Entry into Science: The Effect of Parental Evaluations on Sons and Daughters

Donna M. Kaminski
Western Michigan University

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ENTRY INTO SCIENCE: THE EFFECT OF PARENTAL EVALUATIONS ON SONS AND DAUGHTERS

by

Donna M. Kaminski

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Doctor of Philosophy

Western Michigan University
Kalamazoo, Michigan
April 1978

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I would also like to thank Dr. Erickson, my committee members, and those Sociology faculty, staff and fellow graduate students who have shared their knowledge and experience and have given me their personal support during my graduate career. And, as always, I am grateful to Char, my friend and companion, for his patience and uplifting diversions during these four years.

Donna M. Kaminski
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CHAPTER I

INTRODUCTION, THE PROBLEM, RELATED LITERATURE AND THEORY

Introduction

The National Academy of Science's recent report (1974) that there are far fewer women than men in science careers seems to be no greatly held secret as far as common knowledge is concerned. It is also fairly obvious, as reported in the literature, that courses of study taken by males and females in later high school are important factors influencing later career differences in science occupations for men and women. During high school many mathematics and science courses become optional and females are less likely than males to decide to take these courses (Fox, 1975; Erlick & LeBold, 1975). What is not clear, however, is an understanding of the reasons why fewer females select optional science courses in high school. Many reasons have been suggested including ability limitations, social class and parental influences. The purpose of this study is to contribute to a determination of whether the entry into high school science courses is, as suggested in the literature, a consequence of parental expectations as perceived by students during their earlier adolescent years.

Logically it would seem that parents have some influence on
their children's decisions regarding which courses they take in high school. However, the main interest here is not on whether parents overtly council their children towards or away from science interests. Rather, the concern of this study is the effects of parental evaluations of science ability, as perceived by their children, three and four years prior to later high school decisions. Restated, the main concern of this study is to investigate whether one of the reasons fewer females than males elect optional science courses in high school is that during their earlier middle school years, these females tend to perceive lower parental evaluations of their science ability than do their male counterparts.

Besides focusing on this central issue, this study also addressed certain basic questions. For example, in line with prior research, were females in the sample studied here less likely than males to have taken optional science courses in the 11th and 12th grades? If so, were these sex differences apparent at all social class and general ability levels? And, as the literature would suggest, were social class and ability levels themselves related to the election of advanced science courses?

Other related questions focused specifically on perceived parental evaluations of science ability. Were parental science evaluations in the 8th grade related to students' election of science courses three and four years later? And certainly an important question, did these
early adolescent females actually perceive lower parental evaluations of their science ability than did males? In particular, were females less likely than males to perceive high evaluations of their science ability from parents?

The symbolic interactionist orientation and the supporting research literature (see Brookover, et al., 1967; Johnson, 1970) suggest that the evaluations of important others affect one's decision-making in part through their impact on the individual's self-concept. Thus, it was asked, were students' self-conceptions of their science ability in the 8th grade related to science entry in the 11th and 12th grades? Additionally, did parental science evaluations influence students' science course-taking decisions partly through their impact on students' self-evaluations of their science ability? And further, did females have lower self-concepts of their science ability than males? Particularly, were females less likely to have high self assessments of their ability in science than males?

Several more general questions examined and compared the direct and indirect affects of sex, ability, social class, parental science evaluations and self-concept of science ability on the students' election of optional science courses in the 11th and 12th grades. Males and females were also compared as to possible differences in the patterns of these effects.

In summary, then, the overall issues were these: did parental
evaluations of students' science ability affect course-taking in science; and, were there sex differences in course-taking which were in part explainable by sex differences in parental science evaluations?

The following sections of this chapter elaborate on the problem of, and possible contributing factors to, the under-representation of women in the sciences. Related research literature is discussed which suggested the raising of the above issues and questions. The last section specifies the general theoretical perspective which led to hypothesizing the importance of parental evaluations as a potential contributing factor in explaining the paucity of women in the sciences.

The Problem

In considering why women are under-represented in scientific fields in comparison to their representation in the general population, researchers have documented patterns of discrimination at all levels of science entry, from the initial introduction to science in childhood to the employment/promotion levels in adulthood (Fox, 1976; Rossi, 1965). But perhaps more important than these overt barriers are the covert barriers reflected in the conscious and non-conscious beliefs against female entry and interest in science held by employers, educational personnel at all levels such as counselors and teachers, the media, including advertisements, programs and educational material, the adolescent subculture, parents and indeed by females themselves. These ideological barriers against females have not received adequate
attention for several probable reasons. Many of these are "non-
conscious" beliefs instilled from a long-standing tradition of approp-
riate sex-typed behavior, i.e., females are not competent in math
and science. Also, changing behavior such as overt discrimination
patterns against women, is perhaps easier accomplished than chang-
ing prejudices and beliefs.

As Roe (1951) suggested in her study of eminent scientists listed
in *American Men (!) of Science*, the under-representation of women
in this area may be due less to direct social factors (e.g., the educa-
tional opportunities open for women in the sciences) than to personality
factors (e.g., lack of interest or self confidence in science). But
rather than viewing these personality characteristics as predomin-
antly innate, unalterable psychological attributes of the female, social
scientists are likely to give greater weight to their socio-cultural and
social-psychological development. But there is need for further
research on the origin and development of these sex-related social
psychological characteristics in females--that is, why aren't females
interested in science, or why don't they see themselves as capable
in science?

Unlike many career fields such as sales or elementary educa-
tion, the physical and natural sciences as well as mathematics and
engineering require commitment to and entry into specific courses of
study at a relatively early age. For example, graduate work in
physics requires having done considerable undergraduate work in the area, and this, in turn, generally necessitates having had adequate preparation in physics and mathematics in high school. The students must thus make an important decision in their high school years which will limit or expand their possible future career choices. Studies have indeed supported this—the average social scientist elects his or her career at the undergraduate level, the physical scientist generally does so during high school or earlier (Clark, 1957). Hence, campaigns to encourage college-age women to enter the sciences can only help those women already adequately prepared in mathematics and science at the secondary school level when these courses become optional electives. And national surveys have shown that females are much less likely to take elective high school math and science courses than males, particularly at the advanced levels (Erlick & LeBold, 1975). For this reason, this research centers on explaining why students may or may not have elected optional science courses in the 11th and 12th grades.

Research has also shown that interest in science is generally crystallized by the middle of the high school years and often much earlier, especially for boys (Tyler, 1964). Very few men and women move into the science fields at the college level; any movement is generally out of the sciences. Astin (1963), for example, found that of the students leaving college with science majors, 92% had entered
college as science majors, 6% had been uncommitted, and only 2% had begun college with other majors. Chambers (1964) found that scientific creativity in 12th grade students could be predicted in the 7th grade. Additionally, the National Assessment test found that the sexes were roughly equal in math and science at age 9, but by age 13, girls fell behind boys in both of these areas (Forbes, 1975). It therefore seemed fruitful to investigate whether there were significant sex-related differences in parental evaluations for students aged 12 or 13--about the 8th grade--which act as subtle and indirect barriers to female entry into later science courses.

Relatively little investigative work on science career development patterns has focused on or even included women or minorities (see Eiduson & Beckman, 1973). The vast majority of studies in this area have concerned themselves with the white male subject. Women in science were said to have different (labelled "deviant") career patterns and hence were excluded from analysis (Eiduson, 1973). And those studies which did focus on obstacles facing the prospective woman scientist, generally centered on women already committed to the sciences, for example, the college science major or the adult scientist (White, 1970; Perrucci, 1970; Rossi, 1965). There has yet been relatively little work on earlier familial, educational and societal constraints working against female entry into the sciences at the elementary and secondary school levels.
However, one sub-area of this topic which has only recently begun to receive attention from educators and social scientists is the concern with female entry into mathematics at the high school and college levels (Fox, 1976; Tobin, et al., 1976; Fennema, 1976; Sherman, 1976; Kaminski, 1975). Much of the research literature on impediments to females' mathematics development seems potentially applicable to females and science. For example, studies have shown that females tend to perceive lower parental evaluations of their mathematical ability than do males and that this was related to subsequent achievement and election of math courses (Kaminski, et al., 1976; Fennema & Sherman, 1977). This suggested that the research focus of this study would perhaps yield positive results and be of some value to the field.

Women and mathematics has perhaps been seen as a more central issue of focus than the more general science issue because mathematics is seen to have more widespread implications beyond a specific interest in a mathematics career. Adequate mathematics preparation at the high school level is prerequisite not only to entry into mathematics, but to entry into engineering and the natural sciences, and increasingly for advanced work in the behavioral sciences as well. Mathematical training is also useful/necessary for many academic and occupational aptitude and screening tests as college and graduate school entry tests and federal and state civil service tests, all of
which have considerable portions measuring one's quantitative skills and abstract reasoning skills. An individual's mathematical skills are also called upon for day-to-day functioning, i.e., balancing a checkbook, figuring taxes, price comparisons in shopping, etc. For these reasons, increasing the proportions of women and minorities taking elective high school courses is more than a matter of interest in a mathematics career; it is a matter of equality (Kaminski, et al, 1977b).

It would seem that for these reasons, researchers have given considerably more attention to investigating women's development in mathematics than to their development in the sciences. However, at this point in time, it could easily be argued that it would also be desirable to increase the proportions of students—and females and minorities in particular because of their under-representation—electing optional science courses in high school. The potential benefits from this emphasis on greater female involvement in science can be viewed from several value perspectives. It would certainly seem to be in the interest of society as a whole (e.g., increasing the number of possible scientists and the potential for scientific contributions to society) as well as for its value for women in particular (e.g., increasing women's career options, opening up higher paying/higher status jobs to women). Besides improving and enlarging the future potential pool of scientists, increasing the number of students/females
taking elective science courses has the potential for contributing to a more knowledgeable and scientifically aware future adult population of non-scientists. For example, in dealing with issues as energy conservation and environmental pollution, in maintaining one's technological conveniences, in dealing with an increasingly computerized society, a more scientifically informed citizenry seems desirable. Women in particular stand to benefit from improved investigative, mechanical, analytic and problem-solving skills (in which they have traditionally been weak) developed through science training and laboratory work.

Related Literature

Women in Science

This section focuses specifically on the actual representation of women in the sciences. The National Academy of Science (1974) states that 9% of the doctoral population of scientists and engineers in the U.S. are women, with a breakdown by field shown in Table 1.1. The Academy used a "maximum sort of criterion in defining the scientist--namely, a doctorate in the field. Using a broader definition, the U.S. Census Bureau used what might be seen as a "minimum"

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1For this discussion, "science" generally refers to the natural sciences, and also includes the related fields of engineering, mathematics and computer specialists. The social/behavioral sciences are generally not included because the career development pattern seems to differ for the social and the natural scientists.
criterion—they used individual self-reporting of occupation or self-
definitions. Table 1.2 presents these figures. By census definition, there is somewhat greater proportion of women in each field suggesting that the woman scientist tends to rank somewhat lower educationally than the male scientist. By either definition, however, Tables 1.1 and 1.2 show that except for the behavioral sciences where women comprise up to a quarter of the scientists, women comprise less than 15% of the natural scientists and less than 1% of the engineers—certainly an under-representation of women when compared with their proportions in the general labor force or the proportion of college degrees they earn.

TABLE 1.1 Percent of Doctoral Scientists/Engineers Who are Women by Field - 1973 (National Academy of Science)

<table>
<thead>
<tr>
<th>Field</th>
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<th>Percent</th>
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<tbody>
<tr>
<td>Engineering</td>
<td>.4</td>
<td>Mathematics</td>
<td>6.3</td>
</tr>
<tr>
<td>Physics</td>
<td>2.7</td>
<td>Social Sciences</td>
<td>10.9</td>
</tr>
<tr>
<td>Earth Sciences</td>
<td>2.7</td>
<td>Biological Sciences</td>
<td>11.8</td>
</tr>
<tr>
<td>Chemistry</td>
<td>5.6</td>
<td>Psychology</td>
<td>20.5</td>
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</tbody>
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TABLE 1.2 Percent of Scientists/Engineers Who are Women by Field 1974 (U.S. Census Bureau)

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<thead>
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<th>Field</th>
<th>Percent</th>
<th>Field</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers</td>
<td>.5</td>
<td>Life Scientists</td>
<td>13.2</td>
</tr>
<tr>
<td>Environmental Scientists</td>
<td>3.0</td>
<td>Mathematics Specialists</td>
<td>14.5</td>
</tr>
<tr>
<td>Physical Scientists</td>
<td>7.5</td>
<td>Social Scientists</td>
<td>21.0</td>
</tr>
<tr>
<td>Computer Specialists</td>
<td>12.5</td>
<td>Psychologists</td>
<td>28.1</td>
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Women in these traditional male professions also tend to be over-represented in the lower level specialties within the profession and are more likely than their male counterparts to be serving minority status clients, according to studies cited by Perrucci (1970). Women are also more likely than men to begin their science careers in a pre-professional capacity, to experience less career advancement, to have lower salaries, to hold lower levels of career responsibility and to be in fewer supervisory positions at the highest levels (Perrucci, 1970). The specialties which women tend to gravitate to are the types of jobs which require less investment in training and which have characteristics often associated with the feminine role in society such as deference, conscientiousness, obedience and working with people rather than things (Helson, 1974). For example, women are more likely to become math or science teachers, computer programmers or operators or research assistants, as opposed to entering careers as physicists, chemists, engineers, mathematicians, or statisticians. Women also tend to gravitate toward those science areas which are less mathematically oriented such as biology as opposed to physics.

Why this shortage of women? Looking to the immediate obstacles women face, there are many of the same barriers facing women in many areas of employment, for example, hiring and promotional practices attributed to female career patterns (e.g., interruption/termina-
tion because of marriage, children, or husband's geographical mobility). This "deviant" career pattern of women may be an even greater burden for the woman scientist. Rossi (1965) notes two barriers to women specific to science. First of all, a career in science makes heavy time and commitment demands with no provisions for the part-time scientist, making it even more difficult for women to combine a career with child-rearing. A definite choice of alternative priorities is often required for the woman/wife/mother. For example, a commitment to extra work required for advancement may be more difficult.

Secondly, Rossi and others (McClelland, 1962; Roe, 1951) note that the characteristics of actual scientists were often traits which tend to differentiate the male role from the female role in our society:

1. high intellectual ability, particularly spatial and mathematical aptitudes;

2. persistence in work and intense channelling of personal satisfaction into one's research;

3. independence--preference for working on one's own;

4. low interest in social activities (without accompanying guilt feelings); and

5. preference for working with things rather than people.

Many of these studies of actual scientists based their conclusions on samples of male scientists only. However, similar results have been found from related research on women scientists as well. One study,
for example, found that academic women psychologists tended to differ from adult women in general and from the average female college student in many of the same personality characteristics in which these psychologists resembled successful academic men. As a group these academic women were more intelligent, socially aloof, introspective, dominant, serious, adventuresome, flexible, unconventional, secure, independent, self-sufficient, self-assertive and enjoyed working alone (Bachtold & Werner, 1970). Helson (1971) likewise found that women mathematicians tended to be independent, flexible, introverted, serious, highly intelligent, and to have strong symbolic interest and strong ego involvement in their work. Similar characteristics of independence, stronger intellectual interests, and less traditional values also tended to differentiate between women choosing careers versus those choosing homemaking and between those choosing pioneering careers (e.g., science, law, architecture) versus those women in traditional careers (e.g., teaching, librarianship (Edwards, 1968; Rossi, 1964; Tangri, 1972).

These findings suggest that by adhering to the traditional sex role definitions, females' socialization might not adequately develop in them the personality characteristics necessary for a successful science career. Thus, research might look to the family for further investigation.

