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ABSTRACT

This study sought to identify factors that motivate girls to complete a four-year sequence of academic mathematics. Forty variables involving community, family, school and personal factors were measured and analyzed by a MANOVA for correlations with two criterion variables. The first criterion was a classification of schools on the basis of the fraction of its college-bound graduates who successfully completed at least one semester of advanced mathematics in their senior year; no factor was found which was well correlated with this criterion. The second criterion classified the students by whether they were taking advanced mathematics and whether they intended to major in a strongly mathematics-related subject at college. Well correlated with this criterion were a belief that high school mathematics would be useful in future studies and a preference for natural over social science. Preference for masculine-type tasks did not show a strong relation, and encouragement by relatives, teachers, counselors, or friends was a better predictor than parent's education. As a result of this study, the author recommends more attention to affective factors in the teaching of mathematics. (MM)

RB-72-12

RESEARCH BULLETIN

FACTORS ASSOCIATED WITH THE SELECTION OF ADVANCED ACADEMIC MATHEMATICS COURSES BY GIRLS IN HIGH SCHOOL

Elizabeth W. Haven

A dissertation in Education presented to the Faculty of the Graduate School of Arts and Sciences of the University of Pennsylvania in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1971.

Educational Testing Service
Princeton, New Jersey
March 1972

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However, this study would not have been possible without the assistance of chairmen of mathematics departments and senior girls in New Jersey public high schools who completed the questionnaires, and the patience and consideration of Mr. Robert H. Haven, husband of the author.

ABSTRACT OF STUDY

This study emerged from a need for information on ways to encourage women talented in mathematics to pursue careers in this and related fields. It focuses on the specific problem of identifying the characteristics of girls, teachers, schools, and communities that are associated with the selection of advanced mathematics courses in high school. It assumes that this preparation can provide flexibility in future study and occupational pursuits, thereby creating a new source of potential workers in technological areas.

The results in this study are based on returns from mathematics supervisors or departmental heads and senior girls from 63 New Jersey public high schools. This represents 38 percent of the high schools invited to participate. These high schools are representative of the population contacted in size and percentage of girls continuing full-time education. The school districts in which they are located are representative of all New Jersey public school districts in their ability and effort to support education, and in their geographical location.

The high schools were grouped according to their success in motivating girls to study advanced mathematics. While none of the differences in school means for the 20 variables used in the comparisons were statistically significant at .05 or less, the distributions of these variables showed that "high" success schools tended to be regional high schools, which means that they served several elementary school districts, to use tracking (or grouping) within the mathematics curriculum for accommodating individual differences, and to use modern

as opposed to traditional texts in their advanced mathematics courses. The three most differentiating variables and their correlations with the criterion included the following: number of professional staff per 1,000 weighted pupils for the school district (.15), use of tracking in the mathematics curriculum (.12), and regionalization (.11). (These correlations, with the present sample size, were significant at the .01 level.)

Among the responses from the senior girls, the following were identified: 220 girls who studied advanced mathematics with expectations of majoring in it or related fields (Group I), 1,076 girls who studied advanced mathematics but who had interests in nonrelated fields (Group II), and 544 girls who did <u>not</u> study advanced mathematics even though they had been high achievers in mathematics (Group III). Unlike the results in the school comparisons, 11 of the 20 variables used to contrast these three groups of girls were significant at the .001 level. Two variables had moderately high correlations (.41 and .36) with the criterion. Two discriminant functions, both significant at .001, accounted for most of the variance among these groups.

The two most significant variables included a three-point scale evaluating the usefulness of the mathematics studied in high school to future studies and occupations, and a 36-item scale measuring interest in natural science as opposed to social studies. While practically all of the potential mathematics-science majors (Group I) felt that it was "very likely" that they would use the mathematics they studied in high school, this percentage dropped to 41 percent for the girls in Group II and to 24 percent for the girls in Group III. On the natural science interest scale, half of the girls in Group I had high scores (21 or higher). This was true for 18 percent of those in Group II and 9 percent of those in Group III.

The remaining significant variables and their correlations with the criterion included: encouragement to take advanced mathematics courses by mother and father (.21), by guidance counselor (.17), by members of the mathematics department (.15), and by peers (.12); interest in masculine (commercial) versus feminine (nurturant) activities as measured by a 43-item inventory (.19); and the girls' ratings of their third-year mathematics teachers on success in making mathematics interesting (.14), ability to emphasize both abstract and practical aspects of mathematics (.09), and personality and range of interests (.08).

Responses to the question on why they did or did not elect to study advanced mathematics showed that "liking and finding mathematics interesting" was the main reason for electing such courses, and "not particularly liking mathematics" headed the list of reasons for dropping mathematics. Taking mathematics for enjoyment was often combined with comments about personal satisfaction and educational value derived from its study. Not liking mathematics was often linked with statements about feeling incapable of handling the subject, of seeing no need for its study, and of considering other subjects more practical, beneficial, or interesting. In commenting on why girls do not take advanced mathematics, most supervisors of mathematics noted that girls either did not feel the course was needed for future study or work, or they felt the subject was too difficult.

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CHAPTER 1

INTRODUCTION AND STATEMENT OF PROBLEM

Since World War II, increasing numbers of women have invaded the labor force until at the present time nearly 40 million women are gainfully employed. This means that women account for two out of every five workers. Because of the technological changes in our society, many of these women are employed in areas which traditionally were considered as masculine occupations. Women have been welcomed into these fields and they have been successful. Probably no one knows the full extent to which they have penetrated this domain.

However, the tremendous need for women as professionals in the mathematical and scientific areas has not been met. After studying mixed groups of students at the high school level, I. D. Peden (1965) noted that if engineering aptitude alone determined career choice in the field of engineering, we could have two female engineers for every three male engineers. Actually, less than one percent of all engineers in this country are women, even though engineering is one of the highest-paying careers open to women today.

In addition, there is a desperate need for capable women who do not have college aspirations. With strong preparation in high school mathematics and science and some additional training such as that provided in technical institutes or in on-the-job training, women could find more exciting and important life work than the usual occupations offered to unskilled or semiskilled workers. A dramatic example of this is the field of computer programming.

Girls are reputed to excel boys on verbal measures, while boys seem to do better on mathematical measures. However, this situation arises partly because girls study more languages and boys study more mathematics and science. National high school enrollment figures show that boys outnumber girls two-to-one in advanced mathematics courses such as solid geometry and trigonometry, even though essentially the same proportions of girls and boys take beginning algebra (U. S. Department of Health, Education, and Welfare, 1968). A survey of a national sample of collegebound students who had taken the College Entrance Examination Board achievement tests in grade 12 revealed that only 56 percent of the girls (as compared with 84 percent of the boys) took mathematics in the twelfth grade, while 68 percent of the girls (as compared with 53 percent of the boys) studied languages (Haven, 1970). On the other hand, in the collegebound group that took the advanced level of the College Entrance Examination Board test in mathematics for which the prerequisite is some senior-level mathematics, the mean score for girls was only one-fifth of a standard deviation lower than that for boys (College Entrance Examination Board, 1969).

Statement of Problem

Because women can achieve in mathematics and science and are needed in these areas, educators should motivate girls who have these interests and skills to pursue careers in such fields. The present study is concerned with a limited aspect of this problem. It investigates the relationship between a girl's decision to take or not to take advanced mathematics courses in high school and selected variables that are likely to be associated with this decision. It also explores the characteristics of the high schools that show high percentages of college-going girls in advanced mathematics courses.

The research is directed toward answering such questions as:

- What factors in the community, the high school, the mathematics program, and the mathematics teachers are associated with a school's success in motivating girls to study advanced mathematics?

- What factors--school, home, and personal--are associated with a girl's decision to elect advanced mathematics courses?

- How do girls taking advanced mathematics differ in vocational and subject matter preferences from girls who choose other courses even though they had done well in mathematics?

- What motivates girls to select advanced mathematics courses? What reasons do they give for taking or not taking such courses?

- What do mathematics supervisors consider as primary reasons for girls not taking advanced mathematics in high school?

CHAPTER 2

RELATED RESEARCH

The problem under scrutiny involves possible factors determining students' attitudes toward mathematics, on the assumption that favorable attitudes affect students' decisions to take advanced mathematics courses. A substantial amount of research on students' attitudes toward mathematics was done during this past decade. Aiken (1970) reports that the amount of this research increased geometrically since the Feierabend (1959) summary of research on attitudes toward mathematics. As a result, we are aware of the effect on these attitudes of personal variables such as home background and interactions with family, peers, and school personnel, and of school variables such as the mathematics curriculum and the effort of school systems to provide sound educational programs.

Attitudinal differences between the sexes are relevant to the present problem. Riesman (1965) noted that many high school girls feel that scientific studies are inhumane and that training in them might defeminize them in some way. Kagan (1966) reiterated this finding, pointing out that because of cultural differences in sex training, girls tend to avoid anything that is stereotyped as masculine, and mathematics traditionally is considered a masculine subject.

Reisman (1965) also observed that girls tend to be less abstract, less conceptual, and less ideological than men. Hallworth and Waite (1963) extracted a factor from the value judgments of adolescent girls called "the Feminine Image," which contrasted sharply with a more general group of concepts extracted from the value judgments of adolescent boys. This "feminine image" factor also emerged in the research of Slee (1963), who also showed that boys' and girls' differing perceptions of their future roles influenced their attitudes toward subjects.

