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THE EFFECTS OF HIGH SCHOOL MATHEMATICS GRADUATION REQUIREMENTS ON THE PARTICIPATION OF FEMALES IN ELECTIVE ADVANCED MATHEMATICS

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THE EFFECTS OF HIGH SCHOOL MATHEMATICS GRADUATION REQUIREMENTS ON THE PARTICIPATION OF FEMALES IN ELECTIVE ADVANCED MATHEMATICS

By

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ABSTRACT

THE EFFECTS OF HIGH SCHOOL MATHEMATICS GRADUATION REQUIREMENTS ON THE PARTICIPATION OF FEMALES IN ELECTIVE ADVANCED MATHEMATICS

By

Tony McLain

The purpose of this study was to see what effect high school mathematics graduation requirements have on female enrollment patterns in high school elective advanced mathematics classes.

Of particular concern was the proportion of the female student body that enrolled in eleventh and twelfth grade elective advanced mathematics classes. Also of concern was the female-to-male ratio of students in those elective advanced mathematics classes.

From the responses of seventy-two western Michigan school districts, comparisons were made in the above two areas between schools requiring one year of mathematics for graduation and schools requiring two years of mathematics.

The results demonstrated that schools that require two years of mathematics have a significantly higher proportion of their eleventh and twelfth grade females enrolled in elective advanced mathematics when compared to schools that require only one year of mathematics.

The results also demonstrated that schools that require two years of mathematics have a significantly higher ratio of female-to-male students enrolled in elective advanced mathematics classes when compared to schools that only require one year of mathematics.

In a secondary phase of the study, 316 algebra students in nine schools were assessed regarding their feelings of dread, nervousness

and associated bodily symptoms related to doing mathematics. It was found that ninth grade female algebra students in schools that require three years of mathematics have a significantly higher level of anxiety toward mathematics than ninth grade female algebra students in schools that require only one year of mathematics.

To Michelle and Adelle,

the reasons for my interest.

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CHAPTER ONE

INTRODUCTION

Purpose of the Study

This study was carried out to determine if high school mathematics graduation requirements have an effect on female enrollments in high school elective advanced mathematics courses. A secondary aspect also studied was the effect of increased mathematics graduation requirements on female anxiety toward mathematics.

Background

Throughout the past two decades considerable attention has been given by educators and non-educators alike to the performance and preparation of American students in mathematics. As this interest continues to reach its zenith, a variety of institutions are calling for an increased amount of high school mathematics preparation.

A call for increased student participation in mathematics has been made at the national level by the National Commission on Excellence in Education (Nation at Risk, 1983) and the Carnegie Foundation (Boyer, 1983). At the state level, the Michigan Association of School Principals (Michigan Commission on High Schools, 1983) and the State of Michigan, Board of Education (Better Education for Michigan Citizens, 1984) have also called for increased mathematics requirements.

While attention has concentrated on the low proportion of student enrollment in advanced mathematics in general, a more specific area of concern has developed and become the focus of a number of recent studies. This related concern is the small proportion of females enrolling in elective advanced high school mathematics classes.

In a study of entering freshmen at the University of California at Berkley, Sells (1980) found that 57% of the males had completed four years of mathematics, while only 8% of the females completed four years. This lack of preparation in advanced mathematics left 92% of the females ineligible for 75% of the majors offered at Berkley. More recent studies by Fennema (1981), Armstrong (1981), and Giese (1983) indicate that while the differences in enrollment patterns in mathematics due to sex may not be as drastic as Sells found, there still exists significant sex differences in high school mathematics enrollment patterns, especially in advanced classes.

Jordan (1937), Tyler (1956), and Stanley and Benbow (1980), all suggested that males have higher mathematics ability than females which would ultimately lead to more males in advanced courses.

Other researchers believe that cultural factors account for most of the apparent ability differences based on sex and that lack of participation by females in advanced classes is the most important cultural factor.

Studies by Fennema (1974, 1977, 1981) indicate males and females show no significant differences in mathematics ability well into adolescence. By the time females reach the end of their high school career, however, differences in mathematics achievement are easily recognized. Over the past fifteen years female mean scores on the mathematics portion of the ACT Test have lagged two to three points behind male scores on that test (ACT 1983).

It is felt by many that this achievement difference is based on differing levels of preparation and if high school females enrolled in advanced mathematics classes at the same ratio as males, the significant differences in achievement levels based on sex would disappear entirely.

Welch, Anderson, and Harris (1982), in a study of data from the National Mathematics Assessment, found that the semesters of mathematics classes enrolled in accounted for as much variance in mathematics achievement scores as the total set of background variables including sex and ethnicity. Enrollment in mathematics classes was as important in influencing mathematics achievement scores as was the sum total of background variables.

Jones (1984) found that at age 13 there was no evidence for a male/female sex difference in mathematics achievement among blacks or whites. He found the male/female achievement difference at this age to be less than 1%.

He also found that at age 17, among background variables, the best predictor of achievement score differences was the number of semesters of enrollment in high school algebra and geometry.

Whether sex-related achievement differences would disappear entirely or not, the failure to enroll in advanced mathematics classes becomes a limiting factor for females in both career choice and potential earnings. Sells (1978) and Tobias (1981) noted that advanced mathematics courses become a "critical filter" for career selection, and females failing to enroll in advanced mathematics limit their career choices and future earnings to a greater degree than males.

This problem becomes especially critical when examined in light of other sex-related cultural biases that exist within our society.

Burlin (1976), for example, found that while female high school juniors were aware of a broad range of occupational choices, they did not feel free to pursue them. Donahue and Costar (1977) found that when counselors were asked to pick appropriate occupations for simulated student case studies, they chose lower-paying, more-supervised positions for females.

How to increase the low representation of females in high school advanced mathematics classes has become the concern of a number of educators and authors. Armstrong (1982), Casserly (1980), Haven (1972), Parsons (1979), Sherman (1976), and Stallings (1979) have all examined factors that relate to female decision-making concerning mathematics enrollment.

Sherman and Fennema (1977), in a study of tenth and eleventh grade students, found that a higher proportion of both high and low achieving male students in mathematics classes intend to continue enrollment in mathematics classes. It was also found that while females stated that mathematics was not a male domain, their overt behavior through their enrollment patterns was disproportionate with females enrolling in advanced mathematics classes at a lower rate than males.

Based on studies identifying affective variables that limit female mathematics participation, Fauth (1981) suggested that schools could take an active role in changing sex-differentiated enrollment patterns by providing role models, remedial mathematics programs, career education, and parent support groups. Two separate intervention programs by Fennema (1981) and the Torrence Unified School District (Motivating, 1979) indicate that Fauth's suggestions are accurate and schools can increase the proportion of females enrolled in advanced mathematics classes.

While schools can have an impact on enrollment patterns, the programs proven effective by researchers are time consuming and require a strong commitment in personnel and funds, thus negating the likelihood that they will be implemented universally.

A more efficient method suggested by Farley (1968) and Fox (1977, 1981) would be to simply require four years of mathematics for all students. Farley believes that schools, by requiring less mathematics than English, reflect the idea that mathematical competence is not necessary for everyone. She further suggested that if four years of mathematics were required, more females would choose to enroll in advanced levels of mathematics even though a variety of lower level courses were available to them to complete their requirement. While Fox shared the same opinion, she noted that no research had been completed to test the hypothesis that increasing mathematics requirements would actually change the proportion of females enrolling in advanced mathematics.

Definitions

For the purpose of this study the following definitions are offered for clarification.

Advanced mathematics classes: any of the eleventh and twelfth grade level, college preparatory mathematics classes available to high school students as electives. While titles may vary, these classes include advanced algebra, trigonometry, pre-calculus, calculus, and statistics.

Basic mathematics classes: any of the high school mathematics classes offered that are not considered college preparatory in nature. These include classes that are generally review or applied mathematics classes, such as general mathematics, business mathematics, vocational mathematics, accounting, pre-algebra and non-proof geometry.

Beginning college preparatory mathematics classes: any of the ninth and tenth grade college preparatory mathematics. In a traditional sequence this would include first year algebra and geometry.

Required class: a class that is specifically required of all high school students for graduation.

Elective class: a class that is optional for students to enroll in. While an elective class may fulfill a graduation requirement, (algebra would fulfill a mathematics requirement) the specific class is not required.

Anxiety toward Mathematics: The feeling of dread, nervousness, and associated bodily symptoms related to doing mathematics. Anxiety towards mathematics can be debilitating and prevent one from learning.

Statement of the Problem

The focus of this study is the low representation of females in elective high school advanced mathematics courses and the possibility that high school graduation requirements might be an effective tool to increase female representation in those classes.

This low representation of females in elective advanced mathematics classes is noticed in two separate but related problem areas. The first problem area is the proportion of the female student body that enrolls in elective advanced mathematics. Traditionally, only a small proportion of the female student body has been enrolled in elective advanced mathematics classes at the eleventh and twelfth grade levels.

The second problem area concerns the female-to-male ratio of enrolled students in elective high school advanced mathematics classes. An examination of the female-to-male ratio in elective high school advanced mathematics classes has shown that males traditionally make up a majority of the students in any given elective high school advanced mathematics class. This majority male enrollment in these classes has been a key factor in establishing the concept of mathematics as a male domain. Research has also shown that a low female-to-male ratio in mathematics classes causes some females to elect not to enroll in mathematics (Fox, 1977) and therefore compounding the problem of low female representation in advanced mathematics.

To examine these problem areas, two primary questions were developed:

1. Is there a relationship between high school mathematics graduation requirements and the proportion of the eleventh and twelfth grade female student body enrolled in elective advanced mathematics classes?

2. Is there a relationship between high school mathematics graduation requirements and the ratio of female-to-male students in elective advanced mathematics classes?

In addition to the central focus of the study, a secondary focus was on female student anxiety toward mathematics. Since Perl (1982) found that a positive attitude toward mathematics was the second most important factor, after ability/achievement, in determining whether a student elected to enroll in mathematics, it seemed important to examine the effect of mathematics graduation requirements on female anxiety toward mathematics. A new problem area could develop if increasing mathematics graduation requirements results in a corresponding increase in female anxiety toward mathematics. Therefore, a secondary question arose:

3. Is there a relationship between high school mathematics graduation requirements and female anxiety toward mathematics?

These three questions were derived from research findings which suggest that increasing the number of semesters of high school mathematics required for graduation may, in itself, raise the proportion of the female student body enrolled in elective advanced mathematics classes. In addition, it may change the sex-balance of elective advanced mathematics classes by raising the ratio of females-to-males that comprise those classes.

At first, it might appear that this outcome is obvious since increasing the semesters of required mathematics would certainly increase the number of females enrolling in mathematics classes. What is important to note, however, is that most high schools express their mathematics graduation requirements by the number of semesters of mathematics a student must complete rather than specific advanced mathematics courses. Even in schools requiring three and four years of mathematics, students can avoid taking any advanced mathematics classes.

In a survey of 187 Western Michigan school districts, McLain (1986) found that only 3.6% of the schools require students to take specific mathematics courses for graduation and none require any mathematics beyond basic algebra. Students are free to select from a variety of mathematics classes at both low and high levels of difficulty. While most high schools offer students in their eleventh and twelfth grade the option of advanced mathematics courses such as advanced algebra and trigonometry, they also offer less rigorous courses such as applied or review mathematics as alternatives.

Thus, it is possible that increasing the number of mathematics classes required for graduation may only cause females to enroll in more of the less rigorous courses to meet the increased graduation requirements while males continue or increase their already strong enrollment in the advanced courses. The result may be no significant change in the proportion of the female student body that enrolls in advanced mathematics.

This possibility seems most likely if low female enrollments are due to lower female ability in mathematics as is suggested by Stanley and Benbow (1980). If females are biologically not as capable as males in the area of mathematics, as many previous researchers have believed, then increasing mathematics graduation requirements would tend to increase only male participation in elective advanced classes.

Thus, considerable emphasis was given to a secondary aspect of this study which focused on the effect that increased mathematics graduation requirements might have on female anxiety toward mathematics. Of concern here is the possibility that increasing mathematics graduation requirements for females may cause an increase in female anxiety toward mathematics and cause them to meet the graduation requirement by selecting more low-level courses.

Hypotheses to be Tested

The following four hypotheses were tested as the central focus of the study.

I. At the eleventh grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

II. At the twelfth grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

III. At the eleventh grade level, the ratio of female-to-male students in elective advanced mathematics classes is greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

IV. At the twelfth grade level, the ratio of female-to-male students in elective advanced mathematics classes is greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

The following hypothesis was tested as a secondary aspect of the study.

V. Ninth grade female algebra students enrolled in schools that require three years of mathematics will have greater anxiety toward mathematics than ninth grade female algebra students enrolled in schools that require only one year of mathematics.

Organization of Study

In order to find the effect of differing high school mathematics requirements, high schools had to be identified, then selected, on the basis of their mathematics graduation requirements.

This led to a three-part organization of the study. The first part consisted of a pre-study to determine the high school mathematics requirements in selected high schools in Michigan. The second part was the primary focus of the study and centered on the effect of mathematics graduation requirements on female enrollment in elective advanced mathematics courses. The third part was an analysis of female anxiety toward mathematics in high schools requiring three years of mathematics as compared to that found in schools requiring only one year of mathematics.

Pre-Study

The purpose of the pre-study was to gather information about high school mathematics graduation requirements in Michigan school districts in order to select schools for inclusion in the study.

For reasons of management and cost, the pre-study focused only on public school districts located in counties in the western one-half of the lower peninsula of the State of Michigan (Appendix B). The western one-half of the lower peninsula includes 187 public, K-12 districts.

The Mathematics Requirement Survey (Appendix A), the instrument used in the pre-study, consisted of seven questions regarding the number of semesters of mathematics each district requires for graduation. It also asked for the name, address, and phone number of the person filling out the survey. This identified a contact person in each district.

