1-1-1992

Strategies for overcoming math avoidance in an urban high school.

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STRATEGIES FOR OVERCOMING MATH AVOIDANCE IN AN URBAN HIGH SCHOOL

A Dissertation Presented

by

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Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

DOCTOR OF EDUCATION

February 1992

School of Education

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DEDICATION

This work is dedicated to the women of the '90s in the hope that they will continue to move toward economic equity in our society by achieving new levels of personal awareness to help them think positively and have a belief in themselves that <u>they can do</u> whatever it takes.

It is the role of all who advise women--parents, educators, and counselors--to encourage them in the belief that ability and their own desire are the only appropriate determinants controlling their choice of a career rather than the pervasive social attitudes that have heretofore done much to reserve access to higher paying positions to men.

As the dawn of a new century approaches we, as citizens of a nation committed to a democratic way of life, can no longer afford to be supportive of social attitudes that pit one sex against the other whether it is for first place or an equal economic reality. Equity should be understood to be as much about being fair to everyone as it is about being equal. The broad meaning of being equal, of fairness, is to have access to equal encouragement and equal opportunity regardless of one's gender or color.

ACKNOWLEDGMENTS

I sincerely thank Dr. Jeffrey W. Eiseman for his help, understanding, and patience from the beginnings of my research through its final stages. I also wish to thank Dr. Edward A. Connors and Dr. Alfred L. Karlson for their contributions to the process.

My appreciation and thanks to: Rosemary Reshetar, Lynda Fennessy, and Peg Louraine from the University of Massachusetts in Amherst; Michael Briggs from Clark University; Dr. Bruce Wells, Robert Boulé, David Elworthy, David O'Connor, John Pitt, Maria Stipek, Tina Castagna, Elaine Gendron, June Plante, student participants from North High School; panel participants from the local Worcester area; Dr. Charles Burack and Dr. Mary Lingis from Worcester East Middle School as, without their assistance, support, and/or participation, this research project would not have been possible.

I wish to thank Susan Whitman for her friendship and many positive words of encouragement.

ABSTRACT

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IN AN URBAN HIGH SCHOOL

February 1992

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Typical high school algebra classes contain females, minority males, and white males in somewhat proportionate numbers. In contrast, the usual high school calculus class, three years hence, is but a small percentage of the original total who were in algebra, and they are predominantly white males of average to above-average ability.

In a time span of less than two weeks, through three brief educational presentations that included factual information to demystify math study, showed the importance of math to personal goals, and provided panel presenters who would serve as role models, I sought to influence students, especially females and minority males, to commit to study math through calculus.

When data collected on a questionnaire from 110 students studying Algebra 1 or geometry was analyzed in terms of two of the most important outcomes of the study--factual knowledge acquired and commitment to study math through calculus--there were no results significant at

the .05 level for the experimental group who received the presentations. Regarding five other outcomes: the actual levels of math studied, the ability to match an appropriate amount of math to one's post-high school plans, the choice of counselor over other options for career or educational information, and the choice of any school personnel as opposed to other options for career counseling--the only outcome significant at the .05 level was the selection of school personnel for career counseling.

In conclusion, perhaps a greater use of role models whose job it is to stress the importance of math to one's life goals, over a sustained period of time, might be most effective in changing student attitudes toward studying math through calculus.

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INTRODUCTION

Headlines scream that our national security is being threatened by our loss of dominance in the high-tech computer electronics field (Boston Globe, 1987). The crisis in the field of mathematics and related subjects has also been cited as the cause for the deterioration of our once unchallenged superiority in the field of economics. These problems are well documented in several international studies cited by John Dossey, a mathematics professor at Illinois State University.

At a symposium held in Washington, D.C. (January, 1987) in response to this crisis, Dossey, who, at that time, served as a member of the National Research Council's Mathematical Sciences Education Board, revealed that our top math students were equivalent to the average students found in such countries as Japan, China, and Russia. The future seems to hold little chance for the situation to improve, and the negative implication, given the reasonable expectation that these students would serve as our future leaders as we compete with these countries in the areas of economics and engineering, are evident (Worcester Sunday Telegram, 1987).

In order for the United States to regain its pre-eminent leadership role, it must address this crisis. It obviously begins with a re-examination of the K-12 mathematics curriculum presently in place and the less evident problems attendant to this, particularly the traditionally disproportionate male dominance. In January of 1987, the Mathematical Sciences Education Board released a preliminary draft containing what symposium participants agreed were key mathematics reform recommendations designed to alleviate the problem. Among its findings were the following:

a. Local. Parents and the public should realize that simple admonishments to teachers and students to work harder have not been effective remedies for the serious problems in mathematics education.

b. State. The emphasis should be placed on setting state-wide standards based on the best in current thinking about what is achievable instead of focusing on minimal competency.

c. National. The Mathematical Sciences Education Board should lead a reform of mathematics teaching and learning with initial emphasis placed on the early and primary years, "The long range goal [being] to restore U.S. pre-eminence in mathematics education" (Worcester Sunday Telegram, 1987).

Problem Statement

One need only observe a few high school calculus classes to conclude that the typical student is a white male of average or above-average ability. A reasonable conclusion is that these students must have been deemed the only ones capable of succeeding in this demanding course.

In a pilot study I completed for my dissertation proposal, it became evident that a sizeable number of students of average mathematical aptitude are capable of successfully completing the rigorous demands of an advanced calculus class. There was, however, a discrepancy between those students who were qualified and those actually enrolled in the course. What happened to the women and minority students of average and even above-average aptitude? What has caused this serious underrepresentation?

Significance of the Problem

The problem of sufficient numbers of people succeeding in high-level mathematics has significance in a national as well as a personal sense, as follows:

a. National. Mathematics is so closely tied to science, engineering, and economics that a boost in the numbers of qualified people succeeding in this discipline is going to go a long way toward re-establishing U.S. leadership in these areas.

b. Personal. Since mathematics is a subject needed in many of the high level and technological careers characterized as important to us in this country, it follows that the need for individuals who possess these skills will be great. If somehow greater than the usual numbers of students encouraged to study higher level math are also women and minorities, it should follow that career opportunities and associated higher earnings levels for these groups would be significantly enhanced.