Women face other social obstacles to their advancement in
science. A scientist must keep up-to-date with the field, making career interruption detrimental to the female scientist's effectiveness. Women in science also experience a shortage of professional role models at all levels. Interaction and close ties with colleagues is important for both stimulation, praise and criticism of one's scientific work, as well as for acceptance and recognition by people whose professional opinions are relevant. Sponsorship (the protégé system), professional socialization and even informal signs of belonging and recognition may be denied to the woman scientist because the majority of colleagues and of her field are male (White, 1970).

Women scientists have also noted feeling a "climate of unexpectation" proving detrimental to their productivity—the problem not being one of competency but of recognition of competency (Epstein, 1972).

Bunting (1965) also notes the special difficulties women face in an ever-advancing, fast moving scientific profession where scientific knowledge is additive and where scientific success often depends on access to special equipment and colleagues. Because of many women's family responsibilities, their temporal and geographical career interruptions and their often limited choice of geographic location, they may be denied access to these resources, falling behind in their careers and their fields. A geographic move to follow her husband to an area with limited job opportunities in science may pose yet another problem for the woman scientist. Helson (1971) found that many of the married
women mathematicians in her study had married male mathematicians and had encountered nepotism problems in seeking employment.

One study of college graduates asked women themselves why they thought few women chose careers in medicine, engineering or the sciences (cited by Rossi, 1965). One of the most frequently cited reasons was the difficulty of combining such demanding professional work with home and child responsibilities. And indeed, women scientists and engineers are considerably less likely to be married, and much more likely to be childless than women in general or even compared to male scientists (Rossi, 1965; Perrucci, 1970).

An NORC study (Rossi, 1965) of college seniors found that males and females differed considerably on occupational values. Women rated job characteristics of "people-oriented" and "originality" highest, and "money" lowest--more characteristic of the humanities, education, the social sciences and many health professions. Men rated the job characteristics of "originality" and "money" highest, and "people-oriented" lowest--more characteristic of engineering and the natural sciences. Women also tend to prefer roles which bring vicarious rather than direct achievement satisfactions (Lipman-Blumen, 1975). This pattern would fit with women gravitating to service occupations as teaching or nursing rather than occupations like science, as it is currently stereotyped. It has been suggested that if the human-interest/service orientation of some scientific jobs
were emphasized to females by counselors, more women might be drawn to the sciences (Mead & Metraux, 1957; Fox, 1976).

In spite of not going into science careers themselves, women highly admire other women who do. An NORC study of college educated women found that the kind of success they most often desired for themselves was to be the mother of an accomplished child and the wife of a husband who becomes prominent. But the kind of success they were most likely to admire in other women was scientific or scholarly achievements and, secondly, literary or artistic achievements (cited by Rossi, 1964).

Women and Higher Education

In addition to these obstacles to women's entry and advancement in the sciences, there are also fewer women than men in science because the pool from which they are drawn has a shortage of women. For example, Bisconti and Astin (1973) estimate that 75% of the undergraduate science pool is male (even higher for engineering and the physical sciences), based on a nationwide tabulation. The picture looks even bleaker for the graduate science pool, where women receive even fewer degrees proportionally, as shown in Table 1.3. While women earned about half of all bachelor's degrees (46%), they earned only about a quarter of all doctoral degrees (23%). Compare these figures to the proportion of the natural science (and engineering) degrees which women earned in 1976--they earned about one-fifth of
the bachelor's degrees in natural sciences (22%), but only one-tenth of the doctoral degrees in these areas (11%). This certainly supports a conclusion that the science pool is predominantly male, particularly at the graduate level.

TABLE 1.3 Percent of Science/Engineering Degrees in Each Field which were Earned by Women in 1976 (National Center for Educational Statistics)

<table>
<thead>
<tr>
<th>Major Field</th>
<th>Bachelor's %</th>
<th>Master's %</th>
<th>Doctoral %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>19</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Computer Science</td>
<td>20</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>35</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>Mathematics</td>
<td>41</td>
<td>34</td>
<td>11</td>
</tr>
<tr>
<td>Math, Science &amp; Eng.</td>
<td>22</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>38</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>Psychology</td>
<td>54</td>
<td>47</td>
<td>32</td>
</tr>
<tr>
<td>All Behavioral Sciences</td>
<td>43</td>
<td>37</td>
<td>26</td>
</tr>
<tr>
<td>All College Curricula</td>
<td>46</td>
<td>46</td>
<td>23</td>
</tr>
</tbody>
</table>

Note that there is not the same deficit of women in the behavioral sciences to the extent seen in the natural sciences and engineering. In psychology and the social sciences, women were earning nearly half of the bachelor's degrees (43%)—similar to their proportionate share of all bachelor's degrees earned (46%). However, women still earned only a quarter (26%) of the doctoral degrees in the behavioral sciences. But even these figures represent quite a range as far as women's proportionate representation. Women tended to be more heavily repre-
sented in fields such as psychology and anthropology and less so in economics and political science.

And also, varying proportions of these women with science degrees, especially at the lower levels, reflect commitment to high school teaching as opposed to research and involvement in higher education, particularly in fields as mathematics and biology. Hence the pool of science talent shown in Table 1.3 may somewhat overestimate the proportion of potential women "scientists." However, the proportion of women earning degrees in the sciences at all levels has been increasing in the last decade.

The paucity of women in academic science programs does not seem to apply equally for all racial groups. Sell's (1976) study at Berkeley found that the percentages of each sex enrolled in the math and science curriculums for the three main racial groups there varied considerably as shown in Table 1.4. These findings were not suggesting genetic, racially-based cognitive differences. Rather, it would be hypothesized that these differences in family socialization practices and sub-cultural variations in the acceptance of women in various fields.

Looking at the percentage of the Asian-American women majoring in math or science, it is obvious that women can become interested in sciences. Nearly half of these women were science majors (45%) as compared to less than one-fifth (17%) of the Caucasian and Black
TABLE 1.4 Percent of Females and Males Enrolled in Mathematics and the Natural Sciences by Racial Group (1972)

<table>
<thead>
<tr>
<th>Racial Group</th>
<th>Percent Majoring in Math and Science</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian-Americans</td>
<td></td>
<td>45</td>
<td>68</td>
</tr>
<tr>
<td>Caucasians</td>
<td></td>
<td>17</td>
<td>41</td>
</tr>
<tr>
<td>Blacks</td>
<td></td>
<td>17</td>
<td>37</td>
</tr>
</tbody>
</table>

women. Two-thirds of the Asian-American males were science majors (68%) as compared with about two-fifths of the Caucasian and Black males (41% and 37% respectively). There were proportionately more Asian-American women than Caucasian men majoring in the sciences at Berkeley in 1972.

The paucity of graduate and undergraduate science degrees earned by women is in large part directly attributable to their own decision (in congruence with parents, teachers, counselors, etc.) of whether or not to pursue science careers. However, the higher admission standards for women, the academic quota systems in some curricula, the denial of loans, assistantships, and fellowships along with deterance from part-time study still exist, hindering women’s entry into the sciences in some curriculums, colleges and universities, particularly at the upper levels (Osen, 1974). But perhaps more critical than these obstacles is women's lack of adequate high school preparation in mathematics and science which is a prerequisite to their admission into science in college.
Sex Differences in Elementary and Secondary Students

In general, only a minority of all students take advanced science courses in high school. In a sample of suburban California high schools, Bridgham (1973) found that half of the students took chemistry and only a fifth took physics. Erlick and LeBold's (1975) national survey found that less than 30% and 15% of the students had taken chemistry and physics respectively. But females are considerably less likely to take these courses than males. In a survey of a national sample of teachers, Welch (1969) found that only 23% of their physics students were girls. In a more recent nationwide survey of high school students, a third of the boys and a quarter of the girls had taken chemistry; even fewer students took physics, with boys twice as likely to have taken it (15% and 8% of the boys and girls, respectively) (Erlick & LeBold, 1975). The proportions electing advanced high school math are similarly differentiated by sex. In a citywide sample of high school students, three times as many males as females took 12th grade math courses (Kaminski, 1975). And according to statewide statistics in Wisconsin, there were nearly twice as many males as females in that state enrolled in advanced high school math courses such as trigonometry, calculus, statistics and computer math (Fennema, 1976).

The research questions in this study, therefore, begin by assessing whether fewer girls than boys in this research sample have
taken advanced science elective courses in the 11th and 12th grades.

High school girls also appear less likely to participate in optional science programs. For instance, of the mathematically and scientifically precocious students studied, girls took less advantage of special educational opportunities such as skipping a grade, trying college courses, and enrolling in accelerated programs (Fox, 1974). Another study of high school students participating in a science honors program for gifted students found that less than a quarter were female (Hansen & Neujahr, 1973). And scientifically gifted females tend to lose interest or self-confidence in science during the middle school years (Astin, 1974).

Although some studies find that boys tend to have a greater overall science orientation than girls, particularly in the physical sciences (i.e., they like it better, they have a greater interest in it, they have more ambition to continue in science) (Shrigley, 1972; Meyer, 1970; Keeves & Read, 1974; Erlick & LeBold, 1975; Epstein & McPartland, 1977), other studies report no overall sex differences in science attitudes (Hofstein, et al., 1976; Novick & Dudvani, 1976; Ayers & Price, 1975). Graybill (1975) did find, however, that even when girls did take science classes, they were less likely than males to actually set up and manipulate the equipment for experiments—rather, they tended to be responsible for clean up.

There also have been some studies suggesting that females
perform less well in science than do males, particularly after the junior high school period. On the National Assessment of Education Progress tests, boys and girls did about equally well in science at age 9, but by age 13 girls fell behind, with the gap between the sexes increasing in adulthood (Forbes, 1975). However, if results from the biological and physical science sections of the tests are separated, there is only a sex difference for the physical sciences (Mullis, 1975). Suydam & Riedesel's review also concluded that "from junior high school and beyond . . . boys now surpass girls in studies involving science and mathematics" (1969:129 in Fennema, 1977). Hardin and Dede (1973) also note that it is in this junior high school period that girls' interest in science begins to wane. Forslund and Hull (1974) found that for upper elementary students, boys achieved at a significantly higher level in science than girls. Keeves' (1973) study of 14 year old and pre-university students in 10 countries found that in all instances boys out-performed girls in science (there was less difference between males and females in the U.S. than in most of the other countries). However, there was considerable variation between countries. Astin's (1974) study of precocious middle school students found that while 19% of the boys scored over 100 on the science test, only 3% of the girls had. Boys also tend to reach Piaget's formal operations stage earlier and are able to perform these tasks better than girls at the high school level (Graybill, 1975). High school
students themselves are also likely to see boys as better in science (47% said boys do better, 5% said girls do better) if they see one sex as superior (48% said "no difference") (Ernest, 1976).

A somewhat smaller number of studies would suggest that males are not necessarily superior in science performance. On the Piagetian tasks, for instance, Lawson (1975) notes that boys or girls will out-perform the opposite sex depending on certain aspects of the test situation (e.g., male vs. female examiner, subject vs. examiner manipulation of the object). In looking at high school students actually taking science courses, Bridgham (1972) found that compared to males, females tend to be graded more severely in science (i.e., compared to grades in other courses), especially in chemistry and physics. However, females actually received higher science grades than males, particularly in biology. And studies by Fritz and Szabo (1974) and Shrigley (1972) of junior high school students found no significant differences between males and females in science achievement.

The issue of sex differences in math ability has recently become a topic of considerable interest. It had long been held that overall, compared to girls, boys excel in mathematical ability (see Maccoby & Jacklin's review, 1974). This sex difference in math seemed to emerge at the junior high school level, however (Hilton & Berglund, 1974; Forbes, 1975; and see literature reviews by Maccoby, 1966 and Kaminski, 1975). More current reviews of the
literature on this have not drawn this same conclusion on ability differences. Fennema's (1974) review of more recent studies, for example, found little evidence that sex differences in math ability exist at the high school level. Further studies by Fennema and Sherman found that only in certain types of high school did such a difference appear—and this male superiority reflected only a 2-item difference on the tests (Fennema, 1977). They also 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" (Fox, 1976:1).

The problem then may not be one of female inferiority in mathematical aptitude, but rather of females' reluctance to elect optional math courses in high school. These findings may have some generalizability to science as well.

This would suggest that perhaps researchers should be more concerned with investigating and explaining sex differences in science course-taking in high school rather than in science achievement per se. This differential course-taking in high school was the focus of this study in which it was investigated whether parental evaluations were at least one contributing factor to this problem.
Social Class and Ability Influences

The research literature seems to suggest that there are social class and general ability differences between science and non-science students. In their national sample, Erlick and LeBold (1975) found that those high school students who were considering math/science/engineering careers were more likely to have well-educated fathers, and high academic achievement in general as compared with the non-science-learning students. James (1972) found that high academic achievement was one important variable in distinguishing between those college females interested in science and those who weren't. Other studies have found that both social class and IQ were related to elective course-taking in mathematics in high school (Kaminski, 1975).

Social class and general ability level seem to be more important to males' science behavior than females'. Bridgham (1972), for example, found that for males, the best predictor of whether the student would take physics was his father's occupational level and his average non-science grades; for females these were less important. Werts (1966) also reports that in a national sample of college freshmen, social class did affect career preferences, but this effect was not as clear-cut for women as for men. He suggested that this was in part the result of an additional way in which father's occupation may influence a child's career choice—that is, through father-model-
ing which was less applicable for females. Goodale and Hall (1973) also found that high school girls' career interests were much more independent of parental background (i.e., father's occupation) than boys' career interests. Fox (1976) also notes that father's profession did not appear to be related to achievement or course-taking in mathematics for girls.

Because these variables—social class and general ability—seem to have some impact upon science behavior, there were included in the analysis in this study. There was no reason to suspect that the males and females in this research sample would differ substantially with respect to these variables. However, the questions were posed as to whether social class and general ability had an impact on males' and females' science course taking levels and whether this impact differed for each. The literature would suggest that these variables are important for males, but probably less so for females.

**Parental Influence**

The social class of the family is only one way in which parents have input into their children's career decisions in science. There is much literature on other sources of direct and indirect parental influence. As Eiduson and Beckman ask in their volume on science as a career choice (1973:67):
Science is an intellectual profession which demands high achievement, and aspiration toward intellectual goals. Science demands originality, a questioning of authority, an eagerness to examine the "taken for granted." Thus it places a high premium on independence in thinking, autonomy, setting goals for oneself, and a willingness to work in isolation. What characteristics in a child's early environmental milieu, what attitudes and values espoused by the family, would predispose him to such activity?

There are, of course, other individuals besides parents who influence students in high school with respect to science. The impact of peers, teachers and counselors has been amply documented; likewise, there is evidence citing the impact of specific educational policies and practices (see Fox's 1976 review). However, the concern here was whether the family had influenced students' decisions to take science.

Parental influence can take a number of different forms. The impact of family social class, for example, was discussed above. Other familial variables and early socialization practices, as identification and modeling, independence training, sex-typed toys, free time activities, parental achievement expectations and parental encouragement have been shown to be related to sex differences in mathematics and science as well.

Looking at sex role identification and role modeling in the family, research has suggested that these processes may encourage the differential development of science-related skills in males and females. The feminine role in society (and mothers in particular)
have traditionally been more verbal, while the masculine role (and fathers) have been more quantitative—consequently, in role learning through modeling in same-sex parent, different cognitive skills are developed (Milton, 1957; Aiken, 1976). Carrying this a step further, Bieri's (1960) study of undergraduate women and Plank and Plank's (1954) study of the autobiographies of outstanding women mathematicians found that analytical ability was strongly associated with a high level of identification with, and a strong attachment to, fathers rather than mothers. However, in a separate study of women mathematicians, Helson (1971) found that these women had mothers with strong intellects, which suggests that perhaps the mother may have some influence as well.