The Mathematics Requirement Survey was delivered in February, 1985 with 91% of the school districts returning their questionnaires. The results of the pre-study are summarized in Appendix C. Part of that summary is reproduced in Table 1.

Table 1
School Mathematics Requirements

Semesters of Required Mathematics	Number of Schools
8	2
7	0
6	5
5	1
4	96
3	6
2	55
1	5
0	0
Total	170

The original intent was to select a number of school districts with a three year mathematics requirement and compare the female advanced mathematics enrollments in those districts with female advanced mathematics enrollments in schools having a one-year mathematics requirement. What the pre-study revealed, however, was that only five districts required three years of mathematics and all five districts had just implemented the three-year requirement. This meant that none of the current advanced students in the districts were under a three-year mathematics requirement. Only the incoming students were required to take three years of mathematics.

Two districts required four years of mathematics, but one of the districts had also just raised requirements, and the other district had only seventeen students in grades nine through twelve, a population too small to be of any value.

The small number of schools found with a three-year requirement and the fact that the schools had just implemented that requirement left little chance for carrying out the original plan for the study.

Instead, the study was directed toward a comparison of enrollments by females in elective advanced mathematics classes between schools requiring one year of mathematics and schools requiring two years of mathematics. Those few schools that did require three years of mathematics were used in the secondary aspect of the study to compare female anxiety levels toward mathematics between schools requiring one year of mathematics and schools requiring three years of mathematics.

Design of the Study

From the responses of the 170 schools that answered the pre-study questionnaire, 105 schools that met all criteria for the study were identified. Fifty-two of these schools required one year of mathematics while fifty-three required two years of mathematics. This number is smaller than indicated in Table 1, but many of the schools listed in the Table 1 had also just raised their requirements and could not provide the information desired. Five schools that required one year of mathematics were selected out for use in the secondary phase of the study leaving a population of forty-seven schools that required one year and fifty-three that required two years of mathematics.

These one hundred school districts were asked to provide the number of male and female students enrolled in their elective advanced mathematics classes during the eleventh and twelfth grades.

Each of the one hundred school districts were sent a copy of the College Preparatory Mathematics Enrollment Survey (Appendix D) requesting information on male and female enrollments in elective advanced mathematics classes in the eleventh and twelfth grades. Seventy-three percent of the surveys were returned.

To examine the secondary aspect of female anxiety toward mathematics, a total of 316 ninth grade algebra students in nine schools were surveyed. Five of the schools required three years of mathematics and four of the schools required one year of mathematics. While five schools that require one year of mathematics agreed to be in this phase of the study, one school dropped out of the study leaving only four schools. Students were administered the Fennema-Sherman Scale (1976, Appendix E), on anxiety toward mathematics. Female mean anxiety scores in schools that require three years of mathematics were compared to female mean anxiety scores in schools that require only one year of mathematics.

Limitations and Delimitations of the Study

This study included only public school districts in Western Michigan. While there is no indication that these public school districts are unique in relationship to other school districts, care should be taken in generalizing results from this study.

This study was specifically delimited to consider only high school graduation requirements and high school enrollments in mathematics.

The secondary aspect of the study regarding female anxiety toward mathematics was limited by the truthfulness with which each subject completed the questionnaires.

Another limitation in the secondary aspect of the study on female anxiety was the fact that the questionnaires were administered by different persons in each school and may have been administered in a somewhat different manner. In addition, all districts were small rural schools and may not be representative of the total population of school districts.

Summary

An overview of the study was presented in this chapter. A review of the literature will be found in chapter two. The methodology used is described in chapter three. Chapter four includes an analysis of the data; and in chapter five, the conclusions and recommendations are listed.

CHAPTER TWO

A REVIEW OF THE LITERATURE

Theory of Vocational Choice

Over the past thirty-five years, theorists have attempted to explain the process of individual career development by establishing and researching theories of career development and choice. These theories are systematic attempts to explain the complex process by which an individual selects and enters an occupational field.

As could be expected in any area dealing with the complex human animal, no theory has yet come forth which fully explains all the possibilities of career development or that has highly reliable predictive abilities for any given individual.

Despite the limitations of current theory, many counselors and sociologists use career theories in an attempt to explain and control individual vocational choice. The theory serves as a way of organizing and systematizing what is currently known about the process of career development.

While there is a diversity of theories to explain vocational choice, an examination of major theories finds areas of similarity and general agreement. Two such areas are important as background for this research project.

Career Development as a Developmental Process

One of the most important areas of agreement among theories is that the career process is a developmental process. Ginzburg (1972) theorized that each individual passed through three distinct phases, fantasy choice, tentative choice, and realistic choice, in their career development. According to Ginzburg the process of decision-making extends from pre-adolescence until the mid-twenties and while the process is not irreversible each career related decision influences later decisions.

Super (1953) also believed that the career development process was made up of a series of stages through which an individual progressed. While decisions made in each of these stages, growth, exploration, establishment, and decline, were not irreversible, he felt that childhood and adolescent identifications played a part in shaping future vocational interests. He also believed that development through these life stages can be guided by the provision of adequate opportunities for one to develop and use their aptitudes.

In a later revision of his theory, Super (1980) suggested that decision points in a life career are affected by personal and situational determinants which consist of genetic factors modified by individual experiences.

Krumboltz (1976) felt that career selection was a lifelong process that is shaped by events and decisions that occur from infancy to retirement. He also believed that an individual was more likely to enter an occupation if the individual has been exposed to learning and employment opportunities in that field. He further believed that an individual would be more likely to enter an occupation if the individual's learned skills matched those required by that occupation.

The concept of career development as a process in which decisions and experiences in early stages affect decisions and outcomes of future stages seems to be fairly universal among theorists. While only three theories were examined here, a look at the writings of Roe

(1972), Holland (1959), and Hoppock (1976) reveals a consistent realization that early developmental experiences and learning affect later vocational outcomes. According to current theory then, providing an individual with opportunity to experience classes or simulations in a career area increases the probability that an individual will gain interest and enter that field.

Singleness of Vocational Choice

Another area in which there seems to be considerable agreement is a movement away from the concept that every individual has a perfect or ideal job waiting to be discovered. Instead most theorists agree that individuals can often fit into a number of occupations or fields. In Super's (1953) ten propositions, the first two propositions stated that people differed in abilities, interests, and personalities and are qualified for many occupations.

Roe (1972) stated that there is no one occupational slot that is perfect for any individual, nor is there any individual that is perfect for a given occupational slot. Instead each person can fit a variety of occupations and each occupation can hold a range of people. Holland (1959) felt that individuals were guided by stereotypes of occupations and their preferences for occupations were associated with their individual self-concepts.

It would seem that there are a number of occupations or fields in which each person has the potential for success and happiness and that individual experiences and opportunities would be very influential in directing a person toward a single vocational field. It would also seem that an individual is open to intervention by guidance counselors and significant others in the career development process especially if they can provide varied experiences and opportunities. These two theoretical concepts combined with current research and data lead to the conclusion that an individual's early pre-vocational and educational choices become important factors in the eventual occupational choice.

In a study of college-bound, high school seniors, Noeth (1984) found the classroom experience has a significant impact on the career development of high school students and that impact is greater among females than males. An enjoyable and successful classroom experience was labeled by females as the most helpful factor in their career decision-making.

Since early pre-vocational and educational decisions can have such a significant effect on the eventual occupational choice of young people, it is easy to understand the concern that currently exists among many groups about the educational preparation and experiences of adolescents in today's high school.

CALLS FOR INCREASED PARTICIPATION IN ADVANCED MATHEMATICS STUDY

No single area of education seems to be under as much professional, public, and media attention as mathematics is at this time. Studies such as the "Second Study of Mathematics" ("Math: Adding up the Score," 1984) indicate that the majority of United States juniors and seniors perform at or below the 25th percentile when compared to students of other nations. This data has caused considerable alarm among politicians, educators, and the general public.

A historical review of student performance in mathematics also indicates a need for concern. From 1963 to 1980 the average SAT mathematics score fell nearly 40 points while remedial mathematics courses increased by 72% (A Nation at Risk, 1983).

With data such as this, it's not surprising to find a number of calls for solutions to the perceived problem. The "National Commission on Excellence in Education", recommended that every student be required to complete three years of mathematics, including an understanding of algebra, geometry, probabilities, and statistics, in order to graduate (A Nation at Risk, 1983). In, "High School: A report of Secondary Education in America," (Boyer 1983) the recommendation is made for all students to complete a minimum of two years of mathematics in order to graduate from high school.

When one examines the data from the "16th Annual Gallup Poll of the Publics attitudes toward the Public Schools" (Gallup 1984), one finds a strong public response favoring required mathematics in high school. When asked about high school mathematics, 96% of the public felt mathematics should be required for all students going to college while 92% felt it should be required of all students in the public schools. Support for required mathematics classes was stronger among the general public than it was for any other subject area.

In the State of Michigan the historical trend of declining mathematics scores is similar to that of the nation as a whole. Student mathematics scores on the A.C.T., the most commonly used college entrance test in Michigan, show a continued decline from 1968 to 1983. The male mean score dropped from 20.5 in 1968 to 19.2 in 1983, while the female mean score during the same period fell from

18.3 to 16.6 (Mulligan, 1979 and ACT, 1983).

The Michigan Commission on High Schools (The Michigan Commission on High Schools, 1984) noted that 43% of Michigan Students take one year of high school mathematics, 41% take two years of high school mathematics and only 3% take more than two years of math. This commission recommended to the Michigan State Board of Education that two years of mathematics, including algebra, be required for all students for high school graduation and three years of math, including algebra, advanced algebra, geometry, and trigonometry, be required for college preparatory students.

The Michigan State Board of Education adopted a similar stance in their report "Better Education for Michigan Citizens" (1984) by recommending two years of high school math, including algebra, for all high school students and three years of math, including algebra, advanced algebra, geometry, and trigonometry, for college preparatory students.

In a poll of Michigan citizens (Opinions of Michigan Citizens, 1983), 92% of those polled supported three years of mathematics requirements for all high school graduates and 75% favored having the State Department of Education mandate those graduation requirements.

The overall pattern that emerges is a focus by educators and the general public alike on terminal mathematics skills among high school students and a desire to increase the levels of terminal mathematics skills among those students.

Mathematics Performance by Sex

Prior to the increased national attention to student mathematics performance, another area gained the attention of educators and researchers. That area was the continued difference in performance levels in mathematics between males and females.

During the fifteen year period from 1968 to 1983, the average male mathematics score on the A.C.T. test was 20.5 while the average female score on the same test was only 17.7 (Mulligan 1979, A.C.T., 1983).

Stanley and Benbow (1980) in reviewing the data from the study of mathematically precocious youth found that male S.A.T. mathematics scores were higher than females. Reviewing the years from 1972 to 1979 they found that males outperformed females every year and the smallest mean difference was a full 32 points in favor of the males. It was this study that caused some media to carry articles about a math gene suggesting biological superiority of males in mathematics ability.

When Fennema (1981) examined the data from the National Assessment of Educational Progress, she found that at age seventeen, males exceeded females in every area of mathematics performance.

Armstrong (1981) using the data from two national surveys, the 1977-78 mathematics assessment of the National Assessment of Educational Progress and the Women in Mathematics Project of the Education Commission of the States, found that at grade twelve males surpassed females in all areas of mathematics tested.

The case for male superiority in high school mathematics achievement and performance is so overwhelming that Badger (1981) in a review of the research concluded that "in any random sample of high school males and females, beyond tenth grade, the males will show higher performance in mathematics."

Mathematics Participation by Sex

While almost all researchers agree that males in late high school have higher mathematics performance than females, there is another trend that has been noticed by researchers that is almost as universal. Males participate in advanced mathematics classes in higher proportions than females. Since males and females are distributed almost equally in public schools this means that most advanced level mathematics classes in public schools will have a majority of male students.

The study that has perhaps received the most attention in this area was a study by Sells (1980) of incoming freshman at the University of California at Berkley. She found that 57% of the incoming male freshman had completed 3.5 years or more of mathematics the minimum needed for entrance into calculus. Among females, however, only 8% of the incoming freshmen had completed 3.5 years or more of mathematics.

Numerous other studies have been completed and while all do not show the drastic differences Sells found, they all point to a consistent pattern that females participate in advanced mathematics in lower numbers than males.

When examining nationwide data, Armstrong (1981) found that in high school trigonometry classes the male students made up 55% of the class enrollment and in pre-calculus male enrollments jumped to 60% of the classroom total.

In a study of enrollment patterns for students in the State of

Wisconsin, Fennema (1977) found that while enrollment ratios in basic algebra were equal between males and females there emerged a continuous drop in the proportion of females enrolled as the difficulty of the class level increased. By the time students reached advanced algebra, males accounted for 54% of the students. At the level of trigonometry 59% of the students were males and in probability/statistics 66% of the students were males. By the time students enrolled in high school calculus or computer mathematics a full 70% of the students were males with only 30% females.

When using the data from the National Assessment of Educational Progress, Fennema and Carpenter (1981) found that one third more males than females enroll in trigonometry, pre-calculus, and calculus.

In a study of 113 Michigan School Districts, Giese, (1982) found that in trigonometry the proportion of males to females was 56% to 44% and in calculus the proportion of males increased to 63%. Giese also noted that enrollments in beginning algebra were equal among males and females.

Occupational Implications of Mathematics Study for Females

The occupational and economic implications of mathematics study for all students are extensive. For females, however, the implications are even greater since the levels of career achievement and earnings of males and females in our society is grossly unequal.

In 1970, the median weekly earnings of full-time employed males was $151 while females in that category earned $94 (Statistical Abstract 1984). This meant that a full-time employed female earned only 62% of the income of a full-time employed male. By 1982 these figures had changed to $371 in weekly earnings for the male and $241 in weekly earnings for the female. Despite a small improvement, females still had only 65% of the income of a male (Statistical Abstract, 1984).

For females with college degrees the difference is even greater. The estimated lifetime income of a male with a college degree is $671,000 while a females projected lifetime income is only $314,000 (Statistical Abstract, 1984). This projection indicates a female college graduate will earn, in a lifetime, only 47% of what her male counterpart earns.

