DOCUMENT RESUME

ED 363 512 SE 053 839

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TITLE Gender Differences in Science Course-Taking Patterns among College Undergraduates.
PUB DATE Apr 93
NOTE 71p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 1993).
PUB TYPE Reports - Research/Technical (143) -- Information Analyses (070)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Career Choice; *College Science; *Course Selection (Students); Educational Research; Family Influence; Females; Higher Education; High Schools; Mathematics Education; Minority Group Influences; *Science Curriculum; *Science Education; Secondary School Science; *Sex Differences; Undergraduate Students

ABSTRACT

This study was conducted from the perspective that the under-representation of women in science is, at least partially, a consequence of learning, and therefore, may be considered a symptom of a hidden curriculum in science education. A nine page review of the literature is presented on this subject. This study investigated the direct and indirect influences of sex and several intervening variables on the quantitative science course selection among college undergraduates using the High School and Beyond database. The analyses yielded three major findings: (1) after statistically controlling for all of the other independent variables in the model, being female still resulted in taking fewer undergraduate quantitative science courses, (2) the number of high school science and math courses was the most important mediating variable between SEX and QUANTITATIVE, and (3) within-sex analyses indicated strong interactions between sex and several of the other independent variables. Contains 50 references. (PR)

Gender differences in science course-taking patterns among college undergraduates.

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Paper presented at the annual meeting of the American Educational Research Association. Atlanta, GA. April 12-16, 1993.

Introduction

The paucity of women choosing careers in science, mathematics, and other technical fields is of great concern to scientists and science educators (AAAS, 1990). While the percentage of women choosing to pursue undergraduate degrees in science has been increasing in recent years, women are still underrepresented as science majors, graduate students, and practicing scientists. Additionally, much of the recent gain in undergraduate women science majors is due to increased rates of female participation in the life sciences; women continue to be markedly underrepresented in the physical sciences (Office of Technology Assessment, 1988). These trends may be attributed to two broad categories of reasons. They may be tied to discriminatory practices which prevent women's access to science and the under-representation of women in science may be tied to learning. This study was conducted from the perspective that the under-representation of women in science is, at least partially, a consequence of learning, and therefore, may be considered a symptom of hidden curriculum in science education.

Describing the problem of under-participation may help formulate effective policies and programs to address hidden curriculum and increase the participation of women in science (Chipman & Thomas, 1987). Much of the difficulty in alleviating this problem lies in the fact that hidden curricula are fluid and continually undergoing change (Martin, 1976). As a contribution to hidden curriculum research and theory, this study aims to identify and understand the learning states, settings, and sources that may underlie variability in science course-taking behavior of undergraduate students. The major research question concerns how a hidden curriculum in science education may lead to an under-representation of women in science. Specifically, what factors, such as particular learning states, settings, and sources, can help explain why women and men differ in the number of undergraduate science courses they select? The following section presents an analysis of the hidden curriculum concept and an explanation of how this concept serves to structure this study.

Hidden Curriculum

Most hidden curriculum research and intervention focuses on formal school settings, but the concept extends beyond the realm of formal schooling to include the learning that occurs in many non-school settings (Martin, 1976). It has been suggested that the under-representation of women in science is partly related to hidden curriculum in science education (Martin, 1989). The following section will briefly review the "hidden curriculum" concept and its significance for this study.

Defining the hidden curriculum concept. While several writers have commented on the difficulty of explicitly defining a hidden curriculum (e.g. Cornbleth, 1984; Cummins, Pinar, & Good, 1989; Vallance, 1980), Martin (1976) offers a broad definition: "...a hidden curriculum consists of some of the outcomes or by-products of schools or of nonschool settings, particularly those states which are learned yet not openly intended. There is no special subject matter which always and everywhere characterizes hidden curriculum, although, of course, a hidden curriculum must have *some* subject matter" (p. 124). Martin differs from Vallance (1980) in respect to the intention associated with a hidden curriculum. Valance suggests that the term "hidden curriculum" refers to an after-effect, rather than to any specific process or intention of hiding, while Martin (1976) argues that there are two kinds of hiddenness based on the question of intent. A hidden curriculum may be purposely hidden by someone or some group, or the hiddenness may be consciously unintended, but in either case a hidden curriculum is not openly acknowledged to the learners in a given setting (Martin, 1976). Martin further clarifies her definition of a hidden curriculum: "A hidden curriculum consists of those learning states of a setting which are either unintended or intended but not openly acknowledged to the learners in the setting unless the learners are aware of them (Martin, 1976, pp. 131)."

Learning states can be character traits (e.g. personality), cognitive states (e.g. knowledge or skill), emotional states, attitudes, and dispositions. Whereas a given setting may evoke innumerable learning states, unique learning states are overlooked when studying a particular hidden curriculum, because the hidden curriculum of a setting consists in it's dominant or systematic learning states (Martin, 1976).

If we look beyond specific learning states and settings, the sources of a hidden curriculum may be uncovered. Sources are elements of the relevant setting or settings which produce certain learning states (Martin, 1976). For example, the social structure of the classroom, the teacher's exercise of authority, the rules governing the relationship between teacher and student. Standard learning activities can be also be sources, as can the teacher's use of language, textbooks, tracking systems, and curriculum priorities (Martin, 1976). It is important to examine sources in order to change a setting's hidden curriculum. If educators and policy makers are not cognizant of sources, interventions would not be able to accurately target specific areas for change--they would have to either accept the situation as it is or dismantle the whole setting (Martin, 1976). This study will use Martin's conceptual framework of "hidden curriculum" (see Martin, 1976) to investigate the under-representation of women in science.

Review of the Literature

Despite considerable attention to the "gender gap" in science achievement and career choice during the past 30 years, researchers and theorists only recently have begun to grasp the complexity of the sources of the under-representation of women in quantitative fields. Berryman (1983) used a pipeline as a metaphor to describe the educational steps through which all scientific personnel must flow; Sells (1982) identified mathematics as a "critical filter" (source) limiting women's access to scientific studies and careers. Therefore, one major strand of research has focused on the learning states (primarily cognitive) contributing to gender differences in mathematics ability and achievement. A second area of research has concentrated on the effects of setting-specific (schools) and social sources on mathematics and science outcomes, while additional research has examined the influence of such learning states as attitudes, aspirations, and college performance on the choice of college major in a physical or technical science field.

This section briefly reviews the empirical research which provides information about the learning states, settings, and sources contributing to the under-representation of women in science. (For more detailed examinations of this literature see the following recent reviews: Chipman & Thomas, 1987; Linn & Hyde, 1989; Linn & Peterson, 1986; Oakes, 1990). Following this overview of previous research is a discussion of the findings and limitations of previous studies using the same data base.

Learning States

The literature suggests that sex differences have been decreasing in cognitive areas (e.g., mathematics and science achievement) related to science career choice. As a matter of fact, some suggest that differences may be considered small or nonexistent (Linn & Hyde, 1989). It appears, though, that differences in science-related interest patterns, educational and vocational aspirations, and science and mathematics attitudes are often formulated by the time a student begins high school and these differences seem able to account for most of the sex differences in high school mathematics and science course enrollments leading to higher science achievement and continued participation in scientific fields (Chipman & Thomas, 1987).

The diminishing sex differences in cognitive skills indicates that the hidden curriculum in science education is possibly changing. Previously, females were less-skilled in areas critical to success in science. This is no longer the case, yet women remain underrepresented as college science majors. Martin (1976) writes that "new settings with their own hidden curricula are forever being created and old ones are forever changing (p. 127)." She suggests that the search for the hidden curricula must be expanded, in this case, beyond the learner to settings and sources in order to describe the hidden curriculum related to the under-representation of women in science.

School Sources of Hidden Curricula

The lack of women in science classes and careers may be due in part to gender-related differences in experiences and attitudes in science classrooms. Both implicit and, more rarely, overt teacher behaviors, including lack of attention to different learning styles (Oakes, 1990), offering males more opportunities for higher levels of cognitive learning (Tobin & Garnett, 1987), and sex biases in encouragement for pursuing science coursework (Oakes, 1990) are all sources of a hidden curriculum in science education. In other words, these activities rarely occur as a result of the stated goals and objectives of the curriculum proper, but rather, as a result of covert or subconscious activities by schools and society.

Sex differences in opportunities to learn mathematics and science begin early and seem to increase throughout the school years. They are most apparent in secondary school when tracking and elective courses are prevalent, but clearly have their roots in elementary school and possibly before (Kahle & Lakes, 1983; Oakes, 1990).

Tobin's research program (e.g., Tobin & Fraser, 1989; Tobin & Gallagher, 1987; Tobin & Garnett, 1987) has demonstrated how strongly the students' perceived learning environment is related to teachers' knowledge and beliefs exhibited through classroom practices. These findings illustrate that teachers regularly deal with students in inequitable ways, often based on unsubstantiated beliefs. As a result each student perceives the learning environment differently, not because of inaccurate student perceptions, but because different learning environments (settings) do exist for different students within the same classroom. The acquisition of high-level cognitive science outcomes clearly suffered under this system. Additionally, differential treatment and expectations will further discourage and disadvantage students -- more often female students -- who might have otherwise found science interesting and worthwhile to pursue (Oakes, 1990; Tobin & Garnett, 1987).

Social Sources of a Hidden Curriculum

Increasingly, sex differences in societal expectations and childhood socialization patterns are thought to be responsible for hampering women's confidence, attitudes, and achievement in science (Chipman & Thomas, 1987; Lynn & Hyde, 1989; Oakes, 1990). Additionally, discrimination in the work force and the halls of academe likely work against the participation of women in science.

The importance of societal influences on scientific career choice cannot be overlooked. While there are no SES differences between males and females, SES likely is related to choice of scientific major through intervening variables such as high school achievement. More important than SES in describing sex differences in science achievement and career choice are the effects of societal expectations and discrimination. A growing body of literature argues that differences in social factors -- parental encouragement, role models, and real or perceived societal norms -- may negatively impact women's confidence, aspirations, and career choice and attainment (Oakes, 1990). Additionally, work force and academic discrimination may influence women's choice to persist in the scientific pipeline.

Dispositional Learning States

Dispositional Learning States

To the extent that any of the school-related factors have an effect on science achievement and career choice, it is usually mediated through high school mathematics and science course-taking patterns. There is a large body of research exploring the "differential course-taking hypothesis", particularly through the use of large databases such as NAEP, HSB, and state achievement tests, which have linked students' course-taking patterns to performance on achievement tests (Oakes, 1990). Other work indicates that course-taking in high school is related to the choice of a science major in college (Ethington & Wofle, 1988). In fact, the advent of these large databases and powerful computers has helped decrease the proportion of unexplained variance in this type of study since the early 1970s, as researchers began statistically controlling for the influence of course-taking histories (Oakes, 1990).

Sex differences in mathematics achievement at the beginning of high school are negligible and cannot account for the sex differences in enrollment (Chipman & Thomas, 1987). On the other hand, regression analyses have demonstrated that sex differences in high school course enrollments (after controlling for ability and SES) can account for most of the sex differences in science and mathematics achievement at the end of high school (Chipman & Thomas, 1987). These results suggest that two of the explanatory variables -- mathematics achievement and number of mathematics and science courses taken in high school--simply reflect the decision at a much younger age not to concentrate on such fields (Chipman & Thomas, 1987).

Furthermore, high school course-taking may be the key to the college participation, and sex-differences in this area appears to be the result of choices on the part of young women (Chipman & Thomas, 1987). The information gained from studies of cognitive abilities and aptitudes provides evidence that relatively equal numbers of males and females are qualified for advanced science and mathematics courses as they enter high school. That girls who are academically qualified more often choose not to take more advanced mathematics and science classes, is potential evidence for the effects of the hidden curriculum.

Limitations of previous studies

This review of literature illustrates a paradox: Research reveals small gender differences in few areas of performance, such as mathematics and science achievement, yet large and persistent differences in science-related course selection and career choice exist (Tittle, 1986). Some have suggested that these persistent sex differences in career choice are linked to gender-related differences in attitudes, interests, and other motivational characteristics at the individual level (e.g., Chipman & Thomas, 1987; Eccles, 1990; Tittle, 1986). But studies incorporating attitudinal variables still report that much of the variation in choice of college major remains unexplained (Ethington & Wofle, 1988; Lantz & Smith, 1981).

