-10 and 175-180.

Fennema, Elizabeth. Mathematics learning and the sexes: A review. Journal for Research in Mathematics Education, 1974a, 126-139.

Fennema, Elizabet . Sex differences in mathematics learning: Why??? The Elementary School Journal, 1974b, 75, 183-190.

Fennema, Elizabeth and Sherman, Julia. Sex related differences in mathematics achievement, spatial visualization and socio-cultural factors. Journal of Educational Research, in press.

Ferguson, Lucy Rau and Maccoby, Eleanor. Interpersonal correlates of differential abilities. Child Development, 1966, 37, 549-571.

Fisher, Sarah C. Relationships in attitudes, opinions and values among family members. University of California Publications in Culture and Society, 1948, 2, 29-100.

Fox, Lynn H. A mathematics program for fostering precocious achievement. In J. C. Stanley, D. P. Keating and L. H. Fox (Eds.), Mathematical talent: Discovery, description and development. Baltimore, Maryland: The Johns Hopkins University Press, 1974 (a), 101-125.

Fox, Lynn H. Facilitating the development of mathematical talent in young women. (Doctoral dissertation, The Johns Hopkins University, 1974). Dissertation Abstracts International, 1974 (b), 35, 3553B. (University Microfilms No. 74-29027)

Fox, Lynn H. Mathematically precocious: Male or female. In E. Fennema (Ed.), Mathematics learning: What research says about sex differences. Columbus, Ohio: Ohio State University, December 1975 (a), 1-12.

Fox, Lynn H. Sex differences: Implications for program planning for the academically gifted. Paper presented at the Lewis M. Terman Memorial Symposium on intellectual talent held at The Johns Hopkins University, Baltimore, Maryland, November 1975 (b).

Fox, Lynn H. Career interests and mathematical acceleration for girls. Paper presented at the 1975 annual meeting of the American Psychological Association, Chicago, Illinois, August 1975 (c).

Fox, Lynn H. Sex differences: Implications for program planning. Paper presented at the 1975 meeting of the American Educational Research Association, Washington, D. C., April 1975 (d).

Fox, Lynn H. First Annual report to the Spencer Foundation on its three-year grant to the Evening College and Summer Session of the Johns Hopkins University, covering the first year of the grant, September 1, 1974 through August 31, 1975. "Intellectually Gifted Child Study Group (IGCSG)", Baltimore, Maryland: The Johns Hopkins University, August 1975 (e).

Fox, Lynn H. Gifted girls: Scientists and mathematicians of the future. Paper presented at the 1976 annual meeting of the National Association for Gifted Children, Kansas City, Missouri, October 1976 (a).

Fox, Lynn H. Women and the career relevance of mathematics and science. School Science and Mathematics, 1976 (b), 26 (4), 347-353.

Fox, Lynn H. Sex differences in mathematical precocity: Bridging the gap. In Daniel P. Keating (Ed.), Intellectual talent: Research and development. Baltimore, Maryland: The Johns Hopkins University Press, 1976 (c), 183-214.

Fox, Lynn H. Career Education for gifted pre-adolescents. The Gifted Child Quarterly, Fall 1976 (d), 20 (3), 262-273.

Fox, Lynn H. Changing behaviors and attitudes of gifted girls. Paper presented at the 1976 meeting of the American Psychological Association, Washington, D. C., September 1976 (e).

Fox, Lynn H. Second annual report to the Spencer Foundation on its three-year grant to the Evening College and Summer Session of The Johns Hopkins University, covering the second year of the grant, September 1, 1975 through August 31, 1976. "Intellectually Gifted Child Study Group (IGCSG)", Baltimore, Maryland: The Johns Hopkins University, August 1976 (f).

Fox, Lynn H. The values of gifted youth. In Daniel P. Keating (Ed.), Intellectual talent: Research and development. Baltimore, Maryland: The Johns Hopkins University Press, 1976 (g), 273-284.

Fox, Lynn H. and Denham, Susanne A. Values and career interests of mathematically and scientifically precocious youth. In J. C. Stanley, D. P. Keating and L. H. Fox (Eds.), Mathematical talent: Discovery, description and development. Baltimore, Maryland: The Johns Hopkins University Press, 1974, 140-175.