These major income differences between males and females are due in part to sexual differentiation in career patterns.

Females tend to cluster into a small number of lower paying career fields and do not enter a variety of higher paying career areas. 1981 figures for scientists and engineers show females representing only 2.3% of the total number of engineers in the United States. They also make up only 2.4% of the physical scientists, 22% of the mathematical scientists, and 27% of the computer specialists (Statistical Abstract, 1984).

In the area of business, females make up only 28% of the managers and administrators and in the technical area they comprise only 18% of the science and engineering technicians (Statistical Abstract, 1984).

Instead, 1/3 of all women are clustered into seven occupations: health care workers, clerical, domestic, bookkeepers, elementary teachers, waitress' and retail clerks (Statistical Abstract, 1984). These and other jobs with a majority of female workers tend to be career positions with earnings on the lowest end of the career spectrum with only limited access to advancement.

The major differentiation in career patterns by sex that emerges in our nation is strongly biased, from an economic sense, against the female.

One area of interest that has been noticed in this occupational differentiation is the role mathematics plays in the process. A high percentage of the higher paying career fields require a strong mathematics background. The economic and advancement potential of mathematics skills is a major factor that has put the participation by students in mathematics classes under such close scrutiny.

Sells (1973) referred to high school mathematics participation as the "math filter." When her study of entering freshmen at Berkley revealed that 57% of the males had complete 3.5 years of math while only 18% of the females had completed the same level of mathematics preparation, she noted that it effectively rendered 92% of the females ineligible for three-quarters of the major fields offered at Berkley.

When noting the small number of females in a series of high paying professions, Wise (1978) stated that the lack of sufficient mathematics education was one of the most significant early barriers to women's pursuit of professions.

In a study of college females, Rossi (1965) found that the second highest perceived reason for the low representation of women in engineering was that the job required skills and characteristics that women didn't have. She also found that of the four factors characteristics of a research scientist, the most important characteristic was high test scores of spatial and mathematics ability.

In a study of women seeking a PhD. in political science, Barbara Merril (1976) found that the presence or absence of mathematics or statistics was major factor in whether or not a female would chose that program with females electing not to choose a program that required mathematics.

When examining vocational outcome, MacDonald (1979) found that while 15% of the men with bachelor's degrees were working in a math-related field only 1% of the females with bachelor's degrees had a math related career. With vocational outcomes and earnings so unequal, its not surprising that many advocates of equal opportunity are attempting to change female attitudes and participation in mathematics.

If the career theorists are correct in that early career related decisions effect later career related decisions and outcomes, then keeping females in mathematics classes becomes an important early career decision that may effect later career outcomes.

If the theorists are also correct in that there is no perfect career position for an individual and that each position can hold a range of individuals, then many females who are now selecting into low paying career fields could be selecting into higher paying career fields with potential for more advancement.

Training becomes the major factor in determining if a female goes into a low paying or high paying field and early decisions concerning high school mathematics open or close doors to many training programs.

Mathematics Learning: Factors of Relevance

While there seems to be little dispute about male superiority in mathematics performance and higher levels of male participation in advanced mathematics, there are differences of opinion and theory as to why this phenomenon exists.

Fox (1977) identifies three major hypothesis that are offered as explanation for sex differences in mathematics achievement.

The first of these is the masculine identification hypothesis which suggests that boys and girls who identify with their father or a generalized masculine sex role are better at mathematics than those boys and girls who identify with their mother or a generalized feminine sex role. This hypothesis suggests that psychological masculinity is required for excellence in mathematics.

The second hypothesis has often been referred to in the general media in terms of a "math gene." This hypothesis suggests that heredity is the major factor in differences between males and females in mathematics performance and that there is a genetic sex-linked factor which gives males superior ability.

A third hypothesis is that current socialization practices result in mathematics being sex-typed as a male domain and gives rise to differential mathematics achievement expectations for males and females.

The first hypothesis that psychological masculinity is required for excellence in mathematics has mixed support in the research base and will only be mentioned incidentally in this research.

The second hypothesis, that males are biologically superior in mathematics learning will be addressed, however, and the third hypothesis that the differences between sexes in mathematics performance is due to the socialization practices of our culture is the hypothesis that gives rise to this research and will therefore be discussed extensively.

Biological Bases for Sex Differences in Mathematics

The idea that males have a biological edge in the field of mathematics has been in educational circles for a long time. In an extensive review of biological factors related to sex differences in mathematics, Sherman (1977) notes that in 1873, Clark hypothesized that women were intellectually inferior to men because the womb draws energy away from the brain. A more common belief in the early 1900's mentioned by Sherman was that women were intellectually inferior because their brains were smaller than men.

A similar concept in the specific area of mathematics ability probably began among educators as they observed the superior performance level of males in mathematics.

Early in this century, Jordon (1937), in an article "Sex Differences in Mental Traits" expressed the opinion that the superiority of boys in mathematics had its basis in genetics. While little extensive research was performed, the theory rested on mathematics performance tests given to random samples of males and females.

During the next twenty years, few alternative hypothesis were put forth and Tyler's (1956) summation that "in mathematical ability male superiority is the rule" brought little negative response from the academic community. Male superiority in mathematics became a firmly entrenched concept in education. As Ernest (1976) found in a survey of teachers, almost half expected the boys to do better than the girls in mathematics and none expected the girls to do better than the boys in mathematics.

Three major areas are hypothesized as the biological cause for superior male ability in mathematics. The first is a recessive gene on the X chromosome, which would make high mathematics ability a recessive trait among females. The other two hypotheses are hormonal differences and rate of maturation differences between males and females.

In the past two decades considerable research has taken place in the area of sex-related differences in mathematics ability and performance. While some of the research tends to confirm the idea of male biological superiority in mathematics, much of the research suggests biological differences probably do not exist and if they do, they have minimal effect on the differences in performance.

The hypothesis that sex-differences in mathematics performance is due to inherited biological factors in mathematics ability is currently receiving a lot of response from the academic community. In a critical review of the sex-linked major gene hypothesis, Vandenberg and Kuse (1979) conclude that only further research can sort out the complex inter-weaving of environmental and genetic factors in sex-differences in spatial ability, an underlying concept of mathematical ability.

When Stanley and Benbow (1980) examined the data from a study of mathematically precocious youth, however, they found evidence to support the hypothesis of male superiority in ability as well as performance. The data generated by this study over a six year period found that in mathematically precocious seventh and eighth graders there existed large sex differences in ability in favor of the boys in every year of the study. Since girls and boys have had essentially the same educational background until the eighth grade, Stanley and Benbow conclude that only biological factors can account for the male superiority.

In an extensive examination of all major theories based on biological factors, Sherman (1977) came to a differing conclusion. While she noted the extent and kind of biological factors involved in creating sex differences in mathematics performance is still a matter of scientific controversy, the measured differences between the sexes in intellectual functioning and mathematics ability is minor and couldn't possibly account for the great differences in male and female participation in mathematics classes and mathematical related fields. Even if the X chromosome hypothesis was true and superior mathematics ability was a recessive trait among females, the end result would be three males with superior ability for every female with superior ability. Simply put, female representation in mathematics related careers would be higher than it is now if there was only a genetic factor involved.

Even Stafford (1972) who concludes that there is an underlying hereditary component for proficiency in quantitative reasoning suggests that we cannot discount the very important interaction effects of environmental factors such as home, school, teachers, and attitudes.

Since this research project does not depend on proving or disapproving a biological base for sex-differences in mathematical ability, no conclusion on this matter will be drawn. For the purposes of this research one only needs to conclude that while there may be biological differences in mathematics ability between males and females, social conditioning and environmental factors play an important part in creating sex-related differences in mathematics performance.

Social Bases for Sex Differences in Mathematics

The sex of the student has been considered a factor in educational research dating back to the nineteenth century. When comparisons were made between males and females in most academic areas, males had higher academic performances. As was noted in the section on biological bases, most early researchers assumed that males were genetically superior in intellectual functioning.

As our society changed and females became more active in the process of higher learning, many of the early differences in performance all but disappeared. This led a new generation of researchers to examine social and cultural factors as possible sources for the sex differences that still existed.

In their landmark book, The Psychology of Sex Differences, MacCoby and Jacklin (1974) in reference to spatial ability differences, an underlying concept of mathematics learning, state what many other researchers have concluded about the possibility of genetic factors controlling math ability: "To say there is genetic component--does not imply that this ability is something like male genitals, that men have and women do not."

MacCoby and Jacklin concluded that there was probably some degree of sex-linked control over spatial ability and quantitative ability but they also noted many other factors that influence intellectual functioning in all academic areas; factors that are assimilated differently in males and females.

Self-esteem

In a review of the research of the relationship between self-concept and academic achievement, Leviton (1975) found that there was a consistent, moderate correlation between a student's self-esteem and their academic achievement. While intelligence is the most important variable for predicting high mathematics performance, a high self-esteem also appears to be of major importance.

When Primavera, Simon, and Primevera (1974) studied the sex differences that appear in the relationship between self-esteem and academic achievement, they found some drastic sex differences. While high self-esteem was related to academic achievement in the total group of fifth and sixth graders they studied, it was a more important factor among girls than boys. In girls, self-esteem was related to achievement without exception, whereas self-esteem was related to achievement in only one boy in seven. It would seem that girls are more susceptible than boys to cultural influences that make up self-esteem.

Learned Helplessness

The concept of learned helplessness suggests that individuals in a failure or poor performance situation will improve or fail to improve their performance depending on their perception of the reason for the failure. If the poor performance is attributed to uncontrollable variables such as lack of ability, task difficulty, or fixed attitudes of other people, then the individual is unlikely to improve performance or persist in a task since repeating the task would produce the same results. On the other hand if an individual attributes the failure to variable factors such as luck or effort, the individual is more likely to persist and improve performance, since they believe that repeating the task with a little more luck or increased effort would produce a more successful performance.

In a study of sex-differences in learned helplessness, Dweck and Bush (1976) found that when girls received failure feedback from an adult, such as a teacher, they showed little improvement in performance while boys receiving failure feedback from an adult showed immediate and sustained improvement.

Girls were more likely to attribute failure to lack of ability while boys were more likely to attribute failure to the fault of the evaluator. Dweck and Bush conclude that girls are more likely to exhibit learned helplessness and less likely to try again in an area of poor performance or failure. Applying this concept to the area of mathematics would suggest that girls doing poorly in mathematics would attribute the cause to lack of ability and drop out rather than try again in a mathematics area. Other research by Ernest (1976) does indicate that females with mathematics grades equal to males, drop out in higher numbers than the males.

Achievement Motivation

When Stein and Bailey (1973) examined female achievement motivation they found that achievement motivation theory, originally developed to explain male behavior, didn't apply well to female behavior.

They also found that females set lower levels of aspiration than males and that they exhibited higher levels of aspiration in sex-appropriate areas than in sex-inappropriate areas. They also found that females were more anxious about failure, more cautious in risking failure, and more likely to assume responsibility for failure.

When one examines the findings of Leviton (1975) Primevera et. al. (1976), Dweck and Bush (1976) and Stein and Bailey (1973), a picture emerges of female students achievement dependent to a large degree on their own self-esteem and the feed back they receive from adults. They appear to be more dependent than boys on social and cultural factors and less likely to risk failure or to persist in an area once poor performance has been experienced. This background research provides an explanation for some of the patterns that emerge when one examines the current research concerning sex-differences in mathematics performance and participation and the relationship affective variables play in those differences.

Affective Variables

A wide variety of affective variables have been put forth as contributing to lower female performance and participation in mathematics. Several appear in current research with regularity.

Attitude

Though there is some concern about the impreciseness of the term attitude, Fennema (1977) made several conclusions concerning attitude and it's effect on math achievement. She found a positive relationship between attitude and achievement which seems to increase as students progress in school. She also found attitudes toward mathematics to be fairly stable after sixth grade with grades sixth through eighth especially crucial in establishing attitudes. She also found that extremely positive or negative attitudes were better predictors of achievement and most importantly, that there are sex-related differences in attitude towards mathematics with males having a more positive attitude towards mathematics.

When analyzing the data from the National Longitudinal Study of Mathematics achievement to examine the sex differences in discriminating factors in electing mathematics, Perl (1982) found that while ability and achievement were the most important factors in discriminating between a person who elected to take math from a person who elected not to take math that the sex differences in ability and achievement could not account for the large differences between boys and girls in the decision to elect mathematics. In many areas, girls exceeded boys in mathematic ability, but the boys still elected to take math classes in greater numbers than girls.

As an explanation of this pattern, Perl noted that she also found a positive attitude towards mathematics to be the second most important factor in the decision to elect mathematics with boys having a more positive attitude than girls.

While attitude differences exist between sexes concerning mathematics, Ernest (1976) found that in the area of liking a subject mathematics was the only subject in which there were no sex differences in preference. Girls and boys liked mathematics equally and yet when mathematics becomes an elective far fewer females elect to take it.

When examining other affective variables, a greater understanding takes place of how girls can like math yet fail to have a positive attitude toward mathematics.

Mathematics as a Male Domain

Fennema (1977) notes that it is commonly accepted that mathematics is an activity more appropriate for males than for females.

Fennema and Sherman (1977) found that high school males differed significantly from high school females in their responses to mathematics as a male domain. Males were more stereotyped than females in perceiving math as a male domain. While females in were less stereotyped than males in their responses to a questionnaire concerning mathematics as a male domain, Sherman pointed out that their statements were not carried through into action by actually enrolling in elective mathematics classes.

One only needs to examine the low participation levels of females in mathematics curriculums and mathematics careers to see why the stereotype of mathematics as a male domain still persists in our culture.

In terminal positions requiring mathematic background, females make up a small minority of the total positions. Females account for only 22% of the mathematical scientists, 2.4% of the physical scientists and 2.3% of the engineers, (Statistical Abstract, 1984), thus solidifying the concept that math is still a male domain.