Lynn (1972) also tied sex-role identification to differential mathematical ability. Girls develop memorization skills in their sex-role learning process because the female model (mother) is generally present and directly involved in the early development years from which the female may memorize her appropriate role. Boys, instead, develop better problem-solving skills through their sex-role development since the male model (father) is generally absent during much of this development stage, leaving the male child to solve the male role "problem" from largely negative admonishments where he must restructure these and define the masculine role as his goal. Thus, the sexes develop different mathematical skills.
Kleinman (1968) notes that the father serves as a masculine model of independence and persistence; the mother serves as a feminine model of compliance. Boys are thus more likely to develop independence through modeling. Females are also less independent than males as a direct result of less parental encouragement in early strivings for independence (Hoffman, 1972). The need to experience independence and to pursue one's own way have been found to be important in the formative experiences for scientists (Nichols, 1964). And as the literature in a previous section has shown, independence is a major characteristic of both scientists and science majors (males and females alike) (Roe, 1951; Rossi, 1964).

A particular type of dependence which is more often found in females than males is called field dependence or a global cognitive style (as opposed to field independence or an analytical cognitive style) (Maccoby, 1963). The global style of thinking is less appropriate to scientific work. For example, the field dependent person is likely to be less theoretical, less persevering, more likely to accept external authority, more tolerant of ambiguity, and to be less competent at observing, comparing, classifying, quantifying, measuring, experimenting, inferring and predicting. That person is also more likely to have difficulty in learning in unstructured learning situations and in initiating and carrying out investigations (Walters & Sieben, 1974). This difference in cognitive styles, often reflecting

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a male-female role difference, has been attributed to early socialization practices in the family. As Rossi (1964:115-116) notes:

... what is known is that the key to the difference between boys and girls lies in the kind and degree in independence training the child receives in childhood. If a girl is encouraged to assume initiative, to solve problems for herself, she tends to develop the same analytic abilities as the boy typically does.

Looking at other early familial socialization practices, in their review of the literature on sex differences Maccoby and Jackin (1974) report evidence that parents encourage sex-typed interests by providing children with sex-typed toys. Boys, for example, are much more likely to be given mechanical and scientific toys and books which not only helps foster an interest in science, but also encourages their development of manipulative, mechanical and investigative skills important to science (Hardin & Dede, 1973). For example, by mid-elementary school, girls, unlike boys, have been conditioned to accept toys as they are and not attempt to manipulate or change them (Hardin & Dede, 1973). Parents are also more likely to notice and to foster mathematical and scientific precocity in their sons than their daughters (Astin, 1974). Helson's (1971) work suggests that this may be a cultural factor. In her study of women scientists, she found that many had grown up outside the U.S. or had one European parent. She suggests that perhaps these women were able to avoid some of the anti-intellectual influence females face growing up in
the mainstream of American culture because of cultural family differences. Bing (1963) notes that early interaction with the physical rather than the interpersonal environment also provides greater freedom to experiment, somewhat mirroring male-female socialization differences. And although schools generally provide a more passive experience valuing submissiveness rather than direct manipulation, boys are better able to survive this than girls with respect to their development of problem-solving abilities because of their contrasting out-of-school experiences in problem solving which girls seem to experience less of (Graybill, 1975).

Science students seem to have spent much of their free time outside of school involved in science related activities, particularly in the home. Keating and Stanley's (1972) work with junior high students exceptionally gifted in math and science found that to do well in these areas, the student must have done considerable work on his or her own. Fox (1974) also found that these precocious students' extra learning through independent study was often under the guidance of parents. But they suggest that girls in our culture are not normally encouraged to spend their spare time engaged in scientific pursuits. Hansen and Neujahr's (1973) study of gifted high school science students found that while three-fourths of the males had science-related hobbies, only one-third of the females did. Ayers and Price's (1975) study of low social class, upper elementary
students also found that males were much more likely than females to do science experiments at home. Parents no doubt play a large early role in discouraging this in girls, both overtly and subtly. At home, girls are more encouraged to cultivate popularity and are discouraged from such solitary pursuits (Kleinman, 1968). Parents are more likely to see social popularity as important for daughters than sons (Rossi, 1964).

In relation to this, a number of studies have found that parents hold higher achievement expectations for males than females, and boys tend to perceive more parental academic achievement pressure than did girls (Baumrind, 1972; Aberle & Naegle, 1952). Parents also hold lower educational aspirations for daughters than sons (Levine, 1976; Casserly, 1975). High school girls perceive less parental support, interest and pressure than boys with respect to their educational activities and career plans even when matched on future educational and occupational plans and aspirations (Goodale & Hall, 1973). Parents of boys were more likely to emphasize achievement and competition, girls' parents were more likely to emphasize interpersonal relationships and protection (Blcok, 1973).

There is also a good deal of literature supporting the idea that boys receive more parental encouragement and support in science and math than girls do. Astin's (1974) work with gifted high school students found that girls received less encouragement at home to
consider scientific pursuits. There was also less discussion with
daughters about future careers and when parents did discuss it, they
often focused on the traditional female occupations. Fox (1974)
reports that few of these scientifically precocious girls were encour-
aged to accelerate in their math education or to seek extra aids such
as math books as compared to the boys. Parents were also more
likely to accept lower levels of math achievement for females than
for males (Levine, 1976). Poor math grades for boys were attrib-
uted to his being lazy—for the girls who earned poor math grades,
75% of their mothers accepted this as inevitable because of their own
lack of math ability. In her study of gifted students, Fox (1976) noted
that the boys were more likely to perceive parents as favorable to
their taking advanced mathematics. Poffenberger and Norton's
(1963) study of college students found that parents' achievement
expectations in college algebra were higher for males than females.
Brookover and Gottlieb (1964) likewise noted that differences in
expectations for males and females as students in mathematics are
widely recognized.

It is also widely noted that females are generally more sug-
gestible, more conforming, and more dependent on the opinions of
others. This suggests the importance of parental expectations for
females' academic behavior. Having lower parental expectations of
one's science ability would then be even more detrimental to females.
Patel and Gordon (1960) found high school girls to be more suggestible than boys and particularly responsive to higher prestige persons. Sears (1963) found that females' desire for social approval motivated their achievement efforts. Crandall, et al. (1962) also found that achievement and "approval-seeking" from adults were related for girls, but not for boys. Boys were less susceptible to adult influence than girls were. Johnson (1970) noted that when a child has a need for social approval from adults, expectations will have a more powerful influence on his or her self attitudes. From this one might suspect that the relationship between perceived parental evaluations of science ability and taking advanced science courses would be stronger for females than for males. This was investigated in this study.

The importance of parental expectations and encouragement is also suggested by the following studies of women scientists. Roe and Siegleman's (1964) study of college seniors and adults in engineering and social work supported their hypothesis that the further the occupational choice was from the cultural sex role stereotype, the more likely it was that there had been particular pressures in the person's early history that influenced such a choice. Cartwright's (1972) study of women in medicine found that "encouragement from others" was the most frequently mentioned factor in their career decision. Ruina's (1973) study of women in science and technical
careers found that in most cases these women reported having received encouragement from some male figure in their past. And parents were generally one of the main sources of this early encouragement. Retrospectively, adult women scientists reported that fathers were a strong source of encouragement for their career choice (Rossi, 1965). Females interested in math or science report being discouraged more by their mothers than their fathers (Rossi, 1965).

Parental evaluations and encouragement have been demonstrated as being important to future attitudes, achievement and course-taking in the sciences. In a study of 12th grade students, Tamir, et al. (1974) found that students suggested that one major reason why few girls elect physics and math courses is that parents don't want their daughters to be physicists. Hasan (1975) found that an important variable differentiating between females with high interest and low interest in science in the 11th grade was whether parents desired a science career for their daughters. James' (1972) study of college students found that any prestige effects which tended to attract people to science careers was cancelled out by negative social pressure for females (but much less so for males). Haven (1972) found that those girls who took advanced high school math courses were those who received encouragement from parents, and other significant others. Kaminski, et al. (1976) likewise found that
parental evaluations of the student's math ability which the students perceived were related to future course-taking in math in the 12th grade. Sells (1973) also found that social support from parents, teachers and peers was positively related to pursuit of advanced high school mathematics courses and with the student's performance in them. Alpert, et al. (1963) found that students' attitudes toward mathematics were related to their parents' expectations and attitudes toward mathematics. Aiken and Dreger (1961) found that parents' emphasis and encouragement in mathematics was slightly more significant for females' attitudes toward mathematics than for males. Fennema and Sherman found that sex differences in student perceptions of their mother's and their father's evaluations of their math ability appeared to be related to sex differences in math achievement and intent to take advanced high school math courses (Fennema & Sherman, 1977; Sherman & Fennema, 1977).

In conclusion, then, it would appear that there are many factors in the American family working against females' science career development. Families do seem to have considerable influence on daughters but it appears to be negative rather than positive with respect to science. As Rossi (1964:122) notes:

A young girl with high intelligence and scientific interests must come from a very special family situation and must be a far more rare person than the young boy of high intelligence and scientific interests. If she reaches adolescence with the same intellectual inclination, it is often
despite her early family experiences rather than because of them.

The above literature suggests that the expectations and evaluations of parents are an important factor in students' science development in high school. This study investigated the nature of this influence. In particular, how much did parental evaluations of the students' science ability contribute to explaining their decisions to elect optional science courses in the 11th and 12th grades? And since the literature suggests that females have lower participation rates in these courses, this research examined whether they also tended to perceive lower parental evaluations of their science ability than males. Comparisons were also made as to the relative contributions of parental evaluations, ability and social class to the students' decisions to elect science.

Self-Concept

The theoretical perspective used here would suggest that parental evaluations influence the student's decision to take science in part through their impact on the student's self-concept of ability. The relevant literature on this is discussed below. The research does seem to give support to this perspective.

1 Self-concept has come to have a number of differing meanings. It is used here to refer to role specific self-evaluations (e.g., for general academic ability, or science ability) rather than as a self-esteem measure.
The relationship between the evaluations of important others and one's self-concept has been widely supported by the literature (Johnson, 1970). For instance, Helper (1960) found that children's self-evaluations reflected their parents' evaluations of them, particularly the mothers'. Brookover, et al. (1967) found a significant relationship between students' perceptions of their parents' evaluations and their self-concepts of academic ability in a study involving 7th through 12th grade students. It has also been found that the evaluations which students thought their parents held for their math and science abilities was related to these students' self-concepts of their math and science abilities (Kaminski, et al., 1977a, 1978; Fish, et al., 1977).

Research has consistently shown the importance of one's self-concept for academic decisions. For example, students' self-concepts of their general academic ability are positively related to their future academic achievement (Brookover, et al., 1962, 1965, 1967). Studies have also recognized the importance of both one's academic self-concept and one's specific self-conception of mathematical ability for student's mathematics achievement and future math course-taking (Koch, 1972; Bachman, 1970; Fennema, 1976; Brookover, et al., 1962; Kaminski, 1975). It has also been found that students' self evaluations of their science ability differentiated between those students with high versus low interest in science at both the high
school and college levels (Hasan, 1975; James, 1972). Carey (1955) found that college women's problem solving ability could be improved through group discussions aimed at improving confidence in their ability at the task; this was not true for males. In her study of women mathematicians, Luchins (1976) found that most reported being initially attracted to mathematics because they felt they were good at it.

With respect to sex differences, Wylie (1968) notes several studies which found that females had lower self-concepts of their academic ability, even though they were equal or superior to a comparable male group on academic aptitude tests. Other studies also find that girls are likely to underestimate their intellectual abilities, while boys' estimates are often higher than warranted (Sontag, et al., 1958; and Maccoby & Jacklin's 1974 review). In mathematics, boys are more likely to attribute poor test performance or poor grades to not having worked hard enough while girls are likely to see it as a result of their own lack of ability (Dornbusch, 1974). Success, on the other hand, is more likely to be attributed to luck by females, but to their own skills and abilities by males (Deaux, 1976). The Fennema-Sherman (1977) study of students in grades 6 to 12 found that boys were consistently more confident of their abilities to deal with mathematics than the girls were in spite of equivalence in past math achievement. For science in particular, Smith (1974) found
that females' lack of confidence served as an important barrier to their selection of science as a career choice.

In a nationwide survey of high school students, a number of sex and race differences were found in the proportions of students who had high self assessments of specific science-related abilities, as shown in Table 1.5 (Erlick & LeBold, 1975). It would be hypothesized that these differences would be attributable to socio-cultural factors such as variations in social class and socialization practices, for example. For all of these science-related abilities, males rated themselves higher than females, and whites rated themselves higher than Blacks. Those 10th, 11th and 12th grade students who were even somewhat considering science, math or engineering careers (59% of the males, 41% of the females) reported above average assessments in all of these and other categories (e.g., academic ability, drive to achieve). Of those interested in science, females were most likely to prefer medical or biological sciences (nursing and teaching, perhaps) and males were three times more likely than females to prefer future employment in engineering, the physical sciences, math or architecture.

Thus the literature seems to suggest that the parental evaluations of the student's science ability may have an indirect effect on completing science courses through their impact on the student's self-concept of science ability. This research investigated and compared
TABLE 1.5 Percent of Students with Above Average Self-Concepts by Sex and Race

<table>
<thead>
<tr>
<th>Self-Concept of Specific Abilities</th>
<th>Percent with Above Average Self-Concepts</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>Mechanical Ability</td>
<td>7</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>Science Ability</td>
<td>14</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>24</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>Mathematics Ability</td>
<td>29</td>
<td>19</td>
<td>35</td>
</tr>
</tbody>
</table>

this indirect path of influence through self-concept with the direct influence of evaluations on taking science. Literature previously discussed found that females were less likely to take advanced science courses. Since self-concept appears to have an impact on these academic decisions according to the above literature, did females also have lower self-concepts of their science ability than males? This question was also examined in this study. The above literature suggests a positive answer. The relationship of parental evaluations, self-concept and course-taking was also examined for males and females separately.

Theoretical Orientation

The general theoretical orientation guiding this research was the symbolic interactionist perspective stemming from George Herbert Mead. In this perspective, the concepts of significant others,
expectations, and self-concept play an important role with respect to subsequent behavior. In this study, parents were the significant others of concern. Their evaluations of their children's science ability (from student perceptions) were the expectations which were assessed. The impact of these evaluations on the specific behavior of "electing advanced optional science courses in high school" was the point of focus. And the particular aspect of the intervening variable "self" was the student's self-concepts of science ability.

Through a continuing socialization process, individuals come to see and evaluate themselves and their abilities as others do. But the responses and assessments of all others do not have equal impact. Certain persons and their feedback are naturally more important and relevant to the individuals and their self-assessments. These important others are generally referred to as significant others.

The literature has suggested that parents, teachers and peers tend to be influential significant others for students at the secondary school level (Fox, 1976; Brookover & Erickson, 1975). However, the relative importance of these and other persons may vary with the situation or decision in question. The research of Coleman and others conclude that at the secondary school level, students' age-grade peers are the dominating source of influence on adolescents and it is their norms and expectations which control the academic behavior of adolescents. Other research, as that of Brookover, et al.
(1967), found that high school students were much more likely to identify parents as being their most central significant others with respect to academic activities. Parents also tended to be named as significant others with respect to adolescent-oriented activities (as clothing, or musical interests), but age-grade friends were somewhat more likely to be mentioned in this regard. In Brookover's study, the relative impact of parents', teachers' and friends' evaluations on the students' self-conceptions of their academic ability were compared and parental evaluations were found to have greater impact up to the 10th grade, the evaluations of friends were somewhat more important in the 12th grade. At all levels, parents were more influential than teachers. But the evaluations of all three groups did have some impact which was often shared.