Fox, Lynn H., Pasternak, Sara R. and Peiser, Nancy L. Career related interests of adolescent boys and girls. In Daniel P. Keating (Ed.), Intellectual talent: Research and development. Baltimore, Maryland: The Johns Hopkins University Press, 1976, 242-261.

Frazier, Nancy and Sadker, Myra. Sexism in school and society. New York: Harper & Row, 1973, 215 pp.

Friedersdorf, Nancy Wheeler. A comparative study of counselor attitude toward the further educational and vocational plans of high school girls (Doctoral dissertation, Purdue University, 1969). Dissertation Abstracts International, 1970, 30, 4220A. (University Microfilm No. 70-03887)

Gaetano, Mary Ann Kineer. A study to determine the distribution of male and female figures in elementary science textbooks. Journal of Research in Science Teaching, 1966, 4, 178-179.

Goldberg, Phillip. Are women prejudiced against women? Trans-Action, 1968, 5 (5), 28-30.

Good, Thomas L., Sikes, J. Neville and Brophy, Jere E. Effects of teacher sex and student sex on classroom interaction. Journal of Educational Psychology, 1973, 65 (1), 74-87.

Gough, Sister Mary Fides. Mathemaphobia: Causes and treatments. The Clearing House, 1954, 28, 290-294.

Graebner, Dianne Bennet. A decade of sexism in readers. The Reading Teacher, 1972, 26, 52-58.

Graf, Richard G. and Riddell, James. Sex differences in problem solving as a function of problem context. Journal of Educational Research, 1972, 65 (10), 7-8.

Gray, Susan W. and Klaus, Rubert. The assessment of parental identification. Genetic Psychology Monographs, 1956, 54, 87-114.

Harway, Michele; Astin, Helen; Suhr, Jeanne and Whitely, John. Sex discrimination in guidance and counseling. National Center for Educational Statistics, Education Division, U.S. Department of Health, Education and Welfare, February 1976, 271 pp. (annotated bibliography under separate cover)

Haven, Elizabeth 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, Peggy. What women think men think: Does it affect their career choice? Journal of Counseling Psychology, 1971, 18 (3), 193-199.

Hawley, Peggy. Perceptions of male models of femininity related to career choice. Journal of Counseling Psychology, 1972, 19 (4), 308-313.

Heilbrun, Alfred B., Jr. Parent identification and filial sex role behavior: The importance of biological context. In James K. Cole and Richard Dienstbier (Eds.), Nebraska Symposium on Motivation, 1973. Lincoln: University of Nebraska Press, 1974, 125-195.

Helson, Ravenna. Women mathematicians and the creative personality. Journal of Consulting and Clinical Psychology, 1971, 36 (2), 210-220. Also in: Judith M. Bardwick (Ed.), Readings on the Psychology of Women. New York: Harper & Row, 1972, 93-100.

Henken, Valerie; Unger, Rhoda and Aronow, Edward. Preference for group leaders: Gender vs. sex role. Paper presented at the 84th annual convention of the American Psychological Association, Washington, D. C., September 1976.

Hill, John P. Similarity and accordance between parents and sons in attitudes toward math. Child Development, 1967, 38, 777-791.

Hilton, Thomas L. and Berglund, Gosta W. Sex differences in mathematics achievement: A longitudinal study. Journal of Educational Research, 1974, 67, 231-237.

Horner, Matina S. Toward an understanding of achievement-related conflicts in women. Journal of Social Issues, 1972, 28 (2), 157-175.

Hurley, John F. Report of project evaluation: Instructional grouping by sex at the fifth grade level - a study of all-boy and all-girl groups. August 1964. Prepared by the Office of Psychological Services, Fairfax County School Board, Fairfax, Virginia, 13 pp.

Hurley, John F. Report of project evaluation: A study of all-boy and all-girl groups at the third and fifth grade levels and an evaluation after two years in same-sex classes. December 1965. Prepared by the Office of Psychological Services, Fairfax County School Board, Fairfax, Virginia, 8 pp.

Husbands, Sandra Acker. Women's place in higher education? School Review, 1972, 80 (2), 261-274.