Motivation

While motivation to succeed in mathematics has been suggested as an important variable attributing to sex-differences in mathematics achievement and participation, little research exists to support the idea that there are sex-related differences in motivation.

Achievement motivation models were originally formulated on male models and as Stein and Bailey (1973) found when achievement motivation models were applied to females they seldom fit. The concepts used to explain achievement behavior were generally masculine characteristics which didn't explain motivation in a number of achievement-oriented females who didn't have those masculine characteristics.

Since male-oriented achievement models were the only models in existence for some time, application of those models to females indicated little achievement motivation among females.

In the area of mathematics, Kagan (1964) suggested that females were not as interested as males in problem solving and Horner (1972) found that females feared success in traditional male areas and suggested that females deliberately underachieved in areas such as mathematics.

Recent research by Fennema and Sherman (1977), however, found that effectance motivation did not differ between the sexes at any grade level from six to twelve.

While most researchers agree that motivation to succeed in mathematics is an important factor for the success of any mathematics student, there is little evidence that sex-related differences in this factor exist.

Significant others

The impact of significant others on mathematics achievement and participation has been suggested by a number of authors. The range of people considered to be significant includes parents, peers, teacher and counselors.

Fennema (1980) found evidence that teachers are differently influencing males and females in their learnings and attitudes toward mathematics. According to her research, teachers pay more attention to males than females and males receive more praise from their teachers than females. Given the same achievement level, males are more likely to be referred to remedial mathematics clinics for extra help and teachers hold higher expectations for males than females.

Ernest (1976) came up with a similar conclusion when he found that almost half the mathematics teachers he surveyed expected their male students to do better than female students while none of them expect the female students to do better than the males.

Casserly (1980) found that encouragement from a teacher was one of the factors linked to girls persistence and achievement in advanced placement mathematics classes.

In the few studies that examined the effect counselors had in encouraging females to participate in mathematics classes, counselors appear to have a negative or neutral influence. Haven (1972) found that while the influence of significant others had one of the highest predictive value for females enrolling in advanced mathematics, but she also found that 42% of the girls who were interested in mathematics or science careers reported their counselors discouraged them from taking advanced mathematics courses.

Parents have received considerable attention in recent research as having a significant effect on whether or not females are successful in mathematics.

Ernest (1976) found that both girls and boys go to their mothers more often for help with homework in elementary school. By sixth grade, however, more students reported going to their father for help in mathematics, a pattern which they continued through out high school. In a large majority of families, father is considered the expert on higher mathematics. Ernest suggests this fact alone must have a subtle influence on girls attitudes and decisions.

In a study of junior high school girls, Parsons (1979) found that parents have differentiated expectations for boys and girls and these expectations are linked to the girls decision about future mathematics classes. Parsons also found that whether or not the parent had actually taken higher math classes had little influence on the girls course plans or expectations. Parent expectations not parent role models were the key to girls planning on taking mathematics.

Fox (1977), in reviewing a number of research articles on parental influence, also concluded that the perceptions of parental expectations and maternal attitudes toward mathematics appear to be important factors in determining whether or not females persist in mathematics study.

Fennema and Sherman (1977) found that high school boys perceived a more favorable attitude about themselves as learners of mathematics from their parents than girls perceived and Casserly (1980) in a study of high school girls concluded that parents were seen as a significant factor in establishing a positive attitude toward mathematics.

While it is important to note that parental expectations and attitudes are key factors in influencing female attitudes toward mathematics, it is unfortunate to read the conclusion of MacCoby and Jacklin (1974) concerning parental expectations. In reviewing the literature, they concluded that parents have lower educational expectations for their daughters and a greater acceptance of low level achievement in mathematics for girls than for boys.

The peer group is also assumed to be an important factor in developing individual student attitudes. Therefore, students and their peers have been the subject of researchers attempts to establish the nature and cause of attitudes toward mathematics among individual females.

In a study of elementary students, Ernest (1976) found that each sex believed their own sex-peers were superior in mathematics, however, in high school studies by Ernest (1976) and Fennema and Sherman (1978) both males and females are more likely to view mathematics as a male domain.

Fox (1977) suggests that during adolescence, girls receive real peer pressure against achievement in mathematics.

Another subtle area of peer pressure is in the classroom ratios of males to females. Fox (1977) found that efforts to recruit girls for special mixed-sex mathematics classes were not very successful when the number of girls was small, but when all girl classes were arranged the number of recruits were higher. Similar results in other studies have led some persons to advocate single-sex mathematics classes as a way to increase female participation in mathematics.

Usefulness of Mathematics

An area has been researched extensively and does show considerable effect on females attitudes, participation, and performance in mathematics is the perceived usefulness of mathematics.

Females who can see long-term positive effects of mathematics study are more likely to persist despite negative influences from some of the other affective variables.

In an examination of the data from project talent, Wise (1979) found that virtually all of the sex-differences in the number of mathematics classes taken in high school were the result of differing career interests between males and females already evident by the ninth grade.

Haven (1972) found that the intention to major in a related field to mathematics was the strongest predictor for high school females enrolling in advanced mathematics.

Fox (1976) felt there exists a circular problem where girls avoid mathematics because they see it unrelated to their career goals and since they are not prepared in mathematics, they are unable to compete in mathematically related career areas in later life. With few women in mathematically related career areas, other females conclude mathematics is a male domain and therefore, unrelated to their career goals.

Fennema and Sherman (1978) found that high school boys perceived mathematics as more useful than high school girls and suggested male and female students would both benefit from programs to increase knowledge of the relevance of mathematics to careers.

Confidence-Anxiety

Fennema (1977) suggests that low confidence in mathematics among females helps explain the sex-related differences in mathematics participation. Crandall, Katkovsky, and Preston (1962) found that girls underestimate their own ability to solve mathematical problems. Casserly (1980) found that young women are more likely than young men to opt out of a math class based on a grade in a previous math class.

Hendel (1980), in an attempt to predict math anxiety in females found that there were few variables which were predictive of math anxiety. He did find that math anxiety had the highest predictive value for mathematics performance with high anxiety yielding low performance among females.

In an examination of boys and girls from grades six to twelve, Fennema and Sherman (1977) found that boys were significantly more confident in their ability to learn mathematics than girls. They also found that when girls in a school are found to have lower achievement than their male counterparts, they also exhibit a lower confidence than the males. In some schools, however, there was a lower level of confidence for girls but not a lower level of achievement. It is important to note that even with equal achievement levels, girls still show less confidence.

In a related area, Badger (1981) in a review of the research concluded that girls show significantly less self-confidence than boys in mathematics at a young age before there is any measurable difference in mathematics performance. She concludes that this discovery of less confidence in mathematics among females before there is any drop in performance, confirms the influence of confidence on performance.

Fennema (1977) suggests that the confidence - anxiety dimension is one of the more important affective variables that helps explain the difference in mathematics achievement. With females consistently showing less confidence than males, even in situations where performance is equal, there tends to be a drop in performance and an avoidance of further study in mathematics by females.

Participation-Achievement

Most early studies of mathematics achievement which used sex as a variable compared random samples of males to random samples of females. No attempt was made to control for the fact that males and females do not participate in mathematics classes in equal proportions after the point at which high school mathematics becomes an elective.

Since males participate in advanced classes in higher proportions than females, it is hardly suprising that random sample studies of males and females show significant sex differences in performance.

In the section of this chapter on mathematics performance and sex, a number of studies by Mulligan (1979), Act (1983), Stanley and Benbow (1980), Fennema (1981), and Armstrong (1981), are mentioned and all of them conclude that male performance in mathematics exceeds female performance.

It was also noted in this chapter in the section on mathematics participation by sex, that males enroll in advanced mathematics classes in higher proportions than females. Studies by Sells (1980), Armstrong (1981), Fennema (1981), Fennema and Carpenter (1981), and Giese (1982) confirm the fact the females simply do not take as many mathematics courses as males.

This phenomena is not limited to just the United States. In a study of ten nations Keeves (1973) found that in all ten nations, at a terminal secondary school level, males participated in mathematics in higher proportions than females.

It was this lack of female participation in mathematics that led Fennema (1979) to say, "Since the single most important influence on learning mathematics is studying mathematics, it would indeed be strange if males did not score higher on mathematics achievement tests than females."

Because of the differential in male and female participation in mathematics classes, a number of recent studies have been performed which controlled for the number of mathematics courses taken by each individual. When this was done a different pattern of mathematics achievement by the sexes began to appear.

In a study of four state universities and six community colleges, Stones, et. al. (1982) examined the mathematics abilities of incoming students. Students were classified according to their sex and background in mathematics. Of the ten categories of mathematics examined, males scored significantly higher than females in four categories while females scored higher than males in one category. The overall result was no significant differences between the sexes in mathematical ability when background is taken into consideration.

Fennema and Sherman (1977) studied four high schools with over 1200 students. They examined mathematics achievement and controlled for mathematics background. They found two schools had no significant difference between males and females in mathematics achievement while two schools had significant differences with males scoring higher. The data from these four districts led them to conclude that males are not superior in mathematics ability and that sex-related mathematics differences do not increase with the age of students, but they increase with differential course taking.

In an examination of the data from the National Assessment of Educational Progress, Fennema and Carpenter (1981) found that in high school mathematics course enrollments there was little sex-related differences in enrollments in the early high school mathematics classes. At the higher levels of mathematics sequence, however, only two thirds as many females as males were enrolled in mathematics classes.

In the area of achievement, Fennema and Carpenter (1981) found very little differentiation between the sexes in mathematics performance at ages nine and at ages thirteen. At age seventeen, however, males exceeded females in every area of performance. While not all the differences could be attributed to differences in participation, the high correlation between male participation and superior male achievement suggested that participation was the major factor in achievement differences. They concluded that there was a high need for high schools to increase their female enrollment in advanced level mathematics classes.

Project Talent, is a representative study of United States high school students that began in 1960 and has followed those same students into their adult life. In an examination of the data from Project Talent, Wise (1979) found that in 1960 as ninth graders, there existed very little difference in mathematics achievement scores between male and female students in the study. During their high school career, however, male students in this study made gains in mathematics achievement that were more than twice those of the female students. The sex differences in mathematics increased most sharply after the tenth grade when mathematics becomes an elective in most schools.

Wise (1979) found that sex differences in mathematics achievement were virtually non-existent after controlling for the amount of mathematics taken. In an examination of the amount of variation that could be attributed to different factors in this study, Wise found that math courses taken and ninth grade achievement account for over 71% of the variation found in the mathematics achievement among the twelfth grade students while less than 2% of the variation could be attributed to the student's sex.

This study's correlation between low female participation at higher levels of mathematics and low female achievement at terminal levels of high school becomes even more of a concern when one examines the data for students who drop out of the mathematics sequence.

In an examination of students in college level mathematics sequence, Ernest (1976) found no significant differences between grades for males and females and yet at every point where a student has the opportunity to drop the sequence, the attrition rate for females was higher than males. Casserly (1980) also found that young women opt out of high school mathematics courses based on equivalent grades at a higher rate than males.

Another disturbing finding by Wise (1979) is the apparent irreversibility of the decision to leave the mathematics field. While most career theorist profess that individuals keep the option of changing career fields throughout their lives, the reality is that it doesn't happen in the area of mathematics. Wise found that virtually no one, who was not planning a mathematics related career by grade twelve, had later switched into a mathematics related career. Wise concludes that improving mathematics skills is an important factor for all students in keeping career options open.

Programs to Increase Female Participation

With mathematics achievement for females so dependent on mathematics participation and with the career and economic implications of mathematics achievement, its no wonder that many sources have attempted to increase female participation in advanced high school mathematics.

Most high schools require two years or less of high school mathematics and leave the advanced mathematics classes as electives. Students are generally allowed to select any mathematics course to meet their mathematics graduation requirements and schools provide a variety of remedial and applied mathematics courses. Thus students do not need to ever consider advanced mathematics classes such as geometry, advanced algebra, and trigonometry for the purposes of high school graduation.

In a survey of 186 school districts in Western Michigan, McLain (1986) found that the average high school required only 3.33 semesters of mathematics and only 3.6% of the schools required students to complete a course in algebra. None of the schools required any mathematics beyond algebra.

To generate increased levels of female participation, most programs have focused on those affective variables that seem most likely to change the outcome behavior.

Sherman and Fennema (1977) suggested that since the mathematics sex-role influence seems to work through such factors as confidence - anxiety, usefulness of mathematics, and expectations of significant others that programs designed to increase female participation would be advised to consider all these factors.

Fennema et. al. (1981) examined a program designed to increase female enrollment to see if it had the intended effect. The program concentrated on providing females with factual information on sex-related differences in mathematics and motivating significant others, teachers, counselors, and parents to effect change. The result was an increase in mathematics participation by females in the treatment group and an overall increase in mathematics participation at the treatment schools.

In an extensive program funded by the Office of Education (Motivating Girls, 1979), the major goal was to increase female participation in mathematics. The females involved were given career education and career guidance, visited business and industry, and inservice was provided for parents, teachers, and counselors. The results were an increase in females selecting mathematics in grades eleven and twelve, an increase in confidence in mathematics among females, and an increase in females choosing mathematics related careers.

While some programs to increase female participation have a good record of success, they do have a problem. Those programs that have shown success tend to address several of the root affective variables such as attitudes of significant others, anxiety-confidence, and usefulness of mathematics. While the programs do get results, the commitment to the programs by the school district involved is extensive in the areas of funding, personnel, and parent-community involvement. The scope and cost of such programs alone makes it highly unlikely that the programs will become universal despite their record of success and despite the call of the Carnegie Commission (1973) for schools to place a emphasis on changing policies in school programs which tend to deter women from aspiring to equality with men in their career goals.

Mathematics Graduation Requirements

Knowing the problems inherent in increasing female participation, a small number of individuals have become proponents of increasing female participation through high school graduation requirements.