The sex differences discussed above raise the issue of whether or not girls who do well in mathematics are more masculine in their subject and vocational preferences. Some studies have been reported, but one must be cautious in interpreting the results. In the unpublished doctoral dissertation of Sister Mary de Chantal Farley (1968), eleventh-grade girls who dropped mathematics preferred the kind of work traditionally done by women. On the other hand, this was not true for the eleventh-grade girls who chose to take more mathematics. However, generalizations from this study are hazardous because of small sample sizes. Elton and Rose (1967) found that girls who had higher mathematical than verbal scores on the American College Test (ACT) had more theoretical and less aesthetic (i.e., more masculine) interests as measured by the Omnibus Personality Inventory (OPI), and that girls with higher verbal than mathematical scores on the ACT had more cultural and artistic (i.e., more feminine) interests. Carlsmith (1964) claimed that the masculine conceptual approach, which seems necessary for achievement in mathematics, is acquired through close and harmonious association with the father.

In other studies that involve the effect of sex on course selection, the investigators found that nonintellective factors are more influential in determining the attitudes of girls toward mathematics than of boys. Sister Mary de Chantal Farley (1968) found that girls tend to select a subject because they like it but that boys tend to select a subject because they have done well in it. Harrington (1960) found that the selection of a mathematics course vs. no mathematics course was significantly related to attitude, even though there was an insignificant relationship between attitude and performance in a college mathematics course.

Thus, we can expect differences in the effects of certain variables on women's reactions as contrasted with those of men. Probably one of the most influential factors is the relationship between girls and their teachers. Aiken and Dreger (1961) noted that attitude of girls toward mathematics was more positively correlated with remembered impressions of former mathematics teachers than that of boys. They also found that the correlations between scores on the Mathematics Attitude Scale they had developed and reports given by students on parental encouragement toward school work, while not significant, were more uniformly positive for women than they were for men. Edwards (1957) found that the correlations for women only were significant between scaled scores on a mathematical ability test and scores on items related to student impressions of mathematics teachers such as knowledge of subject matter, patience, and personality traits characterized as "fun-loving" versus "grim" and "clever" versus "dull." Parental encouragement was also found to be significant in the work of Poffenberger and Norton (1959) and Alpert et al. (1963).

Shapiro (1961) found that peer attitudes toward arithmetic in elementary school were influential, especially for girls. However, in the work of Poffenberger et al. (1956), there was no evidence that the peer group had much influence on the individual, except perhaps to reinforce attitudes developed from previous experiences.

Socioeconomic status was investigated as a possible factor in many research studies. The Radcliffe Study (Dement, 1963), which was concerned with making the best use of the finest feminine minds, investigated factors within the college environment that gave the most support or imposed the greatest threat for women in the sciences. Father's education and scholarship aid were the two most significant factors. Girls who persisted in science had a long interest in the field, while those who abandoned the idea of a science career had become interested only through a stimulating high school course. Alpert et al. (1962) found no relationship between measures of socioeconomic status and attitude toward mathematics.

Has the curriculum reform movement in mathematics contributed to attitudinal changes toward mathematics? The "new" mathematics of the fifties involved an effort at content reorganization.

Traditional subjects, such as algebra, solid geometry, and trigonometry, were unified into one naturally related development; analytic geometry, statistics, and calculus were incorporated into the secondary school curriculum; and techniques like "tracking" were used for accommodating individual differences. However, why should one believe that these new programs were appropriately designed to modify the underlying feelings of students and teachers? A possible answer is that if this reorganization resulted in a better understanding and use of the discipline and an appreciation of its inner structure and logic, then it could motivate students to like mathematics.

However, virtually all research to date has failed to show that this reorganization effort has been effective in changing attitudes (Alpert et al., 1963; Bernstein, 1964; Sarason, 1971). Sarason (p.19) noted the following: "After several years of the new math we observed... (its teaching) in a number of classrooms in several school systems.... joy is the last word in the English language that one could apply to the children in those classrooms." Alpert (1963) noted that the attitudes toward mathematics of SMSG students became less positive from fall to spring testing, whereas the attitudes of non-SMSG students remained relatively constant. Dutton and Blum (1968) found that a large percentage of students in the upper elementary grades felt that one cannot use the new mathematics in everyday life.

In contrasting schools with respect to their success in enrolling girls in advanced mathematics classes, it is difficult to identify factors other than the mathematics curriculum, the mathematics teachers, and the guidance facilities, that actually influence attitudes toward mathematics. As Firman (1961) noted, few schools are universally good or universally bad; rather each is a mosaic of specific strengths and weaknesses. Some schools, for example, may do a better job with boys than girls, while other schools may be more effective with girls.

The women's liberation movement undoubtedly has had an effect on the attitudes of girls toward masculine-type subjects. The literature surveyed for this study extended into 1970, but the studies in this area were done primarily in the mid-sixties. In one sense, this present study can serve as a benchmark for charting differences in women's attitudes toward the study of advanced mathemathematics and the possibility of a career in mathematical areas.

CHAPTER 3

METHOD

As stated previously, the primary concern of this study was to identify variables that are associated with a girl's decision to take or not to take advanced mathematics courses in high school. In conjunction with this objective, the characteristics of high schools, including the school districts of which they are a part and the communities in which they are located, were studied to detect characteristics that might relate significantly to the degree of success of a school in encouraging girls to take these advanced courses in mathematics. Definitions of advanced mathematics courses and of the criterion used to measure the success of a high school in accomplishing this objective are provided later in this chapter.

The high schools studied are public high schools in New Jersey. They show wide variation in ability and effort to support education (New Jersey Education Association, 1969), factors that are obviously important in establishing curriculum and attracting qualified administrators and teachers. The high schools span anywhere from three years (senior high schools) to six years. Some are regional high schools that were created to provide comprehensive educational programs more economically. Some are located in large urban centers, others in rural areas. Some are in communities where there is wealth and industrial activity, others are in poor communities. The per capita income varies widely among the communities in which these schools are located.

The girls selected for this study expected to finish high school in June 1969. Each had attended the same high school since the beginning of tenth grade. Every high school in the study had a complete four-year sequence of academic mathematics beginning as far back as the 1965-66 school year; some even provided advanced placement courses in mathematics at that time. Only schools with at least 200 graduates during the 1965-66 year were asked to participate. This provision was set in order to assure sufficient cases from each school for the analyses.

The girls were classified as follows:

Group I: Those taking advanced mathematics courses at the time of the study and those who completed and passed at least one semester of an advanced mathematics course--all of whom were expecting to major in engineering, mathematics, or physical science as indicated on their questionnaires.

Group II: Those taking advanced mathematics courses at the time of the study and those who completed and passed at least one semester of an advanced mathematics course--none of whom expected to major in engineering, mathematics, or physical science as indicated on their questionnaires.

Group III: Those who completed the third year of a four-year sequence of high school academic mathematics with an overall average of "B" or higher, but who did not take an advanced mathematics course.

The high schools were grouped on the basis of a "success" index, which was calculated by dividing the number of senior girls with credit in at least one semester of advanced mathematics by the total number of senior girls who were expected to continue full-time higher education in the Fall of 1969. Both statistics were obtained from the questionnaires completed by the mathematics supervisors. However, it was evident from the replies that these supervisors had delegated the responsibility for obtaining this information to guidance counselors and main office personnel. These data were validated against similar data from a previous year. Substantial differences were checked out with respective schools.

Separate analyses were run for the samples of high schools and of senior girls. In each case, three groups were considered. Twenty variables were used in each comparison study. The revised MANOVA electronic computer program was used to identify the variables that significantly discriminated among these groups. Other statistical tests included Bartlett's test of homogeneity and Kelley's epsilon, a formula used to obtain the estimated correlation between each variable and the criterion of group placement.

Definition of Advanced Mathematics

In this study, "advanced mathematics courses" were defined in terms of the specific subject matter content usually taught as part of the college preparatory curriculum in senior level and college-level mathematics courses, including advanced placement courses. Advanced placement courses are designed for presenting material usually taught in the first year of college, so that high school graduates, upon passing a special examination, can take higher levels of mathematics in college. One such course is sponsored by the College Entrance Examination Board. Since senior-level courses usually occur during the last year of a four-year sequence of mathematics courses beginning in the ninth grade, they are taken mostly by seniors. However, this is not always the case. Some high school mathematics programs are so structured that they are taken in the junior year, leaving the senior year for advanced placement courses or electives such as computer programming, and probability and statistics. Thus, each girl was placed in a group, not on the basis of when she studied advanced mathematics but rather on the basis of whether or not she had taken such courses.

The types of mathematics considered as advanced mathematics in this study are listed and coded on the questionnaires mailed to participants in this study. These are the subjects that were studied most frequently by a national sample of collegebound students in their senior year of high school (Williams, 1969). The girls were given instructions to consult their mathematics teachers if they had problems in coding their courses. Duplicating this list on both questionnaire forms made it possible not only to describe the individual girls' program but also to describe the advanced mathematics offerings in each high school. The supervisors' course descriptions were validated by comparing them with data from two independent sources: the annual reports submitted by high school principals (New Jersey State Department of Education, Report Form B), and a study conducted in 1967 by the Department, in which data on the exact course titles and textbooks in advanced mathematics were reported by mathematics supervisors for the 1965-66 school year. This latter study was also the basis for checking whether these high schools had offered advanced mathematics courses for at least four years.