Part of the difficulty in reaching firm conclusions lies in the complexity of the problem itself. Although we have learned a great deal about associations among many variables apparently related to participation; simply testing bivariate relationships or investigating sex differences on single measures probably will not be fruitful (Oakes, 1990). On the other hand, most of the recent progress has been as a result of the development of theories (e.g., Chipman & Thomas, 1987; Eccles, 1990) and testing of models (Ethington & Wofle, 1988; Maple & Stage, 1991) which has greatly aided our knowledge of the complex processes influencing science career choice.

Investigations guided by well-formulated models have helped, and will continue to help researchers grasp how relationships among variables fit into the dynamics of participation in science. There will likely be disagreement about any one person's conceptual or theoretical model, but when the model is made explicit, there is the advantage that debate can emerge and alternative models may be tested against the data and indirectly against each other (Marini, 1988).

Previous High School and Beyond Studies

In addition to the limitations mentioned above, many previous studies employed small and/or localized samples -- creating concerns about the generalizability of this work. Large, representative, and longitudinal data sets have only recently become available for the testing of proposed models, helping to alleviate problems with external validity. There have been three High School and Beyond (HSB) studies investigating factors contributing to the choice of college science major for women (Ethington & Wofle, 1988; Maples & Stage, 1991; Ware & Lee, 1988). Because the findings of these studies helped inform this study, the design, results, and limitations of each study will be briefly reviewed below. Immediately following this discussion will be an explanation of how this study attempted to ameliorate the shortcomings of these critical studies.

Ware and Lee (1988). This study was based on the 1980 HSB senior cohort who had scored at or above the 50th percentile on the HSB achievement test completed during the senior year of high school. Ware and Lee's conceptual model regressed choice of science or non-science major on the following four independent variables: (a) college characteristics, attitudes, and behaviors; (b) high school courses and achievement; (c) high school characteristics, attitudes, and behaviors; and (d) personal and family background. Their sample of 1280 men and 1312 women included those HSB participants who were enrolled in a 2- or 4-year college in 1982 and who had declared a major. They tested their model for men and women separately to assess the differences in the factors that predict choice of science major.

Ware and Lee (1988) accounted for more variance in choice of major than any of the other HSB studies reviewed here. The independent variables selected for their analyses explained approximately 50% of the variance in the dependent variable for the male sample and 30% for the female sample. For women, years of college math and science courses (2 variables) were most highly correlated with college major. Four other independent variables yielded statistically significant positive effects: (a) the number of high school math courses, (b) educational aspirations, (c) math attitudes, and (d) high school grade point average. These coefficients, while statistically significant, were all relatively small (less than or equal to .10). Attending a four-year versus a two-year college was negatively associated with choice of science major for women, as was the importance of future family matters, years of college social science and English courses, and the influence of high school staff on college plans.

A similar pattern emerged in the analysis restricted to males, although the effects were slightly larger on most variables. Contrary to the results for women, attending a four-year college compared with a two-year institution had a positive effect on choice of science major for men.

There are several methodological and logical problems with the Ware and Lee (1988) study. First, the dependent variable, "declared or intended college major," was a single dichotomous item (science/non-science major) from the 1982 HSB questionnaire. This groups physical and life science majors in the same category, yet research indicates that women are not underrepresented as biological science majors (OTA, 1988). Additionally, this variable was obtained less than two years after high school graduation -- a variable obtained later in the college program will be a more accurate indicator of college major.

Second, the method Ware and Lee (1988) used to compute their independent variables was unclear, thereby clouding the interpretation of their results. Replicating this study would be almost impossible due to the vagueness of their variable construction. These independent variables called "constructs" by Ware and Lee appear to be clusters of single-item HSB variables. If they did compute composite variables (though it appears that they did not), they did not specify how they were computed, nor did they report reliability coefficients. Their apparent use of the single-items is potentially more troublesome for path-analysis. The individual items within each cluster are left unspecified--in other words, no hypothesized relationships among these items was articulated, making the interpretation of the path-analysis very difficult.

Finally, the most serious limitation of Ware and Lee's (1988) study, however, was the use of "courses taken in college" as predictors of choice of science major/non-major. This poses a logical problem, for it is true by definition that a science major would have to take more college mathematics and science courses than a non-major. Thus, the high R^2 in this study is, in effect, largely attributable to the fact that an independent variable in used to predict itself.

Ethington and Wofle (1988). The two other HSB studies mentioned above (Ethington & Wofle, 1988; Maples & Stage, 1991) did not suffer from the logical problems found in Ware and Lee (1988) and both were important advances in understanding the processes leading to sex differences college science majors. Indeed, much of the present study was built on the work of Ethington and Wofle (1988).

Ethington and Wofle (1988) used the HSB 1980 sophomore cohort to test their path-analytic model. Their dependent variable, "field of study", was derived from the 1984 follow-up survey (two years after these students would have graduated from high school). "Field of study" was a self-report of the student's declared college major which was then dichotomously coded to science vs. all other majors. Their study was limited to the 1,312 African American and white women who had participated in the 1980, 1982, and 1984 waves of the survey and had attended a postsecondary institution.

The model developed by Ethington and Wofle (1988) was arranged in three blocks: the first was an exogenous block comprising background variables (race and SES), attitudes (math attitudes and sophomore expectation of college major), and psychological constructs (self-concept and locus of control). The second block of variables represented sex and family orientation, the counselor and teacher influence on post-high school plans, and the number of advanced mathematics and science courses taken in high school. The authors hypothesized that these variables would influence field of study in college through their influence on the third block of variables: high school grades, science achievement, and mathematics achievement.

The results of these analyses indicated that the number of science and mathematics courses completed in high school was the most influential variable in the model followed by sophomore expected college major was the next most important variable in their study. Its direct effect was almost as large as the direct effect of high school courses, but because Ethington and Wofle considered it to be part of the exogenous block, no indirect effects were calculated. Mathematics attitudes did not have a significant direct effect but was significantly associated with field of study through it's indirect influence on high school mathematics and science courses. There was little relationship between either mathematics or science achievement and field of study or between high school grades and field of study.

Ethington and Wofle's (1988) study was limited by several factors. First, their dependent variable was drawn from the 1984 survey. Both Ethington and Wofle (1988) and Maple and Stage (1991) used a dependent variable drawn from the 1984 follow-up survey, only two years after these students would have graduated from high school. Additionally, neither Maples and Stage (1991) nor Ethington and Wofle (1988) controlled for the amount of time a student had been in a postsecondary institution. The reader has no way of knowing if the sample was drawn from students in their first term in college or those who completed two full years. This last point is important because students in their first two years of college often do not have to formally declare a major, yet still might plan on majoring in science. Students in their first or second terms might still consider themselves "science majors" while possibly not even completing any science course. There is a fairly high attrition rate of science majors throughout the undergraduate years, especially among women (Schonberger & Holden, 1984).

Second, the self-report used by Maple and Stage (1991) and Ethington and Wofle (1988), collected very early in the college career, may have validity problems. Based on Schonberger and Holden's (1984) research, the dependent variables used in these two studies will likely lead to an overestimation of the number of actual science majors. Further, this overestimation may be more exaggerated for female compared with male undergraduates.

Finally this study used a female-only sample which did not permit examination of the interactive effects of sex. Additionally, their study, like Maple and Stage (1991), used the sophomore cohort of HSB which lacked certain key variables (e.g., spatial ability) found in the HSB senior-cohort data set, and finally, the used of the dichotomous dependent variable obscured the distinction between physical and life science majors.

Maple and Stage (1991). Maple and Stage (1991) used a more sophisticated form of causal modeling (LISREL) to test their model for four different subgroups: African American males, African American females, white males, and white females. These analyses were based on the 2,456 African American and white students who had participated in the 1980, 1982, and 1984 waves of the sophomore cohort survey. The variables were very similar to those used by Ethington and Wofle (1988), but also included achievement test data from the base-year survey.

Maple and Stage tested their model for each of the four groups, and the variance explained by their independent variables ranged considerably across the different analyses. Their model explained 34% of the variance in choice of major for African American males, 20% for white males and for African American females, and only 11% for white females. The difference in the amount of explained variance indicates an interaction among sex, race, and the intervening variables in the model. Intended field of study as a sophomore in high school and the number of mathematics and science courses completed in high school were significantly associated with choice of major for all four subgroups. Mathematics attitudes was significantly correlated with choice of major only for the two African American subgroups, whereas high school grades was a predictor of choice of major for white males only.

The present study. The present investigation examined the direct and indirect influences of sex and several intervening variables on the quantitative science course selection among college undergraduates. The development of the model in this study was guided largely by three major sources: (a) Martin's (1976) and, to a lesser extent, Vallance's (1980) conceptualization of the hidden curriculum; (b) the complex theoretical framework outlined by Chipman and Thomas (1987) regarding the under-representation of women in science; and (c) Ethington and Wofle's (1988) previous empirical research using HSB. Exploration of hypotheses derived from the model will involve the High School and Beyond database.

This study was designed to ameliorate several of the limitations of research discussed throughout the preceding chapter. First, and similar to the three HSB studies just discussed (Ethington & Wofle, 1988; Maple and Stage, 1991; Ware & Lee, 1988), the longitudinal nature of the HSB database allowed the testing of a theoretical model using path analysis. Path analysis offers a key advantage over multiple regression by allowing us to explore causal relationships among the independent variables. Second, the HSB data contained a substantial number of variables identified by theory and the previous research to add to the knowledge base regarding the observed variability in the selection of college science courses. Several of these variables, such as spatial ability and academic orientation were not used in any of the previous HSB studies. Third, the dependent variable used in this study was based on data collected four years after the senior cohort graduated from high school, giving the college students more time to establish their course-taking patterns. Fourth, analyses were restricted to members of the senior cohort who had completed approximately three years of postsecondary schooling, helping to lessen problems of external validity described for the previous HSB studies.

Finally, and most importantly, the dependent variable in this study was drawn from the HSB Postsecondary Education Transcript surveys (National Opinion Research Center, 1986): the percentage of credit hours in physical and mathematical sciences on the student's transcript by July, 1984. Specific majors are not directly comparable across colleges because of institutional differences in how majors are defined, but percentage of quantitative science credits as function of total credits establishes an easily comparable metric. Additionally, using a dependent variable drawn directly from the students' transcripts eliminates one weakness of most HSB studies--problems with the validity of self-report data. No HSB study investigating this issue has employed a dependent variable with this characteristic.

The major research question addressed by this paper concerns one aspect of a complex problem--a hidden curriculum in science education--and how this leads to an under-representation of women in science. Specifically, this study aimed to answer the following research questions:

1) What are the major variables that predict science course selection for college undergraduates?
2) What are the factors contributing to the differing amounts of undergraduate science courses selected by women and men?
3) How does the interaction among the key predictors contribute to science course selection?
4) Does path-analysis allow for the detection of a hidden curriculum in science education, and if so, does it point to specific sources of a hidden curriculum?

Method

Data Sources and Subjects

Sample. The HSB base-year survey employed a multi-stage sampling scheme (National Opinion Research Center, 1987). In the first stage, a highly stratified national probability sample of 1,122 high schools was selected in the spring of 1980, of which 1,015 schools agreed to participate. Next, 36 seniors were sampled from each school, or in cases where there were fewer than 36 seniors, as much of the entire class as possible was sampled.[2] For a detailed review of the sampling design, see the High School and Beyond data handbooks (National Opinion Research Center, 1987). There were 9373 subjects who participated in the 1980 base year survey and the 1982, 1984, and 1986 follow-up surveys.

All of the independent variables were drawn from the 1980 and 1982 student surveys, but the dependent variable was derived from the High School and Beyond Postsecondary Education Transcript Study (PETS) (National Opinion Research Center, 1986). PETS, conducted in 1984-1985, involved the collection and processing of school transcripts for all members of the HSB senior cohort who had attended any postsecondary institution since leaving high school (N=7,776). As was indicated previously, no study on this topic to date has utilized this data source.