Farley (1968) found that girls required to take a third year of mathematics had a more positive attitude towards mathematics than girls who elected to take a third year of mathematics. She suggested that schools should require at least three years of mathematics for all students as a way of increasing female preparedness in mathematics.

Fox (1977, 1980) suggested that administrative and curricular changes such as requiring four years of mathematics for everyone might be the easiest way to increase enrollments of females in advanced mathematics. She further suggested that follow up research be done with changes in administrative practices to compare programs that require more mathematics with programs that leave mathematics as an elective.

A rationale for increasing mathematics requirements as a way to increase female participation in mathematics can easily be developed in a brief examination of the current literature.

Fox (1976) comments that in order for more women to become scientists and mathematicians some type of intervention must take place to prevent them from self-selecting out of mathematics and science courses.

Sherman and Fennema (1977) found that making females aware of their stereotyped behavior concerning mathematics was not enough as girls consistently indicated that mathematics was not a male domain, but still failed to enroll in mathematics classes.

Ernest (1976) states "Women simply are not taking enough of the optional mathematics courses offered in high school to prepare them to enter college programs in science, engineering or other hard disciplines." Fennema (1977) notes that once mathematics becomes an elective, the ratio of female to male students decreases sharply.

While its easy to develop a rationale for increased high school mathematics requirements, the effect of increased requirements is not certain.

Since Tobias (1981) considers increasing female confidence in mathematics a key to change and that eliminating anxiety is the key to restoring confidence in mathematics, one immediately wonders if requiring females to take more mathematics would actually increase anxiety, thereby decreasing the likelihood that they would remain in mathematics past the required classes.

Another problem that seems to present itself is the feasibility of requiring all students to take three or four years of mathematics and if it would have the intended effect of increasing the ratio of females to males in advanced classes.

Most educators would agree that due to lack of ability many high school students would not be able to meet course requirements in advanced mathematics such as advanced algebra and trigonometry. Because of this, high schools now offer remedial and applied mathematics courses for students not able or willing to enter into advanced mathematics classes.

Schools that choose to increase mathematics requirements would most likely insure that students not capable of advanced mathematics would have available other mathematics courses of a basic, applied or review nature to meet increased requirement demands.

If mathematics classes other than advanced classes were offered, females would still have the option of selecting out of advanced mathematics classes.

It seems that females would be more likely than males to exercise this option, since they already drop out of the existing mathematics sequence in greater numbers than males according to Ernest (1976) and Casserly (1980). The likelihood of this happening would seem even greater if there is indeed a biological difference in abilities as some suggest or if the increased requirements increased female anxiety about mathematics.

The possibility exists then that if requirements increase and females drop out of the advanced sequence at higher rate than males, that an increase in mathematics requirement would actually increase the imbalance of males to females in elective advanced mathematics.

The intent of this study is to examine the overall effect changing high school graduation requirements might have in female participation in advanced mathematics and the effect of those requirements on female anxiety toward mathematics.

CHAPTER THREE

METHODOLOGY

This study was an attempt to discover if increased high school mathematics graduation requirements result in an increase in the enrollment of females in elective advanced mathematics classes.

Because of the lack of available data concerning enrollments of males and females in high school mathematics classes in Michigan and the further lack of data concerning high school mathematics graduation requirements, this study consisted of three separate parts: a pre-study, the primary study, and the secondary study. Each part had its own methodology and instruments and will be discussed separately.

Pre-Study

The purpose of the pre-study was to obtain information about the mathematics classes required for high school graduation in Michigan high schools.

Population and Sample

In order to manage the size and cost of the pre-study, the population was defined as all public K-12 school districts in the western one-half of the State of Michigan. Schools were included if their mailing address was located in one of the counties making up the western one-half of the state (Appendix B).

The *1984 Michigan Education Directory* (Michigan, 1984) was used to identify school districts and obtain mailing addresses. A total of 187, K-12 school districts were identified as western Michigan public schools for the purpose of the pre-study. Since all 187 were surveyed, no sampling techniques were used once the population had been identified.

Instrument

The instrument used for the pre-study was a short seven question survey form (Appendix A). Each school was asked to provide identifying data including the school name, the name of the person filling out the form, and a phone number so later contacts could be made with each school.

The questions identified the school as a three or four-year high school so no confusion would arise about the amount of mathematics required in grades nine through twelve.

Additional questions asked for the minimum number of semesters of mathematics required for graduation; if the school required any specific mathematics classes; and whether the school had increased mathematics requirements during the past four years.

If schools had recently increased requirements, a further question was asked concerning when the new requirement went into effect and what the old requirements had been.

Finally, the schools were asked if they required a mathematics competency test. A section for comments was also provided.

This survey form was mailed with a cover letter to the Director of Guidance of each of the 187 school districts identified. It was believed that guidance personnel would have considerable interest in the project as well as knowledge of graduation requirements in their school.

Results

The pre-study survey was mailed out on February 4, 1985 and within two weeks over 90% of the surveys had been returned. The results of the pre-study were then summarized and can be found in Appendix C.

The pre-study data indicate the amount of attention and concern that mathematics is currently receiving in local schools. Almost 54% of the schools had recently increased their mathematics graduation requirements while another 24% were planning to increase their requirements in the near future.

The data on the number of semesters of required mathematics revealed that 35% of the districts required two semesters or less of mathematics while 60% of the districts required three or four semesters of mathematics. Only 5% of the districts required five semesters or more of mathematics for graduation. (see Table 1, page 12).

The original plan for this study was to compare female enrollments in elective advanced mathematics classes in schools requiring one year of mathematics with female enrollments in elective advanced mathematics classes in schools requiring three years of mathematics. This comparison would clearly demonstrate whether female enrollments are effected by the requirement for students to take three years of mathematics.

The results of the pre-study indicated a modification of the original plan was necessary. While five school districts were identified as requiring three full years of mathematics, all five had only recently raised their requirements. Students governed by those new requirements were still in the ninth grade and, therefore, not in a position to enroll in any advanced mathematics.

Two schools were identified as requiring four years of mathematics and one of those had only recently raised its requirement. The other school had only seventeen students in grades 9-12, an insufficient number to be of use in a study of this type.

Thus, it was found in the pre-study that there are only a few eleventh and twelfth grade students in western Michigan presently enrolled in high schools that require three years or more of mathematics for graduation. While several additional schools will have students enrolling under a three-year requirement in the near future, there was only a small number at the time of this study. Because of this, the focus of the study was changed to analyze the differences in female enrollments in elective advanced mathematics between schools requiring one year of mathematics and schools requiring two years. However, in a secondary phase of the study, female freshmen algebra students in those schools with a three-year requirement were examined to determine their mathematics anxiety level.

Primary Study

The purpose of the primary study was to examine the effect different graduation requirements in mathematics have on female enrollments in elective advanced mathematics classes. It was believed that by comparing student enrollments in elective advanced mathematics classes in schools requiring one year of mathematics with those requiring two years, differences in female enrollment ratios in elective advanced mathematics would appear.

Population and Sample

From the pre-survey results, a total of 105 schools were initially identified as having either a one-year or two-year mathematics requirement. Five schools that require one year of mathematics were randomly selected to use in the secondary aspect of the study and were not used in this population. Of the 100 schools remaining, forty-seven schools required two years of mathematics and fifty-three required one year of mathematics. Schools eliminated from the original population of 187 districts included in the pre-survey either required a different number of years of mathematics, had combination requirements with students able to select classes from combination areas, such as math/science, or had just raised their requirements.

Except for the five schools with a one year mathematics requirement that were randomly selected for use in the secondary aspect of the study, all schools identified as having a one-year or two-year requirement were included in the population and no sampling process was necessary.

Instruments

The instrument used in the primary aspect of the study was a mathematics enrollment survey designed by the author (Appendix D). Respondents were asked to identify mathematics class enrollments in those classes that are considered elective eleventh and twelfth grade college preparatory classes. They were also asked to identify the number of males and the number of females in each elective advanced mathematics class.

Collection of Data

The pre-study survey had identified the name and address of a contact person in each of the 100 high schools to be surveyed.

A short cover letter and the mathematics enrollment survey was sent directly to the contact person in each school requesting that they provide enrollment data for their mathematics classes. A self-addressed envelope was enclosed for returning the survey.

Since a number of contact persons had requested results of the pre-study, a copy of the pre-study results was also enclosed (Appendix C). It was felt that persons receiving such information would be more likely to take the time to complete the mathematics enrollment survey. Since few, if any, schools keep mathematics enrollments by sex, there was some concern that the return rate might be very low.

Of the fifty-three schools that require one year of mathematics, thirty-six (68%) returned completed surveys with only one unusable. From the forty-seven schools that require two years of mathematics, thirty eight (81%) surveys were returned with only one unusable.

Primary Null Hypotheses

In the primary area of the study four separate null hypotheses were tested. At two grade levels hypotheses were tested for the proportion of the female student body enrolled in elective advanced mathematics. Also tested at two grade levels were hypotheses concerning the ratio of female-to-male students in elective advanced mathematics classes.

I. At the eleventh grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is not greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

II. At the twelfth grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is not greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

III. At the eleventh grade level, the ratio of female-to-male students in elective advanced mathematics classes is not greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

IV. At the twelfth grade level, the ratio of female-to-male students in elective advanced mathematics classes is not greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

Design and Analysis

Four separate comparisons were made in response to the four null hypotheses.

In comparison one, the proportion of the eleventh grade female student body enrolled in elective advanced mathematics at each of the requirement levels was determined. These two proportions were compared using a Z-test with alpha=.05.

In the second comparison, the proportion of the twelfth grade female student body enrolled in elective advanced mathematics at each of the requirement levels was determined. These two proportions were compared using a Z-test with alpha=.05.

In the third comparison the ratio of female-to-male students in the eleventh grade elective advanced mathematics classes was determined at each requirement level. The ratio for schools with a one-year requirement and schools with a two-year requirement were compared using a Z-test with alpha=.05.

In the fourth comparison the ratio of female-to-male students in the twelfth grade elective advanced mathematics classes was determined at each requirement level. The female ratio for schools with a one year requirement and schools with a two year requirement were compared using a Z-test with alpha=.05.

Secondary Study

From the pre-study, five schools were identified that required three years of mathematics and two schools that required four years of mathematics. In all schools but one, requirements were recently raised to this level meaning most of the students required to take three years or more of mathematics were in their freshman year. Since enrollments in advanced mathematics were not available for this group, it was decided to use this group to examine the anxiety toward mathematics of female freshmen who were now facing a three-year mathematics requirement.

Population and Sample

Telephone contacts were made with all seven schools that required three or four years of mathematics. One school district that required four years of mathematics had a total of only seventeen students in grades nine through twelve and was located on an island in Lake Michigan. It was eliminated as not-typical for Michigan high schools. Of the remaining six schools, five agreed to participate in the study. As a group these schools could be described as small (under 1,000 students), rural high schools.

Once these five schools had agreed to participate, five other school districts that required only one year of mathematics were selected. Since none of the schools with a three year mathematics requirement were large urban schools, large urban schools were eliminated from the pool of schools that required one year of mathematics. From the remaining schools, five school districts were randomly selected. These five randomly selected schools with a one year mathematics requirement could also be described as small (under 1,000 students), rural high schools.

When contacted, all five schools agreed to participate in the study. After implementation of the study, however, one of the schools in this sample chose not to complete the study and was not replaced. This left four schools in the sample of schools that required only one year of mathematics.

In these two sets of schools, the population consisted of 316 ninth grade algebra students. A total of 195 students were surveyed in schools that required one year of mathematics and 121 students were surveyed in schools that required three years of mathematics (see Table 7, page 73).

All algebra students enrolled in these nine schools were surveyed. While students of each grade level (nine through twelve) were enrolled in algebra, only ninth grade student surveys were used for the purpose of this study. Since all ninth grade students in algebra were surveyed, no sampling process was used to select students.

Instruments

The Student Mathematics Questionnaire (Appendix E) was used to survey students and it included the Anxiety Toward Mathematics scale from the Fennema-Sherman Mathematics Attitudes Survey. This scale has a total of twelve statements and students are instructed to give Likert responses to indicate if they agree or disagree with each statement. The scale has a split-half reliability of .89 (Fennema-Sherman 1976).

The Fennema-Sherman Mathematics Attitudes Survey has been used in previous research projects and is described by the author as a scale designed to "assess an attitude that has been hypothesized to be related to the study and/or learning of mathematics" (Fennema-Sherman, 1976). From the anxiety scale were derived student scores indicating their level of anxiety toward mathematics.

Collection of Data

The Student Mathematics Questionnaire was administered to all algebra students in participating schools by the contact person in that school. Completed questionnaires were collected by the contact person in each high school and mailed back in a self-addressed and postage-paid mailer. The survey was delivered to students in May, 1985.

Secondary Null Hypothesis

> V. Ninth grade female algebra students enrolled in schools that require three years of mathematics will not have higher anxiety towards mathematics than ninth grade female algebra students enrolled in schools that require only one year of mathematics.

Design and Analysis

Using the Fennema-Sherman Anxiety Scale, the mean anxiety scores of ninth grade algebra students were compared using the variables of sex and years of mathematics required.

The analysis was performed with a two-way analysis of variance.

From the anova table it was apparent that the years of mathematics required was the primary source of variability. The mean scores for females were then further analyzed in a post-hoc comparison. Mean female anxiety scores between females in schools that require one year of mathematics and females in schools that require three years of mathematics were compared using the Scheffe' method as described in Hays: <u>Statistics for the Social Science</u> (1973).

<u>Other Data of Interest</u>

In collecting the information for this study a considerable amount of data was collected that was not used. While this information was not a part of the study, it may have value to some educators and researchers and will, therefore, be reported beginning on page 82 in chapter five.

Summary

The primary purpose of this study was to examine the effect of increased high school mathematics graduation requirements on female participation in elective advanced mathematics classes.

To begin a study in this area, first a base of information had to be developed. Since the State of Michigan does not keep data on high school graduation requirements, schools needed to be identified by the level of their mathematics graduation requirement. This step was accomplished with a pre-study. All public schools in Western Michigan were surveyed to determine their mathematics graduation requirements.