Selection of Variables for Study

The literature search was extremely helpful in identifying factors associated with attitudes toward mathematics. While home and school characteristics are part of the picture, research shows that girls' attitudes toward mathematics are influenced more by social considerations than are boys' attitudes. There is even evidence that the masculine image associated with mathematics tends to discourage girls from studying the subject. Women gravitate toward the nurturing professions such as teaching, nursing, and social work, while men are interested in positions that offer power, profit, and independence (Centers, 1954). In other words, girls seem to prefer jobs in which they can help people and where the work is interesting; boys like to be boss and to be paid well. This is compatible with general cultural definitions of so-called "maleness" and "femaleness."

Thus, it seemed appropriate to compare these girls on subject matter preferences and vocational interests, answering questions such as: Is there a significant relationship between the choice of senior-level mathematics and an interest in natural science? Is there a significant relationship between choice of senior-level mathematics and an interest in occupations that are usually considered masculine? If there are no significant differences, we may have a new source of potential scientific personnel involving those who did not take advanced mathematics but who might easily have been encouraged to do so.

The variables used in this study are defined in Tables 1 and 2. The information was collected from three sources: (1) mathematics departmental heads or supervisors, (2) senior girls identified according to the specifications of the study by mathematics supervisors, and (3) published and unpublished statistics available from State groups such as the New Jersey Education Association and the New Jersey State Department of Education. Copies of the questionnaires used in this study can be obtained by writing directly to Educational Testing Service.

Description of the Interest Inventory Used in this Study

The inventory administered to the girls in this study was adapted from the Milwaukee Academic Interest Inventory developed by Andrew R. Baggaley (1963). The complete Milwaukee Academic Interest Inventory is a 150-item, self-report instrument designed to aid in the counseling of college freshmen and sophomores, and collegebound high school seniors. It is scored on variables representing six groups of fields of

Table 1

Definitions of Variables Used in the Comparisons Among Schools

Community characteristics (area in which high school is located)

Type of community (proportion of workers in manufacturing industries as shown by the 1960 Census data)

Evaluation of community by mathematics departmental chairmen with respect to job opportunities in mathematics and science (5-point rating scale)

School district characteristics

Equalized valuation of property per pupil, 1967-68 (measure of ability to pay for education; calculated by dividing the 1968 equalized valuation of property by the average daily enrollment of resident pupils for 1967-68)

Total expenditures per weighted[1] pupil, 1967-68 (measure of effort to support education; calculated by dividing total day school expenditures, including capital outlay and debt service, by weighted pupils in total average daily enrollment)

Number of professional staff (less nurses) per 1,000 weighted[1] pupils, 1967-68 (measure of effort to support a good educational program)

High school characteristics

Type of high school (regional, non-regional)

Size of high school graduating class, 1969

Proportion of girls in high school graduating class going to college, 1969 (estimated by mathematics supervisors)

Has mandatory mathematics requirement (yes,no)

Total credits offerings in advanced academic mathematics

Offers college-level mathematics courses (yes,no)

Offers tracking in mathematics curriculum (refers to the provision of an alternate sequence of mathematics courses--yes,no)

Rating of texts in advanced mathematics courses (rated by two experts[2] on a 5-point scale from "very traditional" to "very modern," results dichotomized as "3 or higher" or "lower than 3.")

Table 1 (continued)

Mean girl ratings by school of teachers of third-year mathematics courses on seven characteristics (ability to explain subject matter especially when it was difficult, accessibility whenever students needed help, success in making mathematics an interesting subject to study, concern with emphasizing both the abstract and the practical aspects of mathematics, knowledge of subject matter, control of class, and personality and range of interests)

Meets guidance staff recommendation of N. J. State Dept. of Education: one counselor per 311 students (ratio calculated by dividing number of full-time equivalent guidance personnel by pupil enrollment from N. J. State Dept. of Education data, Form A, Part 1-A, October 1968)

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[1] Weighting enrollments allows for differences in cost for providing various types of educational programs. In this weighting, the following values are used: 0.5 for pre-first to 6th grade, 1.3 for secondary pupils (grades 7 through 12), and 2.0 for special class students.

[2] Rated by Examiners in Mathematics Section of Test Development Division, Educational Testing Service. Both examiners previously were mathematics supervisors in large school systems.

Table 2

Definitions of Variables Used in the Comparisons Among Girls

General information

Father's education (completing four years of college vs. not completing four years of college)

Mother's education (completing four years of college vs. not completing four years of college)

Father's occupation (professional, technical, or managerial vs. other)

SAT scores, verbal and mathematical

Preparation in mathematics

Total credits taken in advanced mathematics

Highest level of advanced mathematics taken (high school vs. college level)

Type of mathematics studied in the third year of the sequence of academic mathematics courses offered (geometry vs. algebra)

Attitude toward mathematics

Reasons for taking advanced mathematics (open-ended responses coded)

Reasons for not taking advanced mathematics (open-ended responses coded)

Likelihood of mathematics being useful in future studies or occupation (3-point scale: very likely, possibly, very unlikely)

Future educational and occupations plans

Plans for Fall 1969

Probable college major (if expecting to attend college full-time or part-time)

Teaching plans (whether or not girl expects to teach and at what level)

Table 2 (continued)

People with whom girls discussed taking advanced mathematics

(guidance counselor; member of mathematics department; mother, stepmother, or guardian; father, stepfather, or guardian; brother or sister; other relative or friend of family; classmate, friend, or college student; college staff member, i.e., admission officer or department head)

People who encouraged girls to take advanced mathematics

(same list as directly above)

Girls' ratings of their third-year mathematics teachers

(5-point scale for each of 7 characteristics; ability to explain subject, availability for extra help, success in making mathematics interesting, concern with emphasizing both abstract and practical aspects of mathematics, knowledge of subject, control of class, and personality and range of interests.)

Girls' ratings on bipolar interest scales (two scales taken from Milwaukee Academic Interest Inventory)

Natural science vs. social studies interests (36 items)

Commercial vs. nurturant interests (highly related to "masculinity" vs. "femininity"--43 items) concentration: physical science, healing occupations, behavioral science, economics, humanities-social studies, and elementary education. However, subsequent analyses by its originator (Baggaley, 1967; Baggaley, 1968) resulted in identifying two new interest variables, X and Y, which are virtually uncorrelated and which discriminate effectively between academic majors. Variable X is based on a male-female dichotomy and is described as a bipolar factor of commercial versus nurturant interests. Variable Y is a science-nonscience classification, more precisely, a natural science versus social studies interest variable. The senior-girl questionnaire contains the 79 items in Interest Inventory (X + Y).

The items in the (X + Y) Inventory are well balanced between positively-keyed and negatively-keyed responses. While many of these items are concerned with topics associated with specific fields, e.g., "I would like to write advaertising copy," other items related to more general personality characteristics, e.g., "It bothers me a lot to be in a room where 20 or 30 people are talking at one," and "I like to walk hand in hand with a child."

In the actual administration of this Inventory, a girl marked "1" if the statement was true or mostly true as it applied to her; she marked "2" if the statement was false or mostly false as it applied to her; she marked "3" if she was undecided. The instructions urged the respondent not to use the "undecided" alternative too frequently. In the final analysis, only scores for students who answered "1" or "2" for 59 or more items were used.

Development of Hypotheses

Since 40 variables are considered for investigation in this study, there are 40 null hypotheses to test. The first 20 null hypotheses are concerned with comparisons among high schools; the second 20 hypotheses are concerned with comparisons among girls. For the first set of comparisons, each null hypothesis assumes that no difference exists among three defined groups of schools, namely, those with "high" success in enrolling girls in advanced mathematics courses, those with "medium" success in enrolling girls in advanced mathematics courses, and those with "low" success in enrolling girls in advanced mathematics courses. (The intent here is to have approximately equal numbers of schools in each of these three categories.) For the second set of comparisons, each null hypothesis assumes that no difference exists among three groups of girls: those who studied advanced mathematics with the expectation of majoring in a related area such as engineering, mathematics, or physical science, those who studied advanced mathematics but had other than mathematically-related voca-tional interests, and those who had done well in mathematics but who elected to drop the subject after three years in high school. A null hypothesis is rejected if the relationship is significant at a prescribed significance level.

Procedures for Carrying Out the Study

The initial contact in this study was made with departmental chairmen. They were asked to complete a descriptive questionnaire and to identify the girls in their respective high schools who met the specifications established for the study. Questionnaires were then mailed to each supervisor for distribution to the appropriate girls in his school.

Two follow-up procedures were used. A letter was sent to each nonresponding departmental chairman two weeks after the initial contact had been made. This letter promised a copy of the 28-page Williams' report as an incentive for participation. In the beginning of June, personal appeals were made to selected key people in twelve high schools located in areas of the State where a response would increase the representativeness of the sample.

Data Preparation

The Revised MANOVA Program was used as a quick way to compute a large number of univariate analyses of variance. A substantial amount of editing and coding was necessary for adjusting the data to this program. Since the program automatically rejects unmatched data, certain adjustments were made in preparing the data so that the number of unmatched cases would not exceed about 5 percent of the returns. Most of this problem arose in the Interest Inventory where students used the"3"(undecided) response too frequently to make scores valid. A cut-off point was established, and in situations where the girls were undecided on twenty or more items (the total interest inventory included 79 items), scores were not reported, and these cases were excluded from the analyses of variance. When data were missing on student ratings of teachers, average values were calculated for the particular school and used to replace the missing data. Actually, this type of omission was rare. Almost half of the deleted cases were caused by missing data on mother's and father's education and father's occupation. In all, 91 cases were eliminated for the MANOVA Program. However, all 1,840 cases were used in the F4STAT Program utilized to describe the groups. Much work was involved in coding and validating the coding of the open-ended responses to the inquiry on the senior girl questionnaire: "To help us learn why some girls decide to take senior- or college-level mathematics in high school while others do not, please indicate below your main reason for making the decision that you did. Should you feel that in your case there were several reasons that affected your decision, please give all of them here." No more than three reasons were recorded for any one girl. In addition, coding and validating the coding was done also for the open-ended question on the departmental head questionnaire: "In your experiences as teacher and administrator, what have you found to be the two most frequent reasons given by girls for not taking advanced mathematics courses"?