This study, however, was interested in the impact of the family on students' academic decisions. The concern was not on comparing the relative influence of various significant others on students' election of science courses. Rather, the question was whether parents affect students' science course-taking decisions. Discussion of these other significant others is brought up here only to point out that parental evaluations should not totally account for the variance in student decision-making because of possible competing influences.

An important category of academic expectations held for
students is the evaluation of their academic ability. The various significant others form evaluations of the student's ability to learn particular kinds of behavior. Parents, for example, may hold different evaluations of their child's reading and science abilities, which in turn may both differ from teachers' evaluations of the student's reading and science abilities.

Through interaction with parents, teachers, peers and others, the student comes to learn the various evaluations which these others hold of his or her ability to learn specific subjects. The student's perceptions of these evaluations will tend to reflect the actual evaluations which parents, teachers and peers hold. Brookover and Erickson (1975) note that there is evidence showing a high correlation between perceived and actual evaluations. Where discrepant, however, individuals are likely to behave in terms of their perceptions of others' assessments rather than in terms of their actual assessments. For this reason, this study focused on the perceived parental evaluations of the student's science ability as having a more direct impact on subsequent student behavior.

According to the symbolic interactionist approach, one way in which the expectations of others influence a person's behavior is through their impact on the individual's self-concept. From this theoretical perspective, individuals come to evaluate themselves as they think others evaluate them, through the process of taking the
role of others, responding to one's self from their perspective and seeing one's self as an object. For example, the female student comes to evaluate her science ability in part by taking the role of her parents and assessing her science ability as she thinks her parents would. Thus, students' self-concepts of their science ability are in part a function of their perception of their parents' evaluations of their science ability.

The individual's self-concept will in turn affect his or her behavior and decision-making. People are more likely to attempt tasks they feel they will be somewhat successful at. For example, students with high self-concepts of their science ability would be more likely to decide to take elective courses in science. This, of course, is not the only factor entering into the decision-making process. A person may feel competent to carry out a particular act yet decide not to attempt it because it is seen as inappropriate, because of competing tasks or because of insufficient intrinsic or instrumental value attached to carrying out the act (see Brookover & Erickson's (1975) discussion of self-conceptualizing behavior). However, self-concept is certainly a major input into the decision-making process. It is generally a threshold variable in that it is a necessary but not sufficient condition for attempting certain behaviors. For example, students must believe they can be somewhat successful in science before they decide to take elective courses in science. But,
just because they are confident of relative success in science does not mean that they will necessarily take science.¹

The theoretical perspective relating the variables self-concept, expectations and behavior has been formalized by Kinch (1963). He states the following propositions:

1. The individual's self-concept is based on his perception of the way others are responding to him.
2. The individual's self-concept functions to direct his behavior.
3. The individual's perception of the responses of others toward him reflects the actual responses of others toward him.
4. The way the individual perceives the responses of others toward him will influence his behavior.
5. The actual responses of others to the individual will determine the way he sees himself (his self-concept).
6. The actual response of others toward the individual will affect the behavior of the individual.

These propositions dictate the following model:

¹See Brookover & Erickson (1975) for further discussion of the above ideas.
This study focused on propositions 1, 2 and 4. In particular:

Perceived Parental Evaluations of Science Ability

→

Self-Concept of Science Ability

→

The Election of an Advanced Optional Science Course
The data used in this research was from a longitudinal study conducted by Brookover and associates (1962, 1965, 1967) carried on during the academic years 1960-61 through 1965-66—the student years for the current adult cohort this study was attempting to explain. Each year questionnaires were administered and school records obtained for the entire "class" of students as they moved from 7th grade through the 12th grade. The students originally attended four junior high schools in a city with a population of approximately 110,000. These four schools then fed into three senior high schools.

This study used the 8th, 11th and 12th grade data which included 385 females and 299 males. Certain of the total number of students were not able to be included in this data, such as those on whom complete data was not available, those who were not regularly promoted and those in special education programs. Because of the longitudinal nature of the study, any students who moved into or out of the school system were also excluded. Because this was an urban school system, possibly more students from the highest and lowest social classes
were excluded due to a higher tendency to be mobile than other students. On the other hand, school dropouts would also have been excluded who might tend to have been from a lower social class. The exclusion of dropouts may also tend to raise the average IQ since lower IQ students may be more likely to leave school. Whether the "complete data available" restriction of this research biases the present study is difficult to accurately determine. However, the theory does not restrict itself to any given sub-population. These restrictions, then, are probably not of sufficient magnitude so as to invalidate this research.

There are some drawbacks to using secondary data. The type of information which was gathered was geared to the specific questions and hypotheses with which the original study was concerned. But because of the range of information collected, it was possible to obtain the necessary data. However, had data been collected specifically for this study, some of the more general academic questions would have been directed more specifically towards science. Also, more questions would have been directed at parental variables with respect to science.

The 8th grade data was collected in the 1961-62 school year, which is now 16 years old. The age of this information actually makes it more valuable in many respects. The data relevantly describes characteristics of the high school experience of today's 30
year olds, the young adult population for which generalizations were sought in this study. Analysis of this early 1960's data can also serve as a baseline for comparisons with analysis of more recent data offering a general indication of whether current efforts at eliminating sexism have had successful impact in this regard. Furthermore, while differing historically from today's 8th grade students, the theoretical relationship of the variables remains virtually unchanged. The theoretical perspective relating perceived evaluations, self-concept of academic ability and academic behavior remains as applicable then as now. Through studying these high school characteristics of today's young adults, further light may be shed on why women in general are stereotyped as being inferior to men in the area of science.

The selection of grades 8, 11 and 12 in which to measure the variables does have certain advantages. The 11th and 12 grades were selected for measuring the variable "election of a science course" because it is at these levels that science courses become optional. The literature previously discussed also suggests that it is for these types of courses (i.e., generally chemistry and physics) that there begins such a discrepancy between male and female participation rates. The selection of a science course in the 11th or 12th grade also served as an indicator of which students were still interested and able to enter science careers because they have had the
necessary pre-requisites for college work in these areas. This 11th and 12th grade variable was obviously not a perfect measure of potential future scientists since future biologists may have had the necessary pre-requisite biology course at an earlier level (generally the 10th grade). However, biology is a required course in most cases so was not included in this analysis. Use of only the last two years in high school in which to measure the dependent variable should be adequate for answering the questions posed in this research.

The 8th grade was selected in which to measure the predictor variables for a number of reasons. As previously noted, studies have shown that interest and commitment to a science career has usually been crystalized by or during the high school years (Tyler, 1964). Astin (1974) also found a considerable drop between the 7th and 8th grades in the proportion of girls opting to take special science tests for the gifted. And the National Assessment tests found that although boys and girls were about equal in math and science ability and performance in elementary school, by the 8th grade boys were ahead of girls in math and science (Forbes, 1975). Lawson's (1975) conclusion from a review of sex differences on Piagetian tasks suggests that if adolescent males are superior, it must begin during the junior high years. There is also a great deal of related supporting literature on sex differences in various math-related skills (e.g., spatial ability) which suggests that when differ-
ences between the sexes appear, it will usually begin in this early adolescent, junior high school period (Forbes, 1975; Maccoby, 1966; Hilton & Berglund, 1974). Thus, the 8th grade was selected in which to measure parental science evaluations because it would appear that by this age girls have already begun to be "cooled out" from a science career path.

Additionally, students at this age and grade in school are facing many relevant inter-related changes in themselves and their lives: psychological and emotional changes associated with puberty; cognitive changes as noted by Piaget (reaching the formal operational stage); social-educational changes related to the move away from one teacher/self-contained classroom situation; psychological changes associated with reaching the adolescent stage as noted by Erickson (with the development of an ego identity); greater differentiation of the students' self-conceptions of their academic abilities in different areas (Brookover, 1967); increased awareness of and a sharper definition of sex roles and their appropriate sex-typed behavior (as defined by our culture); and a new-found focus on their potential adult role along with the need for establishing a vocational goal. Hence, by beginning the analysis on this cohort of students in the 8th grade, it is possible to study them just upon entry into adolescence.

There are, of course, empirical and theoretical difficulties in relating data measured four years apart. In effect, four years of
intervening variables have occurred which makes prediction that much more difficult. These 9th through 12th grade variables certainly would affect a student's decision-making in the 11th and 12th grade. For this reason, this study may expect to statistically explain less of the variance in the variable, "completion of an advanced science course" than might be accomplished by using all of the intervening variables. As a consequence, this study conducted a very conservative test of the hypothesized relationships between 8th grade evaluations and 11th and 12th grade entry into science.

The Variables

The data for each student was obtained from both a questionnaire administered in the fall of the 8th grade, and the student's school records. The six variables which will be used are as follows:

Sex: Of the 684 students included in this study, 385 were female and 299 were male. Since this variable was coded "O" for males and "1" for females, negative path weights from this variable in the path analysis model would be interpreted as "negative" from the female perspective.

General Ability Level (IQ): This ability measure was obtained from the student's school records as an average of fourth and sixth grade IQ scores. This was the most current IQ score available prior to the administration of the questionnaires in the 8th grade.
**Social Class:** The social class variable was obtained from the student's 8th grade school records based on the occupation of the student's father, or whoever was supporting the family. The Duncan Occupational Prestige Scale (Duncan, 1961) was used where values ranged from 1 to 99 (lowest to highest).

**Perceived Parental Evaluations of Science Ability:** This variable was the student perception of his or her parents' evaluations measured by the student's response to the question: "How do you think your parents would rate your ability in science compared to other students your age?" Scores range from 5 ("among the best") to 1 ("among the poorest"). This variable was measured in the 8th grade.

**Self-Concept of Science Ability:** This score was operationally defined as the sum of the scored responses to the 8-item Michigan State University Self Concept of Ability in Specific Subjects Scale (in Science)--see Appendix A. Each item was scored from 1 through 5 giving a total possible range from 8 to 40 (lowest to highest). This variable was also taken from the student questionnaires from the 8th grade.

**Election of Advanced Optional Science Course:** This was the dependent variable which indicates whether the student selected a course in science in the 11th or 12th grades. It was coded in dummy variable fashion, "1" for those who did take science in
either grade, "O" for those who did not for the path analysis.

The Research Questions and Analysis

The research questions addressed in this study focused on two related major concerns: sex differences in science and the role of parents in students' science development. Tying these together, the overall issue was whether fewer females elected optional science courses in the 11th and 12th grades at least in part because, during their earlier middle school years, females began to perceive lower parental evaluations of their science ability than male students did. In dealing with this issue, this study examined data relevant to the following specific research questions. The method of analysis appropriate to each question is also provided.

Research Question 1: Do fewer females than males take advanced elective science courses in high school?

Research Method 1: To answer this question, the percentages of each sex who selected science courses in the 11th or the 12th grades were compared using the two-sample test for proportions (see Loether & McTavish, 1974b:189-192). A one-tailed significance test was used because prior research, as discussed in the first chapter, suggested that males are more likely to take science than females (see Loether & McTavish, 1974b:141-142). Likewise, subsequent research questions will also be addressed using one-tailed significance tests based on prior research findings. See Table 3.1.
Research Question 2: Do fewer females than males take advanced elective science courses in high school at each of three general ability levels?

Research Method 2: Here the percentages of males and females who selected an advanced science course were compared (as in Question 1) for each of three ability levels. The IQ groupings (lowest, middle, and highest) were based on relative division points with each group being approximately a third of the class of students. Therefore students in the "lowest" IQ group were not necessarily all "low IQ" students in the traditional sense, but rather they were "low IQ" students relatively speaking. See Table 3.1.

Research Question 3: Do fewer females than males take advanced elective science courses in high school at each of three social class levels?

Research Method 3: For this question, the above method (in Question 1) for comparing proportions was again used for three general social class levels. The social class groupings used here were based on relative division points with each group being approximately one-third of the students. These groups did not necessarily correspond to lower, middle and upper classes in the traditional sense. See Table 3.2.

Research Question 4: Is general ability level (as measured by intelligence tests) positively related to taking advanced elective science courses in high school for males and females?
Research Method 4: In this case, male and female samples were analyzed separately. The proportions who elected advanced science courses at the three general ability levels were compared (as in Question 1) testing whether a greater percentage of the highest ability students selected science as compared to the middle group, and for the middle group as compared to the lowest group. See Table 3.1.

Research Question 5: Is social class level positively related to taking advanced elective science courses in high school for males and females?

Research Method 5: For this question, male and female samples were analyzed separately. The proportions who elected science courses at the three social class levels were compared (as in Question 4) testing whether a greater percentage of the highest social class students selected science as compared to the middle group, and for the middle group as compared to the lowest group. See Table 3.2.

Research Question 6: Are parents' evaluations of students' science ability (as perceived by their children in the 8th grade) positively related to their taking advanced elective science courses in high school for males and females?

Research Method 6: Here again, males and females were treated separately. Comparisons were made between the proportions who elected advanced science courses for consecutive groups (as in Question 4)--the proportion of highest evaluation students who elected
science was compared to that of the average and below group. (The response categories of "Below Average" and "Among the Poorest" were combined with the "Average" response category because of low N's for these responses.) See Table 3.3.

Research Question 7: Are students' self-concepts of their science ability in the 8th grade positively related to their taking advanced elective science courses in high school for males and females?

Research Method 7: As for the above question, male and female samples were analyzed separately. The percentages of students who elected optional science courses for each of the three self-concept groupings were compared (as in Question 4), testing whether a greater proportion of the high self-concept students elected science as compared to the middle group and for the middle self-concept group as compared to the lowest group. The self-concept groupings used in the analyses here were based on the following cutting points: "High" = 33-40 (i.e., one to eight of the responses on the 8-item scale were in the top category), "Above Average" = 25-32 (i.e., one to eight of the responses on the 8-item scale were in the above average category), and "Average and Below" = 08-24 (all of the responses on the 8-item scale were in the average or below categories). See Table 3.7.

Research Question 8: Do females in the junior high school years perceive lower parental evaluations of their science ability than do males?
Research Method 8: In addressing this question, two types of analysis were used. First, the average science evaluations for males and females were compared with the two-sample test for means (see Loether & McTavish, 1974b:169-176). Secondly, the two-sample test for proportions was used (see Question 1) to compare the proportion of each sex who perceived high evaluations of their science ability from parents (those in the response category, 'Among the Best').

See Tables 3.4 and 3.5.

Research Question 9: Do females in the junior high school years have lower self-concepts of their science ability than do males?

Research Method 9: Here again, two analysis were employed. A two-sample significance test comparing the male and female averages for self-concept was used (as in Question 8). Secondly a significance test for comparing the proportions of males and females at the high self-concept level was employed. The self-concept groupings used were the same as those described for Question 7. See Tables 3.5 and 3.6.

Research Question 10: Is the relationship between parents' evaluations of their children's science ability (as perceived by their children in the 8th grade) and whether their children take science in high school indirect, in that perceived parental evaluations affect self-conceptions which in turn affect entry into science courses in high school?

Research Method 10: This question was addressed by examining
a simple path model\textsuperscript{1} for the three variables in question and testing
the significance of the path weights among these three variables.
Comparisons were also made between the direct and indirect paths
between parental evaluations and the variable "election of a science
course." See Figure 3.1.

Research Question 11: What are the direct and indirect effects
of the variable sex on taking science
through any influence on parental and
self evaluations of science ability with
controls for social class and ability?

Research Method 11: To address this question a path model was
examined which included the variables sex, general ability level,
social class, perceived parental evaluations of science ability, self-
concept of science ability and entry into advanced science courses.
In particular, the four paths between sex and entry into science were
described and compared, i.e., the direct path, and the three indirect
paths through parental evaluations and self-concept. See Figure 3.2.

Research Question 12: What are the relative impacts of sex,
general ability level, social class, per-
ceived parental evaluations of science
ability and self-concept of science ability
on explaining students' entry into elective science courses in high school?