Hyman, June R. Systematic desensitization of mathematics anxiety in U. S. students: The role of mediating responses, imagery, emotionality and expectancy (Doctoral dissertation, Wayne State University, 1973). Dissertation Abstracts International, 1974, 34, 7585A. (University Microfilms No. 74-12844)

Iglitzen, Lynne B. A child's eye view of sex roles. Today's Education, 1972, 23-25 (shorter version of a talk at the American Political Science Association in Washington, D. C., 1972).

Iglitzen, Lynne B. A child's eye view of sex roles. In Sex Role Stereotyping in the Schools. Washington, D. C.: National Education Association, 1973, 23-30.

Jackson, R[illegible]erick Earle. The attitudes of disadvantaged students toward mathematics (Doctoral dissertation, Indiana University, 1973). *Dissertation Abstracts International*, 1974, *34*, 3690A. (University Microfilms No. 74-380)

Jacobs, Carol and Eaton, Cynthia. Sexism in the elementary school. *Today's Education*, 1972, *61*, 20-22.

Jacobs, Judith Ellen. A comparison of the relationships between the level of acceptance of sex role stereotyping and achievement and attitudes towards mathematics of seventh and eleventh graders in a suburban metropolitan New York community (Doctoral dissertation, New York University, 1974). *Dissertation Abstracts International*, 1974, *34*, 7585A. (University Microfilms No. 74-12844)

Jay, Winifred Tom. Sex stereotyping in selected mathematics textbooks for grades two, four and six (Doctoral dissertation, University of Oregon, 1973). *Dissertation Abstracts International*, 1973, *34*, 3028A. (University Microfilms No. 73-28604)

Jay, Winifred T. and Schminke, Clarence W. Sex bias in elementary school mathematics texts. *The Arithmetic Teacher*, March 1975, 242-246.

Kaminski, Donna M., Erickson, Edsel L., Ross, Martin and Bradfield, Leila. *Why females don't like mathematics: The effect of parental expectations.* Paper presented at the 1976 American Sociological Association meeting, New York, August 1976.

Keating, Daniel P. (Ed.), *Intellectual talent: Research and development.* Baltimore, Maryland: The Johns Hopkins University Press, 1976.

King, Phyliss E. and Blount, H. Parker. *The influence of sex typed verbal math problems on performance of sixth grade students.* Paper presented at National Council on Measurement in Education, Washington, D. C., 1975.

Kohlberg, Lawrence. Cognitive developmental analysis of children's sex-role concepts and attitudes. In E. Maccoby (Ed.), The development of sex differences. Stanford: Stanford University Press, 1966.

Komarovsky, Mirra. Cultural contradictions and sex roles. American Journal of Sociology, 1946, 52 (3), 184-189.

Lambert, Philip. Mathematical ability and masculinity. Arithmetic Teacher, 1960, 7, 19-21.

Landy, F., Rosenberg, B. G. and Sutton-Smith, B. The effect of limited father absence on cognitive development. Child Development, 1969, 40, 941-944.

Lantz, Alma; West, Anita S. and Elliott, Linda. An impact analysis of sponsored projects to increase the participation of women in careers in science and technology. Report to the National Science Foundation, June 1976, 75 pp. and appendices.

Lavach, John F. and Lanier, Hope B. The motive to avoid success in seventh, eighth, ninth and tenth grade high-achieving girls. The Journal of Educational Research, 1975, 68, 216-218.

Leder, Gilah C. Sex differences in mathematics problem appeal as a function of problem context. The Journal of Educational Research, 1974, 67 (8), 351-353.

Leonard, R. Leon; Fein, Jay S.; Freim, James and Fein, Sara B. Recruiting women to engineering careers: Description and evaluation of a summer program. Paper presented at the Eleventh Annual Midwest Regional Conference of the American Society for Engineering Education, Norman, Oklahoma, March 1976.

Levine, Maita. Identification of reasons why qualified women do not pursue mathematical careers. Report to the National Science Foundation, August, 1976.

Levy, Betty. Sex role socialization in schools. Today's Education. December 1972, 27-29. Also in: Sex Role Stereotyping in the Schools, Washington, D. C.: National Education Association, 1973, 1-7.