On the 1982, 1984, and the 1986 surveys, respondents were asked about their postsecondary educational status for eight different time periods (October 1980 through February 1984). Possible responses included: enrolled in a public or private institution, enrolled in 2 or 4 year college, attending post-secondary school as a part-time or full-time student, or not currently in school. A composite variable was created by giving 2 points for full-time attendance, 1 point for part-time attendance, and no points for not being enrolled in school. Therefore, a maximum value of 16 points would be computed for a student who had been enrolled full-time during all eight semesters. Unlike the HSB studies

[2] HSB also sampled 36 sophomores from each school.

mentioned in the previous chapter, all analyses in this study were restricted to individuals who had attended the equivalent of at least six full-time terms (12 points) of postsecondary schooling between October, 1980 and February, 1984. These restrictions yielded a sample 2,928 individuals: 1,489 females and 1,439 males. After listwise deletion of missing cases the final sample included 2,308 individuals: 1,178 females (51%) and 1,130 males (49%).

Transcript data were organized into a four-level hierarchy consisting of data at the student, transcript, term, and course levels. In the present study, data were drawn from the student- and course-level files. Student-level data refer to information about the respondent's educational career and includes summary information found on transcripts for all postsecondary schools attended, such as total credit hours earned and credit hours earned in a variety of subject areas. Course-level records compile data for each course taken by a student during a specific term. The course title, a six-digit academic or vocational program code, course grade, and course credits were entered into each record. The program code, based on *A Classification of Instructional Programs* (CIP), is a taxonomy that groups all instructional programs into 50 major program areas, which are further divided into 371 program groupings and 1,175 individual programs (National Opinion Research Center, 1986).

Procedure. Several steps were required to prepare the data files prior to use in this study. First, all 1,175 course CIP program codes and program titles were examined to identify all science and mathematics course categories from non-vocational postsecondary institutions. One-hundred and forty-three program codes from twenty-three program areas were identified. Next, these course groupings were aggregated at the student level and merged with the student-level files so that a value for each course category (a percentage of total courses) was added to each student record. Finally, the new file, with the science course percentages and the summarizing credit information, was then merged with the main HSB student data file.

Variables and Logic of the Model

Brief descriptions of the variables used in this study are presented in the following description of the logic of the model. Details regarding construction of the composites and their estimates of internal consistency (Cronbach's alpha reliability) are found in Appendix A.

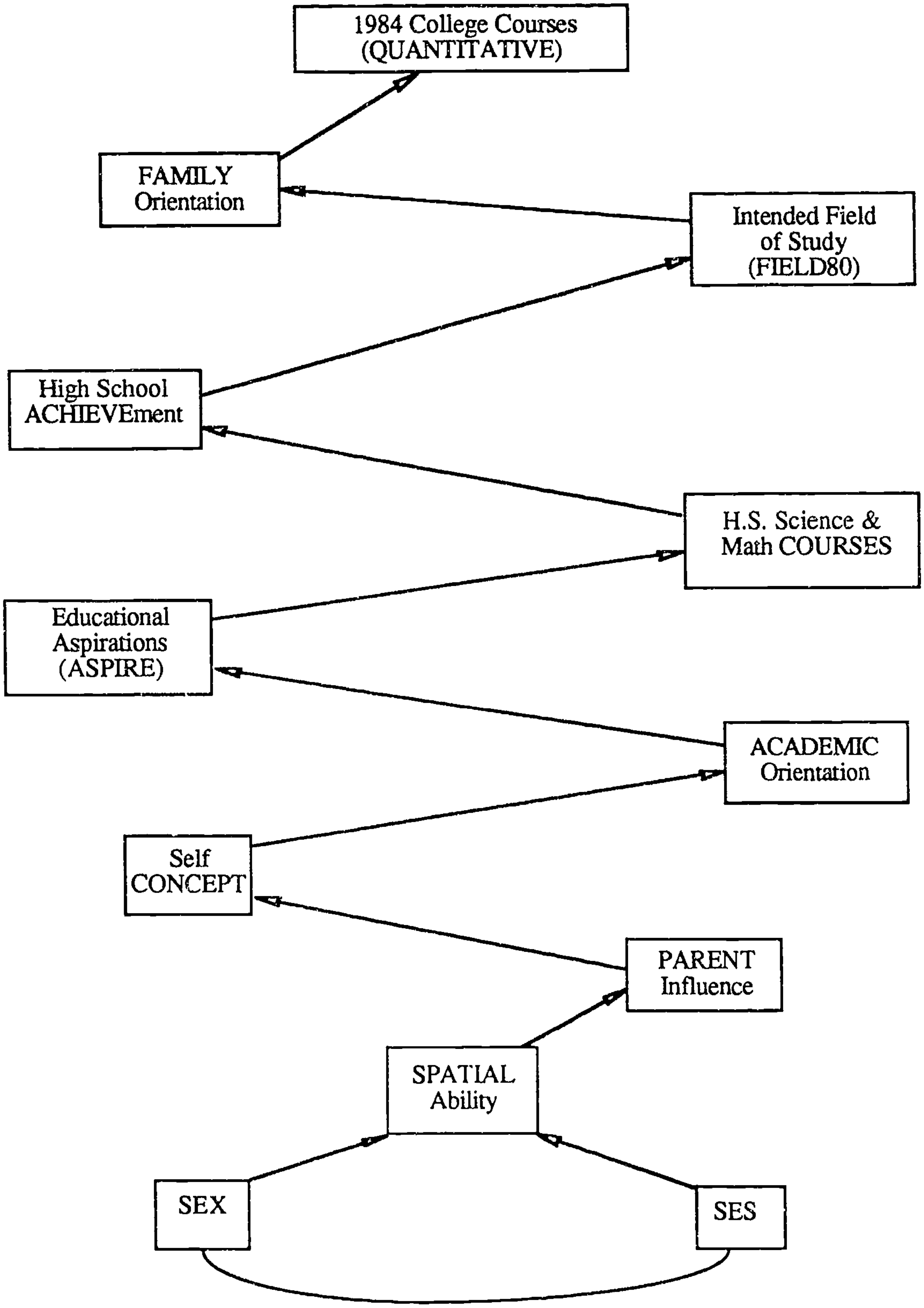
As mentioned previously, the development of the model in this study was guided largely by the work of Martin (1976), Chipman and Thomas (1987), and Ethington and Wofle (1988). Further, this model is consistent with much of the existing literature while adhering to the limitations imposed by using an existing data source (HSB). In certain cases, where supporting literature was lacking, inclusion and placement of specific variables was based on logical hypotheses of the authors. The model and the hypothesized relationships among variables are presented below and depicted in Figure 1. All effects were expected to be positive, with the exception of SEX and FAMILY.

Dependent variable. The dependent variable was QUANTITATIVE: The non-transfer mathematics, computer science, and physical science credits as a percentage of total non-transfer credits a student had completed by July, 1984. This variable was computed from the summary information provided on the student-level file of the Postsecondary Education Transcript tape. This variable reflected the percentage of overall credits which were physical/technical science and mathematics credits.

As a check of this procedure, a similar variable was computed from the information on the course-level file of the Postsecondary Education Transcript tape. The following describes the method used to calculate a variable representing the percentage of courses which were physical/technical science and mathematics courses. The sixteen categories of science courses were compressed into three categories: biological sciences (BIOLOGY), math and computer sciences (MATHCOMP), and physical sciences (PHYSICAL). These were further grouped into quantitative (QUANTITATIVE) (physical sciences + math and computer sciences) and biological sciences (same as BIOLOGY). Correlations among each

Figure 1.

Schematic representation of path model.



of the variables (computed using courses and computed using credits) were all higher than r=.90. We decided to use the credits calculation for the dependent variable because many science courses are only one-credit laboratories and would be over-represented using the courses method, but weighted appropriately using the credit computation method. Further, we decided to include only physical and mathematical science courses, and not life science courses, because that is where the most severe problem of female under-representation occurs.

Independent variables. The model comprised two exogenous and nine endogenous variables. Exogenous variables are usually background variables (e.g., race, SES) which, unlike endogenous variables, have no posited antecedents. The variables are briefly described below in the order of their proximity to QUANTITATIVE. Complete descriptions of all variables may be found in Appendix A.

Family orientation (FAMILY) was designed to assess students' feelings about marriage and having children. Students indicating that they wanted to get married and have children at relatively young ages were considered to have high orientations towards family life (Ethington & Wofle, 1988). These variables was included as an estimation of gender-role stereotype; those with more traditional gender roles were expected to have a high family orientation. It was hypothesized that individuals with high family orientation would be less likely to pursue undergraduate science programs due to the extensive time commitment required in those fields. These temporal commitments often take the form of extensive laboratory work during undergraduate years and the need for graduate school and post-doctoral research in order to pursue a career. It was also hypothesized that sex would interact with this variable: negatively influencing women, while having no effect on men.

Items used to create this composite were taken from the 1980 and 1982 surveys. Data from the first follow-up survey (1982) were used to assess the students' attitudes toward family at a time they might be making decisions about college majors, career choice, and family expectations. An attempt was made to formulate a gender-role variable from

HSB items, but no adequately reliable construct could be computed. However, FAMILY assesses many of the attitudes that characterize traditional gender-role attitudes and many women science majors have been found to place a lower priority than non-science majors and non-college women on future family and personal lives (Oakes,1990).

Intended field of study in college (FIELD80) was taken directly from the 1980 base-year survey when the respondents were seniors in high school. Students were classified as science or non-science based on their selection of intended field of study from a list of twenty-four general programs of study in college. Previous studies (Ethington & Wofle, 1988; Maple & Stage, 1991) have found this variable to be a strong predictor of college science major. Consequently, FIELD80 was expected to directly affect QUANTITATIVE.

High school achievement (ACHIEVE) was an achievement composite weighted heavily (75%) toward math achievement. ACHIEVE comprised (a) the average of the standardized scores from both the 28-item and 10-item math tests administered in 1980, (b) the student's reported math grades in high school, and (d) their overall self-reported high school grades. The self-reports of high school math and overall grades were included in this composite because the results of a single standardized test do not account for the motivation necessary to achieve a high level of academic performance throughout a high school program. It was hypothesized that the type of non-academic characteristics related to getting good grades, in addition to strong math performance (as measured by a standardized test) would be a stronger predictor of science course-taking behavior than either one of these components individually. Mathematics performance has been termed the critical filter for the pursuit of scientific careers (Berryman, 1983; Sells, 1982), especially for the physical sciences, and it was hypothesized to influence QUANTITATIVE directly and indirectly through FIELD80. That is, ACHIEVE was hypothesized to positively influence FIELD80, which in turn, would positively affect QUANTITATIVE.

High school science and math courses (COURSES) was the number of the advanced science and math courses the student reported completing in high school. Science and mathematics course-taking patterns in high school can account for most of the sex differences in science and mathematics achievement by the end of high school (Chipman & Thomas, 1987), and previous research indicates that high school science and mathematics courses is strongly related to choice of college science major (Ethington & Wofle, 1988; Maple & Stage, 1991). It was hypothesized that COURSES would affect QUANTITATIVE directly and indirectly through ACHIEVE and FIELD80.

Educational aspirations (ASPIRE) was a composite designed to assess the durability and level of a student's intentions regarding future educational plans. It was hypothesized that educational aspirations would carry a small direct effect on QUANTITATIVE, but would indirectly affect the dependent variable through COURSES and ACHIEVE. Similarly, academic orientation (ACADEMIC) was a composite assessing a student's general attitude toward schoolwork. It was expected that ACADEMIC would have a small positive effect of QUANTITATIVE, but would serve as a positive influence through ASPIRE, COURSES, ACHIEVE, and FIELD80. Both of these composites were formed from items in the base-year survey.

Self-concept (CONCEPT) has been reportedly related to females' lower participation in science courses and careers. Eleven items on the 1980 survey were designed to assess how students feel about themselves, how confident they are about their abilities, and how they attribute their success and failures. While some (e.g., Doran & Sellers, 1978; Handley & Morse, 1984) refer specifically to the effect of self-concept in science class on science achievement and interest, others have implied that general levels of self-concept influence science achievement and subsequent career choice (AAUW, 1992; Oakes, 1990). HSB does not contain items permitting the construction of a science- or math- self-concept composite, but sufficient items exist to compute a general self-concept composite. CONCEPT was expected to positively influence QUANTITATIVE directly and indirectly through the intervening variables in the model, particularly ASPIRE, COURSES, and ACHIEVE.

Parent influence (PARENT) was a measure of parental involvement with the student's high school work and post-high school plans. There is some evidence indicating that parents may influence choice of college major (Oakes, 1990), and it was hypothesized that PARENT would indirectly affect QUANTITATIVE through ACADEMIC, ASPIRE, COURSES, and ACHIEVE.