Research Method 12: This question was addressed using Goodman's
log-linear analysis\textsuperscript{2} of the multidimensional contingency table of these

\textsuperscript{1}See Appendix B for further description of path analysis.

\textsuperscript{2}See Appendix C for further explanation of the contingency table
analysis technique.
variables (for ease in handling and interpretation, variables were all dichotomized). See Table 3.8. Various models were tested until the best model was found. The gamma parameters of this model were then examined as to the relative importance of each variable and interaction effect for explaining science entry in high school. See Table 3.9. It was then shown how the gamma parameters could be used to estimate the expected odds ratios for each category of students. The specific expected odds ratios are also presented for comparison with the actual observed odds shown in Table 3.8. See Table 3.10.

**Research Question 13:** Do males and females differ with respect to the relative impact of general ability level, social class, perceived parental evaluations of science ability and self-concept of science ability in the 8th grade on whether they later take advanced elective science courses in high school?

**Research Method 13:** For this question, two types of analysis were employed. First of all, separate path models for males and females were examined, described and compared as to the relative impacts of these variables on whether students elected optional science courses in high school. See Figures 3.3 and 3.4. Secondly, the contingency table analysis procedure (used for Question 12) was employed for male and female samples. Here, $X^2$ tests were used to determine the most appropriate model for each separately. These two models and their gamma parameters were then compared as to
the relative impact of general ability level, social class, perceived parental evaluations of science ability, self-concept of science ability and their interaction effects on the likelihood of entry into elective science courses in high school for males and females. See Tables 3.11 and 3.12.
CHAPTER III

FINDINGS

Introduction

In this chapter, a series of tables and path models are examined in order to address the thirteen questions raised in this study as specified in the previous chapter. The emphasis here is on interpreting the results of the analysis. The questions are answered more directly in the subsequent chapter in the summary of findings section.

General Ability Level

The first set of questions dealt with who actually elected a science course in the 11th or 12th grades and how this varied among various groups. Table 3.1 shows these differences by sex and general ability level (IQ). While nearly half of the females selected an advanced science course in high school (45%), almost three-quarters of the males had (71%)--a significant difference. This same significant sex difference was found for students in all three ability level groups. For each of the three IQ groups, 50% more males than females had selected an advanced science course.
TABLE 3.1. Percent of Females and Males Taking Advanced Science Courses by General Ability Level (IQ)

<table>
<thead>
<tr>
<th>General Ability Level (IQ)</th>
<th>Female</th>
<th>Male</th>
<th>Diff</th>
<th>Signif?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Taking Science</td>
<td>Total N</td>
<td>% Taking Science</td>
<td>Total N</td>
</tr>
<tr>
<td>Highest Group</td>
<td>60**</td>
<td>(115)</td>
<td>91**</td>
<td>(109)</td>
</tr>
<tr>
<td>Middle Group</td>
<td>48</td>
<td>(145)</td>
<td>75</td>
<td>(91)</td>
</tr>
<tr>
<td>Lowest Group</td>
<td>30**</td>
<td>(125)</td>
<td>45**</td>
<td>(99)</td>
</tr>
<tr>
<td>All Students</td>
<td>45</td>
<td>(385)</td>
<td>71</td>
<td>(299)</td>
</tr>
</tbody>
</table>

*p < .05; 1-tailed test  
**p < .05; 1-tailed test

Another question which was raised in this regard was whether general ability level was related to taking elective science courses for each sex. This was true for both males and females as shown in Table 3.1. For each sex taken separately, a significantly greater proportion of the highest IQ group elected at least one advanced course as compared with the middle IQ group. Similarly, a significantly greater percentage of the middle than the lowest IQ group had taken an optional science course in high school.

Social Class

Using Table 3.2, the same types of comparisons can be made for social class. At each social class level, there was a significant difference between the percentage of males and females who
### TABLE 3.2. Percent of Females and Males Taking Advanced Science Courses by Social Class Level

<table>
<thead>
<tr>
<th>Social Class</th>
<th>Females</th>
<th></th>
<th>Males</th>
<th></th>
<th>Sex Diff</th>
<th>Signif?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Taking</td>
<td>Total N</td>
<td>% Taking</td>
<td>Total N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest Group</td>
<td>56</td>
<td>(126)</td>
<td>88**</td>
<td>(90)</td>
<td>Yes**</td>
<td></td>
</tr>
<tr>
<td>Middle Group</td>
<td>46</td>
<td>(138)</td>
<td>72</td>
<td>(101)</td>
<td>Yes**</td>
<td></td>
</tr>
<tr>
<td>Lowest Group</td>
<td>35*</td>
<td>(121)</td>
<td>56**</td>
<td>(108)</td>
<td>Yes**</td>
<td></td>
</tr>
<tr>
<td>All Students</td>
<td>45</td>
<td>(385)</td>
<td>71</td>
<td>(299)</td>
<td>Yes**</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05; 1-tailed test  
**p < .01; 1-tailed test

Elected an advanced course in science. In all cases, over 50% more males than females did so.

Was social class related to taking science? Yes, for males the relationship was significant, but for females this was only partially true, as demonstrated in Table 3.2. A significantly greater proportion of highest social class males had selected science as compared to the middle group, and significantly more middle than lowest social class males did so. For females, a X^2 test demonstrated that there was an association between social class level and entry into science (X^2 = 10.26, p < .01). However, although significantly more of the middle than the lowest social class females elected an advanced science course in high school, the difference between the proportions of the highest and the middle social class...
groups who elected science was not significant at the .05 level.

Perceived Parental Evaluations of Science Ability

Comparison of consecutive evaluation response groups in Table 3.3 demonstrated that perceived parental evaluations of students' science ability in the 8th grade was related to their entry into science courses in the 11th and 12th grades. For both sexes, a significantly greater proportion of those students who perceived very high parental evaluations went on to take science as compared with the proportion of above average students who did. Likewise, significantly more of the above average males and females elected advanced science courses in high school as compared with the

<table>
<thead>
<tr>
<th>Perceived Parental Evaluation of Science Ability Response</th>
<th>Females</th>
<th></th>
<th></th>
<th></th>
<th>Males</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Taking Science</td>
<td>Total N</td>
<td></td>
<td>% Taking Science</td>
<td>Total N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among the Best</td>
<td>62**</td>
<td>(164)</td>
<td></td>
<td>83**</td>
<td>(162)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Average</td>
<td>38</td>
<td>(156)</td>
<td></td>
<td>69</td>
<td>(96)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average and Below</td>
<td>23*</td>
<td>(65)</td>
<td></td>
<td>27**</td>
<td>(41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Students</td>
<td>45</td>
<td>(385)</td>
<td></td>
<td>71</td>
<td>(299)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05; 1-tailed test

**p < .05; 1-tailed test

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proportion of students with average or below average parental science evaluations who did.

Table 3.4 shows the distribution of males' and females' perceptions of their parents' evaluations of the student's science ability. For both sexes, the distribution did not follow a normal distribution pattern, but was skewed toward the higher responses.

When examining this table, the conclusion was that males were more likely to perceive high parental science evaluations than were females. While 54% of the males thought their parents would rate them among the best in science, only 43% of these 8th grade females perceived such high evaluations—a significant difference.

A further comparison of males' and females' parental
evaluations of their science ability is demonstrated in Table 3.5.

Here the mean evaluation level for females and males are shown--4.23 and 4.38, respectively. Males would appear to perceive somewhat higher evaluations than females. However, this difference was not significant at the .05 level. But, as the previous table demonstrated, the response distribution was highly skewed, inhibiting detection of the sex differences as found in the previous analysis.

**TABLE 3.5. Comparisons of the Females' and Males' Average (X) Perceived Parental Evaluation of Science Ability and Average (X) Self-Concept of Science Ability**

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th>Males</th>
<th>Sex Diff Signif?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Parental Evaluation of Science Ability</td>
<td>4.23</td>
<td>4.38</td>
<td>No</td>
</tr>
<tr>
<td>Self-Concept of Science Ability</td>
<td>27.98</td>
<td>29.65</td>
<td>No</td>
</tr>
</tbody>
</table>

Self-Concept of Science Ability

Table 3.5 above shows a comparison of the mean self-concepts for females and males, 27.98 and 29.65, respectively. Although these figures would seem to suggest that males would rate their science ability somewhat higher than females, the difference between the averages was, in fact, not significant at the .05
level.

The following analysis in Table 3.6, however, suggests that there were certain differences between the self-concepts of science ability for males and females. While 32% of the males had high self-concepts of their science ability in the 8th grade, only 19% of these adolescent females did—a significant difference.

**TABLE 3.6. Response Distribution for Self-Concept of Science Ability (8th Grade) for Females and Males**

<table>
<thead>
<tr>
<th>Self-Concept of Science Ability Group</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>High</td>
<td>19&lt;sup&gt;a&lt;/sup&gt; (74)</td>
<td>32&lt;sup&gt;a&lt;/sup&gt; (95)</td>
</tr>
<tr>
<td>Above Average</td>
<td>56 (217)</td>
<td>50 (150)</td>
</tr>
<tr>
<td>Average and Below</td>
<td>24 (94)</td>
<td>18 (54)</td>
</tr>
<tr>
<td>Total</td>
<td>100 (385)</td>
<td>100 (299)</td>
</tr>
</tbody>
</table>

<sup>a</sup>A significant difference between the proportions of each sex with high self-concepts of their science ability (p < .01; 1-tailed test).

Table 3.7 demonstrates a comparison of consecutive self-concept of science ability groups for each sex separately. For both sexes, a significantly greater proportion of the high self-concept than the above average self-concept students selected an advanced science course in high school. Similarly, significantly more of the above average group as compared with the average and below self-concept group selected an optional science course in high school.

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TABLE 3.7. Percent of Females and Males Taking Advanced Science Courses by Level of Self-Concept of Science Ability (8th Grade)

| Self-Concept of Science Ability | Females | | | | Males | | |
|---------------------------------|---------|---------|---------|---------|
|                                 | % Taking Science | Total N | % Taking Science | Total N |
| High                            | 63*     | (74)    | 83**    | (95)    |
| Above Average                  | 48†     | (217)   | 73†     | (150)   |
| Average and Below               | 26**    | (94)    | 33**    | (54)    |
| All Students                    | 45      | (385)   | 71      | (299)   |

* p < .05; 1-tailed test
** p < .01; 1-tailed test

Path Models: Direct and Indirect Effects

In looking at Figure 3.1, the direct and indirect effects of perceived parental evaluations of science ability on taking advanced science in high school can be compared. Comparing the relative

FIGURE 3.1. Simple Model Showing Direct and Indirect Effects of Perceived Parental Evaluations of Science Ability on Taking Advanced Science Courses through Self-Concept of Science Ability

![Path Model Diagram]

Indirect path: .17. All paths significant
magnitude of these effects, the students' self assessments of their
science ability had a somewhat greater impact on their taking
advanced science courses than did parental assessments of their
ability (.25 vs .19). However, parental evaluations had a very
high influence on the students' self-concepts (.68). Perceived
parental evaluations, then, had an indirect effect on taking science
through their impact on self-concept. The indirect effect (.17)
was nearly as high as the direct effect (.19). This model would
indicate that the evaluations of their science ability which students
thought their parents held in the 8th grade, directly and indirectly
influenced their decision to take an elective science course three
and four years later.

The following path model, Figure 3.2, also includes the
background variables, sex, general ability level (IQ) and social
class. When these control variables are taken into account, the
direct and indirect effects of parental science evaluations on taking
science were reduced somewhat (both .12) as compared with the
previous model, but were still significant. The impact of parental
assessments on the students' self-concepts remained quite strong,
however. It was, in fact, the largest path weight in the model,
by far.

Together these five independent variables measured
before or during the 8th grade, directly and indirectly accounted
FIGURE 3.2. Path Model for All Students Relating Sex, General Ability (IQ), Social Class, Parental Evaluations of Science Ability, Self-Concept of Science Ability to Taking Advanced Science Courses.

Multiple $R^2$ for taking science: 25%

*Path not significant.

for 25% of the variance in taking advanced science courses three and four years later. Comparing the relative impacts of the direct effects of these variables on taking science, the path from the variable sex had the largest magnitude (-0.21). (The negative effect should be interpreted as being negative from the female perspective.

The variable "sex" should be interpreted as encompassing more than just the biological sex. "Sex role" is perhaps a more accurate concept. This variable may be measuring other sex-related variables not included in the model such as differences in teacher and peer evaluations, differences in home and educational practices or any of the other factors cited in the previous literature review.
because of the coding convention used). IQ and self-concept had similar direct impacts on taking science (.20 and .18, respectively) with parental science evaluations and social class having somewhat less direct influence (.12 and .11, respectively).

Besides the direct path from sex to taking science, there were also three indirect paths between these variables through students' parental and self evaluations of their science ability. Like the direct effect, these indirect paths were also negative. They were not nearly as strong, however, Females were thus less likely to take science because of their sex (see previous footnote), as well as because they perceived lower parental evaluations of their science ability and had lower self-conceptions of their science ability.

IQ and social class also had indirect effects on taking science in the 11th and 12th grades. Both had some impact on parental evaluations (especially IQ) which was directly and indirectly related to taking science. Social class also had some effect through self-concept.

The following two models, Figures 3.3 and 3.4, allow comparison of males and females. For the most part, the path weights in the model for males were greater than in the model for females. For males, the independent variables together explained 29% of the variance in taking advanced science courses in high school. For females, these variables together explained 15% of
FIGURE 3.3. Path Models for Females Relating General Ability (IQ), Social Class, Perceived Parental Evaluations of Science Ability, Self-Concept of Science Ability to Taking Advanced Science Courses

Multiple $R^2$ for Taking Science: 15%
*Paths not significant

FIGURE 3.4. Path Models for Males Relating General Ability (IQ), Social Class, Perceived Parental Evaluations of Science Ability, Self-Concept of Science Ability to Taking Advanced Science Courses

Multiple $R^2$ for Taking Science: 29%
*Paths not significant.
the variance in taking science.

Looking at the impact of parental evaluations on taking science, the direct effect was only significant for males. The indirect effect through self-concept, however, was about the same for males as for females. In both models, the path from parental evaluations to self-concept was by far the strongest effect in the model.

Comparing the direct effects of the four independent variables on taking science, for females, only two paths were significant (from IQ and from self-concept). For males, IQ had a somewhat greater direct impact on taking science than the other three variables which had about equal impact.

Looking at possible indirect effects of IQ and social class on taking science, for both sexes, neither IQ nor social class had a significant direct effect on self-concept. Both both variables had considerable direct impact on parental evaluations. Thus, both IQ and social class also had this indirect effect on taking science through parental evaluations (and in turn, through self-concept).

Contingency Table Analysis

Table 3.8 shows the frequency distribution of the variables of concern in this study for males and females. These frequencies were the basis for the contingency table analysis used in this section.
TABLE 3.8. The Frequency Distribution and the Observed Odds Ratios of Electing an Advanced Science Course in the 11th or 12th Grade for Females and Males Across Dichotomized Categories of General Ability Level, Social Class, Perceived Parental Evaluations of Science Ability and Self-Concept of Science Ability

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
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<td>lo</td>
<td>lo</td>
<td>lo</td>
<td>lo</td>
<td>16</td>
<td>57</td>
<td>.28</td>
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<td>lo</td>
<td>lo</td>
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<td>12</td>
<td>1.25</td>
<td>16</td>
<td>7</td>
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<td>lo</td>
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<td>lo</td>
<td>5</td>
<td>6</td>
<td>.83</td>
<td>2</td>
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<td>3.00</td>
<td>4</td>
<td>2</td>
</tr>
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<td>hi</td>
<td>lo</td>
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<td>.50</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
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<td>hi</td>
<td>hi</td>
<td>lo</td>
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<td>6</td>
<td>.66</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
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<td>lo</td>
<td>lo</td>
<td>hi</td>
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<td>10</td>
<td>.70</td>
<td>4</td>
<td>4</td>
</tr>
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<td>lo</td>
<td>lo</td>
<td>hi</td>
<td>1</td>
<td>4</td>
<td>.25</td>
<td>5</td>
<td>1</td>
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<td>lo</td>
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<td>.50</td>
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<td>hi</td>
<td>hi</td>
<td>16</td>
<td>10</td>
<td>1.60</td>
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<td>hi</td>
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<td>20</td>
<td>5</td>
</tr>
<tr>
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<td>hi</td>
<td>hi</td>
<td>hi</td>
<td>32</td>
<td>21</td>
<td>1.50</td>
<td>50</td>
<td>3</td>
</tr>
</tbody>
</table>

a The variables were all dichotomized so that approximately half of the students were in the high category and half were in the low category.