Two scores were obtained for each girl on the Interest Inventory. These are interpreted as follows: a high score on Variable X means that the girl tends to have commercial (masculine) interests; a high score on Variable Y means that the girl is more interested in natural science than social studies. The maximal score for Variable X is 43. For Variable Y, it is 36.

For the questions with alternatives that could not be assumed to constitute a continuous scale, the data were usually dichotomized. For example, the question on parent's education was treated as follows: "those completing four years of college" versus "those not completing four years of college." The question on father's occupation was treated as follows: "professional, technical, or managerial position" versus "all other types of positions." Some data were directly dichotomous. For example, a girl either was encouraged or not encouraged to study advanced mathematics by the people identified in the study.

Means based on girls' rating of teachers who taught third-year mathematics were calculated for each school. Initially, SAT and CEEB Mathematics Test scores were to be criteria. However, too many girls either could not remember their scores or they had not yet received them. It was helpful, though, to have SAT scores for validating the ability of these girls.

To get an indication of the type of mathematics curriculum within each school, the texts used in advanced mathematics courses were listed on 3 x 5 cards and independently rated by two members of the Mathematics Section of the Test Development Division of Educational Testing Service. The scale ranged from 1 to 5: "1" representing a very traditional text (most of the content predating the modern reform movement of the 1950's), "3" representing a transitional text in which some of the content is new but the spirit or tone of the text is expository rather than heuristic, and "5" reflecting only the very newest mathematics programs, largely experimental, e.g., the Scott Foresman Series. Ratings of "2" and "4" represented intermediate points on this scale.

Since most high schools used several texts, an average rating was obtained for each school. This rating was intended to represent the "flavor" of the advanced mathematics courses. However, as several mathematics educators pointed out, while many mathematics texts were published in the mid-sixties, very few of them were good fourth-year texts. Thus, the textbook ratings were dichotomized, each being described as "3 or higher" or "lower than 3."

Analysis Procedures

As previously stated, the MANOVA electronic computer program was used to compute a large number of univariate analyses of variance. For each variable a univariate $\underline{F}$ ratio and the corresponding probability of obtaining the results by chance are reported. To compensate for sample size, an index of association (Kelley's epsilon) was computed to estimate the strength of each statistically significant relationship (Peters and Van Voorhis, 1940, pp. 319-325 and 421-422).

The MANOVA computer program also identifies discriminant functions, a maximum of one less than the number of groups in the analysis. These provide an estimate of how well the variables discriminate among the groups.

The possibility of nonnormality and heterogeneity of variance for the types of variables used in this study was considered. The assumption was made, however, that the F test, which is very insensitive to both of these, could be safely used under most conditions. Much evidence shows that the F ratio remains "robust" under a variety of violations of the assumptions on which it is mathematically based. The Norton Study (Lindquist, 1953, pp. 78-90) demonstrates the insensitivity of the F distribution to the form or variance in situations where the assumptions of normality and homogeneity of variance were in serious doubt. Examples from the work of Box (Winer, 1963, pp. 92-93) demonstrate the effects of lack of homogeneity of variance.

Actually, the experimenter need be concerned only about relatively large departures from the hypothesis of equal population variances. For this reason, Bartlett's test was applied to the most discriminating variables in this study for the purpose of detecting significant departures from the hypothesis of equal population variances. Total sample frequency distributions are reported for all but dichotomous variables.

CHAPTER 4

RESULTS

For the school year 1965-66, New Jersey State Department records showed that practically every public high school in the State with twelfth grade had students taking courses such as trigonometry, advanced or college algebra, analytic geometry, or calculus. After 88 high schools with fewer than 200 graduates that year were eliminated, the remaining high schools were contacted for this study.

The data in this study include returns from 63 mathematics departmental chairmen and 1,840 senior girls. Since 168 high schools had been contacted and a total of 2,588 senior girls were identified for the study, this means that the results are based on 38 percent of the high schools and 71 percent of the girls. As shown in Table 3 below, the returns represent 76 percent of the girls reported to have studied advanced mathematics and 62 percent of those who did not take such courses, even though they completed the third year of a four-year sequence of academic mathematics with an overall average of "B" or higher.

Table 3

Response Summary in Study

Took Advanced Mathematics	Number of Eligible Girls	Number Responding	Percent Response
Yes	1,710	1,296	76%
No	878	544	62
TOTAL	2,588	1,840	71%

The excellent response among the girls certainly reflects the conscientiousness of mathematics supervisors and the interest and willingness of girls to assist in the project. The response rate in 27 high schools was 90 percent or higher; in 58 schools, at least two-thirds of the eligible girls participated. As a control on response bias, no school was included if less than one-third of the eligible girls submitted returns. This rule of thumb actually eliminated only two high schools from the results.

Representativeness of Sample

The geographical location of each participating high school is indicated on the map of New Jersey provided in Figure 1. Among the five counties not represented in the returns, two did not have a high school that was large enough to be included in the study. The percentages of response among high schools from the northern, central, and southern parts of the State are quite similar, indicating representation of all community types, e.g., large urban areas, rural areas, suburban, industrial, and even resort communities such as those along the Atlantic coast.

The school districts in the sample show variability in their wealth and effort to support education. The cumulative percentage curves for the distributions of equalized valuation per pupil, total expenditure per weighted pupil, and number of professional staff per 1,000 weighted pupils in the sample school districts are not significantly different from those for all high school districts in the State as shown by the application of the nonparametric Kolmogorov-Smirnov Test (Tate and Clelland, 1957, pp. 62, 131). The null hypothesis in each case is not rejected at the one

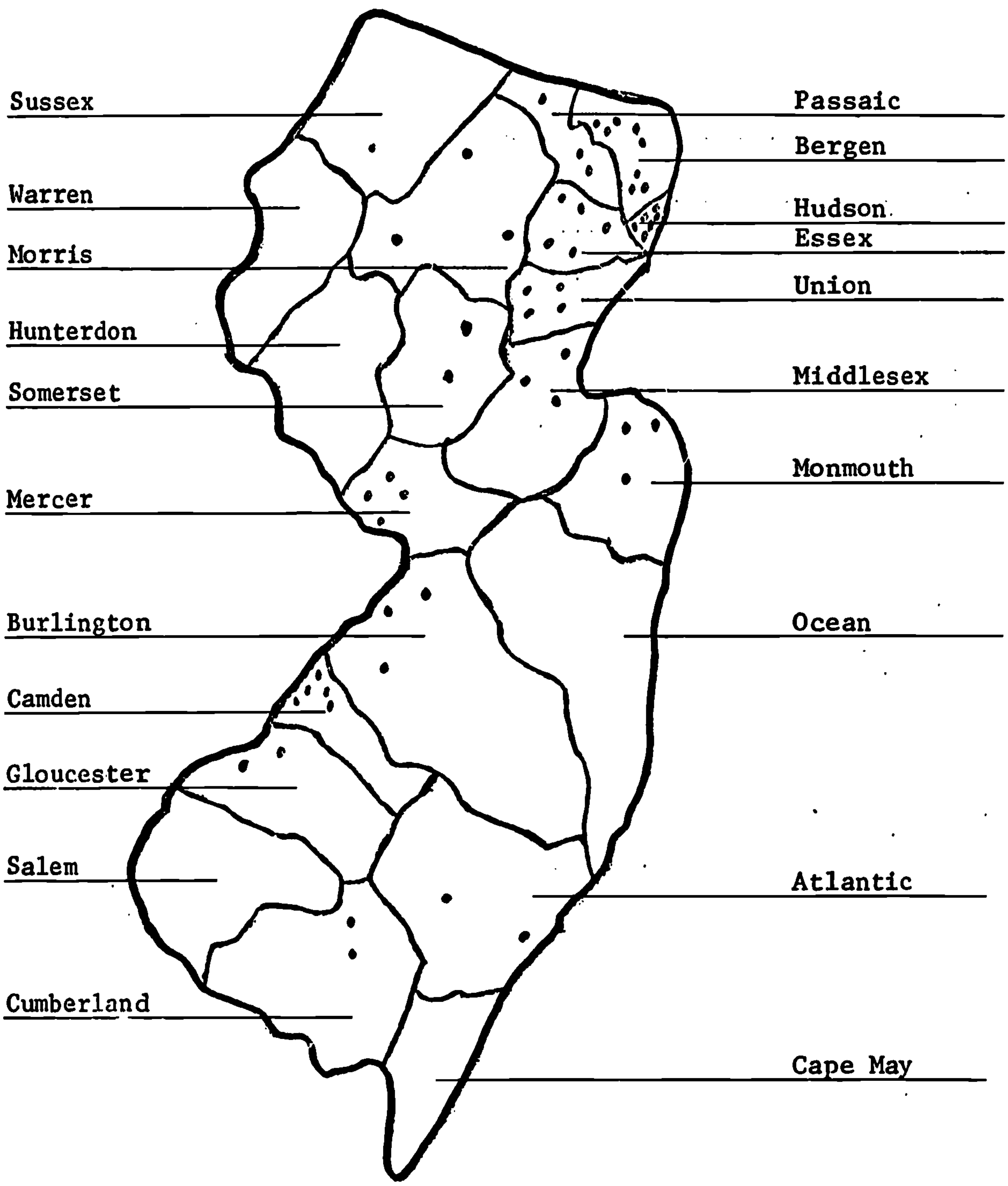

Fig. 1: Geographical Location of High School Districts in Study

percent level.