Sex differences in spatial visualization have often been used as the explanation for sex differences in mathematics and science achievement (Chipman & Thomas, 1987). While the biological explanations of sex differences in spatial ability have been challenged (Linn & Peterson, 1985), mathematics performance, science achievement, and spatial skills appear to share a related component of general analytical ability (Linn & Peterson, 1986) which may account for individual variation in science achievement and career choice. Spatial visualization (SPATIAL), represented by one's performance on the visualization-in-three-dimensions test contained in the base year battery was included in the model as an estimate of spatial skills previously thought to be related to science achievement (e.g., Benbow & Stanley, 1980) and career selection and as an estimate of general analytical ability (Linn & Peterson, 1985). This test was a measure of ability to visualize how a figure would look after it was manipulated in a three-dimensional space. SPATIAL was hypothesized to positively influence QUANTITATIVE directly, and indirectly through COURSES, ACHIEVE, and FIELD80.

SEX, one of two exogenous variables, was of primary interest in these analyses. SEX, coded 0 (male) or 1 (female) was hypothesized to negatively affect QUANTITATIVE, primarily through its effects on intervening variables. That is, we hypothesized that SEX would negatively influence QUANTITATIVE indirectly through CONCEPT, COURSES and FIELD80. Additionally, a small negative direct effect of SEX was expected as a result of the findings reported by Chipman and Thomas (1987) and others (e.g., OTA, 1988). In other words, men were expected to take slightly more science courses in college than women after controlling for all other independent variables in the model. To summarize, we hypothesized that women, compared to men, would take fewer high school science and math courses, be less likely to indicate an intention to study science (FIELD80), and tend to have lower self-concepts (AAUW, 1992), and these factors would, in turn, contribute to women taking fewer science and math courses in college than men. It was expected that SEX would have a positive effect on FAMILY, but would have little effect on PARENT, ACADEMIC, ASPIRE, and ACHIEVE. However, these last variables were all expected to positively influence QUANTITATIVE.

Socioeconomic status (SES), the other exogenous variable, was expected to positively influence QUANTITATIVE indirectly through all of the intervening variables in the model.

Analyses

Sampling Weights. All analyses were conducted with a modified HSB sampling weight in effect. The mean of the HSB sampling weight for students participating in all four waves of the survey was first determined after all of the sample selection criteria were in place. The original weight was then divided by the mean weighting factor to obtain the modified sampling weight. This serves to make the HSB sample representative of students in United States high schools without inflating the size of the sample.

Path analyses. The main analysis involved the use of ordinary least squares (OLS) multiple regression techniques for testing the path-model proposed in Figure 1. Multiple regression allows one to estimate the effect of an independent variable on a dependent measure while statistically controlling for the effects of remaining independent variables. Path analysis, however, goes beyond this by allowing one to test hypotheses regarding causal relationships among the independent variables themselves.

Results

The analyses yielded three major findings: (a) after statistically controlling for all of the other independent variables in the model, being female still resulted in taking fewer undergraduate quantitative science courses, (b) the number of high school science and math courses was the most important mediating variable between SEX and QUANTITATIVE, and (c) within-sex analyses indicated strong interactions between sex and several of the independent variables. This results are reported first for path-analysis with the full model followed by the within sex analyses.

Means, standard deviations, and Pearson correlation coefficients for the full sample are presented in Table 1 and the within-sex correlation matrix is found in Table 2.

Results of the path analyses (full model)

The positive bivariate correlations among QUANTITATIVE, ACHIEVE, COURSES, FIELD80, AND SPATIAL indicate that they may either be influenced by a similar factor (e.g., a general aptitude in mathematics and science) or one or more of these variables may account for most of the correlation that each of them has with QUANTITATIVE. Additionally, path analysis helps uncover factors influencing the under-representation of women in science by examining the relationship of each variable with QUANTITATIVE while statistically controlling for all other independent variables. The following sections present, first, the results of the path analyses with sex included as an exogenous variable; the results of the within-sex analyses follow.

As was the case with the descriptive analyses, statistical tests with large samples tend to yield significant results, even with seemingly small regression coefficients. Pedahzur (1982) suggested that, when using large samples, standardized regression coefficients less than .05--even if they are statistically significant--should not be considered meaningful. Pedahzur's (1982) criterion was followed in reporting the results of these analyses.

Table 1.

Means, standard deviations, and Pearson correlations for all variables (full sample, N=2308).

			Pearson Correlation Coefficients										
Variables	Mean	S. D.	QUANT.	FAMILY	FIELD80	ACHIEVE	COURSES	ASPIRE	ACADEM	CONCEPT	PARENT	SPATIAL	SES
QUANT	20.78	20.15											
FAMILY	50.15	6.53	-.04										
FIELD80	0.40	0.49	.44	-.01									
ACHIEVE	51.11	29.64	.37	-.06	.28								
COURSES	4.41	1.79	.41	-.06	.30	.65							
ASPIRE	50.04	6.07	.11	-.03	.13	.31	.40						
ACADEMIC	50.18	5.35	.01	.01	.06	.20	.19	.19					
CONCEPT	49.85	5.62	.02	.02	.09	.16	.09	.17	.13				
PARENTS	50.13	5.94	.02	.08	.04	.07	.08	.29	.14	.13			
SPATIAL	8.64	3.20	.25	-.03	.13	.38	.33	.13	-.02	.10	-.01		
SES	53.33	6.91	.07	-.08	.03	.16	.24	.29	-.01	.11	.24	.16	
SEX	0.51	0.50	-.28	.12	-.15	-.03	-.12	.08	.19	-.03	.02	-.14	-.01

Note: All correlation coefficients greater than r=.04 are statistically significant (alpha=.05, two-tailed).

Table 2.

Pearson correlation coefficients for males (N=1130) and females (N=1178) separately.

Variables	SEX	QUANT	FAMILY	FIELD80	ACHIEVE	COURSES	ASPIRE	ACADEM	CONCEPT	PARENTS	SPATIAL
QUANT.	M										
	F										
FAMILY	M	.02									
	F	-.04									
FIELD80	M	.48	.02								
	F	.33	.00								
ACHIEVE	M	.40	-.06	.37							
	F	.35	-.05	.17							
COURSES	M	.44	-.03	.32	.67						
	F	.35	-.08	.27	.63						
ASPIRE	M	.16	.03	.15	.35	.43					
	F	.09	-.12	.13	.28	.39					
ACADEMIC	M	.07	.05	.10	.22	.20	.17				
	F	.05	-.06	.09	.20	.24	.19				
CONCEPT	M	.02	.11	.09	.12	.04	.12	.13			
	F	.02	-.04	.09	.19	.14	.24	.15			
PARENTS	M	.02	.07	.05	.11	.10	.35	.12	.12		
	F	.03	.07	.03	.04	.08	.24	.16	.13		
SPATIAL	M	.21	-.05	.11	.35	.33	.17	.00	.08	.02	
	F	.24	.02	.13	.42	.30	.11	.01	.12	-.04	
SES	M	.07	-.10	.05	.15	.24	.30	-.05	.08	.23	.16
	F	.06	-.05	.02	.17	.23	.30	.04	.13	.25	.15

Note: All correlations greater than an absolute value of .05 are statistically significant (alpha=.05).

Direct Effects. Using QUANTITATIVE as the dependent variable, the linear combination of independent variables discussed above explained roughly one-third of the variability among college students in their selection of science courses. Except for one sub-group in the Maple and Stage (1991) study, the model tested here accounted for more variance in science course-taking patterns in than any previous HSB study.

SEX yielded a negative and statistically significant direct effect (*B*= -.19) on QUANTITATIVE. With all other independent variables controlled, women still completed fewer quantitative science courses than men (see Table 3 and Figure 2). In fact, because the number of men and women in the study are comparable (49% and 51%, respectively) this partial regression coefficient, when doubled, approximates an adjusted effect size. In other words, even while controlling for such variables as high school achievement and coursework, spatial ability, and intended field of study, females still took approximately one-third of a standard deviation (.37) fewer quantitative science courses than men. Based on the standard deviation calculated in this study (19.9), this adjusted effect size corresponds to an average of approximately seven (7) fewer physical and technical science credits for college women than for men.

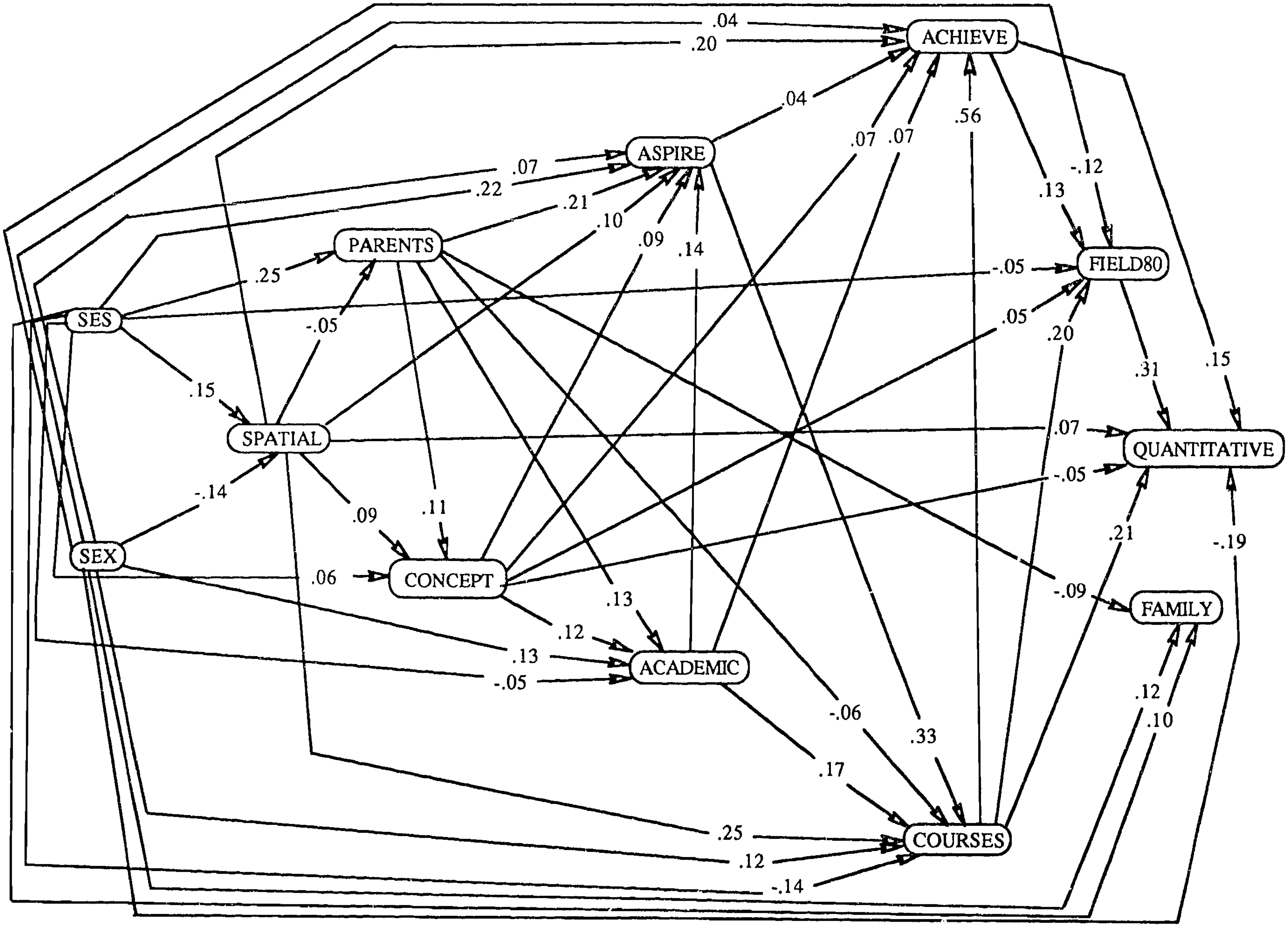
It was hypothesized that the independent variables most proximal to the dependent measure generally would have the largest direct effects, while the effects of the exogenous variables would be realized indirectly through the endogenous variables. Six of the eleven independent variables produced statistically significant direct effects on QUANTITATIVE. FIELD80, not surprisingly, had the largest direct effect on QUANTITATIVE (*B* =.31). High school students indicating an intention to study science ultimately took more college science and math courses than students not indicating an intention to study science. High school courses (*B* =.21) and ACHIEVE (*B* =.15) also produced statistically significant direct effects on QUANTITATIVE. That is, with other variables controlled, high achieving students and those who took more science and mathematics courses in high school tended to take more QUANTITATIVE courses in college. Spatial ability (*B* =.07) had a small, but

Table 3.
Standardized path coefficients (full sample, N=2308).