CHAPTER II

A REVIEW OF THE LITERATURE

This chapter presents some of what educational researchers and interested others had to say about problems related to getting greater numbers of students, especially those who are typically underrepresented--females and minorities, interested in taking higher mathematics. Suggestions for the changes needed to rectify the situation are also presented.

The following review of the literature:

- presents theories important to learning;
- delineates factors directly and indirectly related to a student's willingness and ability to study math;
- critiques the ways in which math is now taught;
- relates approaches taken by researchers to explore problems of anxiety and learning;
- discusses awareness and changes;
- discusses support activities and systems; and
- discusses and suggests programs for improvement

Theories

The following three theories, considered by researchers to be important to learning math, are mentioned first because they are intrinsically involved with practically every aspect of the problem.

Theory of Causal Attribution

According to Causal Attribution Theory, people credit their performance to: ability, effort, task difficulty, or luck (Weiner [1974] as cited in Wolleat, Pedro, Becker, & Fennema, 1980). These four are related to two factors having two levels--see Figure 1 below:

		LOCUS OF CAUSATION	
		Internal	External
STABILITY	Stable	Ability	Task
	Unstable	Effort	Luck

Figure 1. Theory of attribution matrix (Wolleat, Pedro, Becker, & Fennema, 1980)

This theory is important because it is linked to achievement (Bar-Tal [1978] as cited in Wolleat, Pedro, Becker, & Fennema, 1980). Achievement is in turn linked "to expectancy of success" (Weiner [1974] as cited in Wolleat, Pedro, Becker, & Fennema, 1980). For example, success or failure in agreement with expectations are linked to stable causes. Success or failure contrary to expectations are linked to unstable causes.

Related to the expectancy of success, this means, by definition, that stable factors cause recurring results, whereas variable outcomes are the result of unstable factors. When doubt exists as to whether a previous success will be repeated, then behavior trying for that outcome will cease (Weiner [1974] as cited in Wolleat, Pedro, Becker, & Fennema, 1980).

Theory of Alternative Learning Behavior

According to Fennema and Peterson (1985), individuals who exhibit alternative learning behavior don't allow social influences such as the teacher's rules for learning math to prevent them from seeking their own path to solving the problem. They use their own inspiration in a do-it-yourself style to forge ahead to success. This habit, once acquired, seems to be maintained and the individual increases the confidence and aptitude necessary for solving high-level cognitive tasks. These independent thinkers look for challenging things to do and do them independently of others.

Motivation Theory

In the literature on motivation theory, lack of achievement is often due to lack of drive to achieve (Tobias & Weissbrod, 1980). Math nonachievers can't be explained that way, however, because they often achieve in other areas. Another interesting point is that the achievement need in these individuals could be so high as to cause them to avoid the chance of failing by not trying, if they are convinced beforehand that they are lacking in that subject area (Tobias & Weissbrod, 1980).

These three theories are referred to often in the literature that follows and will be useful in understanding how bias deriving from socialization practices related to the female role expectations of our culture operates both in and out of the classroom.

Problem Areas

The problem areas can be viewed in terms of a play. The lead characters are female learners, the supporting cast members are peers, parents, teachers, counselors, and those who conduct research, and the plot derives its main energy from the socialized role expectations of our male-dominant culture.

It was assumed for a long time that gender more than anything else was the reason for differences in achievement between males and females in math, with the advantage clearly belonging to the males (Lazarus [1974] as cited in Tobias & Weissbrod, 1980). This assumption led quite naturally to bias against females and many lingering negative effects of bias even though it is now generally accepted that there are no real differences in math ability between the sexes (Tobias & Weissbrod, 1980).

Inadequate educational practices cover a wide range of topics such as: weaknesses in teaching, teacher role and methods, undesirable classroom activities, conscious or unconscious perpetuation of bias associated with the socialized role expectations of our culture, unequal interactions with students incongruent with the needs of learners, and counselors' bias and lack of awareness.

Perhaps the most thorny problem area is the one involving socialized role expectations that are disadvantageous for females but advantageous for males, at least in learning math or in seeking careers.

Gender Differences

In the preface to her first book, Overcoming Math Anxiety, Sheila Tobias (1978) says, "fear of mathematics is the result and not the cause of their [women and men] negative experiences with mathematics." The fear, better known as math anxiety and further defined as a psychological condition rather than a lack of skills, is a contributing factor in math avoidance (Tobias & Weissbrod, 1980). Math anxiety is the conviction on the part of individuals that they can't comprehend mathematics. The conviction can be the result of any number of turn offs--a bad experience, another person's opinion of their ability, or the perception that math is no fun (Tobias, 1987). Myths commonly held by students that math is only for those of genius ability or that it is boring are other reasons (Hechinger, 1987).

The failure associated with math anxiety is not due to inability as much as to a failure of nerve. Those who have established anxiety clinics have found that ability-affected negative emotion resulted in making the student feel he/she couldn't do it. The student's real ability is blocked rather quickly as the anxiety contributes to clouding the mind, rendering the student unable to think, then fostering the belief that he/she is unable to solve the problem, leading to a loss of confidence and, finally, to cessation of effort (Tobias, 1987).

A researcher studying the attitudes of women toward math found math anxiety to be common among female graduate students in the School of Social Work at Smith College (Kogelman [1976] as cited in Tobias & Weissbrod, 1980). In a report circulated in 1974 by the sociologist, Lucy Sells, only 8 percent of females (versus 57 percent of males) applying to Berkeley in 1972 had studied four years of math as preparation for entering college (Sells, Note 1, as cited in Tobias & Weissbrod, 1980). Some six years later, Wolleat, Pedro, Becker, and Fennema (1980) found that far fewer women than men take elective math courses in high school, indicating that in the intervening time not much had changed. They also found that men do better in math and persist longer by studying it in college and using it in their adult life. The impetus to view this phenomenon as a sex-related difference was partly related to research that uncovered "math anxiety" as a contributing factor in underachievement in math along with the agenda to create change (Tobias & Weissbrod, 1980).