The sample of participating high schools also resembles the high schools contacted with respect to size and percentages of female graduates going on to college. No significant differences exist between the distributions of these variables for the two groups, the null hypothesis again not rejected at the one percent level.

Even though 88 high schools were eliminated from the study because there were fewer than 200 graduates in 1965-66, this apparently did not affect the characteristics of the sample contacted. Distributions of measures such as wealth, educational expenditures, professional staff ratios, and percentages of girls going on to college are not significantly different for these two groups. It is also true that no geographical area of New Jersey is underrepresented as a result of eliminating these 88 high schools from the study. These small schools are well distributed throughout the State.

Criterion Group Identification

The identification of the three criterion groups of high schools in this study is based on a "success" index, which involves the number of girls who took advanced mathematics and the number of girls expected to go on to college full-time in the Fall. The footnote in Table 4 describes how this index was calculated for each school. As defined, this index can exceed 1.00, especially when capable girls who do not expect to continue their education immediately after high school take advanced work in mathematics.

Table 4 presents the frequency distribution of these indices for the 63 high schools in the study. Three groups of approximately equal size were formed, and ratings were assigned to the corresponding ranges of values. Thus, schools with index values of .00 to .19 are "low" success schools, those with values of .20 to .29 are "medium" success schools, and those with values of .30 or more are "high" success schools.

Major field was a determinant in establishing criterion groups for girls in the study. The girls who took advanced mathematics were separated into two groups. Group I includes respondents who expect to be either full-time or part-time college students and who indicate that their major interest is engineering, mathematics, or physical science. Group II includes respondents with college plans who preferred major fields other than engineering, mathematics, or physical science. Girls not planning on college full-time or part-time but who took advanced mathematics are also included in Group II. Group III includes all girls, regardless of future plans, who did not take advanced mathematics, even though they may have done well in previous mathematics courses.

The returns identified 220 girls (12 percent) for Group I, 1,076 girls (58 percent) for Group II, and 544 girls (30 percent) for Group III. As noted in Table 5, only 36 girls in Group II and 28 girls in Group III had no immediate college plans. They planned either to work full-time or get married. A slightly higher percentage

Table 4

Distribution of "Success" Indices and Assigned Ratings for the 63 New Jersey Public High Schools in the Study

Assigned Rating	"Success" Index	No. of High Schools
	.60 and over	2
	.55 - .59	1
"High"	.50 - .54	1
GROUP III	.45 - .49	...
	.40 - .44	3
	.35 - .39	5
	.30 - .34	9
"Medium"	.25 - .29	11
GROUP II	.20 - .24	9
	.15 - .19	7
"Low"	.10 - .14	10
GROUP I	.05 - .09	4
	.00 - .04	1
	No. of high schools	63
	Median	.25
	Mean	.25
	Stand. Deviation	.28
	Range of values	.00 to .70

Note: "Success" Index is calculated by dividing the number of girls who took and passed at least one semester of an advanced mathematics course (including those who were taking advanced mathematics in the Spring of 1969) by the number of girls expected to be attending some institution of higher education in the Fall of 1969. The latter figure is an estimate given by the mathematics department chairman and based on last year's percentages adjusted for differences known to exist in the present graduating class.

of girls in Group II (92 percent), as compared with girls in Group III (88 percent), planned to attend college full-time in the fall.

The distribution of major field of interest for the girls in Groups II and III shows education and humanities, followed by social studies and the biological sciences, to be most popular. However, in comparing Group II with Group III, higher percentages of the girls in Group II are interested in biological sciences, while, in Group III, higher percentages prefer education, humanities, and fine arts. Among the girls in Group II, 9 percent were still undecided about their majors (Table 5).

Results

The results of this study are discussed in three sections. The first section is concerned with investigating the effects of certain community, school district, and high school characteristics on the "success" criterion used to categorize high schools in the study. The second section involves the impact of selected school and personal factors on girls' decisions with respect to taking or not taking advanced mathematics in high school. The final section is devoted to a summary of reasons volunteered by girls when asked to respond to an open-ended question seeking the main reason(s) why they made the decision they did. Also discussed in this section are reasons reported by mathematics departmental chairmen as being given most frequently by girls for not taking advanced mathematics courses in high school.

Table 5

Future Plans of Senior Girls in Study

Future Plan	Group I No.	Group I %	Group II No.	Group II %	Group III No.	Group III %	All Respondents No.	All Respondents %
Attending college full-time	216	98%	992	92%	478	88%	1,686	92%
Attending college part-time and working part-time	3	1	8	1	13	2	24	1
Working full-time	...	...	33	3	25	5	58	3
Getting married	...	...	3	0	3	1	6	...
Other [1]	1	1	40	4	25	5	66	4
Totals	220	100%	1,076	100%	544	100%	1,840	100%

[1] Includes girls going into nurse's training.

Table 6

Intended College Majors of Senior Girls in Study

Major	Group I No.	Group I %	Group II No.	Group II %	Group III No.	Group III %	All Respondents No.	All Respondents %
Education	...	...	248	23%	138	25%	386	21%
Humanities & Fine Arts	...	...	222	21	157	29	379	21
Social sciences	...	...	166	15	78	14	244	13
Biological sciences	...	...	185	17	39	7	224	12
Engineering, mathematics, & physical sciences	220	100%	...	...	...	...	220	12
Home economics	...	...	34	3	16	3	50	3
Nursing	...	...	18	2	11	2	29	2
Other	...	...	33	3	26	5	59	3
Undecided	...	...	92	9	26	5	118	6
None given (includes girls not going to college)	...	...	78	7	53	10	131	8
Totals	220	100%	1,076	100%	544	100%	1,840	100%

I. COMPARISONS AMONG HIGH SCHOOLS

The largest univariate F ratio for any variable in the comparisons among high schools is 1.67 (df = 2, 60), which has a p value of .196. This finding means that all of the null hypotheses tested are accepted and that the three criterion groups are not different for the mean value of any variable investigated. The three most differentiating variables are: number of professional staff per 1,000 weighted pupils, the use of tracking in the mathematics curriculum, and the type of high school. "Tracking" refers to grouping within the mathematics curriculum to provide for both students who want the challenge of advanced work in mathematics and students who want only the normal work sequence within the regular four-year high school program. The "type" of high school referred to here is the regional high school which serves several elementary school districts. While the correlations between these variables and the criterion are low--.15, 12, and .11, respectively, with the present sample size, they are significant at the one percent level.

While the means for these three groups of high schools are not statistically different, certain group characteristics are observable. For example, high schools that have a "high" success index in motivating girls to study advanced mathematics tend to be regional high schools, to use advanced mathematics textbooks that can be characterized as modern (as opposed to traditional), and to provide tracking in the mathematics curriculum. For example, seven high schools in Group III (high schools with a "high" success index), as compared with only two in Group I (high schools with a "low" success index), are regional high schools. Tracking is used in 15 of the 21 high schools in Group III but only in 12 of the 22 high schools in Group I.

On the other hand, the high schools with "medium" success in recruiting girls to take advanced mathematics are located in school districts that have the most wealth, spend the most on education, and have the highest average number of professional staff per 1,000 weighted pupils. Yet, these same high schools have the highest mean percentage of girls going on to college. One might speculate here that girls from affluent areas gravitate toward the humanities and fine arts as opposed to mathematics and science.

Other information about the high schools in this study include the following:

- These 63 high schools offer anywhere from 5 to 20 credits in advanced mathematics: 23 of them offering 15 or more credits and 16 offering only one five-credit course.
- Thirty-seven high schools offer college-level courses.
- The most popular senior-level course, available in 42 high schools, is very general in scope, covering a variety of topics such as logic and sets, groups and fields, probability and statistics, the real number system, and functions (algebraic and trigonometric). This course is

> often called simply Senior Mathematics or has a title such as Foundations of Mathematics, Principles of Mathematics, Elementary Analysis, Advanced Mathematics, or College Mathematics. The content of other senior-level courses is primarily trigonometry and advanced algebra, with a few solid geometry courses still being taught. Electives include courses in computer programming, elementary functions, finite mathematics, and probability and statistics.

It is rather surprising that the availability of college-level mathematics courses does not encourage more girls to take advanced work in high school mathematics. The data in Table 7 show that more than half of the girls in the study attended high schools that offered college-level mathematics. However, only 73 percent took advanced mathematics courses. In contrast, almost as many of the girls enrolled in the high schools that did not offer college-level mathematics (66 percent) took advanced mathematics courses. Of all the girls who could have taken college-level mathematics, only one in seven did; however, this percentage increased to 35 percent of those who were expecting to major in engineering, mathematics, and physical science.