Independent Variables	QUANT.	FAMILY	FIELD80	ACHIEVE	COURSES	ASPIRE	ACADEM	CONCEPT	PARENTS	SPATIAL
	Dependent Variables									
FAMILY	.01									
FIELD80	.31 *	.02								
ACHIEVE	.15 *	-.05	.13 *							
COURSES	.21 *	-.01	.20 *	.56 *						
ASPIRE	-.04	-.03	.02	.04 *	.33 *					
ACADEMIC	-.03	-.01	.01	.07 *	.17 *	.14 *				
CONCEPT	-.05 *	.03	.05 *	.07 *	-.02	.09 *	.12 *			
PARENTS	.00	.10 *	.01	.00	-.06 *	.21 *	.13 *	.11 *		
SPATIAL	.07 *	.02	.00	.20 *	.25 *	.10 *	.00	.09 *	-.05 *	
SES	-.01	-.09 *	-.05 *	-.02	.12 *	.22 *	-.05 *	.06 *	.25 *	.15 *
SEX	-.19 *	.12 *	-.12 *	.04 *	-.14 *	.07 *	.13 *	-.01	.01	-.14 *
R-sq.	.34	.03	.12	.48	.28	.19	.07	.03	.06	.04

* p<.05;

Figure 2. Statistically significant (alpha=.05) standardized path coefficients (full sample, N=2308).



statistically significant and meaningful (Pedahzur, 1982), direct effect on QUANTITATIVE, while CONCEPT (B = -.05) had a statistically significant negative direct effect that was equal to Pedahzur's (1982) criterion (B =.05).

Several variables--FAMILY, ASPIRE, ACADEMIC, AND SES -- did not yield statistically significant direct effects. This may be due to at least two factors: first, they may not be related to QUANTITATIVE once other important variables are taken into consideration, or the variables that were significantly related to QUANTITATIVE may mediate the influence of ASPIRE, ACADEMIC, or SES. Because FAMILY is the most proximal variable to QUANTITATIVE there can be no mediators, therefore FAMILY seems unrelated to QUANTITATIVE. Examination of the indirect effect may help answer some of these questions.

Indirect Effects. Analysis of the indirect effects of independent variables is a principal feature that sets path-analysis apart from conventional multiple regression. Not only can we see how particular variables directly impact the dependent measure, but additionally, the influence of the independent variables in the model on one another is revealed (see Tables 3 and 4 and Figure 2).

The indirect effect of SEX on QUANTITATIVE was -.09, which was by no means the largest indirect effect in the equation. SEX had statistically significant effects on all other variables in the model except CONCEPT and PARENTS. SEX was negatively associated (favoring males) with variables that were most highly correlated with QUANTITATIVE, such as COURSES, FIELD80, and SPATIAL, and was positively associated (favoring females) with variables related to general academic success (ASPIRE, ACADEMIC, and ACHIEVE). The balance of the positive and negative indirect effects contributes to the modest indirect effect of SEX on QUANTITATIVE. Thus, females are less likely to take as many high school science and math courses as males, partially due to the influence on lower levels of spatial ability, and COURSES then influences high school achievement, intended field of study and, ultimately, QUANTITATIVE.

Table 4.
Decomposition of Effects.

	Pearson Corr	Direct Effects	Total Indirect	Total Effects	Spurious Effects
FAMILY	-.04	.01	.00	.01	-.05
FIELD80	.43	.31	.00	.31	.13
ACHIEVE	.37	.15	.04	.19	.19
COURSES	.41	.21	.17	.38	.04
ASPIRE	.11	-.04	.14	.10	.01
ACADEMIC	.01	-.03	.09	.06	-.05
CONCEPT	.02	-.05	.04	-.01	.03
PARENTS	.02	.01	.01	.02	.00
SPATIAL	.24	.06	.14	.21	.04
SES	.07	-.01	.08	.07	.00
SEX	-.28	-.19	-.09	-.28	.00

COURSES (.17), SPATIAL (.14) and ASPIRE (.14) produced the largest total indirect effects in the model. SPATIAL and ASPIRE had a positive effect on COURSES, which then had a strong influence on ACHIEVE and a moderate effect on FIELD80. Additionally, SPATIAL had a significant indirect effect on QUANTITATIVE through ACHIEVE, while ACHIEVE had a positive influence on intended field of study. COURSES served to mediate much of the impact of ASPIRE and SPATIAL on the selection of undergraduate science courses. In other words, much of the influence of ASPIRE and SPATIAL on QUANTITATIVE was due to the effect these variables had on COURSES, which in turn, had a strong direct and indirect influence on the dependent measure.

Total Effects. The total effect (*TE*) is equal to the sum of the direct and indirect effects for a given independent variable on QUANTITATIVE . The total effect of SEX on QUANTITATIVE was -.28 (see Table 4), indicating that SEX had more of an influence on the dependent variable than any of the other variables in the model except COURSES (*TE* = .38) and FIELD80 (*TE* = .31). Two variables, educational aspirations (*TE*= .10) and academic orientation (*TE*= .06), had small total effects due to the conflicting signs of their indirect and direct effects. Both variables had small negative direct effects, but had meaningful indirect influences. Educational aspirations, particularly, had an important effect on COURSES (*B* = .33) and served as a mediating variable for SES, ACADEMIC, PARENTS, and SPATIAL. That is, the effect of SES, ACADEMIC, and PARENTS on QUANTITATIVE was largely a result of their influence on ASPIRE. SPATIAL influenced ASPIRE, but it's affect on QUANTITATIVE was also mediated through COURSES and ACHIEVE.

Within-sex path analyses

In order to search for possible interactions between SEX and other variables in the model, product terms could be created and entered into the regression equations or separate path analyses could be calculated separately for each sex. The latter method provides results which are intuitively more interpretable and therefore was selected for use in this study.

Direct effects. The independent variables explained 34% of the variance in QUANTITATIVE for males but only 23% for the female sample (see Table 5 and Figures 3 & 4). Comparison of the direct effects revealed important differences in the factors influencing college science course-selection for males and for females. Figure 3 presents the standardized partial regression coefficients (beta) for statistically significant paths (alpha=.05, one-tailed); unstandardized regression are presented in Table 6. However, for clarity of presentation, only standardized regression coefficients are discussed below (an analysis of the unstandardized coefficients led to similar conclusions).

In general, the separate analyses yielded results similar to the full-sample path analyses with several notable differences. Intended field of study (males *B*=.37; females *B*= .25) and high school science and math courses (males *B*=.26; females *B*= .17) influenced QUANTITATIVE more for males than females. Conversely, high school achievement had a more pronounced direct effect on QUANTITATIVE for females (*B*=.20) than for males (*B*=.10). All of the other independent variables produced small-to-negligible direct effects on QUANTITATIVE for both sexes.

Indirect Effects. The pattern of indirect effects for the separate analyses generally paralleled the overall analysis. However, some differences emerged in the processes for males and females to select undergraduate science courses (see Tables 5 & 6 and Figures 3 & 4). The most striking finding involved the path coefficient from high school achievement to intended field of study. This was a particularly strong path for males (*B*=.29), while it was essentially zero for females (*B*= -.04). In other words, females of similar high school achievement levels were dramatically less likely than males to indicate an intention to study science. On the other hand, high school science and math courses was a stronger predictor of intended field of study for females (*B*= .26) than for males (*B*= .14), implying that if females take an equivalent number of science and math courses in high school as men they will be more likely to indicate an intention to study science in college.

The total effects for all of the other variables were either equivalent or larger for males than females, except SPATIAL which had a slightly larger total effect for females (*TE*= .23) than males (*TE*=.20).

Table 5.
Standardized path coefficients for males (N=1130) and females (N=1178) separately.

Independent Variables	SEX	Dependent Variables: QUANT.	FAMILY	FIELD80	ACHIEVE	COURSES	ASPIRE	ACADEM	EFFICACY	PARENTS	SPATIAL
FAMILY	M	.03									
	F	-.04									
FIELD80	M	.37 *	.04								
	F	.25 *	.02								
ACHIEVE	M	.10 *	-.13 *	.29 *							
	F	.20 *	.00	-.04							
COURSES	M	.26 *	.05	.14 *	.59 *						
	F	.17 *	-.04	.26 *	.52 *						
ASPIRE	M	-.03	.04	.00	.05 *	.35 *					
	F	-.06 *	-.11 *	.04	.03	.31 *					
ACADEMIC	M	-.03	.03	-.01	.08 *	.16 *	.14 *				
	F	-.04	-.05 *	.02	.05 *	.18 *	.13 *				
CONCEPT	M	-.04	.11 *	.06 *	.06 *	-.04	.04	.12 *			
	F	-.06 *	-.02	.05 *	.08 *	.00	.17 *	.13 *			
PARENTS	M	-.02	.08 *	.01	.03	-.07 *	.27 *	.12 *	.11 *		
	F	.04	.13 *	.02	-.02	-.05 *	.14 *	.15 *	.12 *		
SPATIAL	M	.07 *	-.03	-.04	.14 *	.25	.12 *	.00	.07 *	-.01	
	F	.09 *	.06 *	.07 *	.25 *	.24 *	.06 *	.00	.11 *	-.08 *	
SES	M	-.02	-.13 *	-.03	-.04	.13 *	.22 *	-.09 *	.04	.23 *	.16 *
	F	-.01	-.05	-.07 *	-.01	.11 *	.23 *	-.02	.08 *	.26 *	.15 *
R-squared	M	.34	.04	.15	.49	.29	.21	.03	.02	.05	.03
	F	.23	.03	.08	.47	.26	.17	.04	.04	.07	.02

*p<.05; one-tailed T-statistic.

Figure 3. Statistically significant path coefficients (standardized). Female sample only (R-sq. = .23).

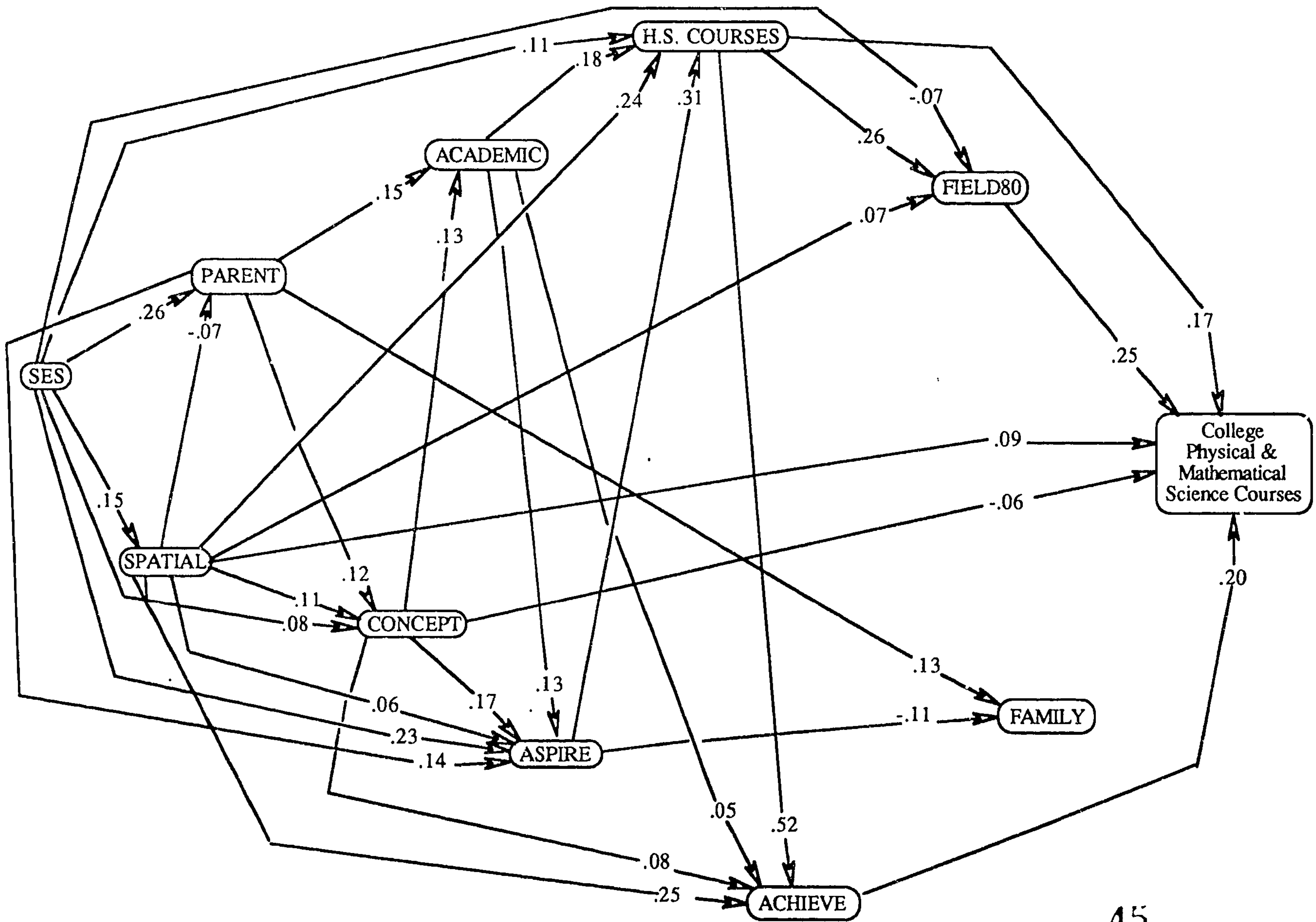


Figure 4. Statistically significant path coefficients (standardized). Male sample only (R-sq. = .34).