Gender Bias. Whatever the causes for math anxiety, math anxiety felt on a personal level is also related to social and institutional barriers that must be overcome by women and minorities if they are to experience greater successes in math (Tobias, 1987).

Concluding that the differences of higher scores obtained by males on Scholastic Aptitude Tests is evidence of females having less ability is an example of biased reasoning (Burns, undated). The following quoted material, indicating that females "can't bring themselves to accept sexual difference in aptitude. But the difference in math is a fact. The best way to help girls is to accept it and go on from there" is a particularly flagrant, rude, and harsh example of bias stated by Benbow (Burns, undated). Taking issue with Benbow's remarks, Burns (undated) tells how the prophecy of inferiority leads to its fulfillment in the "Great Circle Game." In the game, unequal situations are the cause of low test scores; but Benbow explains the inequality by ignoring how unequal socialization factors enhance mathematical skill development for males but work just the opposite for females. The game "proves" that males have greater mathematical abilities. When that spurious fact is accepted, the inequalities are justified and the circle is complete--there is no reason to recognize or change the inequalities if girls are naturally less capable.

A bias of superiority is even found where you would least expect it--among female engineers who, because of the obstacles they overcame to reach their career goals, view themselves as psychologically different, somehow special, and more enthusiastic and committed to their careers than their counterparts in more traditional careers (Elflein, 1985). There is no proof of any sex-related cognitive superiority of males in learning math (Sherman [1978] as cited in Tobias & Weissbrod, 1980). This finding was confirmed when males and females studied equal amounts of math; yet sex-related differences in "expectations of success and patterns of attribution" were found (Fennema [1977] as cited in Tobias & Weissbrod, 1980).

Some Negative Aspects of Gender Bias. An unfortunate aspect of entrenched bias is the repeated need to defend instances of inferior female math ability through disclaimers stating that it is now more or less agreed the lesser performance from females in math and science is due more to their socialization, educational practices, and the opportunities open to them (Elflein, 1985); or, that nonparticipation and lackluster performance in high-level college math is not due to a lack of ability (Tobias, 1978). In spite of prior successes with math, growing discomfort in high school led to math avoidance for Sheila Tobias. Some years later, as she began to grasp the significance of the underlying socialization practices that lead to the "continuing occupational segregation of women," she concluded that "women are predestined to study certain subjects and pursue certain occupations not only because these are 'feminine' but because girls are socialized not to study math" (Tobias, 1978). Inadequate math preparation in high school penalized girls entering college at Berkeley in 1972 by excluding 92 percent of them from 10 of its 12 colleges and 22 of its 48 majors and relegating them to "'feminine' fields: the humanities, guidance and counseling, elementary education, foreign languages, and the fine arts" (Tobias, 1978). Because math is associated with so many high-paying occupations, a girl who avoids studying it seriously affects her choice of occupation and her financial success (Mathison, 1977). Also, an early decision not to pursue math study (before she is fully aware of the consequences) eliminates the possibility of seeking any of the 75 percent of careers considered most financially rewarding (Smith, 1979). Being unable to pursue such careers also means that she will fail to experience the economic well-being taken for granted by men (Smith, 1979).

Inadequacies of Educational Practice

Dr. Edward A. Connors, professor of mathematics at the University of Massachusetts at Amherst, and Dr. Gerald Lallement, math professor at Pennsylvania State University, both criticize weaknesses in the way math is taught on the elementary and secondary levels, saying that those weaknesses are responsible for capable students not pursuing math in college (Fowler, 1988). The practice of many schools that accept the memorization of material as learning is criticized because, according to Weissglass (1975), it actually hinders learning. He advocates working to foster "true learning," described as the ability to take newly presented material, add it to what is already known, store it in the mind, and later be able to retrieve it for use in new situations (Jackins [1966] as cited in Weissglass, 1975).

According to Hechinger (1987), poor teaching methods where the focus is on rules to remember, a quick right answer, and no opportunity for classroom discussion lead to math anxiety and avoidance. Tobias (1981) and Smith (1979) echo that statement, saying that when students unsure of their problem-solving abilities undergo any of four common math classroom practices--time pressure, humiliation, one right answer, or working alone--they develop stress and math avoidance. For example, time pressure activities--which include competition and emphasize speed--reward quicker students to the detriment of slower ones who aren't necessarily less capable. Solving problems on the board may be humiliating to a math-anxious student. Emphasis on right answers overlooks information about the thought process used to get them. Focus on right answers and the importance placed on not cheating foster isolation (Tobias, 1981). It will become evident further on how these practices operate as elements of bias against females and minorities whose learning styles lean more toward the cooperative than the competitive.

Mathison (1977) says math anxiety can start from something as simple as ignoring a student's need for further or clearer explanation. Research by Weissglass (1975) revealing students and teachers as having few pleasurable experiences in the math classroom calls for change because there is a close relationship between feelings and learning--students who feel good will learn better. Also, whether the negative feelings are associated with their personal lives or classroom experiences, teachers should be aware of and work toward eliminating the distress because students focusing on those issues are not free to focus on math (Weissglass, 1975). Mathison (1977), asserting that distress caused by math anxiety leads to lowered ability, and then to more anxiety in a round-robin fashion, stresses the importance of keeping a student's attitude positive because, "their approach to studying mathematics and their attitudes rather than their lack of intelligence usually prevents them from grasping mathematical concepts."

Bias Issues of Education and Socialization. A female engineering student stated that high school teachers assumed girls had less interest in math and taught girls only enough to get by whereas boys received a more in-depth study (Elflein, 1985).