Table 7

Relationship Between Taking or Not Taking Advanced Mathematics and Level of Mathematics Offerings in High Schools in Study

Level of Offerings	Group I No.	Group I % of Total	Group II No.	Group II % of Total	Group III No.	Group III % of Total
IN HIGH SCHOOLS OFFERING BOTH SENIOR- AND COLLEGE-LEVEL MATHEMATICS						
No. of girls taking college-level mathematics	48	22%	107	10%	n.a.	
No. of girls taking senior-level mathematics only	88	40	591	55	n.a.	
No. of girls not taking advanced mathematics	n.a.		n.a.		306	56%
Subtotal	136	62%	698	65%	306	56%
IN HIGH SCHOOLS OFFERING ONLY SENIOR-LEVEL MATHEMATICS						
No. of girls taking senior-level mathematics	84	38	378	35	n.a.	
No. of girls not taking advanced mathematics	n.a.		n.a.		238	44
Subtotal	84	38%	378	35%	238	44%
TOTAL	220	100%	1,076	100%	544	100%

n.a. = not applicable

II. COMPARISONS AMONG SENIOR GIRLS

The revised MANOVA electronic computer program produced for each variable, means and standard deviations by group, and F ratios for testing differences among the group means. These are reported in Tables 8 and 9. In addition, the program produced two discriminant functions, each a linear combination of the 20 variables.

Eleven of the 20 independent variables show significant differences (p less than .001) for the three specified groups of senior girls: Group I--Those who passed at least one semester of advanced mathematics and who expect to major in engineering, mathematics, or physical science; Group II--Those who passed at least one semester of advanced mathematics but do not expect to major in engineering, mathematics, or physical science; and Group III--Those who completed the third year of a four-year sequence of high school academic mathematics with an overall average of "B" or higher but who did not take an advanced mathematics course. Both discriminant functions are significant at the .001 level, which indicates that most of the between-group variance is accounted for by them. Three variables contribute the greatest weights to the variate described by the first discriminant function. Two variables are highly correlated with the criterion.

The application of Bartlett's test to group variances for each of the 11 most discriminating variables shows that not all of the distributions fulfilled the assumption of homogeneity, which is required for the F test. This condition was fulfilled (p less than .01) for only five variables. These are asterisked in Table 9. Large sample sizes, by increasing the variances within the groups, contributed to the sensitivity of Bartlett's test. However, as noted earlier, the F ratio is "robust" under the assumption of homoscedasticity.

The estimated relationships between the 20 variables and the criterion as measured by correlations calculated using Kelley's epsilon $\left[\epsilon = \frac{(k - 1)(F - 1)}{N - k + F(k - 1)} \right.$, where k = number of groups, N = total sample size, and F is the F ratio$\left. \right]$ are also reported in Table 9. This formula compensates for sample size in assessing the strength of each statistically significant relationship.

Discussion of the Results

The discussion above points to the fact that there are two variables which show the greatest contrast among the three groups of girls, namely, the UMF and the Y Variables. The UMF variable is a three-point rating scale used to describe how these girls felt about the usefulness of the mathematics they had studied in high school to future studies or occupations. The Y Variable is a 36-item scale measuring their interest in natural science as opposed to social studies. The estimated relationships between these two variables and the criterion are moderately high (.41 and .36, respectively), while correlations for the next four most significant variables cluster around .20 (Table (9). (Correlations of .09 or higher, while low correlation values, are

Table 8

Group Means and Standard Deviations for the Twenty Variables in the Comparisons Among Girls

Variable	Group I Mean	Group I S.D.	Group II Mean	Group II S.D.	Group III Mean	Group III S.D.
	(n = 211)		(n = 1,029)		(n = 511)	
Type of math taken prior to first advanced math course*	1.8	.42	1.8	.38	1.8	.41
Student rating of 3rd-year math teachers on:						
Ability to explain subject matter	3.7	1.09	3.7	1.04	3.5	1.09
Availability for extra help	3.8	1.08	4.0	.99	3.9	1.03
Success in making math interesting	3.4	1.26	3.3	1.13	3.0	1.09
Concern with emphasizing both abstract and practical aspects of math	3.3	1.09	3.4	1.01	3.2	1.04
Knowledge of subject matter	4.4	.78	4.4	.76	4.3	.83
Control of class	3.8	1.16	3.8	1.12	3.7	1.18
Personality and range of interests	3.7	1.18	3.7	1.12	3.5	1.16
Usefulness of h.s. mathematics in future studies or job**	1.0	.18	1.7	.68	2.0	.72
Father's education	1.4	.49	1.4	.49	1.3	.47
Mother's education	1.2	.38	1.3	.43	1.2	.40
Father's occupation	1.4	.49	1.4	.48	1.4	.49
Variable X: Commercial vs. nurturant interests	14.9	6.07	11.9	5.81	11.1	5.49
Variable Y: Natural science vs. social studies interests	20.2	5.32	15.0	5.84	13.0	4.86
Intention to teach°°	1.5	.50	1.5	.50	1.5	.50
Girl encouraged to take advanced mathematics by:°°						
Guidance counselor	1.5	.50	1.5	.50	1.7	.46
Member of mathematics department	1.6	.50	1.7	.47	1.8	.40
Mother, stepmother, or guardian	1.6	.50	1.7	.47	1.8	.36
Father, stepfather, or guardian	1.5	.50	1.6	.49	1.8	.39
Classmate, friend, or college student	1.8	.43	1.8	.40	1.9	.31

* 1 = plane or solid geometry, 2 = intermediate algebra, trigonometry, or other

** 1 = Very likely, 2 = possibly, 3 = very unlikely

°° 1 = Yes, 2 = No

Table 9
Univariate F Ratio, Probability Value, and Estimate of Correlation For Variables in the Comparisons Among Girls

Variable	Univariate F Ratio (df=2, 1748)	Probability Value	Correlation Ratio[1]
Likelihood that high school math will be useful in future studies or job	174.82	<.001	.41
Natural science vs. social studies interests (Y)	128.54	<.001	.36
Girl encouraged by father, stepfather, or guardian to take advanced math.	42.95	<.001	.21
Girl encouraged by mother, stepmother, or guardian to take advanced math	39.56	<.001	.21
*Commercial vs. nurturant interests (X)	34.76	<.001	.19
*Girl encouraged by guidance counselor to take advanced math	25.61	<.001	.17
Girl encouraged by member of math department to take advanced math	22.46	<.001	.15
*Girl's rating of third-year math teacher on success in making math interesting	18.05	<.001	.14
Girl encouraged by classmate, friend or college student to take advanced math	14.14	<.001	.12
*Girl's rating of third-year math teacher on concern with emphasizing both abstract and practical aspects of math	8.19	<.001	.09
*Girl's rating of third-year math teacher on personality and range of interests	6.74	<.001	.08
Mother's education	4.65	.010	.06
Father's education	4.18	.015	.06
Girl's rating of third-year math teacher on ability to explain subject matter	3.68	.025	.06
Intention to teach	2.70	.067	.04
Girl's rating of third-year math teacher on knowledge of subject matter	2.18	.113	.04
Girl's rating of third-year math teacher on control of class	2.14	.117	.04
Girl's rating of third-year math teacher on availability for extra help	2.02	.133	.03
Type of math taken just prior to first advanced math course	2.01	.134	.03
Father's occupation	.95	.389	.00[2]

[1] Based on the value of Kelley's epsilon, which is independent of sample size and the number of classes into which the sample is divided (Peters, C C. and Van Voorhis, W.R., 1940. Pp. 319-325, 421-422).

[2] The value is closer to .00 than to .01.

*Fulfilled the assumption of homogeneity using Bartlett's test.

significant at the .01 level).

The distribution of ratings on the UMF Variable appears in Table 10. It can be seen that practically all girls expecting to major in mathematics, engineering, or physical science (Group I) felt that it was "very likely" that they would use the mathematics they had studied in high school. However, this percentage dropped to 41 percent for those who took advanced mathematics even though their interests were in nonmathematical areas (Group II) and to 24 percent for those who did not take advanced mathematics (Group III).

Table 10

Distribution of Ratings by Girls on the Likelihood That the Mathematics Studied in High School Would Be Useful in Future Studies or Vocation

Rating	Group I		Group II		Group III		All Respondents	
	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
Very likely	213	97%	440	41%	129	24%	782	42%
Possibly	7	3	490	46	265	49	762	41
Very unlikely	...	..	146	14	147	27	293	16
No response	...	..	...	..	3	.2	3	.6
Total	220		1,076		544		1,840	

The Y Variable is derived from an interest inventory; a high score shows greater interest in natural science, while a low score shows more interest in social studies. The mean Y score for Group I is 20.2, 5.2 points higher than the mean Y score for Group II (15.0) and 7.2 points higher than for Group III (13.0). In looking at the distribution of these scores within each of the three groups (Table 11), we find 50 percent of the girls in Group I scoring 21 or higher, by comparison with 18 percent of the girls in Group II and 9 percent of the girls in Group III. The scores for the girls in Group III vary least as shown by the lowest standard deviation, thus indicating a greater similarity of interests as measured by this inventory among the girls in Group III.

The fact that there is less relationship than might be expected between taking advanced mathematics and interest in masculine-type (commercial) activities (correlation of .19) is an interesting finding. However, as might be expected, girls who intend to major in engineering, mathematics, and physical sciences show considerable interest in business and commercial pursuits, as indicated by high scores on the 43-item variable, labeled as Variable X.