Once schools were identified by semesters of mathematics required for graduation, a comparison of eleventh and twelfth grade female enrollments in elective advanced mathematics classes in seventy-two high schools was made. Thirty-five of these schools required one year of mathematics and thirty-seven required two years of mathematics.

In a secondary aspect of this study, female ninth grade algebra students in nine schools were administered the Fennema-Sherman Mathematics Anxiety Scale. Scores for females in schools that require one year of mathematics were compared to the scores for females in schools that require three years of mathematics.

CHAPTER FOUR

ANALYSIS OF DATA

Primary Study

The central focus of the primary study was to determine if high school mathematics graduation requirements have an effect on the proportion of the female student body enrolling in elective advanced mathematics classes and the female-to-male ratio of students enrolling in elective advanced mathematics classes.

Sample

The sample for the primary study was a group of 100 western Michigan high schools. These schools represented 100 of the 105 western Michigan schools that had been identified in the pre-study as requiring one or two years of mathematics for high school graduation. Five schools that required one year of mathematics were not used since they were selected for inclusion in the secondary study.

Of the 100 schools that were surveyed, forty-seven of the schools required one year of mathematics and fifty-three of the schools required two years of mathematics.

Since virtually the entire population was surveyed, no sampling procedure was used.

Questionnaire Responses

The Mathematics Enrollment Survey (Appendix D) requested information from high schools on the enrollments by sex of their eleventh and twelfth grade elective advanced mathematics classes.

Of the 100 surveys mailed, a total of seventy-four (74%) of the surveys were returned. A breakdown by requirement indicated thirty-six (77%) of the schools with a one year requirement returned their surveys and thirty-eight (66%) of the schools with a two year requirement returned their surveys. One survey from each requirement category was not usable.

These seventy-two high schools represent a total student enrollment of 9,232 eleventh grade students and 8,759 twelfth grade students. Enrollment data is listed in Table 2.

Table 2
Enrollment Data

Eleventh Grade Enrollment	Schools	School Enrollment	Male Enrollment	Female Enrollment
One Year Schools	35	5424	2760	2764
Two Year Schools	37	3708	1879	1829
Twelfth Grade Enrollment				
One Year Schools	35	5395	2686	2709
Two Year Schools	37	3364	1696	1668

Null Hypothesis I

At the eleventh grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is not greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

Null hypothesis I was analyzed using a Z-test at the .05 confidence level. The raw data for this analysis is contained in Table 3.

Table 3
Eleventh Grade Female Advanced Mathematics Enrollment

Math Requirement	Schools	School Enrollment	Math Enrollment	Proportion
One Year	35	2764	1063	.385
Two Year	37	1829	810	.443

Since Z is significant if it is greater than 1.645 and in this comparison Z=4.2, the null hypothesis was rejected. A significantly higher proportion of the eleventh grade female student body in schools that require two years of mathematics are enrolled in elective advanced mathematics.

Null Hypothesis II

At the twelfth grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is not greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

Null hypothesis II was analyzed using a Z-test at the .05 confidence level. The raw data for this analysis is contained in Table 4.

Table 4
Twelfth Grade Female Advanced Mathematics Enrollment

Math Requirement	Schools	School Enrollment	Math Enrollment	Proportion
One Year	35	2709	433	.160
Two Year	37	1668	387	.232

Since Z is significant if it is greater than 1.645 and in this comparison Z=5.76, the null hypothesis was rejected. A significantly higher proportion of the twelfth grade female student body in schools that require two years of mathematics are enrolled in elective advanced mathematics.

Null Hypothesis III

At the eleventh grade level, the ratio of female-to-male students in elective advanced mathematics classes is not greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

Null hypothesis III was analyzed using a Z-test at the .05 confidence level. The raw data for this analysis is contained in Table 5.

Table 5
Female-to-Male Student Ratio/Eleventh Grade Advanced Mathematics

Math Requirement	Schools	Male	Female	Female/Male Ratio
One Year	35	1276	1063	.833
Two Year	37	904	810	.890

Since Z is significant if it is greater than 1.645 and in this comparison Z=1.89, the null hypothesis was rejected. In schools that require two years of mathematics, the elective advanced mathematics classes have a significantly higher female-to-male ratio than elective advanced mathematics classes in schools that require only one year of mathematics.

Null Hypothesis IV

At the twelfth grade level, the ratio of female-to-male students in elective advanced mathematics classes is not greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

Null hypothesis IV was analyzed using a Z-test at the .05 confidence level. The raw data for this analysis is contained in Table 6.

Table 6
Female-to-Male Student Ratio/Twelfth Grade Advanced Mathematics

Math Requirement	Schools	Males	Females	Female/Male Ratio
One Year	35	665	433	.651
Two Year	37	509	387	.760

Since Z is significant if it is greater than 1.645 and in this comparison Z=1.73, the null hypothesis was rejected. In schools that require two years of mathematics, the elective advanced mathematics classes had a significantly higher female-to-male ratio than elective advanced mathematics classes in schools that require only one year of mathematics.

Summary

This study attempted to find if differences in female enrollments in advanced mathematics classes exist between schools that require only one year of mathematics and schools that require two years of mathematics.

Using a Z test at the .05 level of confidence an analysis of the data collected in the primary study led to a rejection of all four null hypotheses.

In summation, at the eleventh and twelfth grade levels, a significantly higher proportion of the female student body is enrolled in elective advanced mathematics classes in schools that require two years of mathematics when compared to schools that require only one year of mathematics.

An examination of female-to-male student ratios of eleventh and twelfth grade elective advanced mathematics classes found a significantly higher female-to-male student ratio in elective advanced mathematics classes in schools that require two years of mathematics when compared to schools that require only one year of mathematics.

Secondary Study

The focus of the secondary study was on the effect high school mathematics graduation requirements have on female anxiety toward mathematics.

Sample

The sample for the secondary study included all ninth grade algebra students in nine high schools. Four of these schools required one year of mathematics for graduation while five schools required three years of mathematics.

All schools participating were small (under 1,000 students), rural high schools.

While five high schools that required one year of mathematics were selected for inclusion and agreed to participate, one school withdrew from the study at the last minute leaving four schools with a one year mathematics requirement.

A total of 316 algebra students were surveyed with 195 students enrolled in schools that required one year of mathematics and 121 students enrolled in schools that require three years or more of mathematics. Table 7 provides a breakdown of the students surveyed.

Table 7
Secondary Study Sample

Mathematics Requirement	Schools Participating	Ninth Grade Students Surveyed Total	Male	Female
1 year	4	195	101	94
3 years	5	121	54	67

Questionnaire Response

While approximately 400 algebra students were surveyed in the nine schools, only ninth grade student surveys were used for the purpose of this study. A total of 316 ninth grade students were surveyed and 100% of the surveys were complete and usable.

Null Hypothesis V

Ninth grade female algebra students enrolled in schools that require three years of mathematics will not have greater anxiety toward mathematics than ninth grade female algebra students enrolled in schools that require only one year of mathematics.

This hypothesis was analyzed using a two-way analysis of variance at the .05 confidence level. The main effect of years of mathematics required was significant while the main effect for sex was not significant.

The analysis is summarized in Table 8.

Table 8
Anxiety Scores: Analysis of Variance

Source of Variation	Sum of Squares	D.F	Mean Square	F	Significance of F
Years of Math Required	13.95	1	13.95	21.81	.001
Sex	2.02	1	2.02	3.16	.076
Explained	16.90	3	5.63	8.81	.001
Error	199.52	312	.64		
Total	216.42	315	.69		

The mean anxiety scores for females were further analyzed using a post-hoc comparison on the effect of the years of mathematics required. The results of this analysis found that anxiety scores were significantly higher (lower anxiety) for females in schools with a one year mathematics requirement than for females in schools with a three year mathematics requirement.

A summary of the post-hoc analysis results for anxiety are found in Table 9. The post-hoc comparisons used the Scheffe' method as described in Hays: Statistics for the Social Science (1973).

Table 9
Post-Hoc Comparison of One Year and Three Year Requirements

Mean Female Anxiety Score	Critical Value*
3.5	2.8

*Scores were considered significant if they exceeded the critical value. The post-hoc analysis was conducted at the .05 confidence level.

Summary

The secondary study examined the effect of high school mathematics graduation requirements on ninth grade female algebra students' anxiety toward mathematics. An examination of the data demonstrates that ninth grade female algebra students in schools that require three years of mathematics have a higher level of anxiety toward mathematics than ninth grade female algebra students in schools that require only one year of mathematics.

Chapter Summary

A summary of the findings in both the primary and secondary aspects of this study are found in Table 10.

Table 10
Summary of Findings

Primary Hypotheses		Level of Confidence	Z-Level	Action
I	Eleventh Enrollments	.05	Z=4.2	reject
II	Twelfth Enrollments	.05	Z=5.76	reject
III	Eleventh Female-to-Male Ratio	.05	Z=1.89	reject
IV	Twelfth Female-to-Male Ratio	.05	Z=1.73	reject

Secondary Hypothesis		Level of Confidence	Mean Score/ Critical Value	Action
V	Anxiety/Female	.05	3.5/2.8	reject

Chapter Five

Summary and Conclusions

Background

Based on current trends of female performance in mathematics, many educators are concerned about the low proportion of females enrolled in high school elective advanced mathematics classes. Elective advanced mathematics classes are those elective mathematics classes generally thought of as college preparatory in nature that are offered at the eleventh and twelfth grades. While course titles may vary, they are usually courses in advanced algebra, trigonometry, and calculus.

Historically, females have scored lower than males in mathematics performance. This phenomenon is so consistent that Badger (1981), in a review of the research, concluded that "in any random sample of high school students, males will show a higher performance in mathematics."

In searching for an answer for this pattern of sex-differentiated achievement in mathematics, several possibilities have been theorized. Stanley and Benbow (1980) conclude that males are genetically superior to females in mathematics. A number of researchers have suggested different social and cultural bases for the differences in male and female performance.

Another factor that has come to the attention of researchers is the sex-difference in the studying of mathematics.

While performance scores of males and females in mathematics are usually equal at the ninth grade (Fennema and Carpenter 1981, Wise 1979), male superiority in mathematics is well established by the time

students leave high school (Armstrong 1981, Badger 1981). Researchers have noticed a similar pattern when it comes to enrolling in mathematics classes. At the ninth grade, male and female enrollments in mathematics are similar, but at each grade level beyond the ninth grade, the female-to-male ratio declines in elective advanced mathematics classes (Fennema 1977, Fennema and Carpenter, 1981, and Giese 1983).

This tendency for females to elect not to enroll in advanced mathematics classes parallels the tendency for females to show lower achievement on standardized tests in mathematics.

Research in this area by Wise (1979), Stone (1982), and Fennema and Sherman (1977) concluded that much, if not all, of the difference in sex-related achievement in mathematics could be attributed to sex-related differences in the study of mathematics. Because of these findings, an emphasis has been placed on increasing female participation in elective advanced mathematics classes.

Most research in this attempt to increase female participation has focused on cultural and affective variables believed to cause low female participation. While many programs have been successful in increasing female participation (Fenemma 1981, Motivating Girls 1979), these programs require a strong commitment in personnel and funds to make them succeed. This commitment is lacking in most public schools and, therefore, it is unlikely that many schools will implement the programs needed to change the current trend of low female participation in elective advanced mathematics.

Farley (1968) and Fox (1977, 1981) suggest using administrative techniques such as requirements for increasing female participation in advanced mathematics. Fox (1980) suggests research be done to compare programs that require mathematics with programs that leave mathematics as an elective.

While increasing mathematics graduation requirements would certainly increase the number of males and females taking mathematics classes, it wouldn't necessarily increase the number or proportion of females taking elective "advanced" mathematics classes. In virtually all schools students have the option of electing which mathematics classes to take to meet their school's requirement and if schools increased the number of semesters of required mathematics, females could elect to take basic or remedial classes rather than any advanced mathematics.

Purpose of Study

The primary focus of this study was to investigate the effect high school mathematics graduation requirements have on the proportion of eleventh and twelfth grade females that enroll in high school elective advanced mathematics classes and the effect of high school mathematics graduation requirements on the female-to-male ratio in elective advanced mathematics classes. A secondary focus was the effect such requirements have on female anxiety toward mathematics.

Organization of the Study

The primary study compared female enrollments in elective advanced mathematics classes in thirty-five Michigan high schools that require one year of mathematics with female enrollments in elective advanced mathematics classes in thirty-seven Michigan high schools that require two years of mathematics. The intent was to examine the effect such requirements have on the proportion of the female student body that enroll in elective advanced mathematics classes.

Since males have traditionally made up the majority of enrolled students in elective advanced mathematics, an examination was also made of the ratio of female-to-male students enrolled in the elective advanced mathematics classes. The female-to-male ratio in elective advanced mathematics classes in schools that require one year of mathematics was compared to the female-to-male ratio in elective advanced mathematics classes in schools that require two years of mathematics.

In a secondary aspect of the study, ninth grade algebra students in nine schools were surveyed. Five of the schools required at least three years of mathematics and four of the schools required only one year of mathematics. Students were administered the scale on anxiety towards mathematics from the Fennema-Sherman Mathematics Attitudes Scales (Fennema, Sherman 1976). The intent was to examine the effect that a three-year mathematics requirement has on female anxiety toward mathematics.

Statement of Problem

This study examined the problem of the low representation of females in high school elective advanced mathematics courses and the possibility that high school graduation requirements might be an effective tool to increase female representation in those classes. To address the general problem of the under-representation of females in elective advanced mathematics classes, four primary null hypotheses and one secondary null hypothesis were developed and tested.

Null Hypotheses

Null Hypothesis I

At the eleventh grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is not greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

Null Hypothesis II

At the twelfth grade level, the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require two years of mathematics is not greater than the proportion of the female student body that is enrolled in elective advanced mathematics classes in schools that require only one year of mathematics.