The most important findings in a study concerned with effective teaching practices by Peterson and Fennema (1985) were the differences between competitive and cooperative math activities in relation to low-level and high-level math achievement of boys and girls. Competitive math activities are defined as spelling bee-type activities using math facts and producing winners or losers and timed tests. Cooperative activity is defined as working with one or more people to find the answer. They found cooperative activity leads to the greatest gains in low-level and high-level achievement for girls and that losses result from competitive activities, whereas for boys the opposite was true. Competitive activities make good use of the greater assertiveness and aggressiveness exhibited by males whose approved social role is enhanced by their manifestation (Maccoby & Jacklin [1974] as cited in Peterson & Fennema, 1985). Typically, since the social role-expectations for females are not accepting of assertive or aggressive behavior, girls are at a disadvantage in competitive classroom activities. In contrast, female social-role expectations stress dependency as opposed to independence. Therefore, it should not be surprising that females learn better in cooperative classroom activities, in small groups, or that they wait more often for help from the teacher.

One question raised by Fennema and Peterson (1987) is whether or not gender-related differences in high-level achievement is due to teachers participating in more effective teaching behaviors with males than they do with females. It has been documented that teachers interact more with males and males interact more with them--is this one reason for their greater achievement in high-level cognitive tasks? It has been found that females learned more high-level math with increased teacher interaction--but this is not typical teacher behavior toward females. A related issue is whether or not females need something they aren't receiving from teachers to help them have a different, more positive attitude toward math. Do these issues mean that the effective teaching behaviors of teachers should be different for females than they are for males who have been getting along just fine? Fennema and Peterson quickly add the caveat that, if it is found differences are necessary, providing for them would be in direct opposition to the equal education philosophy of education. Furthermore, they question the legality of providing differential teaching for females arguing that inadvertently it promotes a perpetuation of the inequities we seek to eliminate in the opposite direction--toward males (Fennema & Peterson, 1987). The implication is that providing for the special educational needs of girls somehow now will be harmful to boys. While the essence of that argument is good it somehow contributes to devaluing the plight of girls whose educational needs have for so long been lost in biased circumstances clouded by patriarchal-role expectations (see Cabana [1985], below, for a different perspective).

Since alternative learning behavior is stated as positively necessary to high-level learning Fennema and Peterson (1985) studied interactions between teachers and students and the classroom activities they participate in to see if they could discover why males are far superior to females in high-level achievement starting in fourth grade and continuing through high school (Carpenter, Corbitt, Kepner, & Reys [1981] as cited in Peterson & Fennema, 1985). They focused on schools because students spend a lot of time in classrooms; but, they do not see schools teaching alternative learning behavior as such, only as reinforcing what is already there. However, since an independent style of thinking is considered necessary to the development of alternative learning behavior, one can assume that the characteristic social role expectations of independence for males versus dependence for females may be implicated, which would be similar to the findings involving competitive versus cooperative activities in Peterson and Fennema (1985).

Fennema and Peterson (1985) found that teacher-to-student and student-to-teacher interactions considered beneficial to optimal development occur more often for boys than girls. They also assume some connection and effect relating to these interactions exists affecting the students' internal motivational beliefs, i.e., the more dependent style of the female learner would contribute to a reluctance on her part to initiate an interaction with the teacher. Social tolerance of boys' behavior (independent learning styles) on the part of teachers versus pressures they apply to girls in the learning situation to follow the classroom rules is possibly related to girls' not doing as well in the problem-solving areas of math. In spite of the foregoing, they conclude that, "there are few direct data suggesting that differential teacher treatment is the cause of gender-related differences in achievement." In contrast to this, Eccles, MacIver, and Lange (1986) present figures showing that, in regard to girls and high-level learning, teacher behaviors toward them are infrequent (not conforming with what is known about their more dependent style of learning). This is all the more remarkable since the girls express a need for teacher input by frequent questions

(Eccles, MacIver, & Lange, 1986). Also, girls in high-level learning situations get more negative feedback, whereas boys get more praise. All of the foregoing seem proof enough that teacher treatment has a hand in gender-related differences in achievement. In fact, Peterson and Fennema (1985), in their other work involving effective teaching, say the gains of girls in high-level learning are greatest when girls show the same type of independence as boys who have high-level success (less engagement with teachers and less need for help from them or others). This appears to constitute recognition that if girls do not conform to their more dependent role-identified style they succeed like boys. Speculatively, the greater success in high-level learning these girls show could be due to their being brighter or better problem solvers.

In tandem fashion, Cabana (1985) views the causal attribution patterns of learners together with perceptions of both too little and too much teacher control. When some students perceive too much control it leads to anxiety and lessened performance (Skinner [1968] as cited in Cabana, 1985). Too little perceived control was found to produce identical results (Bettleheim [1969] as cited in Cabana, 1985). Two other researchers say those results occur also where students attribute their success to external reasons rather than ability (Rotter [1966] and Weiner [1974] as cited in Cabana, 1985). The attribution of success to external reasons, of course, is a frequent occurrence among females (Wolleat, Pedro, Becker, & Fennema, 1980). Cabana (1985) stated that teacher reinforcement, i.e., too much control (in the sense of highly directed, highly monitored) or too little control (less feedback, allowance for more independence on the part of the learner) is generally inconsistent because it is not properly perceived by teachers which students need it and which do not. In a study seeking to match attribution patterns to a teacher control format that would maximize learning, he took care to test learners to discover their attributional patterns. For those who credited success to external reasons, he provided high teacher control methods--frequent formal checking of their work after each section of the text and retesting until a 90 percent level of understanding of material was attained. When problems came up, there was discussion and practice until the section was well understood. For those who credited success to internal reasons--ability--low teacher control methods were used allowing learners to "use their ability more independently" (Cabana, 1986). He found, as others did, that females had more anxiety than males, and that they more often credited success to external reasons (Cabana, 1986). He found that adult female learners whose attribution patterns were matched to the appropriate level of teacher control performed better and had less anxiety than those who weren't matched (Cabana, 1986). This is another instance that stands in contrast to the conclusion drawn by Fennema and Peterson (1985) that there is not much data to support the idea differential teacher treatment causes gender-related differences in achievement. It certainly seems that if teachers ignore learner attributional patterns and use only one method for all learners many would fail.