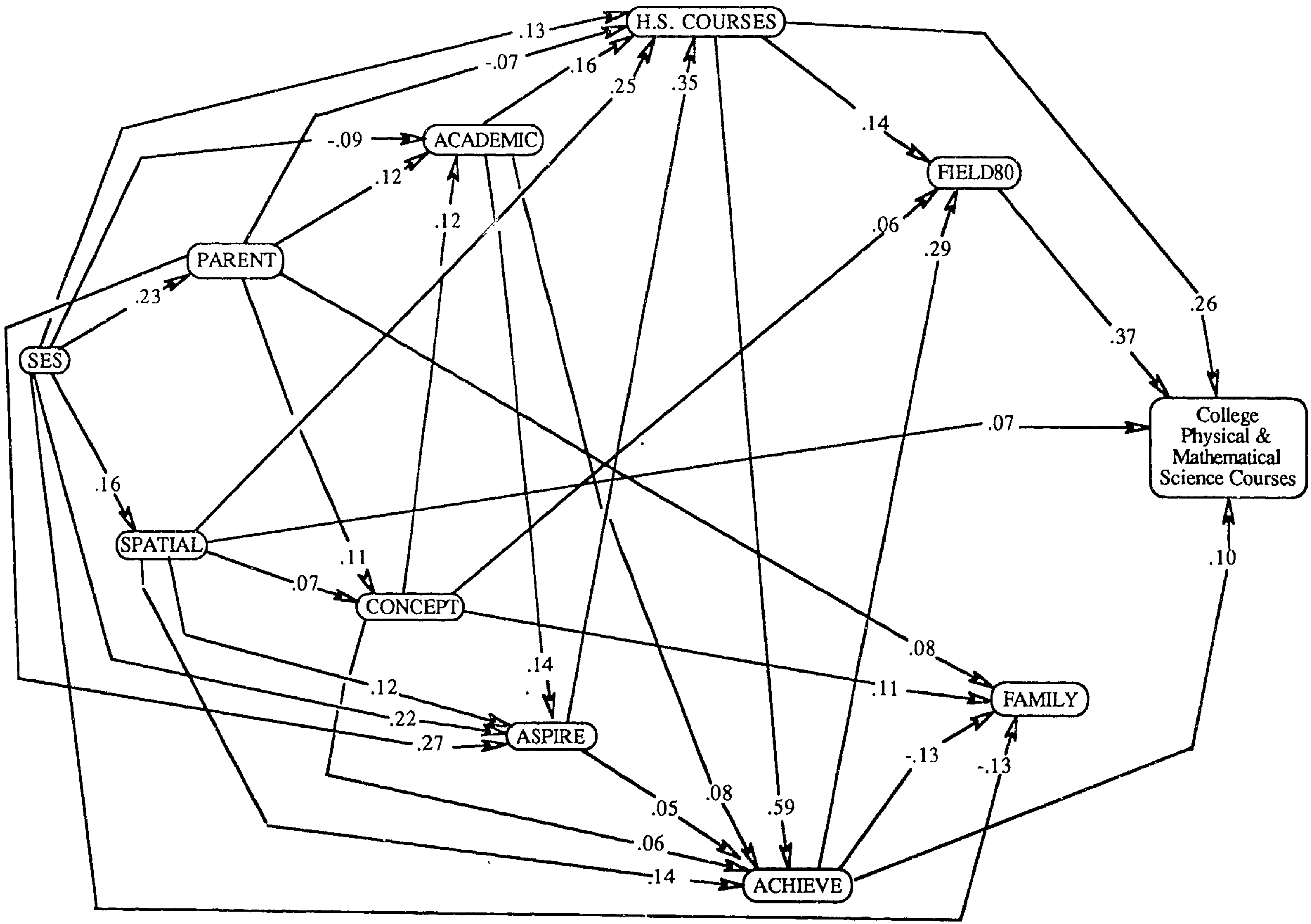


Table 6.
Unstandardized path coefficients for males (N=1130) and females (N=1178) separately.

Independent Variables	SEX	Dependent Variables: QUANT.	FAMILY	FIELD80	ACHIEVE	COURSES	ASPIRE	ACADEM	EFFICACY	PARENTS	SPATIAL
FAMILY	M	.11									
	F	-.10									
FIELD80	M	16.82 *	.51								
	F	8.26 *	.27								
ACHIEVE	M	.07 *	-.03 *	.00 *							
	F	.11 *	.00	.00							
COURSES	M	3.15 *	.17	.04 *	9.58 *						
	F	1.58 *	-.16	.07 *	9.05 *						
ASPIRE	M	-.10	.04	.00	.23 *	.10 *					
	F	-.20 *	-.14 *	.00	.15	.10 *					
ACADMEIC	M	-.11	.03	.00	.45 *	.06 *	.18 *				
	F	-.11	-.07 *	.00	.31 *	.06 *	.14 *				
CONCEPT	M	-.16	.13 *	.01 *	.35 *	-.01	.05	.12 *			
	F	-.18 *	-.02	.00 *	.38 *	.00	.15 *	.12 *			
PARENTS	M	-.08	.09 *	.00	.13	-.02 *	.32 *	.12 *	.1099 **		
	F	.10	.14 *	.00	-.08	-.01 *	.12 *	.13 *	.1185 **		
SPATIAL	M	.45 *	-.05	-.01	1.29 *	.14	.25 *	.01	.0722 *	-.0122	
	F	.42 *	.14 *	.01 *	2.44 *	.13 *	.11 *	.01	.1086 **	-.0770 *	
SES	M	-.07	-.12 *	.00	-.17	.04 *	.22 *	-.07 *	.0388	.2338 **	.1589 **
	F	-.01	-.05	-.01 *	-.02	.03 *	.17 *	-.01	.0821 *	.2609 **	.1530 **
R-squared	M	.34	.04	.15	.49	.29	.21	.03	.02	.05	.03
	F	.23	.03	.08	.47	.26	.17	.04	.04	.07	.02

*p<.05; one-tailed T-statistic.

Table 7.
Decomposition of effects by sex.

Independent Variables	SEX	Pearson Corr	Direct Effect	Indirect Effect	Total Effect	Spurious Effect
FAMILY	Male	.02	.03	.00	.03	-.01
	Female	-.04	-.04	.00	-.04	-.01
FIELD80	Male	.48	.37	.00	.37	.11
	Female	.33	.25	.00	.25	.07
ACHIEVE	Male	.41	.10	.11	.20	.20
	Female	.35	.20	-.01	.19	.16
COURSES	Male	.44	.26	.17	.43	.00
	Female	.35	.17	.17	.34	.01
ASPIRE	Male	.16	-.03	.16	.13	.03
	Female	.09	-.06	.12	.09	.00
ACADMEIC	Male	.07	-.03	.10	.08	.00
	Female	.06	-.04	.09	.02	.03
CONCEPT	Male	.02	-.04	.03	.00	.02
	Female	.02	-.06	.04	-.02	.04
PARENTS	Male	.02	-.02	.02	.00	.01
	Female	.03	.04	-.01	.03	.00
SPATIAL	Male	.21	.07	.14	.20	.01
	Female	.24	.09	.14	.23	.00
SES	Male	.07	-.02	.09	.07	.00
	Female	.07	-.01	.07	.06	.00

Discussion

This study investigated the direct and indirect influences of sex and several intervening variables on college course selection in the quantitative sciences. The High School and Beyond Data Set was used to test hypotheses developed in this study. The four research questions are reviewed below along with a summary of the corresponding results.

1) What are the major predictors of science course selection for college undergraduates?

High school advanced math and science courses was the most important predictor of quantitative course selection, but intention to study science and sex were also important predictors. Sex significantly influenced QUANTITATIVE (B=.19) even after controlling for all of the intervening variables in the model. The path model explained 34% of the variance in the dependent measure, which is substantially more than the 9% reported by Ethington and Wofle (1988) or the 11-20% percent explained by Stage and Maple (1991) (except for the 34% in the sample of black males).

2) What are the factors contributing to the differing amounts of undergraduate science courses selected by women and men?

The path analyses of the full model revealed that females still completed fewer quantitative courses than males even after statistically controlling for all other independent variables: the adjusted effect size was .38. The model explained 34% of the variance in QUANTITATIVE for the male sample, but only 23% for females, indicating an interaction between sex and other independent variables in the model. The within-sex analyses illustrated several differences in the processes by which male and female undergraduate students select college science courses. The source of this interaction appears to be in relationships among FIELD80, COURSES, SEX, and QUANTITATIVE. That is, intended field of study and high school courses were more important predictors for males than females, while high school achievement was more important for females.

The most striking distinction involved the path from high school achievement to intended field. This path yielded a large regression coefficient for the male sample, yet was not even statistically significant for the female sample. This means that high achieving male students tended to indicate an intention to study science, while achievement appeared unrelated to an intention to study science for women. On the other hand, even though COURSES had a lower direct effect for females, it was a more important predictor of intention to study science for females than for males.

3) How does the interaction among the key predictors contribute to science course selection?

Analyses of the indirect effects illustrates how several of the independent variables interact to influence science course-taking patterns. For instance, ASPIRE had a relatively small direct effect on QUANTITATIVE, but had a powerful influence on COURSES which influenced QUANTITATIVE directly and indirectly through FIELD80. It appears, though, that the interaction of COURSES, ACHIEVE, and FIELD80 is critical if students are to continue in the scientific pipeline. It appears that of these factors, none alone is sufficient for continuation in science, but all, in varying degrees, are necessary. As mentioned above, gender-related differences were evident in the interaction of these and other variables.

4) Does path-analysis allow for the detection of a hidden curriculum in science education, and if so, does it point to specific sources of a hidden curriculum?

Path-analysis and quantitative methods proved useful in disentangling the influences of several important sources of the hidden curriculum in science course selection. For instance, the differences in the explanatory ability of the model for males and females, as well as the differences of several key path coefficients leads one to suspect the presence of certain sex- or gender-related factors which may be influencing the model.

The following sections, first explore the results of the path analyses to help uncover key "paths" on the way to declaring a science major for males and females. Second, the fruitfulness of the theoretical model is evaluated. In other words, what do the results tell us about variables that contributed to the success of the model and those that did not help predict QUANTITATIVE or any of the key mediating variables? Also, do the results suggest any modification of the model? Third, the methodological limitations of the study are discussed, and fourth, suggestions for future research are presented. The fifth section of this chapter revisits the hidden curriculum concept while the final section discusses the implications for science education.