Linsenmeier, Joan A. W. Random vs. nonrandom study of values. In Daniel P. Keating (Ed.), Intellectual talent: Research and development. Baltimore, Maryland: The Johns Hopkins University Press, 1976, 285-292.

Lipman-Blumen, Jean. Vicarious achievement roles for women?: A serious challenge to guidance counselors. Unpublished paper. Also appears untitled in Personnel and Guidance Journal, 1975, 53, (9), 680.

Lockheed, Marlaine. Some determinants and consequences of teacher expectations concerning pupil performance. Beginning Teacher Evaluation Study, Phase II Final Report (Vol.II). Princeton, N. J.: Educational Testing Service, 1975, 45 pp.

Looft, William R. Sex differences in the expression of vocational aspirations by elementary school children. Developmental Psychology, 1971, 5, (2), 366. (See also Looft, William R. Vocational aspirations of second grade girls. Psychological Reports, 1971, 28, 241-242).

Luchins, Edith H. Women mathematicians: A contemporary appraisal. Paper presented at the 1976 meeting of the American Association for the Advancement of Science, Boston, February 1976.

Lynn, David B. Determinants of intellectual growth in women. School Review, 1972, 80 (2), 241-260.

Maccoby, Eleanor E. (Ed.), The development of sex differences. Stanford, California: The Stanford University Press, 1966, 351 pp.

Maccoby, Eleanor E. and Jacklin, Carol N. The Psychology of sex differences. Stanford, California: The Stanford University Press, 1974, 634 pp.

Maccoby, Eleanor E. and Jacklin, Carol N. Intellectual abilities and cognitive styles. In E. Maccoby and C. Jacklin, The psychology of sex differences. Stanford, California: The Stanford University Press, 1974, 63-133.

Maccoby, Eleanor E. and Jacklin, Carol N. Achievement motivation and self-concept. In E. Maccoby and C. Jacklin, The psychology of sex differences. Stanford, California: The Stanford University Press, 1974, 134-163.

Maccoby, Eleanor E. and Jacklin, Carol N. Sex-typing and the role of modeling. In E. Maccoby and C. Jacklin, The psychology of sex differences. Stanford, California: The Stanford University Press, 1974, 277-302.

Maccoby, Eleanor E. and Jacklin, Carol N. Differential socialization of boys and girls. In E. Maccoby and C. Jacklin, The psychology of sex differences. Stanford, California: The Stanford University Press, 1974, 303-348.

MacDonald, Carolyn T. An experiment in mathematics education at the college level. Paper presented at the meeting of the Association for the Advancement of Science, Boston, February 1976.

MacKinnon, Donald W. The highly effective individual. Teachers College Record, 1960, 61, 367-378.

McGuire, William J. The nature of attitudes and attitude changes. In G. Lindzey and E. Aronson (Eds.), The Handbook of Social Psychology (Vol. III). Reading, Massachusetts: Addison-Wesley Publishing Company, 1969, 136-314.

Mead, Margaret and Metraux, Rhoda. Image of the scientist among high school students. Science, 1957, 12, 384-390.

Milton, G. A. Sex differences in problem solving as a function of role appropriateness of the problem content. Psychological Reports, 1959, 5, 705-708.

Mischel, Walter. A social-learning view of sex differences in behavior. In E. Maccoby (Ed.), The development of sex differences. Stanford, California: The Stanford University Press, 1966, 56-81.

Mischel, Harriet N. Sex bias in the evaluation of professional achievements. Journal of Educational Psychology, 1974, 66 (2), 157-166.

Mullis, Ina V. S. Educational achievement and sex discrimination. National Assessment of Educational Progress, 1975, 15 pp.

Nelson, Edward A. and Maccoby, Eleanor E. The relationship between social development and differential abilities on the Scholastic Aptitude Test. Merrill-Palmer Quarterly, 1966, 4 (12), 269-284.

Oden, Melita H. The fulfillment of promise: 40-year follow-up of the Terman gifted group. Genetic Psychology Monographs, 1968, 77, 3-93.

Ory, John C. and Helfrich, Linda M. A study of individual characteristics and career aspirations. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, California, April 1976.

Page, Ellis Batten. A historical step beyond Terman. In D. Keating (Ed.), Intellectual talent: Research and development. Baltimore, Maryland: The Johns Hopkins University Press, 1976, 295-307.