The observed odds ratios (see Appendix C) are also presented in the table which will be used subsequently for comparison with the corresponding expected odds ratios when the selected model is discussed.
The following model was found to be the best model (see Appendix C) for describing the observed frequencies shown in Table 3.8:

Sex + Ability + Social Class + Parental Evaluations
+ Self-Concept + (Sex/Ability) + (Sex/Social Class)
+ (Ability/Parental Evaluations) → Science Entry

Based on this model, Table 3.9 shows the relative impacts (i.e., the multiplicative gamma parameters) of each level of the independent variables and their interaction effects on the likelihood (i.e., odds) of students' electing an optional science course in the 11th and 12th grades.

By comparing the magnitudes of an effect of each variable shown in Table 3.9, sex had a considerably greater impact on the odds of taking science than any of the other factors in the model—and this effect was positive (1.792) for males, but negative (.558) for females. The second most important factor was whether the student had a high or low general ability level—here again, the effect was positive (1.610) for the high IQ student and negative (.621) for the low IQ student.

These two variables, sex and ability, were not operating independently, however. For males, the interaction effect between sex and general ability was positive (1.297)—thus, not only did the characteristics of being male or being a high ability student contribute independently to the odds of their taking advanced science,
TABLE 3.9. Relative Effects (Gamma Parameters and Magnitudes) of Sex, General Ability Level, Social Class, Perceived Parental Evaluations of Science Ability, Self-Concept of Science Ability and Their Interaction Effects on Entry into Advanced Optional Science Courses in High School

<table>
<thead>
<tr>
<th>Single Variable Effects:</th>
<th>Rel. Effect on Science Entry (Multiplicative)</th>
<th>Magnitude&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex:</strong> Female</td>
<td>.558</td>
<td>.792</td>
</tr>
<tr>
<td>Male</td>
<td>1.792</td>
<td></td>
</tr>
<tr>
<td><strong>General Ability:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>.621</td>
<td>.610</td>
</tr>
<tr>
<td>High</td>
<td>1.610</td>
<td></td>
</tr>
<tr>
<td><strong>Social Class:</strong></td>
<td></td>
<td></td>
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<tr>
<td>Low</td>
<td>.773</td>
<td>.294</td>
</tr>
<tr>
<td>High</td>
<td>1.294</td>
<td></td>
</tr>
<tr>
<td><strong>Parental Evaluations:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>.753</td>
<td>.327</td>
</tr>
<tr>
<td>High</td>
<td>1.327</td>
<td></td>
</tr>
<tr>
<td><strong>Self-Concept:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>.676</td>
<td>.480</td>
</tr>
<tr>
<td>High</td>
<td>1.480</td>
<td></td>
</tr>
</tbody>
</table>

| Interaction Effects:                 |                                               |                       |
| **Sex/General Ability:**             |                                               |                       |
| Female/Low                           | 1.297                                         | .297                  |
| Female/High                          | .771                                          |                       |
| Male/Low                             | .771                                          |                       |
| Male/High                            | 1.297                                         |                       |
| **Sex/Social Class:**                |                                               |                       |
| Female/Low                           | 1.284                                         | .284                  |
| Female/High                          | .779                                          |                       |
| Male/Low                             | .779                                          |                       |
| Male/High                            | 1.284                                         |                       |
| **Gen. Ability/Parental Eval.:**     |                                               |                       |
| Low/Parental Eval.                   | .801                                          |                       |
| Low/High                             | 1.248                                         | .248                  |
| High/Parental Eval.                  | 1.248                                         |                       |
| High/High                            | .801                                          |                       |
| All others                           | 1.000                                         |                       |

General Mean for Science Entry: 1.721

\[X^2 = 21.30\] with 23 degrees of freedom (probability over .5 - a significant model).


<sup>a</sup>See Appendix C.
but having both of these characteristics together further increased their likelihood of science entry. For females, the effect was the opposite. While being female or having a low IQ each independently decreased the odds of taking science, their effect was countered somewhat by the effect of the interaction term. The positive interaction effect (1.297) showed that having a low IQ was less detrimental to females' than to males' overall likelihood of taking science. But similarly, being both female and having a high general ability level countered some of the positive effects of the direct impact of having a high general ability (.771 for high ability females).

In a multiplicative sense, then, being male and having a high general ability resulted in an overall positive effect (1.792 x 1.610 x 1.297 = 3.742) and being male and having a low general ability resulted in an overall negative effect (1.792 x .621 x .771 = .858). For females, having a high ability yielded an overall negative effect (.558 x 1.610 x .771 = .693) as did having a low general ability level (.558 x .621 x 1.297 = .449) which was somewhat lower, however. Note that the positive interaction term somewhat countered the original negative impact of the independent effects of being female and having a low IQ (.558 x .621 = .347). (This same procedure for calculating the estimates of the expected effects of various factors on the likelihood of taking science can be followed for any set of factors in the model).
The same type of effects applied when the impact of social class on science entry was examined. Being in the high social class group (relatively speaking), contributed to the student's likelihood of electing an advanced science course in high school (1.294). Likewise, being in the low social class group had a negative impact on the odds of science entry (.773). Looking at the interaction effect between sex and social class, being male and being in the high social class group increased the odds of science entry even further (1.284) with a magnitude similar to that of being a high ability male. But, although being female or being in the low social class group (relatively speaking) independently contributed negatively to one's odds of science entry, both characteristics taken together countered this trend somewhat (1.284). Overall, then, social class was less important to females' than to males' likelihood of taking advanced science courses in high school.

As previous analysis had suggested both parental and self evaluations of science ability were positively related to taking science. Having a high self-concept or perceiving high evaluations both increased the likelihood of the student's taking science (1.480 and 1.327, respectively)--self-concept contributed somewhat more to the odds of science entry. Conversely, having a low self-concept or perceiving low parental science evaluations both decreased the likelihood of the student's taking science (.676 and
The interaction effect of general ability level and parental evaluations was more complex to interpret. As shown above, the "high" value for each variable taken independently increased the likelihood of science entry (1.610 and 1.327). However, having both a high general ability and perceiving high parental science evaluations together slightly decreased the overall positive effect (.801). The total effect of these factors was still positive, however (1.610 x 1.327 x .801 = 1.711 - down slightly from the two independent effects: 1.610 x 1.327 = 2.136). However, the interaction effects for these two variables, increased the likelihood of science entry for those students with either (but not both) high ability or high evaluations (1.248)--in both cases, the overall effect was positive (1.513 and 1.028, respectively).

Note the gamma parameter of 1.000 for the category "all other interaction effects." Because of the multiplicative nature of the gamma's, a parameter of 1.0 means that these other effects had "no effect" on the odds of taking science, given the model that was being used. See Appendix C for further discussion.

Table 3.10 summarizes the expected likelihood of students with various characteristics electing optional science courses in the 11th and 12th grades (in accordance with the model used here). Any of these expected odds ratios can be estimated by selecting the
### TABLE 3.10. Expected Likelihood (Odds Ratios) of Students Taking Elective Science Courses in the 11th and 12th Grades for Dichotomized Categories of Sex, General Ability Level, Social Class, Perceived Parental Evaluations of Science Ability and Self-Concept of Science Ability

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Females</td>
</tr>
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<td>.312</td>
</tr>
<tr>
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<td>lo</td>
<td>lo</td>
<td>lo</td>
<td>.749</td>
</tr>
<tr>
<td>3</td>
<td>lo</td>
<td>hi</td>
<td>lo</td>
<td>lo</td>
<td>.318</td>
</tr>
<tr>
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<td>lo</td>
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<td>lo</td>
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<td>hi</td>
<td>lo</td>
<td>.856</td>
</tr>
<tr>
<td>9</td>
<td>lo</td>
<td>lo</td>
<td>lo</td>
<td>hi</td>
<td>.645</td>
</tr>
<tr>
<td>10</td>
<td>hi</td>
<td>lo</td>
<td>lo</td>
<td>hi</td>
<td>1.650</td>
</tr>
<tr>
<td>11</td>
<td>lo</td>
<td>hi</td>
<td>lo</td>
<td>hi</td>
<td>.697</td>
</tr>
<tr>
<td>12</td>
<td>hi</td>
<td>hi</td>
<td>lo</td>
<td>hi</td>
<td>1.670</td>
</tr>
<tr>
<td>13</td>
<td>lo</td>
<td>lo</td>
<td>hi</td>
<td>hi</td>
<td>1.880</td>
</tr>
<tr>
<td>14</td>
<td>hi</td>
<td>lo</td>
<td>hi</td>
<td>hi</td>
<td>1.863</td>
</tr>
<tr>
<td>15</td>
<td>lo</td>
<td>hi</td>
<td>hi</td>
<td>hi</td>
<td>1.914</td>
</tr>
<tr>
<td>16</td>
<td>hi</td>
<td>hi</td>
<td>hi</td>
<td>hi</td>
<td>1.896</td>
</tr>
</tbody>
</table>


<sup>a</sup>There may be slight differences between the expected odds shown here and the estimation of these odds from the gamma parameters in Table 3.9 because of the number of significant digits used in the calculations. Also, see Appendix C for further discussion of odds ratios (or likelihood ratios).

Gamma parameters from Table 3.9 and computing their product (since gammas are multiplicative parameters). For example, a
high ability female from the high social class group who perceives low parental evaluations of her science ability and holds a low self-concept of her science ability (category 4) has an expected likelihood of electing an optional science course equal to .762—that is, one would expect that she is somewhat more likely not to take science. These expected odds can be calculated by multiplying the following parameters:

\[
\begin{align*}
0.558 & \quad \text{(female)} \\
1.610 & \quad \text{(high general ability)} \\
1.294 & \quad \text{(high social class)} \\
0.753 & \quad \text{(low parental evaluations)} \\
0.676 & \quad \text{(low self-concept)} \\
0.771 & \quad \text{(female, high general ability)} \\
0.779 & \quad \text{(female, high social class)} \\
1.248 & \quad \text{(high ability, low evaluations)} \\
x & \quad 1.721 \\
& \quad \text{(general mean for science entry)}
\end{align*}
\]

Table 3.10 can be used to compare the likelihood of science entry for various categories of students as well as for comparing males and females in each category. For example, although in each case, males have a higher likelihood of science entry than females, for those students with low ability and low social class (categories 1, 5, 9, and 13), males' and females' odds ratios are fairly similar. Or note that, for females with high parental evaluations (categories 5-8, and 13-16), the level of general ability and social class do not have much effect on the likelihood of science entry, although the level of self-concept does—all about .8 for low self-concept female students (categories 5-8) and about 1.8 for
high self-concept females (categories 13-16). As a third example, note that for males, having both a low general ability and a low social class (categories 1, 5, 9, and 13) has a negative influence on science entry as compared with categories of similar parental and self evaluations. Likewise, males having high ratings on these two variables (categories 4, 8, 12 and 16) are generally more likely to take science as compared with other males with similar parental and self evaluations. These are some of the more general comparisons that can be made—obviously many others can be seen in examining Table 3.10.

The expected odds ratios (or likelihood ratios) shown in Table 3.10 for each category of students are based on the best fitting model. Because of the criteria for fitting models, these expected odds ratios should be very similar to the actual observed odds ratios shown in Table 3.8. In comparing the two sets of likelihood ratios, it is apparent that in most cases they are fairly close. A somewhat closer correspondence would have been met had larger cell frequencies been used.

Contingency tables were also analyzed for males and females separately. As above, the best fitting significant models were determined for each sample and are presented along with their gamma parameters in Tables 3.11 and 3.12. Note that for females, social class was not included in the model because it did not signifi-
TABLE 3.11. Relative Effects (Gamma Parameters and Magnitudes) of General Ability Level, Social Class, Perceived Parental Evaluations of Science Ability, Self-Concept of Science Ability and Their Interaction Effects on Entry into Advanced Optional Science Courses in High School for Females

<table>
<thead>
<tr>
<th></th>
<th>Rel. Effect on Science Entry (Multiplicative)</th>
<th>Magnitude&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Gamma Parameter)</td>
<td></td>
</tr>
<tr>
<td><strong>Single Variable Effects:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Ability:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>.814</td>
<td>.229</td>
</tr>
<tr>
<td>High</td>
<td>1.229</td>
<td></td>
</tr>
<tr>
<td>Social Class:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Parental Eval.:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>.709</td>
<td>.411</td>
</tr>
<tr>
<td>High</td>
<td>1.411</td>
<td></td>
</tr>
<tr>
<td>Self-Concept:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>.734</td>
<td>.362</td>
</tr>
<tr>
<td>High</td>
<td>1.362</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction Effects:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gen. Abil/Parental Eval.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low/Low</td>
<td>.724</td>
<td></td>
</tr>
<tr>
<td>Low/High</td>
<td>1.381</td>
<td>.381</td>
</tr>
<tr>
<td>High/Low</td>
<td>1.381</td>
<td></td>
</tr>
<tr>
<td>High/High</td>
<td>.724</td>
<td></td>
</tr>
<tr>
<td>All Others</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td><strong>General Mean for Science Entry</strong></td>
<td></td>
<td>.980</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 13.09 \text{ with 11 degrees of freedom (prob. } = .287 - \text{ a sig. model).} \]


<sup>a</sup>See Appendix C.

...cantly improve the fit of the model to the observed frequency distribution (hence, the gamma parameter of 1.0 meaning "no effect").

Likewise, the variable "perceived parental evaluations of science
<table>
<thead>
<tr>
<th>Single Variable Effects:</th>
<th>Rel. Effect on Science Entry (Multiplicative)</th>
<th>Magnitude&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Ability: Low</td>
<td>.461</td>
<td>1.169</td>
</tr>
<tr>
<td>High</td>
<td>2.169</td>
<td>1.169</td>
</tr>
<tr>
<td>Social Class: Low</td>
<td>.613</td>
<td>.631</td>
</tr>
<tr>
<td>High</td>
<td>1.631</td>
<td>.631</td>
</tr>
<tr>
<td>Parental Eval.: Low</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>High</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Self-Concept: Low</td>
<td>.487</td>
<td>1.053</td>
</tr>
<tr>
<td>High</td>
<td>2.053</td>
<td>1.053</td>
</tr>
</tbody>
</table>

| Interaction Effects:     |                                             |                        |
| All Effects              | 1.000                                       |                        |

| General Mean for Science Entry | 3.049                                      |

\[ X^2 = 5.22 \text{ with 12 degrees of freedom (probability over } .5 \text{ - a significant model).} \]


<sup>a</sup>See Appendix C.

ability" was not included in the model for males (i.e., the gamma parameter was set equal to 1.0) because it did not make a significant contribution when the other independent variables were taken into account.