The distribution of scores on X for the three groups and total appears in Table 12. In Group I, only 16 percent of the girls had scores of 10 or less. In Groups II and III, however, about one-third of the girls had low scores of 10 or less, with much smaller score differences evident between these two groups than between them and Group I. This indicates that many girls who take advanced mathe-

Table 11

Distribution of Scores on Variable Y for Senior Girls in Study ("Natural Science" Versus "Social Studies" Interests)

Score	Group I		Group II		Group III		Total	
	No.	Mid-%ile	No.	Mid-%ile	No.	Mid-%ile	No.	Mid-%ile
32-33	2	99.5	1	99.9			3	99.9
30-31	5	98	6	99.6			11	99.5
28-29	11	94	5	99			16	99
26-27	20	87	17	98	2	99.8	39	97
24-25	26	76	45	95	10	99	81	94
22-23	34	63	74	89	23	96	131	88
20-21	21	50	86	82	22	91	129	81
18-19	23	40	101	73	39	85	163	72
16-17	31	27	119	62	56	76	206	62
14-15	20	16	144	50	62	65	226	50
12-13	14	8	144	36	89	51	247	37
10-11	5	4	127	23	95	33	227	24
8-9	5	1	85	13	68	18	158	13
6-7	...	...	56	6	35	8	91	6
4-5	...	...	26	2	18	3	44	2
2-3	...	...	8	.5	5	.5	13	.4
0-1	...	...	1	.0	...	...	1	...
Totals	217		1,045		524		1,786	

Note: These include all girls who answered at least 60 of the 79 items in the Interest Inventory.

Table 12

Distribution of Scores on Variable X for Senior Girls in Study
("Commercial" Versus "Nurturant" Interests)

Score	Group I No.	Group I Mid-%ile	Group II No.	Group II Mid-%ile	Group III No.	Group III Mid-%ile	Total No.	Total Mid-%ile
36-37			1	99.9			1	99.9
34-35			...	99.9			...	...
32-33	1	99.8	...	99.9			1	99.9
30-31	1	99.	4	99.7	2	99.8	7	99.7
28-29	4	98	5	99	...	99.6	9	99
26-27	8	95	11	98	3	99.	22	98
24-25	7	92	16	97	13	98	36	97
22-23	13	87	27	95	11	96	51	94
20-21	14	81	53	91	13	93	80	91
18-19	23	73	64	86	30	89	117	85
16-17	28	61	84	79	36	83	148	78
14-15	26	48	106	70	51	74	183	68
12-13	29	36	139	58	66	63	234	57
10-11	22	24	128	45	74	50	224	44
8-9	14	16	140	32	77	36	231	31
6-7	18	8	129	20	60	22	207	19
4-5	9	2	104	8	61	11	174	8
2-3	...	...	31	2	24	3	55	2
0-1	...	...	4	.2	3	.3	7	.2
Totals	217		1,046		524		1,787	

Note: These include all girls who answered at least 60 of the 79 items in the Interest Inventory.

matics courses also enjoy activities associated with characteristically feminine (nurturant) professions such as teaching, nursing, and social work.

Since teaching attracts so many young women, the intention to teach was considered as a possible motivating force in encouraging girls to have a stronger background in mathematics. Actually, 29 percent of the girls who expect to teach in elementary school indicated that it was "very likely" that the mathematics they studied in high school would be useful to them in their future work. However, the relationship between the desire to teach and the decision to take advanced mathematics is very low (.04). On a percentage basis, more girls in Group III were undecided about teaching; yet, 51 percent of them, as compared with 47 percent of the others, expected to teach (Table 13). There is a tendency for girls in Group III to look more favorably upon secondary and college teaching than is true for girls in Group II; however, close to one-fourth of the girls in Groups II and III expect to teach in elementary school. Prospective teachers in Group I were almost unanimous in wanting to teach at the upper educational levels.

What effect does encouragement have on girls' decisions with respect to taking advanced mathematics? The fact that girls seek advice is very evident from the data in Table 14. The fact that encouragement by certain types of people is significantly related to whether or not the girl takes mathematics is evident from the data in

Table 13

Intention to Teach as Expressed by Senior Girls in Study

Intention to Teach	Group I No.	Group I %	Group II No.	Group II %	Group III No.	Group III %	All Respondents No.	All Respondents %
Will probably not teach	116	53%	499	46%	211	39%	826	45%
Will probably teach in elementary school	2	1	245	23	130	24	377	20
Will probably teach in secondary school	96	44	222	21	139	26	457	25
Will probably teach in college	6	3	31	3	11	2	48	3
No response	...	..	79	7	53	10	132	7
Total	220	100%	1,076	100%	544	100%	1,840	100%

Table 9. Generally speaking, encouragement is more effective than most variables in the study, including mother's and father's education.

The percentages in columns A and B of Table 14 are mutually exclusive. For example, column B shows that guidance counselors encouraged 30 percent of the girls in Group III to take advanced mathematics. However, 54 percent of the girls had discussed taking advanced mathematics with their guidance counselors but were not encouraged to take courses. Actually, 84 percent of the girls in Group III had been influenced in some way by guidance counselors. The inference here is that some guidance counselors may be objective, leaving the final decision to the girl; however, others may actually discourage girls from taking advanced mathematics. It is not possible to learn this information from these data.

The overall picture shows that more girls in Group III, as compared with Groups I and II, discussed taking advanced mathematics with guidance counselors, parents, and peer groups but that fewer were encouraged to take the course. These data indicate, too, that mathematics teachers tend to encourage girls to take advanced courses in the subject. The noncommittal attitude of guidance counselors reflected in the response of girls in Group I could be a result of the fact that these girls had already made up their minds to take advanced mathematics and did not consider counselors as having encouraged them to take these courses. Girls also discussed taking advanced mathematics more with their mothers than with their fathers; however, fathers were more apt to encourage them than mothers.

Table 14

The Effect of Selected Personnel on Girls' Decisions to Take or Not to Take Advanced Mathematics in High School

Type	Group I		Group II		Group III	
	A	B	A	B	A	B
Guidance counselor	42%	45%	35%	48%	54%	30%
Member of mathematics department	20	44	14	32	13	21
Mother, stepmother, or guardian	29	43	32	32	48	15
Father, stepfather, or guardian	17	49	24	38	36	19
Brother or sister	16	19	13	14	20	8
Other relative or friend of the family	13	16	10	10	14	5
Classmate, friend, or college student	31	23	32	20	45	10
College staff member	9	6	2	5	4	3

Note: A refers to the percentages of girls within each group who reported discussing taking advanced math with each of the personnel listed but received no encouragement to do so.

B refers to the percentages of girls within each group who were encouraged by the personnel listed to take advanced mathematics.

Only three of the seven characteristics selected for evaluating teachers of third-year mathematics show a group differentiation that is significant at the .001 level. These involve the teachers' success in making mathematics interesting, ability to emphasize both abstract and practical aspects of mathematics, and personality and range of interests, in that order. However, the correlations (Kelley's epsilon values) between these variables and the criterion are low -- .14, .09, and .08, respectively.

The distributions of these ratings by group and for all girls in the sample appear in Table 15. Some group differences are striking. For example, only about one-third of the girls in Group III rate their mathematics teachers as "relatively high" or "very high" on success in making mathematics interesting and on concern with emphasizing both the abstract and the practical aspects of mathematics, as compared with well over half of the girls in Groups I and II. In Group III, highest teacher ratings are given on knowledge of subject matter and accessibility for extra help.

The low F value for father's occupation may be attributable to the classification scheme used. It is a dichotomy in which managerial, professional, and technical jobs constitute the first category; and all other type jobs fall into the second category. More than three girls in five in the total group have fathers whose occupations fit the first category. Yet, about the same percentage of girls have fathers who did not complete four years of college. A better classification scheme may have been to contrast "some college or technical school"versus"no college or technical school."

Table 15

Percentage Distributions of Senior Girls' Ratings of Teachers Who Taught Third-Year Mathematics

Characteristic	Group	Well Below Average	Somewhat Below Average	Average	Relatively High	Very High
Ability to explain subject matter especially when it was difficult	I	3.6%	10.5%	25.0%	33.2%	27.7%
	II	2.8	10.5	28.6	34.2	23.9
	III	4.6	12.2	30.8	32.4	20.1
	Total	3.4	11.0	28.8	33.6	23.2
Accessibility whenever students needed extra help	I	1.8	10.5	24.1	27.3	36.4
	II	1.5	6.1	23.6	31.3	37.5
	III	1.5	9.0	21.4	32.8	35.4
	Total	1.5	7.5	23.0	31.3	36.7
Success in making mathematics an interesting subject to study	I	7.3	17.3	26.4	22.3	26.8
	II	6.1	17.8	33.6	25.4	17.2
	III	10.5	19.5	40.9	19.7	9.4
	Total	7.6	18.2	34.8	23.3	16.0
Concern with emphasizing both the abstract and the practical aspects of mathematics	I	5.9	14.1	36.8	26.4	16.8
	II	3.6	12.4	40.1	27.7	16.2
	III	5.5	17.3	41.5	24.2	11.4
	Total	4.5	14.0	40.2	26.5	14.9
Knowledge of subject matter	I	0.0	0.9	15.0	28.2	55.9
	II	0.2	1.2	12.4	33.0	53.3
	III	.7	1.7	15.1	33.1	49.4
	Total	.3	1.3	13.5	32.5	52.4
Control of class	I	5.5	6.4	27.3	27.3	33.6
	II	4.4	8.1	23.5	30.4	33.6
	III	7.0	6.8	28.0	28.2	30.0
	Total	5.3	7.5	25.3	29.4	32.6
Personality and range of interests	I	7.3	6.4	25.1	28.8	32.4
	II	4.2	9.7	29.2	26.7	30.2
	III	6.8	11.2	34.1	24.1	23.8
	Total	5.3	9.7	30.2	26.2	28.6

III. REASONS WHY GIRLS TAKE OR DO NOT TAKE ADVANCED MATHEMATICS COURSES IN HIGH SCHOOL

Why girls take or do not take advanced mathematics in high school was asked in a free-response question phrased in a manner that permitted each girl to give more than one reason if several had influenced her decision. Mathematics chairmen were also asked to give what they felt were the two main reasons why girls did not take advanced mathematics. The results were carefully read for meaning, content-coded, and reviewed by two independent readers. Discrepancies were resolved in consultation with the project director.