The Path to College Science Courses for Females and Males

The factors influencing selection of undergraduate science courses are fairly similar for males and females. The key predictors in both models are almost identical, but the specific links between variables are different for males and females. Figures 5 & 6 pictorially represent these paths for both females and males. The paths and variables included in these figures were limited to standardized path coefficients greater than .20. This was an arbitrary criterion, as is any criterion, but it was useful for illuminating the most important paths as well as pointing out the differences in the results of the within-sex path analyses.

SES, SPATIAL, ASPIRE, COURSES, ACHIEVE, and FIELD80 all contributed to physical and technical science course-taking behavior by college undergraduates. PARENT exerted a positive influence on mediating variables in the male model, but did not have a strong effect on variables influencing QUANTITATIVE in the female model. For males, SES influenced ASPIRE both directly and indirectly through PARENT, and to a lesser extent SES positively influenced SPATIAL. This part of the female model looked similar to the male model except for the lack of parental influence. For both samples, ASPIRE and SPATIAL both had a positive influence on COURSES, which then positively influenced high school math achievement. The relationship between COURSES and ACHIEVE was the strongest path in the model for both samples.

Figure 5. Reduced model highlighting key paths to college science and mathematics for females.

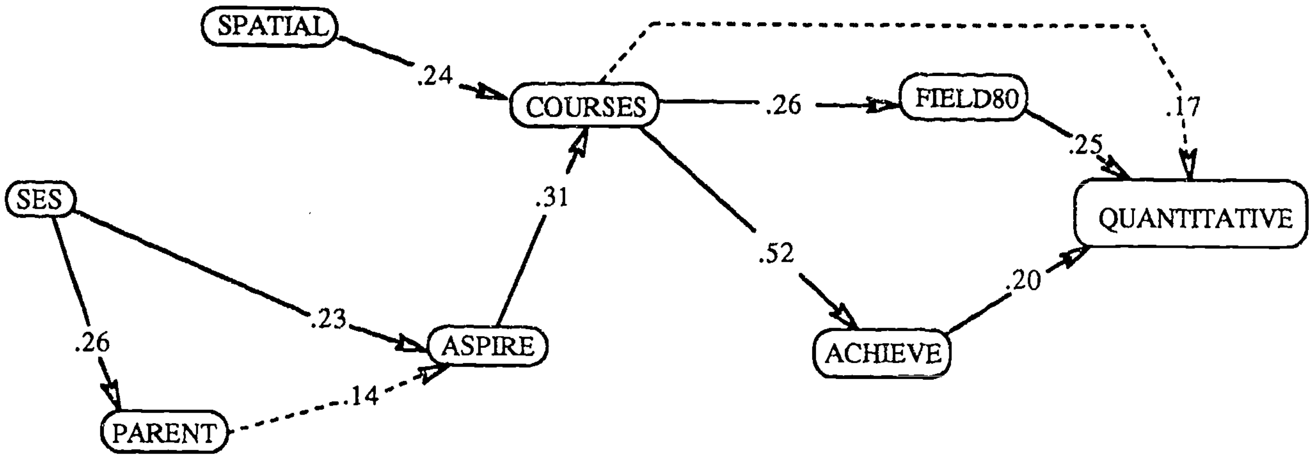
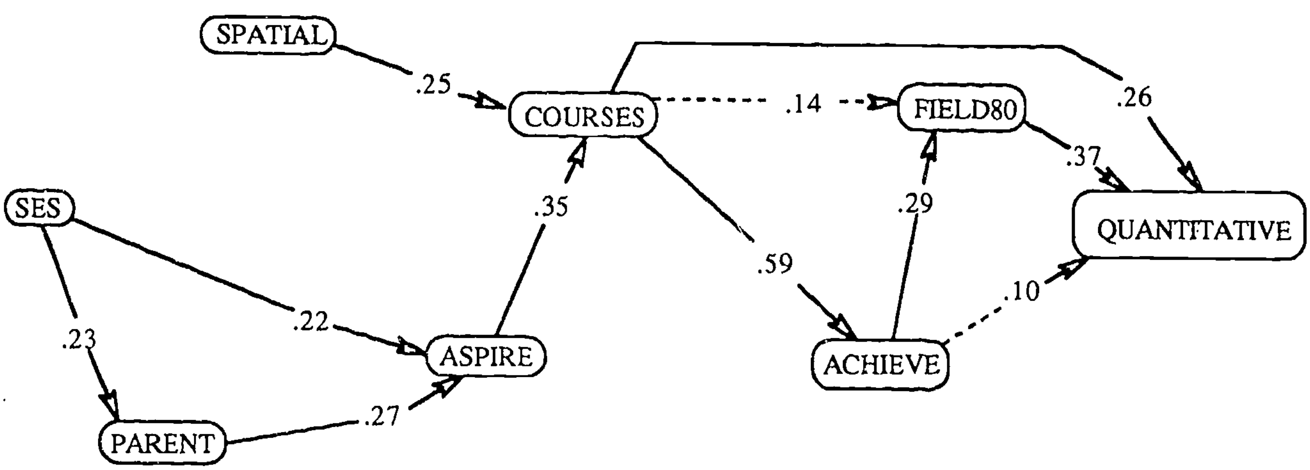


Figure 6. Reduced model highlighting key paths to college science and mathematics for males.



Note: The dashed lines represent statistically significant path coefficients which were greater than .20 in the model for the other sex.

There were several noticeable sex-related differences in the section of the model involving COURSES, ACHIEVE, FIELD80, and QUANTITATIVE. COURSES was the most important predictor of FIELD80 for females, but this was not the case for males. As mentioned previously, the most notable distinction in the within-sex analyses involved the relationship between ACHIEVE and FIELD80. ACHIEVE was the most important predictor of FIELD80 for males, yet that path was not statistically significant in the female model. On the other hand, ACHIEVE was a stronger predictor of QUANTITATIVE for females than for males. Additionally, COURSES was a stronger predictor of FIELD80 for women than for men, while FIELD80 had a more powerful influence on QUANTITATIVE for men than women.

In conclusion, it appears that the same factors influence college science course selection for both males and females, although the actual processes seems to be slightly different. However, it is important to remain mindful of the fact that females still completed far fewer physical and technical science classes in college than men. Taking advanced high school science and math courses was a more important predictor of college science course-taking for males than females, yet high school science and mathematics courses had a relatively more important influence on FIELD80 for girls than for boys. That is, with other independent variables controlled, taking science and mathematics courses in high school had a greater relative influence on intention to study science for girls than for boys. Eccles (1990) suggested that girls tend to take fewer advanced mathematics and science courses in high school than boys due to interests in other subjects (e.g., English, foreign language). As an extension of Eccles' (1990) writing, the present study demonstrated that even while controlling for the number of advanced high school science and mathematics courses in high school, high-achieving girls do not indicate an intention to study science any more than lower achieving girls. Further, the results of this study indicate that the choice for high-achieving girls to indicate an intention to study science may compete with other options, while ACHIEVE was the strongest predictor of FIELD80 for males. High mathematics achievement, therefore, may be a necessary, but not a sufficient condition for women to remain in the scientific pipeline. However, girls indicating the disposition to take advanced science and mathematics classes in high school appear to select college science and mathematics courses at a rate similar to men.

An Evaluation of the Path Model

At this point, it is important to step back and evaluate the fruitfulness of the path model developed for this study. How did the model used in this study compare to causal models used in previous studies? Did all variables contribute to the prediction of QUANTITATIVE as hypothesized, and do the results of the analyses support the causal ordering of variables as postulated here? Finally, after controlling for the intervening variables in this study, why did SEX still have a significant affect on physical and technical science course selection in college?

The amount of variance explained by the independent variables in this model was substantially greater than previous HSB studies except Ware and Lee's (1998) study, which, because of the logical problems described earlier, reported an inflated R^2. The causal model constructed by Maple and Stage (1991) also accounted for approximately 34% of the variance with one of their analyses, but far less with the other three samples. The R^2 of 23% in the present analyses with the female sample was still higher than the 20% reported by Maple and Stage (1991) for similar samples.

There are several reasons why the variables used in this study were able to account for more variance than other studies. First, and most importantly, the dependent variable in this study was a higher quality measure of "science major" than the ones used in any of the three previous HSB studies. Whereas previous studies used a self-reported, dichotomously-coded variable that groups all science majors together, the present study used a continuous measure taken directly from the students' transcript and focused only physical science and mathematics course-taking -- where the problem of women's under-representation is most severe. Additionally, this study assessed students' science course-taking patterns after they had completed at least three years of college while previous studies assessed the dependent variable if their subjects had simply attended a minimum of one term and a maximum of two years of postsecondary education. Pratt (1989) reported that the aspirations of young adults were fairly unstable, especially during the first few years following high school. Drawing the dependent variable later in these students' lives, as was the case here, may have eliminated some of the error variance experienced in previous studies.

As mentioned above, Figures 5 and 6 highlight the most important predictors of QUANTITATIVE. Seven of the ten independent variables fit the criteria to be included in these figures, indicating that directly or indirectly, the majority of the predictors contributed to our understanding of the factors influence college science course-taking patterns. Three variables -- CONCEPT, ACADEMIC, and FAMILY -- did not add to the predictive ability of the model. The following paragraphs discuss why these three variables did not contribute to the explanatory ability of the path model.

FAMILY was a composite of several items assessing how strongly the respondent felt about having children and getting married. It was included in the model as a proxy for traditional gender role attitudes, and it was hypothesized that young women expressing a strong interest in having children and getting married would be less likely to pursue a scientific major in college. Expressing higher scores on FAMILY did tend to be associated with taking fewer college science and mathematics courses for women, but this was not a statistically significant relationship. The construct validity of FAMILY as a representation of gender-role attitudes and stereotypes needs to be more clearly established before it can be concluded that gender-role stereotypes are unrelated to QUANTITATIVE. If gender-role stereotyping is important for girls to continue in the scientific pipeline as some suggest (e.g., Eccles, 1986), we need to develop a better instrument to assess this construct if it is to be employed in these types of analyses.

ACADEMIC and CONCEPT were both expected to positively influence quantitative course-taking patterns in college. ACADEMIC was designed to assess attitudes toward school and academic work, with the assumption that a positive academic orientation is necessary to study science. However, the academic orientation variable did not discriminate among students majoring in science and other majors; perhaps a more specific variable assessing orientation toward science classes would prove more relevant to the model in this study.

Similarly, CONCEPT was constructed from HSB items as a general self-concept composite. While this variable had a slight negative effect on QUANTITATIVE for females, it was positively related to ASPIRE and ACADEMIC. These effects were relatively small and therefore CONCEPT had essentially no total effect on the dependent variable. Many researchers (e.g., Doran & Sellers, 1978; Handley & Morse, 1984) refer specifically to the effect of self-concept in science class on science achievement and interest, while others have implied that general levels of self-concept influence science achievement and subsequent career choice (AAUW, 1992; Oakes, 1990).

Finally, the reason SEX still had a significant direct effect may be due to the omission of other important intervening variables. The literature review discussed several findings related to the classroom environment (e.g., Tobin & Garnett, 1987), teacher questioning behavior (Peterson & Fennema, 1985), and extra-curricular experiences (Kahle, Matyas, & Cho, 1985) which affect girl's attitudes, achievement, and potential career choice in science. A variable or variables assessing such characteristics would likely be placed prior to COURSES (see Figure 1) in the current model.

<u>Limitations of this Study</u>

The High School and Beyond data set provided many advantages as discussed throughout this paper, however there were several conceptual and methodological limitations imposed by choosing to use these data. First, we had no control over the types of items included on the surveys, and therefore could not include important variables such as teachers' expectations and encouragement, and sex-role stereotyping in science classes. This clearly limited the type of path model we were able to construct. Second, because the base-year survey was conducted while the students were seniors, much of the antecedent or "historic" data (e.g., spatial ability, parent influence, self-concept) were collected at the same time as data which logically followed these antecedents in the path model.

Third, a decision was made to include only those subjects who participated in all waves of the student survey and met the criteria described in the methods section for postsecondary educational attendance. This sampling decision was made for sound logical reasons, yet the resulting subject pool (N=2308) was less than 25% of the original HSB sample. The analyses were weighted to ensure that this sample was still representative of the HSB target population, but because this study was designed to generalize to a different target population (students who completed the equivalent of three years of college by 1985) than the original HSB sample, the extent to which the findings presented here can be generalized to the intended target population is unclear. Handling cases with "missing values" often leads to questions about external validity. After inspection, we concluded that listwise deletion of missing values did not pose a threat to the external validity of this study.