For females, having a high general ability, high parental evaluations or a high self-concept had a positive effect on their
likelihood of taking science, with parental evaluations having the
greatest single impact (1.411). However, if the student had both
high evaluations and high ability, the overall effect was decreased
somewhat (0.724). The importance of having high parental evaluations
can be seen from the following comparisons. For high ability and
high self-concept females, having high parental evaluations resulted
in a 1.676 expected likelihood of science entry (1.229 x 1.411 x
1.362 x 0.724 x 0.980), while having low parental evaluations resulted
in a 1.606 likelihood of taking science (1.229 x 0.709 x 1.362 x 1.381
x 0.980). Parental evaluations, then, didn't have a great deal of
influence for the high ability, high self-concept females' likelihood
of electing an optional science course in high school. Similarly,
parental evaluations didn't have as much impact for the high ability
female who had a low self-concept of her science ability (0.902 vs 0.865).
However, perceived parental evaluations of science ability did have
a considerable impact on the low ability students. For females with
low self-concepts, the expected likelihood of their entry into science
was 0.301 for those with low parental evaluations, yet 1.141 for those
with high parental evaluations. Parents had an even greater in-
fluence for those with high self-concepts---0.558 likelihood for those
perceiving low parental evaluations of their science ability and
2.117 for those perceiving high parental evaluations. One could
also make the same sorts of comparisons for the importance of
self-concept and general ability. Given the interaction effect of evaluations and ability, self-concept of science ability turned out to be the most influential in affecting the expected likelihood of science entry for females using this best fitting model.¹

Examining the gamma parameters for the male model in comparison with those of the female model, the evidence indicates that the effects of the predictor variables were somewhat more important for explaining males' than females' likelihood of taking optional science courses in the 11th and 12th grades (note the differences in magnitudes). For males, high general ability level and high self-concept of science ability had about equal impacts on the expected likelihood of science entry (2.169 and 2.053 respectively). Likewise, having low ability or low self-concept had very negative impacts on the odds of science entry (.461 and .487 respectively—considerably lower than any of the negative effects for females. Social class had somewhat less impact on the expected likelihood of males taking science—though still an important influence, particularly when compared to the female model where social class had no influence when the other factors were taken into account.

¹In selecting the best fitting significant model for the female sample, a second model also proved to have a good fit: Abil. + Par. Eval. + Self-Con. + (Abil/Self-Con.) → Science Entry. However, the X² for this model (13.88) was not as small as the X² for the model selected (13.09). This does leave room for a wider interpretation of the relative importance of parental evaluations and self-concept. Analysis of the 2nd best fitting model suggests that parental evaluations are somewhat more important than self-concept of science ability.
CHAPTER IV
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

In this section the findings reported in detail in Chapter III are summarized and related to the 13 basic research questions which guided this study.

Research Question 1: Do fewer females than males take advanced elective science courses in high school?

In the population investigated, significantly (p < .01) more males (71%) than females (45%) had completed elective science courses when they were in the 11th and 12th grades.

Research Question 2: Do fewer females than males take advanced elective science courses in high school at each of three general ability levels?

At each ability level, significantly (p < .05) more of the males than females had elected one of the advanced science courses when they were in high school. Of the highest ability students, 91% of the males but only 60% of the females had taken science. For the middle ability students, the proportions were 75% and 48% respectively. And of the lowest ability students, 45% of the males but 30% of the females had elected an advanced science course. Interestingly, even the middle ability level males were more likely to have taken advanced science courses in high school than were the highest ability females.
Research Question 3: Do fewer females than males take advanced elective science courses in high school at each of three social class levels?

In this study it was found that a significantly ($p < .01$) greater proportion of the males than females had elected science courses in the 11th and 12th grades at all social class levels. Of the highest social class students, 88% of the males but only 56% of the females had taken optional science courses in high school. For students in the middle third on social class, 72% and 46% of the males and females respectively had taken science. Of the lowest social class students, 56% of the males but only 35% of the females had elected an optional science course in high school. Somewhat surprisingly, males in the lowest social class group were as likely to have completed advanced science courses in high school as females in the highest social class group (56%).

Research Question 4: Is general ability level (as measured by intelligence tests) positively related to taking advanced elective science courses in high school for males and females?

For both males and females, general ability level, as measured by intelligence tests, was positively related to whether they had taken advanced science courses when they were in high school. Ninety-one percent of the highest ability males, 75% of the middle ability males and 45% of the lowest ability males had completed 11th and 12th grade...
science courses when they were in high school differences significant at the .01 level). Similarly, 60% of the highest ability females, 48% of the middle ability females and 30% of the lowest ability female students had elected an advanced optional science course in high school (differences significant at the .05 level).

Research Question 5: Is social class level positively related to taking advanced elective science courses in high school for males and females?

Social class level was positively related to completing elective science courses in high school for males. Significantly (p < .01) more of the highest social class males (88%) than the middle social class males (72%) and, in turn, significantly (p < .01) more of the middle than the lowest social class males (56%) had taken elective science courses when they were in high school.

For females, while there was a significant (p < .01) association between social class and entry into science, the differences between consecutive social class groups in the proportions who had taken science were not all significant (at the .05 level). Significantly more (p < .05) of the middle than the lowest social class females had elected an optional science course (46% vs. 35%). However, although there was an observed difference between the highest and middle social class females (56% and 46% respectively), this difference was not significant (at the .05 level).
Research Question 6: Are parents' evaluations of students' science ability (as perceived by their children in the 8th grade) positively related to their taking advanced elective science courses in high school for males and females?

In the population studied here, it was found that parents' evaluations of their children's science ability, as perceived by their children when in the 8th grade, was positively related to whether their children completed advanced elective science courses three and four years later when in the 11th and 12th grades. For males, 83% of those with high evaluations, 69% of those with above average evaluations and only 27% of those students who perceived average or below parental evaluations elected an advanced science course—significant differences (p < .01). Similarly, for females, significantly (p < .01) more of those who perceived high parental evaluations (62%) as compared with those with above average evaluations (38%), and significantly (p < .05) more of the above average group as compared with those females with average or below evaluations (23%) had selected an optional science course in the 11th and 12th grade.

Research Question 7: Are students' self-concepts of their ability in the 8th grade positively related to their taking advanced elective science courses in high school for males and females?

Here again, for both male and female students, self-concept of science ability was positively related to selection of an advanced optional science course in high school. For males, significantly
(p < .01) more of the high self-concept students (89%) than the above average self-concept students (73%) took science, and significantly (p < .01) more of the above average than the average and below self-concept males (33%) elected an optional science course in high school. For females, 65% of the high self-concept students 48% of the above average self-concept students and only 26% of the average and below self-concept students had elected science in the 11th and 12th grade--both significant differences (p < .05).

Research Question 8: Do females in the junior high school years perceive lower parental evaluations of their science ability than do males?

In a general comparison of the average parental evaluations for males and females (4.38 and 4.24 respectively), while there was an observed difference between them, it was not significant at the .05 level. However, males and females did differ as to their levels of perceived parental evaluations of their science ability in certain important respects. Significantly (p < .01) more of the males (54%) than the females (43%) thought that their parents would rank them as being among the best in science in the 8th grade--an important consideration.

Research Question 9: Do females in the junior high school years have lower self-concepts of their science ability than do males?

As in the previous answer, a comparison of the average self-concept levels for males and females found that while males appeared
to have higher self-concepts of their science ability than females (29.65 vs. 27.98 respectively), this difference was, in fact, not significant (at the .05 level). The two sexes did differ on self-concept, however, with respect to their distribution across categories—in particular significantly \((p < .01)\) more males (32%) than females (19%) evaluated their science ability as being high.

**Research Question 10:** Is the relationship between parents' evaluations of their children's science ability (as perceived by their children in the 8th grade) and whether their children take science in high school indirect, in that perceived parental evaluations affect self-conceptions, which in turn affect entry into science courses in high school?

In the population studied here, the parents' science evaluations which the students perceived in the 8th grade had both significant \((p < .05)\) direct and indirect effects on taking science courses three and four years later. The indirect influence of parents' evaluations on taking elective science courses in high school through their children's self-concepts of their science ability was nearly as strong as the direct relationship between perceived parental evaluations in the 8th grade and taking science courses in the 11th and 12 grades.

**Research Question 11:** What are the direct and indirect effects of the variable sex on taking science through any influence on parental and self-evaluations of science ability with controls for social class and ability?

The variable sex exhibited both a direct and indirect impact on taking elective science courses in the 11th and 12th grades when social
class and general ability were taken into account. Being female was associated with less likelihood of taking advanced optional science courses than was the case for males. Being female was associated with less likelihood of taking advanced optional science courses than was the case for males. Of the four possible direct and indirect paths of influence of sex on taking science examined here, the direct effect was the strongest. This indicates that other sex-related variables which were not included in the model together accounted for somewhat more of the discrepancy between males' and females' course-taking rates than did the indirect influence of sex through parental evaluations and self-concept. However, the indirect influence of sex on taking advanced science courses through parental and self evaluations of science ability did indicate that females were also somewhat less likely to take elective science courses than males because of lower evaluations and self-conceptions.

Together these three variables—sex, perceived parental evaluations of science ability and self-concept of science ability measured in the 8th grade—along with social class and general ability level, accounted for 25% of the variation in whether the students took elective science courses three and four years later in high school.

**Research Question 12:** What are the relative impacts of sex, general ability level, social class, perceived parental evaluations of science ability and self-concept of science ability on explaining students' entry into elective science courses in high school?
The model found to be most appropriate for explaining the frequency distribution of students in this sample across categories of the five independent variables was the following:

Sex + Ability + Social Class + Parental Evaluations + Self-Concept + (Sex/Ability) + (Sex/Social Class) + (Ability/Parental Evaluations) \( \Rightarrow \) Science Entry

This model states that all five of the variables had a direct effect on student entry into science. And there are also three interaction effects which had an impact on the election of science courses.

In comparing the relative impacts of each variable independently, sex had the strongest direct impact with general ability, self-concept and parental evaluations being the next most influential in that order. Social class had the least independent direct effect on science entry. As the previous analyses have shown, here again being male or being in the high category of any of these variables was associated with a greater likelihood of having taken science in high school.

A comparison of the relative importance of each of these five variables is somewhat confounded because of their inclusion in several interaction effects. For example, the impact of being male and being in either the high ability group or the high social class group depressed their likelihood of having taken science. Thus, taking these interaction factors into account, the overall impact of general ability and social class were not as strong across the board as self-concept was, for
Research Question 13: Do males and females differ with respect to the relative impact of general ability level, social class, perceived parental evaluations of science ability and self-concept of science ability in the 8th grade on whether they later take advanced elective science courses in high school?

One overall difference in the impact of these four variables on whether students had taken science was that general ability level, social class, perceived parental evaluation of science ability and self-concept of science ability accounted for more of the variation in males' science course-taking than for females'. For males, these four independent variables accounted for 29% of the variation in whether they elected optional science courses in the 11th and 12th grades. For females, these variables accounted for 15% of the variation in their elective science course-taking 3 and 4 years later in high school. This same situation was found when male and female contingency tables were compared. Fewer variables and interaction effects were needed to account for the differences in course-taking for males than for females. For males, general ability, social class and self-concept were sufficient to account for whether males had elected science or not. For females, general ability, parental evaluations, self-concept and the interaction of ability and parental evaluations were necessary to account for variation in science entry. Further, when the best models were selected for males and for females (specified above), the male model more accurately accounted for the variation in science
course-taking than did the female model (i.e., the $X^2$ measuring the "fit" of the male model was 5.22, considerably smaller than the $X^2$ of 13.09 for the female model). The conclusion is that there are other factors occurring which further account for the variations in both female and male entry into optional science courses in high school, but particularly for females' course selection.

The parental evaluations of their science ability which students perceived had a somewhat greater influence on females' than on males' election of science courses when all variables were dichotomized in the ECTA technique. Self-concept, on the other hand, had more impact for males. The path analysis, however, suggested that these two variables were somewhat similar as to their influence on males' and females' election of optional science courses.

General ability level had somewhat greater influence on males' than females' science entry in both types of analysis. But the impact of social class was considerably stronger for males than for females with respect to whether they elected an advanced optional science course in the 11th and the 12th grade.

Conclusions

The major problem of concern directing this research is the current paucity of women in science-related careers, which is in part a consequence of females' under-representation in elective science courses at the high school level. This study questioned whether one
contributing factor to this differential course-taking between the sexes was an earlier difference between males' and females' perceptions of their parents' views. Rather than addressing questions as to whether parents overtly counselled their children towards or away from science interests (which may itself be a contributing factor), this study was concerned with the possible covert influences parents might have had. Did parents subtly communicate to their daughters their own conscious or unconscious ideological biases about the inappropriateness of science careers for women through their evaluations which they transmitted to their daughters of their science ability? In particular, this research investigated whether one of the reasons fewer females than males decided to take advanced elective science courses in the 11th and 12th grades was that during their earlier middle school years, these females tended to perceive lower parental evaluations of their science ability than did their male counterparts.

According to the results of the analysis in this study, the evaluations which students thought their parents held of them with respect to their science ability in the 8th grade did have some impact on the students' future decisions to elect science courses in the 11th and 12th grades. The magnitude of this effect was somewhat lower than one might initially expect. However, these two variables, parental evaluations and taking science, were measured over a four-year period. Other intervening variables, as the parental evaluations students
perceived in the 9th, 10th, 11th and 12th grades would, no doubt, have greater predictive power given their closer temporal distance to the dependent variable.

The interest here, however, was in focusing on this earlier period of development when females begin to fall behind males in many science-related areas. The importance of focusing on this early period is to enable the identification of impediments at this level so that corrective efforts may be implemented before females develop negative ideas about science and about their own abilities in science.

Perceived parental evaluations in the 8th grade, then, did contribute somewhat to students' course-taking decisions several years later. Furthermore, as predicted, considerably fewer females than males completed advanced elective science courses (45% vs. 71%). And concomitantly, fewer females than males perceived high parental evaluations regarding their science abilities (43% vs. 54%).

One of the ways in which parental evaluations affected students' course-taking was through their impact on the students' self-conceptions of their science ability. (There may, of course, be other direct and indirect ways in which parents affected course-taking which were unspecified in this model.) Here again, considerably fewer females than males had high self-concepts of their science ability--40% of the males but only 19% of the females fell into the highest group.

In evaluating the factors contributing to the differences in course-
taking, social class and general ability level were also found to have some impact. However, this impact was much more pronounced for males than for females, particularly as it related to social class.

Another conclusion from the analysis here was that there were other sex-related factors besides parent and self evaluations contributing to the females' lesser participation in advanced science courses in high school. In the path analysis of the model, sex had direct as well as indirect effects on taking science. This variable, "sex," may encompass sex-related factors such as differences in teacher and peer evaluations of the students' science abilities, differences in the intrinsic value attached to science behavior, differences in perceptions of the future usefulness of science or differences in perceptions of appropriateness of science-interest/involvement. These and other potential factors should be given attention for their possible impact on the future adoption of science courses.

One further interesting finding, although not specifically investigated in this study, was suggested by both the path analysis and the contingency table analysis. The four independent variables of concern here—general ability, social class, perceived parental and self evaluations of science ability—together accounted for more of the variation in science course-taking for males than for females. This would suggest that additional variables such as those mentioned about might have greater impact on females than on males. For example, perhaps
general ability level has less impact on females' self-concepts of their science ability and on their election of science courses as compared to the influence of their perceptions of the appropriateness of science interest and achievement held by male peers. Certainly these conditions warrant further investigation.

In conclusion, this study has identified one of the many factors contributing to the under-representation of females in advanced science courses in high school. Even as early as the 8th grade, females begin to perceive lower parental evaluations of their science ability than males. This would suggest that even if overt discrimination patterns are ended (e.g., overt counseling of females to avoid taking elective science courses) as current efforts have been focusing on, we may still find that females do not participate in high school science courses to the extent that males do. The subtle and latent residual conditions left over from prior discrimination patterns may be equally effective in keeping many potentially qualified females out of optional science courses. Efforts need to be focused on the unconscious ideologies apparently held by parents (and others, no doubt) which their children come to perceive. Whether or not parents actually hold lower evaluations of their daughters' than the sons' science abilities (which was not measured here) is less important than whether daughters perceive lower science evaluations (as found here). For it is the students' perceptions which will more directly influence their subsequent behavior.
These findings would give rise to a number of recommendations with respect to corrective attempts as well as future directions for further related research.