Only those reasons reported by at least one percent of the girls are included in Tables 16 and 17. As a result, 14 reasons were identified as influencing girls to take advanced mathematics, and 11 reasons as influencing them to drop mathematics after three years even though their grades had been good. All reasons given by mathematics supervisors as to why girls do not take advanced mathematics are listed in Table 18.

Liking mathematics and finding it interesting topped all reasons given by girls for taking advanced mathematics. In fact, it was given by 45 percent of the total group and 61 percent of the girls planning to major in engineering, mathematics, or physical science. This same reason was given almost as frequently by girls in Group I as was the reason that advanced mathematics was necessary for future vocations. More than half of these girls had given several reasons, and liking mathematics was frequently mentioned in combination with previous success in mathematics, personal satisfaction, and appreciation of the logic of mathematics.

In comparing reasons given by girls in Groups I and II, we find that the two most popular reasons accounted for 73 percent of the frequencies in Group I but only 44 percent in Group II. In Group II, girls seem more conscious of the basic educational value of mathematics in making their decisions, mentioning the need for such courses to fulfill college requirements and to maintain basic mathematical skills to a much greater extent than the girls in Group I. About the same percentages of girls in both groups took advanced mathematics because they had always done well in mathematics and because mathematics provided a challenge and personal satisfaction to them. One girl in twelve took advanced mathematics because she had been encouraged to do so.

Girls who had not taken advanced mathematics were less inclined to give reasons for this decision than girls who had taken such courses. This was true, even though the statement of the purpose of the study emphasized the need to "learn more about the conditions that both motivate and dissuade girls from taking advanced mathematics courses in high school." Moreover, girls who responded to this question often gave several reasons. (A maximum of three reasons per questionnaire was coded.)

Table 16

Reasons Why Girls Took Advanced Mathematics Courses
(As Reported by Senior Girls Who Took Advanced Mathematics Courses)

Reason	Total		Group I		Group II	
	No.	% of Girls	No.	% of Girls	No.	% of Girls
Always liked mathematics; found it interesting	593	45%	134	61%	459	43%
Course was related to or needed for intended major field or future work	448	34	154	70	294	27
Always did well in mathematics	252	19	44	20	208	19
Advanced mathematics has basic educational value	151	11	6	3	145	13
Needed the course to meet college requirements (includes taking it now rather than in college)	114	9	5	2	109	10
Provides a challenge and personal satisfaction	102	8	17	8	85	8
Was encouraged to take it	102	8	7	3	95	9
Did not want to lose mathematical skills	82	6	3	1	79	7
It is part of the high school program	61	5	4	2	57	5
It is a useful subject	61	5	6	3	55	5
Preferred advanced mathematics to other electives	56	4	2	1	54	5
Mathematics teachers and courses are good in this high school	34	3	8	4	26	2
Took it for extra credits	33	3	3	1	30	3
Took it but had no real interest in it	17	1	1	0.5	16	1
Other reasons[1]	18	1	1	0.5	17	2
No reason given	87	7	8	4	79	7

[1] Includes such reasons as: my friends were taking the course; I could not learn it without a teacher; it was my last chance to take mathematics.

Note: Girls in Group I were expecting to major in engineering, mathematics, or physical science; those in Group II were interested in other subject areas.

Heading the list of reasons for dropping mathematics after three years is the same complaint of not particularly liking the subject (Table 17). These 141 girls often combined this reason with statements about feeling incapable of handling advanced mathematics, of seeing no need to take more mathematics, and of considering other subjects to be more practical, beneficial, and interesting.

In view of the way in which these girls had been selected for this study, it is disturbing that so many of them (20 percent) had felt incapable of taking advanced courses in mathematics. Whether or not these 109 girls actually had less mathematical ability was investigated by comparing their self-reported mathematical scores with those of girls who had not given this as a major reason for pursuing advanced work in the field.

Mean scores on the Scholastic Aptitude Test indicate that the girls in Group III (those who dropped mathematics after three years) scored lower on the mathematical section of this Test than did the girls in both Groups I and II. A further breakdown of Group III girls into (a) those who felt incapable of handling advanced mathematics and (b) those who did not feel this way, shows mean scores on the mathematical section not too different: for (a) the mean was 527; for (b) the mean was 537. Both groups, however, are well above average when compared with national samples of students, and especially when compared with national samples of girls (College Entrance Examination Board, 1970). (SAT scores were reported by 92 percent of Group I girls, 90 percent of Group II girls, and 85 percent of Group III girls. Their respective means on the mathematical section were 619, 574, and 535, respectively.)

Table 17

Reasons Why Girls Did Not Take Advanced Mathematics Courses
(As Reported by Senior Girls With Good Grades in Mathematics
Who Dropped Mathematics After Three Years)

Reason	No. of Girls	Percent of Girls
Did not particularly like mathematics	141	26%
Felt incapable of handling advanced mathematics	109	20
Did not need any more mathematics	94	17
Had already met mathematics requirement for college admission	83	15
Felt other subjects would be more beneficial	78	14
Could not fit advanced mathematics into schedule	76	14
Did not want a heavy load	71	13
Felt other subjects would be more interesting	53	10
Could find no practical use for taking more mathematics	34	6
Had bad experiences with previous mathematics courses and/or teachers	18	3
Felt that taking advanced mathematics might lower high school average	14	3
Other reasons[1]	21	4
No reason given	102	19

[1] Includes such reasons as: discouraged from taking mathematics, did not like the advanced mathematics offerings, senior mathematics course rumored to be poor; class too competitive; had not anticipated going to college.

Interestingly enough, finding mathematics too difficult also ranks high on the list of reasons given by girls for not taking advanced mathematics, as reported by mathematics departmental chairmen. Table 18 shows that this reason is second only to the fact that mathematics was not needed for their future career. Yet, only four supervisors indicated that girls felt they lacked the ability and background for advanced work in the field.

While many of the same reasons appear in Tables 17 and 18, some interesting similarities and differences are evident. Primary reasons given by both groups include not needing more mathematics and problems in scheduling. In contrast, the chairmen did not feel that liking mathematics and being interested in it were as important to girls for continuing on in the area as did the girls. Some of this difference could have arisen from the girls' reluctance to tell mathematics teachers that this was their real reason for dropping the subject. In their unsigned questionnaires, girls were quite frank in stating that subjects other than mathematics were more interesting and beneficial.

Implications of Results

When James Conant conducted his first national investigation of secondary schools (Conant, 1959), he lamented the paucity of courses in advanced mathematics and science and the few girls enrolled in the existing courses. Since then, the situation has improved primarily as a result of federal activity and national concern for training in technological

Table 18

Reasons Why Girls Do Not Take Advanced Mathematics Courses
(As Reported by 63 Mathematics Department Heads[1])

Reason	No. of Dept. Heads	Percent of Dept. Heads
Did not need mathematics for future career	24	38%
Found mathematics too difficult	15	24
Preferred other electives	14	22
Could not fit mathematics into schedule	12	19
Was not interested in mathematics; didn't like mathematics	11	17
Did not need any more mathematics for college	11	17
Did not want to lower grade-point average	9	14
Did not want a heavy load	6	10
Felt it was not a good field for women	6	10
Lacked ability and background for advanced work	4	6
Did not see a need for taking mathematics	4	6
Feared mathematics	3	5
Greater emphasis was put on other courses in high school	2	3
High school had a wide selection of electives to choose from	2	3
Mathematics teachers were poor in earlier grades	1	2
Felt mathematics lacked glamour	1	2

[1] Each department head was asked for the two reasons given most frequently by girls for not taking advanced mathematics courses.

areas. A more recent impetus is the "equal rights for women" movement, based on the conviction that there should be no sex discrimination in employment. It is significant that only three girls among the more than 500 who had not taken advanced mathematics indicated concern for the lack of job opportunities for women in scientific areas. In fact, 47 percent of those who studied advanced mathematics did not expect to teach, which suggests that they had plans for using their mathematics in other areas.

Since the statistics on working women indicate that most women will work at some time during their lives, it is the responsibility of schools to prepare them for something that is both useful to the economy and society and rewarding to them. Therefore, school personnel should keep informed of potentialities of careers in all areas, emphasizing the implications of training in mathematics as a means for developing marketable skills. For, as this study demonstrates, girls are much concerned with practicality of what they have studied.

Schools must attempt to eliminate stereotyped ideas and prejudices about mathematics; that it is difficult, that it is unfeminine, and that mathematicians are generally strange. The concept that girls cannot succeed in mathematics still persists. While it is generally true that boys perform better in mathematics than girls, this is confounded by the fact that boys study more mathematics than girls.

In conclusion, schools must build motivational factors into the mathematics curriculum. Parents must be made more aware of their impact on girls' education. And girls must be taught to aim higher, thus demanding more of themselves and their future vocations.

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