Perrucci, Carolyn Cummings. Minority status and the pursuit of professional careers: Women in science and engineering. Social Forces, 1970, 19 (2), 245-259.

Pheterson, Gail I., Kusler, Sara B. and Goldberg, Philip A. Evaluation of the performance of women as a function of their sex, achievement and personal history. Journal of Personality and Social Psychology, 1971, 19 (1), 114-118.

Plank, Emma N. and Plank, Robert. Emotional components in arithmetical learning as seen through autobiographies. Psychoanalytic studies of the child, 1954, 9, 274-296.

Plost, Myrna and Rosen, Marvin J. Effect of sex of career models on occupational preferences of adolescents. AV Communication Review, 1974, 22 (1), 41-50.

Poffenberger, Thomas M. and Norton, Donald A. Factors determining attitudes toward arithmetic and mathematics. The Arithmetic Teacher, April 1956, 113-116.

Poffenberger, Thomas M. and Norton, Donald A. Factors in the formation of attitudes toward mathematics. Journal of Educational Research, 1959, 52 (5), 171-176.

Prediger, Dale J., McLure, Gail T. and Noeth, Richard J. Promoting the exploration of personally relevant career options in science and technology. Report to the National Science Foundation, October 1976.

Pyryt, Michael C. Value congruity between gifted students and their parents. Paper presented at the meeting of the American Psychological Association, Washington, D. C., September 1976.

Richardson, Frank C. and Suinn, Richard M. The mathematics anxiety rating scale: Psychometric data. Journal of Counseling Psychology, 1972, 19 (6), 551-554.

Rogers, Margaret Anne. A different look at word problems. Mathematics Teacher, 1975, 68 (4), 285-288.

Romer, Nancy. The motive to avoid success and its effects on performance in school-age males and females. Developmenyal Psychology, 1975, 11 (6), 689-699.

Rosenthal, Robert and Jacobson, Lenore. Pygmalion in the classroom. New York: Holt, Rinehart and Winston, Inc., 1968, 220 pp.

Rossi, Alice S. Women in science: Why so few? Science, 1965 (a), 148 (3674): 1196-1202. Also in: Safilios-Rothschild, Constantina, (Ed.), Toward a sociology of women. Lexington, Massachusetts: Xerox College Publishing, 1972, 141-153.

Rossi, Alice S. Barriers to the career choice of engineering, medicine or science among American women. In J. Mattfeld and C. Van Aken (Eds.), Women and the scientific professions, Cambridge, Massachuetts: M.I.T. Press, 1965 (b), 51-127.

Ruehl, Franklin R., Jr. Women's lib and the physics lab. Mensa Journal, April 1975.

Sanderson, Goulding E. and Anderson, Kenneth E. A study of the influence of an inspirational science or mathematics teacher upon student achievement as measured by the National Merit Qualifying Test. School Science and Mathematics, 1960, 60, 339-345.

Sarason, I. G. and Winkel, G. H. Individual differences among subjects and experimenters and subjects' self description. Journal of Personality and Social Psychology, 1966, 3, 448-457.

Schafer, Alice T. Brief description of the Wellesley College mathematics project. Unpublished paper, 1976.

Schlossberg, Nancy K. and Goodman, J. A woman's place: Children's sex stereotyping of occupations. Vocational Guidance Quarterly, 1972, 20 (4), 266-270.

Schlossberg, Nancy K. and Pietrofesa, J. J. Perspectives on counselors bias: Implications for counselor education. The Counseling Psychologist, 1974, 4 (1), 44-54.

Sears, Pauline S. and Barbee, Ann H. Career and life satisfaction among Terman's gifted women. Paper presented at the Lewis M. Terman Memorial Symposium on Intellectual Talent held at The Johns Hopkins University, Baltimore, Maryland, November 1975.

Sears, Robert R. Sources of life satisfaction in the Terman gifted men. Paper presented at the 1976 meeting of the American Psychological Association, Washington, D. C., September 1976.

Sells, Lucy W. The mathematics filter and the education of women and minorities. Paper presented at the annual meeting of the American Association for the Advancement of Science, Boston, Massachusetts, February 1976.