Likewise, in contrast to the philosophical position taken by Fennema and Peterson (1987) that there is a danger of perpetuating inequities by providing for the special needs of female learners, Cabana (1986) provided high teacher control learning situations for those who related their success to external causes. For example, luck (through lots of teacher reinforcement, working at one's own pace, and a high learning rate of material before moving on) and low teacher control situations allowing greater freedom and independent use of ability for those who related their success to internal causes, i.e., ability, thus proving that, by being aware of the causal attribution patterns of learners and taking care to provide proper teacher reinforcement, a difference in achievement outcomes can occur.

Lack of Awareness and Bias in Counselors. Counselors come in for their share of criticism as women engineers state they weren't made aware of what engineering was all about (Elflein, 1985). Counselors who are not technologically oriented might fail to encourage girls in that direction (Hitchner, with Tifft-Hitchner, 1987). There could be just such a lack of awareness as well as bias present in the case of a girl who told her guidance counselor that she wanted to go to RPI only to hear the counselor suggest, "it was too technical, that it would be too hard for a girl and that I [she] should go to the nice little girls' college down the road" (Elflein, 1985).

Socialized Roles

Socialized roles are disadvantageous for females but advantageous for males in learning math or in seeking careers. It is not a girl's fault she isn't encouraged to pick activities that enhance her math skills. This is due more to the norms of socialization and education as they apply to girls (Elflein, 1985). Burns (undated) lists a variety of reasons why girls are short-changed in relation to acquiring math skills or being prepared for careers that are math dependent. One socialization factor biased toward males occurs at playtime when the female is given a doll but the male is given an Erector set. Another, involving reduced expectations for the female, occurs when a girl offers a dislike for math as a reason for not taking more courses and it is readily accepted but when a boy says the same thing it is not so readily accepted. The dearth of opportunities being offered to girls and the fact that they are discouraged from entering professions requiring a strong math background leads them to wonder why they should take more math if they can't see a real need for it. The end result for girls is that their socialization and designated role expectations don't provide them with experiences or reasons to continue and/or excel in what prove to be experiences enhancing the development of mathematical ability.

A girl's expectation of success is related to her sense of herself as a female and is seen as affecting her willingness to do math (Weissbrod & Yates [1979] as cited in Tobias & Weissbrod, 1980). Both sexes see math as something males do (Stein & Smithell [1969]; Stein [1971] as cited in Tobias & Weissbrod, 1980). Thus, a girl who cares what her male peers think and who believes men are prejudiced against women who excel in math will not pursue it (Fox [1977] as cited in Tobias & Weissbrod, 1980).

In her teen years when role identification is most important to a girl she must decide whether or not to take the math and science courses that are necessary if she wants a future in engineering (Elflein, 1985). Since people seek congruence between their sex-role and achievements girls are forced to go against the norm of their internal beliefs if they seek success in high-level math (because math is male) by overcoming the roles their male peers see for them (Fennema & Peterson, 1985). Meeting the patriarchal role expectations of her culture don't often let a girl take the risk of taking courses identified as male--math and sciences, mechanical drawing, analytical geometry, or get involved in model making or other mechanical things that help boys develop math skills (Elflein, 1985). Boys prefer "things"--activities, video arcades, whereas girls pick people-oriented activities over "things" activities (Hitchner, with Tifft- Hitchner, 1987).

Hitchner with Tifft-Hitchner (1987) say boys and girls are aware of the stereotypes of occupations, i.e., girls are secretaries and nurses rather than boys because these are not masculine; whereas math, science, and computer occupations associated with male abilities are considered unnatural for females.

Elflein (1985) finds that conflicts do arise for girls who consider engineering because of the stereotypical and discriminatory ideas that view girls who want to be engineers as less feminine. Even after women overcome the initial obstacles and are in the profession they continue to face discrimination and stereotyping behavior from their peers, especially if they try to enter mechanical or industrial engineering, which are considered the real he-man branches of the profession (Elflein, 1985).

Fathers are seen as the most important influence in career choices for girls, so the low numbers of girls in math, science, or computers could be because fathers don't give females the same encouragement that they give males in these areas (Hitchner, with Tifft-Hitchner, 1987). Male/female socialization from birth onward, what society thinks (peer pressures), mistaken notions that technical careers affect family life adversely for women, and the fact that some families emphasize the role of woman as mother, and that of man as wage earner are other factors preventing women from considering nontraditional studies and careers (Hitchner, with Tifft-Hitchner, 1987).

Confidence Issues. Since girls have a high need for approval from others in their sex-role functioning they are handicapped in developing confidence in their math ability or in seeing its usefulness in their lives (Fennema & Peterson, 1985).

Sheila Tobias (1981) says it is not uncommon for women in her 'math anxiety reduction' workshops to stop working on math problems for no better reason than that, if the solution was something that popped into their heads, it couldn't be right. This mistrust comes from being afraid to learn from mistakes. Fear of asking questions and thinking that their questions are too dumb are other elements that lead to stress that becomes anxiety and math avoidance. Even when females know they have the same skills as males they may not feel confident enough to follow through to develop and use them because of their socialized role coupled to causal attribution (Hitchner, with Tifft-Hitchner, 1987).

Success in learning math is associated with motivation, temperament, attitude, and interest as well as general intelligence (Tobias, 1978). Both sexes lose interest in math by the time they are seventeen but it is only a problem for girls. The problem with girls learning math is not ability but more a lack of willingness to study it (Fennema [1976] as cited in Tobias, 1978). People who can work at the college level in other subjects should be able to do college-level math--proof that a mathematical mind is needed doesn't exist (Tobias, 1978). Yet, Tobias concedes, reassurance doesn't work to convince the reasonably intelligent person that they can do it because the feeling of defeat associated with math failure is not rational. An attitude of less confidence, underestimation of ability, and feelings of doubt about math being useful to them may interact with the attribution of causation to produce the "math avoidance" syndrome (Crandall, Katkovsky, & Crandall [1965]; Fennema & Sherman [1973]; Hilton & Berglund [1974] as cited in Wolleat, Pedro, Becker & Fennema, 1980).