Null Hypothesis III

At the eleventh grade level, the ratio of female-to-male students in elective advanced mathematics classes is not greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

Null Hypothesis IV

At the twelfth grade level, the ratio of female-to-male students in elective advanced mathematics classes is not greater in schools that require two years of mathematics than in schools that require only one year of mathematics.

Null Hypothesis V

Ninth grade female algebra students enrolled in schools that require three years of mathematics will not have greater anxiety toward mathematics than ninth grade female algebra students enrolled in schools that require only one year of mathematics.

Findings of the Study

The findings of the study are as follows:

1. Schools that require two years of mathematics have a significantly higher proportion of their eleventh grade females enrolled in elective advanced mathematics classes than schools that require only one year of mathematics.

2. Schools that require two years of mathematics have a significantly higher proportion of their twelfth grade females enrolled in elective advanced mathematics classes than schools that require only one year of mathematics.

3. At the eleventh grade level, schools that require two years of mathematics have a significantly higher female-to-male ratio of students enrolled in elective advanced mathematics classes than schools that require only one year of mathematics.

4. At the twelfth grade level, schools that require two years of mathematics have a significantly higher female-to-male ratio of students enrolled in elective advanced mathematics classes than schools that require only one year of mathematics.

5. Ninth grade female algebra students in schools that require three years or more of mathematics will have a significantly higher level of anxiety toward mathematics than ninth grade female algebra students in schools that require only one year of mathematics.

Conclusions

1. If schools that currently require one year of mathematics were to increase their high school graduation requirements to two years of mathematics the following results would occur:

a. There would be a significant increase in the proportion of the female student body that elected to take eleventh and twelfth grade advanced mathematics courses.

b. There would be a significant increase in the female-to-male ratio of students enrolled in eleventh and twelfth grade elective advanced mathematics classes.

2. If schools that currently require one year of mathematics were to increase their high school graduation requirements to three years of mathematics, there would be a significant increase in anxiety toward mathematics among their female freshmen algebra students.

Discussion of Other Data of Interest

In gathering data to support this study, a considerable amount of the data collected could be used for other comparisons. While this information is not an integral part of the study itself, it was felt that providing the data here might be of help to others with an interest in this field.

It should be noted that none of the trends or concerns highlighted in this section "Discussion of Other Data of Interest" can be considered conclusions. This study was not designed to draw conclusions in these areas and any formed from this data would disregard the scientific process so necessary in forming valid findings.

Male and Female Elective Advanced Mathematics Enrollment

Tables 11 and 12 list the combined totals for all seventy-two high schools that participated in this study. Thirty-five of these schools require one year of mathematics and thirty-seven require two years of mathematics.

In these tables, column one is the total enrollment in a grade while column two is the total elective advanced mathematics enrollment. Column three is the proportion of each grade that was enrolled in elective advanced mathematics class. Column four reports the proportion that each sex represents in those mathematics classes.

Table 11
Eleventh Grade Elective Advanced Mathematics Enrollments

	Student Enrollment	Math Enrollment	Proportion	Sex Proportion
Male	4591	2180	.475	.538
Female	4512	1873	.415	.462
Total	9103	4053	.445	1.000

Table 12
Twelfth Grade Elective Advanced Mathematics Enrollments

	Student Enrollment	Math Enrollment	Proportion	Sex Proportion
Male	4382	1174	.268	.589
Female	4377	820	.187	.411
Total	8759	1994	.228	1.000

As Tables 11 and 12 indicate, at the eleventh grade 44.5% of the high school students were enrolled in an elective advanced mathematics class. At the twelfth grade, however, the proportion of students enrolled in elective advanced mathematics drops to 22.8%. That means that less than one in four seniors is enrolled in an elective advanced mathematics class.

The data collected in this study, seems to support the current public concern that few high school students are preparing themselves for the future by completing a strong background in mathematics.

Female Dropout in Elective Advanced Mathematics

The data from these tables also support a possible trend among high school students that was identified by Ernest (1976) among college students. That trend was for females to drop out of mathematics in greater numbers than males each succeeding semester.

Data from Tables 11 and 12 indicate that females account for 46.2% of the students enrolled in eleventh grade elective advanced mathematics but only 41.1% of the students enrolled in twelfth grade elective advanced mathematics. It appears that as coursework advances in mathematics, females become a smaller minority in those classes.

This female representation in elective advanced mathematics classes is important because low female representation in these classes supports the concept that advanced mathematics is a male domain, thus convincing many qualified females not to enroll in elective advanced mathematics.

Looking at the same data from another perspective, only 18.7% of the females in the twelfth grade were enrolled in an elective advanced mathematics class while 26.8% of the males in the twelfth grade were enrolled in an elective advanced mathematics class.

No matter what comparisons were made in these seventy-two school districts, female representation was low in the elective advanced mathematics classes and as coursework became more advanced, female representation diminished.

Requirements and Students Enrollments in Elective Advanced Mathematics

Tables 13 and 14 give the raw totals from the seventy-two high schools that participated in this study for male and female enrollments in advanced mathematics broken down by mathematics requirements. Table 15 gives the proportion of the students that are enrolled in elective advanced mathematics.

Table 13
Eleventh Grade Enrollment Data by Requirements

	School Enrollment			Advanced Math Enrollment		
	Total	Male	Female	Total	Male	Female
1 year	5,524	2,760	2,709	2,339	1,276	1,063
2 year	3,708	1,879	1,829	1,714	904	810

Table 14
Twelfth Grade Enrollment Data by Requirements

	School Enrollment			Advanced Math Enrollment		
	Total	Male	Female	Total	Male	Female
1 year	5,395	2,686	2,709	1,098	665	433
2 year	3,364	1,696	1,668	896	509	387

Table 15
Proportion of Students Enrolled in Elective Advanced Mathematics

	Eleventh Grade			Twelfth Grade		
	Male	Female	Total	Male	Female	Total
1 year	.462	.385	.423	.248	.160	.204
2 year	.481	.443	.462	.300	.232	.266

While the focus of this study was on female enrollments in elective advanced mathematics classes, an examination of Tables 13, 14 and 15 reveals an interesting trend. Both male and female enrollments in elective advanced mathematics increased in schools where two years of mathematics were required.

The proportion of males enrolled in elective advanced mathematics in schools that require one year of mathematics was only 24.8% of the twelfth grade males while 30% of the twelfth grade males were enrolled in elective advanced mathematics in schools that require two years of mathematics.

This becomes an important factor to note when examining the findings of this study concerning the female-to-male ratio in elective advanced mathematics classes. The study finds that a two year mathematics requirement creates a significant increase in the female-to-male ratio in elective advanced mathematics. This additional data confirms that while female enrollments increased in these classes creating new female-to-male ratio, male enrollments also increased. Males and females both benefit from the increased requirement level.

To further examine the effect of requirements on total student enrollment in elective advanced mathematics, Z-tests were performed on the proportion of the total students enrolled in elective advanced mathematics at each grade level between schools requiring one year and schools requiring two years of mathematics.

At the .05 level of confidence, the results were significant at both the eleventh and twelfth grade levels. The proportion of total students enrolled in elective advanced mathematics at the eleventh grade level is significantly higher in schools that require two years of mathematics when compared to schools that require only one year of mathematics. At the twelfth grade level, the proportion of total students enrolled in elective advanced mathematics is also significantly higher in schools that require two years of mathematics when compared to schools that require only one year of mathematics.

Thus, while a two year mathematics requirement generates increased female enrollments in elective advanced mathematics sufficient to alter the female-to-male ratio, a two-year requirement also increases total student enrollment in those same classes.

Also of interest is the fact that the difference in the proportion of students enrolled in elective advanced mathematics classes between requirement levels is greater at the twelfth grade level than at the eleventh grade level. This could indicate that requiring a second year of mathematics creates a ripple effect of larger numbers of students that carries on throughout the mathematics curriculum.

College Intentions and Mathematics Enrollment

In the descriptive data from the secondary study on female anxiety, it was found that in high schools that require one year of mathematics 61% of the females and 40% of the males indicated the intention to get a bachelor's degree. When this data is compared to the data on elective advanced mathematics enrollments from one-year schools in the primary study, a glaring discrepancy appears. While 40% of the males express intentions to attend college, 46% are enrolled in eleventh grade advanced mathematics and 25% are enrolled in twelfth grade advanced mathematics. Among females, however, while 61% intend to go to college, only 39% are enrolled in eleventh grade advanced mathematics and only 16% are enrolled in twelfth grade advanced mathematics. This comparison is listed in Table 16.

Table 16
College Intentions/Mathematics Enrollment

	College Intentions	Advanced Mathematics Enrollments	
		Eleventh Grade	Twelfth Grade
Male	40%	46%	25%
Female	61%	39%	16%

Since the group of students that declared their college intentions and the group of students from which enrollment figures were derived are different populations and this study was not designed to compare college plans and mathematics preparation, no conclusion can be drawn. It does raise some interesting speculation about current preparation in mathematics by college preparatory females, especially in light of the poor preparation in mathematics that Sells (1973) found in female college freshmen at the University of California at Berkley.

Advanced Mathematics Intended Enrollments

Tables 17 and 18 give data for males and females and their intentions to enroll in advanced mathematics classes at the eleventh and twelfth grades. These figures are based on surveys given to algebra students in nine high schools with a total of 316 students participating. Figures expressed are the proportion of ninth grade algebra students who indicated they would be taking advanced mathematics when they were in the eleventh and twelfth grades.

Table 17
Intended Enrollments: One-Year Requirement

	Male	Female	Total
Eleventh Grade	86.1	76.6	81.5
Twelfth Grade	64.4	59.6	62.1

Table 18
Intended Enrollments: Three-Year Requirement

	Male	Female	Total
Eleventh Grade	79.6	83.6	81.1
Twelfth Grade	27.8	34.3	31.4

In comparing freshmen algebra students' intentions to enroll in advanced mathematics classes, there is little difference between students at one-year or three-year schools when it comes to their intention to enroll in eleventh grade advanced mathematics.

At the twelfth grade, however, major differences appear. While 62.1% of the algebra students in schools requiring one year of mathematics plan to enroll in twelfth grade elective advanced mathematics, only 31.4% of the students in schools requiring three years of mathematics plan to enroll in elective advanced mathematics in the twelfth grade. This trend appeared among males (three year = 27.8%, one year = 64.4%), as well as females (three year = 34.3%, one year = 59.6%).

It appears that most students in schools with a three-year requirement plan to complete their mathematics requirements and then drop out of the mathematics sequence. This may result from freshmen students' fears and concerns as they look ahead at a hard road of advanced mathematics and that as they progress in the mathematics sequence their attitudes will change. Still it's certainly worth watching to see if implementation of a three-year requirement might mean a reduction in enrollments in twelfth grade elective advanced mathematics.

Enrollments by Mathematics Grade

Tables 19 and 20 provide a breakdown by sex of student intentions to enroll in advanced mathematics based on their self-reported grade in algebra. This data is based on surveys given to 316 algebra students in nine high schools. Seven students did not report grades, leaving a total of 309 students in these tables. Figures provided are the proportion of males and females receiving a grade who indicated they would be enrolling in advanced mathematics. Thus, in Table 19 algebra grade "A" indicates that 95.9% of the males receiving an "A" and 95.1% of the females receiving an "A" planned to enroll in eleventh grade advanced mathematics.

Table 19
Eleventh Grade Advanced Mathematics Enrollment Plans

Math Grade	Male	Female
A	.959	.951
B	.909	.772
C	.750	.667
D	.600	.778
E	1.000	.800

Table 20
Twelfth Grade Advanced Mathematics Enrollment Plans

Math Grade	Male	Female
A	.837	.732
B	.545	.544
C	.250	.333
D	.200	.167
E	.500	.200

As one might expect, the students with higher mathematics grades, plan to enroll in elective advanced mathematics in higher proportions than their lower grade counterparts.

When comparing males to females, however, one finds that in almost all comparisons, given the same grade in mathematics, males intend to enroll in elective advanced mathematics in higher proportions than females. This is similar to a trend found by Ernest (1976) among female college students. He found that given the same grade in a mathematics class, females dropped out of the mathematics sequence in higher proportions than males.

Here we find that female ninth grade algebra students apparently plan to start that trend. If females drop out of mathematics in higher proportions than males at every level despite identical grades, it is not surprising that elective advanced mathematics classes have a majority of male students and are considered a male domain.

Anxiety by Mathematics Grade

Table 21 provides data on the breakdown of student scores on the Fennema-Sherman Mathematics Anxiety Scale based on self-reported algebra grades. Scores were derived from the survey results of 309 ninth grade algebra students in nine high schools.

Scores could range from 1 to 5 with a higher score meaning a more positive attitude (lower anxiety) toward mathematics. Scores on Table 21 are expressed as group means.

Table 21
Male and Female Anxiety Scores

Grade	Male	Female
A	4.33	4.18
B	3.84	3.70
C	3.41	3.11
D	2.96	2.81
E	2.50	2.93
Population Mean	3.75	3.56

An examination of Table 21 finds that, except for those students who were failing, males held a more positive attitude toward mathematics than females at every achievement level. Whether the mathematics grade was A, B, C, or D, male scores indicated lower anxiety toward mathematics.

Perhaps the trend for females to drop out of the mathematics sequence is related to higher anxiety levels than males even though females may be earning identical grades.

Recommendations

1. Schools that currently require only one year of mathematics should increase their graduation requirements for all students to a two-year requirement. This would be a first step in meeting the recommendations and demands of educational organizations, politicians, and the public concerning high school mathematics requirements.

In addition to meeting some of the demands placed on local schools, the results of increasing to a two-year mathematics requirement would be a higher proportion of the female student body that would enroll in eleventh and twelfth grade elective advanced mathematics classes. At the same time, there would also be a significant increase in the proportion of all students enrolling in eleventh and twelfth grade elective advanced mathematics.