Recommendations

Whether it would be desirable to see more women scientists is inherently a value judgment of course. Many women will still choose the homemaker or other work roles for reasons of personal interest or perhaps compatibility with familial responsibilities (which are issues of debate beyond the scope of this study). But are these actual career decisions or do they at times result in part from a narrowing of available options due to inadequate preparation in high school in certain areas? By not electing courses in mathematics and science at the high school level, women are, in effect, erecting barriers to career options—mathematics and science in particular, but also fields requiring their application such as engineering or agriculture. At the present time, it appears that more males are at least leaving these options open so that career decisions can be made later at an age of greater experience and maturity. For these reasons, it can be argued that it would be desirable to increase the proportion of females electing optional mathematics and science courses in high school.

However, such policy goals might also be argued from a more basic value commitment. This type of course work in high school certainly has wider implications beyond the training of potential
scientists. Courses of this sort also help develop students' investigative, manipulative and abstract reasoning abilities. These types of skills are increasingly being called upon in everyday life as society moves in a direction of greater technical, computerized and scientific orientation. The measurement of these skills also functions as a screening mechanism for entry into many colleges, graduate school programs and occupations with respect to various entry tests. Therefore, if society, and schools in particular, are truly committed to the concept of equality of educational opportunity, then females, like other minority groups, must not be excluded from mathematics and science instruction.

With respect to policy recommendations, the results of this study suggest that perhaps it may be fruitful for educational systems to devote more efforts toward working with parents. Although evidence from this study is not directly conclusive, it is certainly very suggestive that efforts in this regard may contribute to increasing females' participation in elective science courses.

While this study did not specifically measure and find that females' parents actually rate their children's science ability lower than males' parents, this conclusion might be accurately inferred. A close correspondence between the expectations actually held for an individual and that individual's perceptions of these expectations is generally supported (Johnson, 1970; Kinch, 1963; Brookover & Erickson, 1975).
However, whether or not this situation for parents themselves is accurate, the results found here show that considerably fewer females than males think that their parents would rate their science ability as very high. This would suggest that parents need to either raise their level of evaluations for their daughters or, if they actually hold equal evaluations for sons and daughters, then parents need to communicate these evaluations more clearly to daughters. Brookover, et al. (1962, 1965, 1967) have provided some strategies for working with parents in this regard.

Parents, perhaps, need to be made more aware of the important role their expectations and evaluations play in their children's science development. It is not only their overt directives which influence their children's decisions of whether or not to study science when it becomes optional. The conscious or unconscious biases parents may hold as to the inappropriateness of science careers for women may be translated into their being less likely to see their daughters as having high levels of science ability, even as early as the junior high school period.

Another significant difference found between males and females was in their own self evaluations of their science ability. Considerably fewer females than males had high self-concepts. This also contributed to the lesser participation of females in optional science courses in the 11th and 12th grades. Evidence here suggests that one important source of these science self-concepts was the level of parental science.
evaluations discussed above. Certainly there are others. For example, are teachers and peers less likely to hold high evaluations of females' science ability as compared with those for males? And is there a more general view in the American society (the generalized other) which holds that females are less likely to have high ability in science than males? Past research would suggest that these factors do contribute to women's inferior participation in the sciences (see Fox's 1976 and Fennema's 1976 reviews). The level of these others' evaluations and the role that they play in the development and maintenance of students' self-conceptions of their science ability needs further investigation. (These additional factors would have been addressed in this research had the data been specifically collected for analysis of the problem in this study.)

The evaluations of parents also had a direct effect on students' decisions to take science beyond the minimum required level. Further elaboration and specification of this pattern of influence should be investigated. Likewise, other sources of direct influence from the expectations and evaluations of significant others as teachers, peers and counselors should be considered. For example, there is evidence of direct counseling of females out of taking optional science courses in high school by counselors (Haven, 1972; Casserly, 1975; Luchins, 1976).

Besides further investigation of these possible impediments to females' entry into science, other elements of the decision-making process would seem to be potentially important to the problem at hand.
For example, Brookover and Erickson's (1975) decision-making model specifies several important elements in self-conceptualizing behavior. Not only do students evaluate their own ability to carry out particular role requirements (i.e., the self-concept of ability studied here), but they assess the intrinsic and instrumental values attached to the particular role performance. For the problem at hand, future research might investigate whether females see less intrinsic worth in studying science or whether they see less future usefulness or payoff in their taking optional science courses as compared with their male counterparts' values on these. Another element of the self-conceptualizing process is the students' consideration of the role requirements for specific, general and competing roles. Here, future research might investigate students' perceptions of the appropriateness of taking advanced elective science courses as well as the appropriateness of following competing choices or roles. Related research cited in earlier chapters suggests that these factors may also be impeding females' election of science courses beyond the minimum requirements (and see Fox's 1976 review).

Perhaps future studies should also focus on the development and stability of the variables considered here. Fewer females than males perceived high evaluations of their science ability in the 8th grade. At what age does this sex difference emerge? Does this male-female discrepancy in science evaluations increase through high school as the
differential rates of course-taking in the 11th and 12th grades would suggest? Likewise, how stable are students' self evaluations of their science ability? Do these self conceptions decline through the high school period? Does the male-female difference increase with age? Only data of a longitudinal nature can answer these types of questions.

Another recommended avenue of investigation concerns other minority groups' development in the sciences. Prior research noted previously suggests that blacks, like women, are less likely to select science majors in college or to enter science careers as compared with white males. Perhaps this variable, race, should also be included in future research if the minority population in the sample is large enough to warrant separate analysis.

A last recommendation is for the collection and analysis of more current data on this problem of providing equity of science education for the sexes. The data used here used variables collected in the high school years of today's 20-year-olds. These young adults were part of the target group of consideration in this study. Why do we currently find so few women in science-related careers today? What early factors in the high school experience of these men and women of today might help explain this current paucity of women in science? The time frame of the data used here (the high school class of 1966) reflected a time period before any great public concern for equality between the sexes arose. However, in light of these and other findings, one would
question whether this same situation found in this earlier period still exists today. Particularly, given the current emphasis on eliminating sexism in educational policies and practices as well as the wider focus on sexism within society in general, does the situation on adolescent females and science which was documented over a decade ago still reflect females' science participation rates in high school? Are junior high school females still less likely to perceive high parental and self evaluations of their science ability than their male counterparts? One might hope that this situation has changed as a result of the more equalitarian views currently espoused by many. The question is still open to investigation, however. Current work on females' development in mathematics suggests that perhaps the situation for females and science has not substantially changed. But I would recommend further investigation of this problem in the students of today.

In conclusion, then, given the importance of taking elective science courses in high school for future science career development, this study gives some evidence that one of the reasons why fewer females than males elect science courses in the 11th and 12th grades is that during their middle school years, females begin to perceive lower parental evaluations of their science ability than do males. This would suggest that, among other things, schools must try to increasingly involve parents in the educational process. Parents must be made more aware of their significant role with respect to their
children's science development through the ideologies they transmit to their children.

This is, no doubt, only one of a number of factors contributing to the under-representation of women in the sciences. Further research on this problem is certainly needed. But studies must consider not only the overt discriminatory practices keeping females out of science at all levels. There must also be consideration and investigation of the residual unconscious effects of past discrimination against women which deters their early crucial development in science.


Epstein, Joyce L. and James M. McPartland. 1977. Sex Differences in Family and School Influences on Student Outcomes, Report No. 236, Center for Social Organization of Schools, Johns Hopkins University.


Fennema, Elizabeth. 1976. Influences of Selected Cognitive, Affective and Educational Variables on Sex-Related Differences in Mathematics Learning and Studying. National Institute of Education.


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APPENDIX A

MICHIGAN STATE UNIVERSITY SELF-CONCEPT OF ABILITY IN SPECIFIC SUBJECTS SCALE

1. How do you rate your ability in Science compared with your close friends?
   a. I am the best
   b. I am above average
   c. I am average
   d. I am below average
   e. I am the poorest

2. How do you rate your ability in Science compared with those in your class at school?
   a. I am among the best
   b. I am above average
   c. I am average
   d. I am below average
   e. I am among the poorest

3. Where do you think you would rank in your high school graduating class in Science?
   a. among the best
   b. above average
   c. average
   d. below average
   e. among the poorest

4. Do you think you have the ability to do college work in Science?
   a. yes, definitely
   b. yes, probably
   c. not sure either way
   d. probably not
   e. no

5. Where do you think you would rank in your college class in Science?
   a. among the best
   b. above average
   c. average
   d. below average
   e. among the poorest
6. How likely do you think it is that you could complete advanced work beyond college in Science?
   a. very likely
   b. somewhat likely
   c. not sure either way
   d. unlikely
   e. most unlikely

7. Forget for a moment how others grade your work. In your own opinion, how good do you think your work is in Science?
   a. my work is excellent
   b. my work is good
   c. my work is average
   d. my work is below average
   e. my work is much below average

8. What kind of grades do you think you are capable of getting in Science?
   a. mostly A's
   b. mostly B's
   c. mostly C's
   d. mostly D's
   e. mostly E's.
APPENDIX B

PATH ANALYSIS

Final analysis is a multiple regression technique (see Loether & McTavish, 1974a:321-335) in which the variables are entered into a model with the casual ordering between all variables being pre-determined. It should be noted that the data analysis does not determine casual ordering, but rather temporal, theoretical, and prior research considerations dictate the casual relations set up in the model to be tested.

Ideally, path analysis is perhaps not totally appropriate for use with certain of the variables incorporated in this study. In particular, as a regression technique it is not strictly appropriate for use with a dichotomous dependent variable (i.e., whether or not the student elected an advanced science course in high school) nor with a nominal level independent variable (i.e., sex). It is, however, a useful and fairly common practice (see Goldberg, 1971 and Boyle 1971) particularly when supported by further analysis of a non-parametric nature. In light of the violations of these assumptions in using path analysis, further complimentary strategies (i.e., contingency table analysis) were also employed in this study.
APPENDIX C

CONTINGENCY TABLE ANALYSIS

Goodman's log-linear analysis procedure for examining multi-dimensional contingency tables is often referred to as ECTA (Every-man's Contingency Table Analysis)--see Goodman (1972). This technique permits the estimation of the relative effects of the independent variables on the frequency distribution of the dependent variable. In using this process, various models are tested to see which variables and interaction effects are necessary to explain the observed differences in the dependent variable (e.g., science entry).

To select the best model, an iterative procedure is used which holds certain marginals constant (those specified in the model). Expected cell frequencies are computed for the particular model being tested which are then compared with the observed frequencies. An $X^2$ (the likelihood ratio $X^2$) is used to test whether the resulting hypothesized model "fits" the data (i.e., no significant differences between the model's expected frequencies and the actual observed frequencies in the contingency table). If the $X^2$ for a model is significantly small relative to its degrees of freedom, the model is said to be significant.

Related models (each leaving off one of the variables or interaction terms from the best model) are then examined to test whether
each variable and interaction effect in the hypothesized model makes a significant contribution to the "fit." Likewise, further models are analyzed to test whether additional variables or interaction effects can significantly improve the fit of the model (i.e., a significant drop in the $X^2$).

A number of models may be identified as significant models for a particular data set. However, a "best" model may be selected according to criteria suggested by Goodman (1972) and Burke and Turk (1975)—i.e., a parsimonious model, inclusion of all lower level effects, the model could not be significantly improved, all effects are significant, smallest $X^2$ fit, etc.

Once the best model is selected, the gamma parameters associated with that model can be examined and compared. These parameters show the relative importance of each variable and interaction effect for prediction of the distribution of the dependent variable. Because of the multiplicative nature of these parameters, those factors having gamma values greater than 1.0 are interpreted as having a positive effect on the dependent variable (e.g., a positive effect on the students' likelihood of taking science); those with gamma values less than 1.0 have a negative impact. Those factors with gammas equal to 1.0 have no effect, given the model being used (although the variable may actually have some effect, it is set equal to 1.0 in the model because it does not make a significant contribution to the fit of
the model to the actual data).

The two gamma parameters associated with each variable are reciprocals of one another (i.e., the gamma for males equals one divided by the gamma for females). Thus, because of their multiplicative nature, the effect of being male has the same magnitude as the effect of being female, with the former being positive, the latter being negative. Thus the magnitude of only one factor need be considered for each variable. In this analysis, only the magnitude of the positive factor (i.e., the gamma greater than one) will be reported for each variable so that the relative impacts of each variable and interaction effect may be compared.

By selecting the appropriate gamma parameter for each of the variables and interaction effects in the model, an estimate can be calculated for the expected odds ratio (explained below) for the dependent variable for a person with those specified characteristics. As an example, use the gamma parameters shown in Table 3.8. The expected odds of a low ability, low social class female with high parental and self evaluations of her science ability electing an advanced optional science course would be computed as follows:

<table>
<thead>
<tr>
<th>Gamma Parameter</th>
<th>Category of Each Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>.558</td>
<td>female</td>
</tr>
<tr>
<td>.621</td>
<td>low general ability</td>
</tr>
<tr>
<td>.778</td>
<td>low social class</td>
</tr>
<tr>
<td>1.327</td>
<td>high parental evaluations</td>
</tr>
<tr>
<td>1.480</td>
<td>high self-concept</td>
</tr>
<tr>
<td>1.297</td>
<td>female, low general ability</td>
</tr>
</tbody>
</table>

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### Gamma Parameter

| 1.284 | female, low social class |
| 1.248 | low ability, high parental evaluation |
| 1.000 | all other factors |
|x 1.721 | general mean for science entry |
| 1.882 | |

(The gamma parameter associated with the general mean for the variable "science entry" merely reflects the unequal distribution of this dependent variable in the sample studied here.) A male having the same characteristics would use slightly different gamma parameters, i.e., the same ones as above except replacing all those which include the variable sex (1.792 instead of .558, .771 instead of 1.297, and .799 instead of 1.284). These expected odds ratios are calculated for each combination of categories of the five independent variables. These expected odds based on the best fitting model (presented in Table 3.10) should be fairly close to the actual observed odds presented (in Table 3.8).

The odds or odds ratio for a dichotomous variable are calculated from the ratio of category 1 to category 2. As a simple example, if the odds of winning were 2:1, the individual would be twice as likely to win as to lose (or 2 wins for every 1 loss). The odds ratio would be 1/2 or \( \frac{1}{2} \). As an example from this study, the odds (or likelihood) of taking science (for a particular category of sex, IQ, social class, evaluations, and self-concept) would be computed as:

\[
\frac{\text{number who elected science}}{\text{number who did not elect science}} = \frac{\text{Yes}}{\text{No}}
\]
Looking at Table 3.8, the observed odds for a female categorized as low on the other four variables would be calculated as follows: $16/57 = .28$. This observed odds ratio might be interpreted as follows: for every 2.8 females with the specified characteristics who selected a science course, there are 10 females who did not—or, there is an approximate 1 to 4 likelihood of selecting science.

The idea of odds ratios is similar to that of probability. The probability of taking science for a particular category would be computed as:

\[
\frac{\text{number who elected science}}{\text{number who did PLUS number who did not elect science}} = \frac{\text{Yes}}{\text{Total}}
\]

For the above example, this would be calculated as follows: $16/(16+57) = .219$. The two concepts, then, are different, but very much related. The probability could be calculated from the odds ratio as follows:

\[
\text{Probability} = \frac{\text{the odds ratio}}{\text{the odds ratio} + 1}
\]