Women are adversely affected by the attribution patterns they learn to use (Wolleat, Pedro, Becker & Fennema, 1980). The dependence needs associated with a girl's culturally approved socialized role have a bearing on her fit in the theory model of causal attribution that, when understood in relationship to her math learning and career seeking behavior, can be easily understood as negative and nonenhancing to her life. Success attributed to unstable or external factors, in turn, linked to "learned helplessness" (more frequently seen in girls) where failure is unavoidable no matter what one does means less persistence (Dweck, Davidson, Nelson, & Enna [1978] as cited in Wolleat, Pedro, Becker, & Fennema, 1980). As stated, a girl views her success as attributable to "unstable or external factors," (luck, effort) meaning she is unsure about repeating her success, and this lowered expectation contributes to lessened persistence. She views failure, on the other hand, as related to internal or stable causes (her ability) which because of the learned helplessness she is unable to improve enough to succeed.

The independence needs associated with a boy's culturally approved socialized role have a bearing on his fit in the theory model of causal attribution that is directly opposite to a girl's in that, when understood in relationship to his math learning and career seeking behavior, they are positive and enhancing to his life. He attributes success to stable or internal factors (his ability, skill), and his positive view that if he provides effort he will continue to succeed are quite different from the girl's view of success. He credits any failures to external or unstable causes (his effort) but instinctively feels that can be changed just by trying harder (Wolleat, Pedro, Becker & Fennema, 1980).

Strong performance and achievement are related to the factors described in the male model and decreasing persistence and lowered achievement are related to the female model. The sex-related differences of attribution theory are more pronounced if the task in question is seen as male (Wolleat, Pedro, Becker & Fennema, 1980). Since math is a male domain according to many there is a very strong connection to math avoidance for females (Ernest [1976]; Fennema [1977]; Stein [1969]; Casserly, Note 2, as cited in Wolleat, Pedro, Becker & Fennema, 1980). In fourth grade, differences in a girl's belief system start to appear as less confidence and self esteem when compared to boys and the differences continue into high school (Fox [1980]; Fennema [1984] as cited in Fennema & Peterson, 1985). The outperformance of females by males in math starts at this time in both the areas of application and understanding (high-level cognitive complexity) and continues as the difficulty level of math increases (Carpenter, Corbitt, Kepner & Reys [1981] as cited in Peterson & Fennema, 1985). This is true "even when the number of mathematics courses taken by girls and boys in high school is held constant" (Fennema [1984] as cited in Peterson & Fennema, 1985). By sixth grade and continuing through life, the usefulness of math starts to be seen differently, with boys valuing it more (Fennema & Carpenter [1981] as cited in Peterson & Fennema, 1985). These factors, related to the female socialized role, and already identified with causal attribution are seen as evidence that "sex-role identity serves as a mediator of cognitive functioning" (Weiner [1974] as cited in Peterson & Fennema, 1985). "These three interrelated beliefs (confidence, perceived usefulness, and attributional style) clearly influence participation in alternative learning behavior." To reiterate, alternative learning behavior leading to success in high-level achievement is characterized by the learner looking for the hard things to do and doing them independently (Peterson &

Fennema, 1985). Therefore, it is not difficult to see why boys have the edge over girls in high-level math, as his socialized role encourages an independent style of behavior whereas hers encourages a dependent style of behavior.

To change this and achieve in high-level math, it is implied that a female has to be able to have the same feelings of being in control of the outcome (success based on ability) and has to feel free of, or not care about, socially approved sex-role functioning. In a study that shows how these factors operate in relation to a girl's career choice, it was found that "cultural beliefs about science and the scientist implies a mismatch between a young woman's beliefs about herself as a person and the possibility of herself as a scientist" (Frieze & Hanusa [1984] as cited in Peterson & Fennema, 1985). The achieving woman is perceived as getting satisfaction in career involvement at the expense of personal and social values. The either-or kind of choice has greater ramifications for females than for males, who are always free to have a career no matter what their other social roles are (Peterson & Fennema, 1985).

Interventions

There are three main categories of interventions: awareness issues, support activities and systems, and educational changes.

In the awareness category consciousness-raising activities are enhanced by the addition of statistical facts and information relating to careers, i.e., realizing the role of interests in career decisions, the career opportunities that exist, and the preparation necessary for them.

Support from many quarters is a necessary adjunct to awareness if change is to take place. Colleges provide much in the way of support, private business plays a part, and both government and business play a role in funding.

Interventions in educational practice include a range of suggested changes including teacher role and methods, more active roles for counselors, retraining activities and improvement programs, program evaluation, and advice for students, parents, and teachers.

Awareness

Girls should hear facts and be exposed to awareness activities to raise their awareness levels so that their personal views of math will change, they will value it more, and they will be more interested in studying it.

Consciousness Raising. Positive strategies useful to a girl for dealing with subtle or direct discrimination are: to know success depends on effort, failure, at times, may be due to things beyond her control, and she should seek out peers of both sexes to be supportive. As a girl progresses it is suggested that she look for mentors in the same field, join professional organizations, and keep her sense of humor (Kenschaft, undated).

Countering the idea of math as dull and boring Menzin and Goldman (1987) describe it as exciting and a way to make a major contribution to the world's of business, medicine, and government through one's talents. Good points are that many areas of math overlap each other and one doesn't have to like all of math to be in it anymore than one has to like all of music to be a musician (Menzin & Goldman, 1987).