Another effect of the increase to two years of mathematics would be an increase in the female-to-male ratio of students enrolled in elective advanced mathematics. This change in the sex-balance of enrolled students would help to counter the concept of mathematics as a male domain.

2. Schools that require three years of mathematics for graduation should provide services designed to keep students enrolled in the mathematics sequence after they meet their graduation requirements.

A survey conducted along with this study (Table 18, page 89) indicated that freshmen algebra students in schools that require three years of mathematics, when asked about their future plans for mathematics study, did not intend to carry on in the field of mathematics beyond the required number of semesters. If students actually carry out their stated intentions, it would mean a decrease in males and females electing to take a fourth year of advanced mathematics.

To prevent a decrease in student enrollment in the fourth year of elective advanced mathematics, schools requiring three years of mathematics should provide the following services:

a. Career education beginning no later than the junior high level on the positive outcomes of mathematics study on occupational choice and career earnings.

b. Provide academic counseling support for all students in the advanced mathematics sequence in high school. In many schools counseling support goes to students with a high risk of dropping out of school while college preparatory students make academic course selections with little input from trained professionals on the long term implications of their choices. Academic counseling support would be helpful in providing high school students in the mathematics sequence with support to continue mathematics study.

3. Schools that require three years of mathematics for graduation should provide services designed to reduce student anxiety toward mathematics. These services need to be provided in the areas of counseling support, teacher inservice, and curriculum reform.

a. Students should receive group counseling beginning at the junior high level with the intent of reducing student anxiety toward mathematics.

b. Mathematics teachers in high schools that require three years of mathematics should be made aware of the increased level of anxiety toward mathematics among their students. These same teachers should be helped to acquire improved techniques in teaching style and classroom management designed to provide student support and decrease anxiety. These techniques should include:

(1). More explanation and more classroom practice when introducing new mathematics concepts.

(2). Provisions for remedial or tutorial help for mathematics students who fail to keep up with the classroom pace.

(3). Positive feedback for all mathematics students that are progressing in the classroom, not just the few top students.

c. In the area of curriculum reform, schools with a three-year mathematics requirement should provide advanced courses that cover the same material but at a slower pace. Many students could be successful in learning advanced mathematics concepts but may not be successful in learning these concepts at the traditional pace. An alternate advanced mathematics sequence that allowed students to continue advanced mathematics study at a slower pace would reduce the high risk of student failure and allow students to continue a successful study in advanced mathematics with lower risk and reduced anxiety.

Suggestions for Further Research

The possibility that required mathematics courses are an effective tool to increase female participation in elective advanced mathematics was confirmed by this study. Females in schools requiring two years of mathematics participate in elective advanced mathematics in greater proportions than females in schools where only one year of mathematics is required.

It appears certain that increasing mathematics requirements from one year to two years will increase the overall proportion of females taking elective advanced mathematics in their eleventh and twelfth grades of high school. It will also increase the female-to-male ratio of students enrolled in the elective advanced mathematics classes.

What is not certain is what happens to student enrollments in mathematics in schools that require three years of mathematics. This area could not be studied at this time due to the small number of schools today that require three years of mathematics. This area of uncertainty leads to several suggestions for further research.

1. There is a need to compare the enrollment by sex in advanced mathematics classes between schools that require three years of mathematics and schools that require one year of mathematics. In this study, none of the available schools with a three-year mathematics requirement had students at the eleventh and twelfth grades due to the recent implementation of that requirement. In a few years, however, students in the schools requiring three years of mathematics will be enrolling in advanced mathematics classes and then a comparison of actual enrollments in advanced mathematics can be conducted.

2. Student mathematics anxiety levels need to be studied further in relation to mathematics requirements.

Ninth grade female algebra students facing a three-year mathematics requirement are more anxious about their ability to do mathematics than their counterparts facing a one-year mathematics requirement.

What is not known is if that anxiety continues as students progress through mathematics courses. An area that needs attention is a comparison of anxiety between ninth grade students in schools that require three years of mathematics and twelfth grade students in those same schools. This would indicate if anxiety levels subside as students progress in mathematics.

3. A comparison of high school exit level mathematics achievement should be made for schools requiring different levels of mathematics requirements. If the purpose of the current focus by educators, politicians and the public is to increase mathematics knowledge, some comparisons have to be made concerning the effect mathematics requirements have on exit level mathematics achievement of high school students.

APPENDIX A

IDENTIFYING DATA (Sample Pre-Study Survey)

Name of school ______________________________

Name of person filling out survey ______________________________

Position ______________________ Phone number ______________________

MATHEMATICS REQUIREMENTS SURVEY

I. Your high school graduation requirements apply to what grades?

_______ grades 9, 10, 11, and 12

_______ grades 10, 11, and 12

_______ Other (specify) ______________________________

II. What is the minimum number of semesters of mathematics your school requires for all students (excluding special education) for high school graduation? (If you have recently increased your requirements, please list your new requirements in this question. If your students have options such as a combination of credits from math and science, please indicate here the minimum that must come from mathematics and explain the option in the comments section.)

1 2 3 4 5 6 7 8

III. Does your school require any specific mathematics courses of all students (excluding special education) in order to graduate? If so please list course titles.

_______ No specific courses required

Course Titles ______________________________

IV. Have you increased your mathematics graduation requirements in the past four years?

_______ Yes _______ No

V. If you answered yes to question number IV, please specify what your old requirements were and what graduating class is first affected by your new requirements.

Old requirements ______________________________

____

____

____

New requirements will first affect the graduating class of:

_______ 1985 _______ 1987
_______ 1966 _______ 1988

VI. Are you considering increasing your graduation requirements in mathematics?

_______ Yes _______ No

VII. Do you require any type of competency test in mathematics for high school graduation?

_______ Yes _______ No

VIII. COMMENTS

APPENDIX B

LIST OF COUNTIES--WESTERN MICHIGAN

1. ALLEGAN
2. ANTRIM
3. BARRY
4. BENZIE
5. BERRIEN
6. BRANCH
7. CALHOUN
8. CASS
9. CHARLEVOIX
10. CLARE
11. EATON
12. EMMETT
13. GRAND TRAVERSE
14. IONIA
15. ISABELLA
16. KALKASKA
17. KENT
18. KALAMAZOO
19. LAKE
20. LEELANAU
21. MANISTEE
22. MASON
23. MECOSTA
24. MISSAUKEE
25. MONTCALM
26. MUSKEGON
27. NEWAYGO
28. OCEANA
29. OSCEOLA
30. OTTOWA
31. ST. JOSEPH
32. VAN BUREN
33. WEXFORD

APPENDIX C

Summary of Mathematics Requirement Survey

The Survey was mailed to all K-12 public school districts in the western one-half of the lower peninsula of Michigan. The total number of districts surveyed was 187 with 170 (91%) of the schools responding.

School districts located within the following counties were surveyed:

Allegan	Cass	Isabella	Mason	Osceola
Antrim	Charlevoix	Kalkaska	Mecosta	Ottawa
Barry	Clare	Kent	Missaukee	Saint Joseph
Benzie	Eaton	Kalamazoo	Montcalm	Van Buren
Berrien	Emmett	Lake	Muskegon	Wexford
Branch	Grand Traverse	Leelanau	Newaygo	
Calhoun	Ionia	Manistee	Oceana	

RESULTS-

Average number of semesters of mathematics required for high school graduation: 3.34

Highest level of mathematics required for graduation: 3.6% require algebra

The percentage of schools who have increased mathematics graduation requirements in the past four years: 53.9%

The percentage of schools planning on increasing mathematics graduation requirements: 24.2%

Number of schools at each requirement level

Number of semesters of required math	Number of schools responding
0	0
1	5
2	55
3	6
4	96
5	1
6	5
7	0
8	2

3S

Tony McLain
510 Payne Lake Road
Middleville, MI 49333

Survey delivered: February 1985

APPENDIX D

College Preparatory Mathematics Enrollment Survey

Most high schools offer a college preparatory sequence of advanced mathematics. The sequence varies from school to school depending on school size and curriculum. A most common sequence is:

9th grade Algebra
10th grade Geometry
11th grade Advanced Algebra
12th grade Trigonometry

Many schools also offer advanced classes beyond trigonometry.

For research purposes, my interest is in any college preparatory mathematics classes that you offer at a 11th or 12th grade level. Would you please list the course title of thos classes under the grade level that is most common for the students in that class. Then list the male and female enrollment figures for that class.

11th grade college preparatory mathematics classe(es)

Course name	Number of male students	Number of female students
____________	________	________
____________	________	________

12th grade college preparatory mathematics class(es)

Course name	Number of male students	Number of female students
____________	________	________
____________	________	________

What is your high school's total enrollment for the 11th grade? ________

What is your high school's total enrollment for the 12th grade? ________

APPENDIX E

DIRECTIONS

The student Mathematics Questionaire is a research device and will be used for research purposes only.

<u>DO NOT WRITE YOUR NAME ON THE QUESTIONAIRE.</u>

If you do not wish to participate please feel free to return your questionaire blank. There will be no penalty for not completing this questionaire and participation is voluntary. If you have any questions about participation or how to fill out this questionaire, please ask your instructor.

Your voluntary completion and return of this questionaire indicates your assent in participation.

STUDENT MATHEMATICS QUESTIONAIRE

1. GRADE: 9 10 11 12

2. SEX: M F

3. WHAT MATH CLASS ARE YOU CURRENTLY ENROLLED IN______________________

4. WHAT WAS YOUR LAST MARKING PERIOD GRADE IN THIS CLASS?_____________

5. DO YOU INTEND TO ENROLL IN A MATH CLASS NEXT YEAR? YES NO UNDECIDED

6. IF YES, WHAT CLASS WILL YOU ENROLL IN ?__________________

7. IF YOU INTEND TO ENROLL IN MATH NEXT YEAR WHAT IS THE MOST IMPORTANT REASON?

_____PARENTS REQUIRE IT
_____HIGH SCHOOL GRADUATION REQUIREMENT
_____COLLEGE REQUIRES IT
_____NEED IT FOR MY CAREER AREA
_____I'M GOOD IN MATH
_____OTHER (specify)________________________________

8. IF YOUR NOT GOING TO ENROLL IN A MATH CLASS NEXT YEAR, WHY NOT?
_____POOR GRADES IN MATH
_____DON'T NEED IT FOR MY CAREER OR COLLEGE
_____I DON'T HAVE ANY ABILITY IN MATH
_____I DISLIKE MATH
_____OTHER (specify)_________________________________

9. WHAT ARE YOUR FUTURE PLANS?
_____TRADE OR TECHANICAL SCHOOL
_____TWO YEAR COLLEGE DEGREE
_____FOUR YEAR COLLEGE DEGREE
_____ARMED SERVICES
_____GET A JOB
_____UNDECIDED
_____OTHER (specify)__________________________________

FOLLOWING IS A SERIES OF STATEMENTS. THERE ARE NO CORRECT ANSWERS FOR THESE STATEMENTS. THEY ARE SET UP IN A WAY WHICH PERMITS YOU TO INDICATE THE EXTENT TO WHICH YOU AGREE OR DISAGREE WITH THE IDEAS EXPRESSED.

READ EACH STATEMENT AND CIRCLE THE LETTER WHICH BEST FITS YOU FOR THAT STATEMENT.

CIRCLE LETTER "A" IF YOU STRONGLY AGREE WITH A STATEMENT
CIRCLE LETTER "B" IF YOU AGREE WITH A STATEMENT
CIRCLE LETTER "C" IF YOU ARE UNDECIDED
CIRCLE LETTER "D" IF YOU DISAGREE WITH A STATEMENT
CIRCLE LETTER "E" IF YOU STRONGLY DISAGREE WITH A STATEMENT

BE SURE TO ANSWER EVERY QUESTION AND DON'T SPEND TOO MUCH TIME WITH ANY ONE QUESTION. REMEMBER THERE ARE NO RIGHT ANSWERS, SO CHOOSE THOSE THAT BEST DESCRIBE YOU.

THIS INVENTORY IS BEING USED FOR RESEARCH PURPOSES ONLY AND NO ONE WILL KNOW WHAT YOUR RESPONSES ARE.
(This inventory was developed under a grant from the National Science Foundation)

A B C D E 1. Mathematics usually makes me feel uncomfortable and nervous.

F B C D E 2. Generally, I have felt secure about attempting mathematics.

A B C D E 3. I get a sinking feeling when I think of trying hard math problems.

A B C D E 4. I usually have been at ease in math classes.

A B C D E 5. I usually have been at ease during math tests.

A B C D E 6. My mind goes blank and I am unable to think clearly when working mathematics.

A B C D E 7. I haven't usually worried about being able to solve math problems.

A B C D E 8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.

A B C D E 9. Math has been my worst subject.

A B C D E 10. I'm no good in math.

A B C D E 11. I have a lot of self-confidence when it comes to math.

A B C D E 12. A math test would scare me.

A B C D E 13. I can get good grades in mathematics.

A B C D E 14. Math doesn't scare me at all.

A B C D E 15. I am sure I could do advanced work in mathematics.

A B C D E 16. Mathematics makes me feel uneasy and confused.

A B C D E 17. I am sure I can learn mathematics.

A B C D E 18. I'm not the type to do well in mathematics.

A B C D E 19. It wouldn't bother me at all to take more math courses.

A B C D E 20. For some reason even though I study, math seems unusually hard for me.

A B C D E 21. I think I could handle more difficult mathematics.

A B C D E 22. Most subjects I can handle O.K., but I have a knack for flubbing up math.

A B C D E 23. I don't think I could do advanced mathematics.

A B C D E 24. I almost have never gotten shook up during a math test.

Your high school requires you to take 4 years (8 semesters) of mathematics for graduation. Listed below are your high school's mathematics classes. Please put a check (✓) on the line next to those classes you plan on taking before you graduate. Be sure to mark the class you are enrolled in and any classes you have completed.

_____ General Math

_____ General Business

_____ Junior/Senior Math

_____ Computer Science

_____ Algebra I

_____ Algebra II

_____ Geometry

_____ Senior Math Analysis

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