Shapiro, Esther Winkler. Attitudes toward arithmetic among public school children in the intermediate grades (Doctoral dissertation, University of Denver, 1961). Dissertation Abstracts International, 1962, 22, 3927A. (University Microfilms No. 62-1222)

Sherman, Julia and Fennema, Elizabeth. The study of mathematics by high school girls and boys: Related variables. Journal of Educational Research (in press).

Smith, Walter Scott. Science education in the affective domain: The effect of a self-awareness treatment on career choice of talented high school women. Paper presented at the national convention of the National Association for Research in Science Teaching, San Francisco, April 1976.

Solano, Cecilia H. Teacher and pupil stereotypes of gifted boys and girls. Paper presented at the 1976 meeting of the American Psychological Association, Washington, D. C., September 1976.

Spence, Janet L., Helmreich, Robert and Stapp, Joy. Ratings of self and peers on sex role attributes and their relation to self esteem and conceptions of masculinity and femininity. Journal of Personality and Social Psychology, 1975, 32 (1), 29-39.

Stacey, Judith; Bereand, Susan and Daniels, Joan. (Eds.). And Jill came tumbling after: Sexism in American education, 1974, New York: Dell Publishing Company, Inc., 461 pp.

Stafford, Richard E. Hereditary and environmental components of quantitative reasoning. Review of Educational Research, 1972, 42 (2), 183-201.

Stanley, Julian C. Accelerating the educational progress of intellectually gifted youths. Educational Psychologist, 1973, 10 (3), 133-146.

Stanley, Julian C., Keating, Daniel P. and Fox, Lynn H. (Eds.). Mathematical talent: Discovery, description and development. Baltimore, Maryland: The Johns Hopkins University Press, 1974.

Starkey, Kathryn Towns. The effect of teacher comments on attitude toward and achievement in secondary mathematics class: An experimental study (Doctoral dissertation, Pennsylvania State University, 1970). Dissertation Abstracts International, 1971, 32, 259A. (University Microfilms No. 71-16677)

Stein, A. H. and Bailey, M. M. The socialization of achievement orientation in females. Psychological Bulletin, 1973, 80 (5), 345-366.

Sternglanz, Sarah H. and Serbin, Lisa A. Sex role stereotyping in children's television programs. Developmental Psychology, 1974, 10 (5), 710-715.

Strassberg-Rosenberg, Barbara and Donlon, Thomas F. Content influences on sex differences in performance on aptitude tests. Paper presented at the meeting of the National Council of Measurement in Education, 1975.

Stright, Virginia M. A study of the attitudes toward arithmetic of students and teachers in the third, fourth and sixth grades. The Arithmetic Teacher, 1960, 280-286.

Suinn, Richard M., Edie, Cecil A., Nicolette, John and Spinelli, Ronald. The MARS, a measure of mathematics anxiety: Psychometric data. Journal of Clinical Psychology, 1972, 28, 373-375.

Thomas, A. H. and Stewart, N. R. Counselor response to female clients with deviate and conforming career goals. Journal of Counseling Psychology, 1971, 18, 352-357.

Thompson, Donald D. Increasing women in science through reshaping role perception. Interim report to the National Science Foundation, February 1976, 45pp.

Tittle, C. K., McCarthy, K. and Steckler, J. F. Women and educational testing. Princeton, New Jersey: Educational Testing Service, 1974, 83 pp. plus appendices.

Tobias, Sheila. Math anxiety. Ms., September 1976.

Trecker, Janice Law. Sex stereotyping in the elementary school curriculum. Phi Delta Kappan, 1973, 55 (2), 110-112.

Weitzman, Lenore J. and Rizzo, Diane. Biased textbooks: A research perspective. National Foundation for the Improvement of Education, 1974.

White, Burton. Experience and environment: Major influences on the development of the younger child. Englewood Cliffs, New Jersey: Prentice Hall, 1973.

White, William F. and Aaron, Robert L. Teachers motivation cues and anxiety in relation to achievement levels in secondary school mathematics. Journal of Educational Research, 1967, 61 (1), 6-9.

Zuckerman, Miron and Wheeler, Ladd. To dispel fantasies about the fantasy-based measure of fear and success. Journal of Personality and Social Psychology, 1973, 82 (5), 932-946.