Leventman (undated) says girls who are good at math and science should be told to consider a career in engineering. The credentials gained from engineering studies will get them jobs that pay well and that will help them to overcome inequities in pay where women earn only 70 percent of what men earn. Most women work whether married or not so they should take every possible opportunity to overcome any barriers that remain defining technical careers as "male turf."

Girls should be told progress has been made in numbers, i.e., "15-20 percent of all engineering students are women" and "women made up over 12 percent of the bachelor's class in 1982" whereas in 1972 they were only "1.2 percent of graduates" (Elflein, 1985).

According to Burns (undated), both sexes should be told about misleading games that show gender-related differences in achievement where none really exist (the "Great Circle

Game" example was given earlier) as a way of helping them overcome bias.

The causes of underachievement for women related to "the cultural, educational, and occupational barriers" they experience need to be understood to prepare the way for needed interventions to be developed. The aim of interventions should be toward allowing free-informed-choice decisions no more limiting to the success of women than they are for men who by custom don't operate under negative and limiting conditions. Math therapy involving demystification of math and finding a solution to math avoidance are favored as ways to eliminate "occupational segregation." If it can be proved that lower female performance "is learned in conformity to sex-role expectations," then it might be possible to "design effective compensatory programs for women and girls" (Tobias & Weissbrod, 1980).

Smith (1979) says the unique idea there is such a thing as a mathematical mind should be refuted, i.e., she has never encountered students who felt they couldn't read or that they didn't have a historical mind because they didn't pass history tests. She says a better attitude for students to have is that if one has the required intelligence to succeed in other subjects then one should be able to do math. It is also important to dispel other old messages involved with past socially encouraged and accepted role expectations promoting the idea math is a subject more for men to study, it is unimportant to a woman's future, or that it is only for the smartest wherever these ideas still exist (Mathison, 1977).

Girls should be informed that even if they are not going to college knowing algebra and geometry can make a difference in how they do on standardized entry-level tests given by civil service, federal service, armed services, and the private business and industrial sectors. Vocationally a knowledge of algebra and geometry makes the difference between qualifying for unskilled and clerical jobs and those that pay better with more chances for advancement that become available to the high school graduate (Tobias, 1978). This is another way of saying it is as important to be able to think mathematically as it is to be able to read a newspaper. Math avoidance is limiting for people at all levels of work because it is a vocational filter (Tobias, 1978).

Peterson and Fennema (1985) state that expanded career opportunities in keeping with a modern view of a woman's place in society require that negative views of gender-role expectations be altered so as to encourage females to be willing to display traits like alternative learning behavior.

<u>Items Gleaned from Statistics Contribute to Awareness</u>. Annual American Mathematical Surveys providing information on the economic status of teachers have been conducted since 1957 by the American Mathematical Society. Dr. Edward A. Connors, Chairman of the Math Department at the University

of Massachusetts at Amherst and Chair of the Society's Committee on Employment and Educational Policy (CEEP) provided surveys from 1986 and 1987 that contain data on the numbers of new doctorates awarded in math as well as their employment, and data on faculty salary, tenure, and women employed in college math departments. These reports served as a resource for the commentary below:

In the Chicago Tribune (1987), Dr. Connors lays blame for the decline (about 20 percent between 72-73 and 86-87) in the number of doctorates awarded to our citizens to the fact there haven't been enough qualified teachers on the elementary and secondary levels for decades. He cautioned that unless the decline is reversed severe shortages will be with us in business, industry, and government by the year 2000. During the decline many researchers and college professors, traditionally white males, left teaching to go into investment banking and computer science creating a crisis in college and university math departments that were seeking high-level graduates to teach from among declining numbers. This was true even though according to the 1st AMS Survey in 1986 the numbers of new doctorates grew four percent between 84-85 and 85-86 and there were higher percentages of women (19 percent versus 13 percent in 84-86) hired for positions in colleges and universities granting doctoral degrees in mathematics (2nd AMS Survey, 1986). A sizeable number of the doctorates were earned by foreign recipients and the trend among them to accept foreign employment in increasing numbers also did not help (Mass High Tech, 1988).

Besides students taking college math being fewer in number their lack of preparation makes it necessary to give them remedial courses and precalculus (2nd AMS Survey, 1987). According to the 2nd AMS Survey of 1987, roughly half of those earning doctorates in math chose to find employment outside college math departments. This created a situation where many classes were taught by nondoctoral professionals.

Another major drawback reported in the 1st AMS Survey of 1986 was that salaries haven't kept up with the cost of living since 1970. Also mentioned was the fact that the small salary gains in the early and middle '80s didn't help significantly to attract or keep people on math faculties in colleges (1st AMS Survey, 1987). Since most math majors become teachers lack of proper remuneration on the one hand prevents them considering that profession and on the other hand propels capable students toward business and computer science positions (Union-News/Springfield, 1987).

A very serious drawback is that an underrepresentation of women and ethnic minorities results in a lack of role models that discourage those groups from taking math in high school (Union News/Springfield, 1987). Tobias (1987) says the number of advanced degrees going to women hasn't changed in the last 15 years and minorities who seek role models in math or math education won't find many because few of the top 10,000 black and Hispanic college freshmen have selected careers in those areas.

<u>Exploring Interests to Help in Decision Making</u>. Students who want to be engineers should spend time finding out if their interests relate to engineering (Marshall, undated). Sometimes arrangements can be made through parents or a counselor to meet with practicing engineers. Groups of students who want to explore engineering careers can get information about how to plan an Engineering Career Exploration Seminar by writing to: Stanley N. Marshall, c/o University of Maine Pulp & Paper Foundation, 217 Jenness Hall, University of Maine at Orono, Orono, ME 04469.

<u>Rewarding Career Opportunities</u>. The same great economy that siphoned off college math professors has contributed to expanded opportunities for women, who now make up about 50 percent of those studying math on the college level (Fowler, 1988). Many opportunities exist to teach math on the college level in a part-time capacity or without doctoral credentials as colleges seek to fill those gaps (<u>2nd AMS Survey</u>, 1986). Of course, a doctorate is still necessary if a woman wants to achieve the rank of professor because, according to this survey, no woman achieved that rank without one whereas some men did. Once women achieve that rank, however, they do as well or better than male professors in obtaining tenure (<u>1st AMS Survey</u>, 1986). Women math majors can also look forward to highly attractive and popular careers in genetic engineering, computer

science, and many well-paid positions in business (Fowler, 1988).