The Hidden Curriculum Revisited

What was learned about the effects of a hidden curriculum in science education through this study? The most powerful sources uncovered through this study relate to the influence of certain systematic learning states on the selection of undergraduate physical and technical science courses. Cognitive states such as high school achievement and spatial ability exerted a notable influence on the dispositional states under investigation in this study. Belief states, such as self-concept, and attitudinal states, such as educational aspirations and academic orientation, contributed little to our understanding of the mechanisms of hidden curricula in science education. Societal sources also had a small effect on the dispositional learning states. This pattern is similar to the findings reported previously in a comprehensive review of sex differences in science achievement and career choice (Chipman & Thomas, 1987).

These analyses uncovered an important finding that, until very recently (Kahle & Meece, 1992), has not been addressed by other researchers. As mentioned above, the most important sex difference involved the path from high school achievement to intended field. High achieving male students tended to indicate an intention to study science, while achievement seemed unrelated to an intention to study science for women. On the other hand, high school science and mathematics course selection was a more important predictor of intention to study science for females than for males. Thus, while high achieving females did not necessarily express an interest in studying science, those females completing many high school science and mathematics courses were more likely than other women to indicate an intention to study science.

These findings are contrary to prevailing hypotheses regarding the importance of mathematics achievement as the "critical filter" for women's entry into scientific careers (e.g., Berryman, 1983; Sells, 1982). While this study does not refute the need for adequate mathematics preparation for scientific careers, the results clearly indicate that high achievement in mathematics, in and of itself, is not a guarantee of choice and/or success in scientific fields of study for women. This is similar to a conclusion reached by Kahle and Meece (1992) in a recent review of research on girls in science.

What might be the cause of this discrepancy between men and women in the way that achievement influences intention to study science? Based on the combination of this empirical inquiry and literature review it seems that the source of this difference is related to attitudes and expectations of teachers and society, science and mathematics attitudes and sex-role stereotyping of mathematics and science by students, or the structure of science classrooms. The results of this study indicated that while controlling for variables such as achievement, high school courses, and intentions, females were still less likely to take physical and technical science courses in college, therefore we may hypothesize that these societal and classroom factors are the critical sources of the genderized hidden curriculum in science. Many of these factors have been studied in detail (e.g., Kahle, 1985; Steinkamp & Maehr, 1984; Tobin & Garnett, 1987), yet rarely in long-term longitudinal investigations. They would be interesting and worthwhile variables to incorporate in future longitudinal studies.

Implications for Science Education

Rosser (1989) examined approaches to teaching science that she considered to be more attractive to women than traditional science teaching techniques. Yet, her suggestions, if carried out, would undoubtedly improve science education for both females and males. For instance, her contention that science laboratory experiences often rush through the critical observation stage, proving more harmful to girls than boys who, according to Rosser (1989), have adequate opportunities to experience science outside of the formal classroom is unfounded. While it has been documented that boys have more out-of-school science experiences than girls (Kahle, Matyas, & Cho, 1985), Rosser offers no evidence that science education for boys would improve at a slower rate than girls if her suggestions were followed. Rosser's emphasis on teaching techniques to attract women to science may be counterproductive if we are ever to rise above the sex-difference mentality present in much educational research. Further, Rosser's suggestions sound very much like the type of improvement called for by many science educators (Rutherford & Ahlgren, 1990) to improve science for all students.

Martin's (1989) response to science educators based upon her examination of the philosophical literature is more succinct than the detailed intervention outlined by Rosser. "What should science educators do about gender bias in science when they find it? Openly acknowledge and address it by bringing the gender-base critique of science into the science curriculum" (p. 253). This would involve the teaching "about science" as well as the teaching of science. Martin argues that since the science disciplines have been slow to incorporate modern critiques of science into their practice, it is incumbent upon science educators to take up the responsibility themselves. According to Martin (1989), if science educators deny the presence of androcentric and gender bias, they are, in fact, sanctioning a hidden curriculum in the genderization of science. However, just as Rosser's suggestions would likely result in an improved science education for all students, opening science to criticism will likely have benefits beyond uncovering a gender-biased hidden curriculum. Historians of science such as Stephen Jay Gould (1984) have been arguing for openly examining the methods and biases by which human have carried out their scientific pursuits. Teaching students to search for, and uncover bias in science will improve their critical thinking skills while concurrently helping to demystify their view of science.

In fact, many of the goals for science described above are contained in one of the current major science education reform efforts (Rutherford & Ahlgren, 1990). Project 2061 emphasizes connections between science and other subjects, suggests reducing the need for memorization while increasing the emphasis on thinking skills. Project 2061 also focuses on examining historical perspectives of science (teaching about science), as well as incorporating lessons related to the role of values and attitudes in science (Rutherford & Ahlgren, 1990). Further, Project 2061 emphasizes that subtitle of the reform effort, "Science for all Americans", means all Americans. To this end, Project 2061 contains an "equity blueprint" as one of its ten blueprints for reform. The equity blueprint is intended to ensure that equity issues are infused throughout the other nine reforms (Project 2061, 1991).

Finally, instead of intervention and research programs designed to uncover or remediate sex differences in science, our collective energy may be better spent by using the suggestions put forth by, among others, Rosser (1989), Martin (1989), and Rutherford and Ahlgren (1990) to improve science education for all students. It is probably true that these suggestions would increase the participation rates of women, but making science more attractive to women will likely improve the quality of science education for males as well, an important objective in today's world. As Gould (1984) says, "...good science will be done in about the same way by sufficiently critical women and men. The reason for opening science to women is not that they will do it differently and better, but that good scientists are hard to find...(pp. 7)." Heeding the reforms suggested in Project 2061 may fill our need for quality scientists while helping to bring more women into the population of scientists.

Areas for Future Research

Several ideas for continued research have already been identified throughout this chapter. The inclusion of variables such as science and mathematics attitudes, classroom behaviors of teachers and peers, and the structure of mathematics and science classrooms would be important additions to future studies. A relatively new database, *Longitudinal Studies of American Youth* (Miller, Suchner, Hoffer, Brown, & Pifer, 1991), specifically designed to assess students' science and mathematics attitudes, achievement, and career interest and choice offers exciting possibilities for research in this field.

One of the major questions uncovered by this study is why high achieving girls are not disposed to indicate an intention to study science. The model used in this study was not conceived within a framework specifically concerned with dispositional learning states. Eccles (1990), though, proposed a model within an attributional theoretical framework designed to predict educational and occupational choices made by young women. HSB does not contain variables to adequately test Eccles' model, but the *Longitudinal Studies of American Youth* data set (Miller, et al., 1991) may offer promise for this line of inquiry. The model proposed by Chipman and Thomas (1987), is incredibly complex and beyond the scope of path analysis. However, as new techniques such as LISREL become more prevalent, Chipman and Thomas' model may provide the most information yet about the complex process of choosing a scientific career.

The use of path analysis to test a theoretical model has proven advantageous in uncovering interactions among independent variables; this would have been impossible in a study focusing on bivariate relationships or even multiple regression analyses. However, quantitative analyses of existing databases are always going to have certain limits. Some of these limits to validity may be alleviated by qualitative inquiry. This investigation points to a research focus where quantitative and qualitative techniques would be complementary. For instance, the results from this study illustrating that high achieving girls express much less of an intention to study science than high achieving boys would be an interesting qualitative study. Interviewing high achieving girls and boys may uncover some of the sources of the hidden curriculum exposed here.

Finally, there needs to be more work by theorists and philosophers to help clarify the hidden curriculum concept, especially if it is to by empirically investigated. Part of the difficulty in relating the results of this study to the hidden curriculum concept is due to the elusive nature of the concept itself. However, framing this study within the hidden curriculum concept helped provide more information about the gender differences in science education than would have been possible in a study not guided by theory. As investigations continue to expose hidden curricula, it is hoped that women or others who are the victims of unequal treatment in schools will have opportunities to choose any career they might find rewarding and meaningful.

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Appendix A

Descriptions of variables and constructs included in the path model.

Variable	Variable Label	Alpha reliability	Description
Percent of physical science, mathematics, and computer science credits.	QUANTITATIVE	N/A	Total computer, mathematics, and physical science non-transfer credits as a percentage of total non-transfer credits. Calculated from the student-level data file from the Postsecondary Education Transcript Study.
Family orientation	FAMILY	.84	Average of the standardized scores of items from 1980 and 1982 surveys. The importance of "finding the right person to marry and having a happy family life", "living close to parents and relatives", "having children" (each coded as: 1=not important, 2=somewhat important, 3=very important); age that the student expects to get married; and age that the student expects to have children (the youngest age was coded highest). An additional item, "How many children to you eventually expect to have" was taken from the 1982 survey (values ranged from 0 to 6 or more).
Intended field of study	FIELD80	N/A	As seniors, students were asked to select their intended field of study from a list of 24 general programs of study in college. The 9 science related fields were coded '1' and all other intended fields were coded '0'. (agriculture, biological sciences, computer science, engineering, health occupations, health sciences, mathematics, physical sciences, and preprofessional) Taken directly from the 1980 base-year survey.
High school achievement	ACHIEVE	.75	This composite comprised standardized scores from the 28-item and 10-item math tests administered during the 1980 HSB survey, the student's reported math grades in high school, and their overall high school grades. Consequently, ACHIEVE is weighted heavily (75%) toward mathematics achievement.

Appendix A (cont.)

Variable	Variable Label	Alpha reliability	Description
High school advanced science and mathematics courses	COURSES	N/A	The sum of the following advanced science and math courses the student reported completing in high school: algebra I, algebra II, geometry, trigonometry, calculus, chemistry, and physics (coded 0=not-taken, 1=taken course). These items were taken from the 1980 survey.
Educational aspirations	ASPIRE	.79	The following items from the base-year survey were included in ASPIRE: whether or not the student was planning to attend college while they were in (a) eighth grade, (b) ninth grade, (c) tenth grade, and (d) eleventh grade; and (e) their expected post-secondary educational plans, taken from a 1980 item "As things stand now, how far in school do you think you will get?" Choices ranged from "less than high school graduation" to "Ph.D., M.D., or other advanced professional degree". The scores were standardized and then averaged to form the composite.
Academic orientation	ACADEMIC	.66	The average standardized scores of the following 1980 survey items comprised ACADEMIC: (a) amount of time spent on homework, (b) do you work hard in school, (c) how satisfied are you with your education, (d) are you interested in school, (e) is your closest friend interested in school, and (f) does your closest friend attend classes regularly.
Self-concept	CONCEPT	.84	The standardized scores of the following base-year Likert-type items (recoded so higher scores reflect higher levels of self-concept): (a) "I take a positive attitude toward myself", (b) "I am a person of worth", (c) "I can do things as well as others", (d) "Every time I try to get ahead, something or somebody stops me", (e) "planning ahead makes a person unhappy, since plans hardly ever work out anyway", (f) "People who accept their condition in life are happier than those who try to change things", (g) "On the whole, I am satisfied with myself", (h) "What happens to me is my own doing", (i) "At times I think I am no good at all", (j) "When I make plans, I am almost certain I can make them work", and (k) "I feel I do not have much to be proud of."

Appendix A (cont.)

Variable	Variable Label	Alpha reliability	Description
Parent influence	PARENT	.66	The mean of the following standardized items from the 1980 student survey assessed whether their mother and father (separate items): (a) "keeps close track of how well I am doing in school" (0=false, 1=true), (b) influenced high school plans (1=not at all, 2=somewhat, 3=a great deal), and (c) what their parents (separate items) want them to do after high school (1=don't know/don't care, 2=get a job or enter military, 3=enter trade school or apprenticeship, 4=go to college).
Spatial visualization	SPATIAL	N/A	The raw score from the Visualization in Three Dimensions on the 1980 HSB student test battery. During the 16 item test, students were required to project how a flat piece of metal would look after folding to make a three-dimensional figure (Rock, Hilton, Pollack, Ekstrom, & Goertz, 1985).
Socio-economic status	SES	N/A	A HSB-created composite based on five components: a) father's occupation, b) father's education, c) mother's education d) family income, and e) material possessions in the household (e.g. personal calculator, 50 or more books, place to study). The socioeconomic composite is the simple average of the non-missing components from the 1980 survey, after each of the five scores was standardized.
Sex	SEX	N/A	Coded 1 if female and 0 if male.