The worth of math skills is obvious to any reader of an article rating the best and worst 250 jobs in the United States, as nine of the top-ten-ranked jobs depend on having good math skills (Daily Hampshire Gazette, 1988).

Adequate Math Preparation is Necessary. Math is so important in all but a few careers that the person who doesn't have it will not be able to advance (Tobias, 1987). On the high school level, Dr. McCollom (1981), who is a professor of engineering at Oklahoma State University, says students wanting a career in engineering should be told in ninth grade that four years each of math and science is the best possible preparation for them. To have too many math courses is better than not having enough math and will guarantee them the greatest number of options. Students who are inadequately prepared spend up to two years of extra time acquiring the coursework necessary to be accepted into a college program of engineering. A plus for students taking several math and science courses is that their rigorousness trains the mind "to analyze logically," an attribute that is useful in any career (McCollom, 1981). On the college level a student will learn the most math and get the best possible preparation by getting a broad undergraduate background before seeking a specialized degree according to Dr. Connors at the University of Massachusetts at Amherst (Fowler, 1988). Menzin and Goldman (1987) say a bachelor's degree in Mathematics is good preparation for jobs ranging from statistics to cryptography as well as teaching and research in math or statistics. A strong background is also called for in computer science, social science, and engineering.

Support

Increasing the numbers of women in nontraditional areas of study and careers will require sensitivity to what is causing the differences and the development of strategies to help women overcome the career barriers (Hitchner, with Tifft-Hitchner, 1987).

The Role of Colleges. Dr. Connors stated in Mass High Tech (1988) that colleges should examine the resources they have and dispense them in the manner best suited to increase the numbers of students (including women and ethnic minorities) who will choose to enter the field of mathematics.

Math Avoidance Programs. Sheila Tobias' early findings linking certain aspects of socialization to female underachievement in math led her to establish a math clinic at Wesleyan University whose purpose was to help dispel math anxiety and attract more women to the field of math (Tobias [1976] as cited in Tobias & Weissbrod, 1980).

In colleges across the country the basic ways developed to deal with math anxiety were remediation, content manipulation (labs, individualized instruction, games, class discussion), coursework and psychological intervention

(Mathison, 1977). Mathison (1977) describes the University of Minnesota model as having four components i.e., diagnosis, classes, anxiety support groups, and tutorials. She found that coursework coupled with psychological counseling showed the greatest success "with a wide range of anxieties and levels of mathematics," while remediation and content manipulation was found to be mostly effective with those who had only low amounts of anxiety. The most important thing to do to assure a successful math anxiety program on the college level is to select faculty who are respectful of and attuned to the problems of those who suffer from math anxiety as they are able to establish the rapport that seems necessary with these students. They, together with other members of the faculty in math and subjects that relate to math, should be sensitive to the special needs of students who are fragile and work cooperatively toward the goal of their continued success. In other words, all the resources of an institution need to be called to the same goal at the very least in an assisting manner for the special work being intensely pursued by an attuned faculty.

The goal in some math anxiety workshops is to create an atmosphere of trust where students don't feel they're asking "dumb" questions (Tobias & Weissbrod, 1980). Sometimes the goal is achieved by sharing fears and frustrations (Donady & Auslander [1979] as cited in Tobias & Weissbrod, 1980). Other times replacing the teacher/student model of the usual classroom with more of an equality-leader-learner model works well (Baylis [1979] as cited in Tobias & Weissbrod, 1980). Still other workshops focus on learning how to manage anxiety, becoming aware of letting go of attitudes that stand in the way of learning, and having the group decide what math problems will be focused on (Tobias & Weissbrod, 1980).

Tobias' (1987) model for dealing with anxiety involves concentrating attention on what is causing the emotional distress rather than trying to solve the actual math problem. It is important to accept that working on the obstacle in this manner is legitimate and equivalent to working on the actual math problem. She found examination of the emotional components in this manner can lead to sufficient relaxation of the anxiety that work on the math problem can resume. The important thing is that the student keeps working rather than quitting (Tobias, 1987).

From information provided by Dr. Doris Stockton, I learned math fearing students at the University of Massachusetts at Amherst can participate in a workshop where they will cover topics such as identifying fears about math, techniques for both more effective study and test-taking methods, and making use of campus resources.

<u>Other College-Based Support Activities</u>. According to Leventman (undated), a number of colleges on the East Coast accept greater numbers of female engineering students than others--MIT, Cornell, Princeton, Brown, Harvard and

Columbia. Some, like Georgia Institute of Technology and Northeastern in Boston, recognize there are special needs on the part of women accepted into programs formerly filled only by men that go beyond just accepting them into the program. They provide good support services and a welcoming atmosphere rather than a you're-here-now-shift-for-yourself-attitude.

Marshall (undated), at the University of Maine at Orono, developed Engineering Career Exploration Seminars. These seminars offer exploratory activities, opportunities for students to meet with engineers, and provide for the distribution of informative materials about engineering specialties.

Engineering career days are hosted by colleges. On a yearly basis the University of Massachusetts at Amherst invites a small number of qualified female students who have an interest in engineering to attend an all day presentation. Along similar lines the student affiliate of the Society of Women Engineers at Western New England College in Springfield, MA sponsors an event that requires no more than an expressed interest and will accommodate a large group. Typically organizers of these career days are concerned with promoting opportunities for women and ethnic minorities and take care to insure that presenters will be representative of those groups.

In California, Math-Science Network workshops were developed for junior and senior high school girls so that they could find out about career possibilities in math and sciences (Tobias & Weissbrod, 1980).

Miscellaneous Support Activities and Advice. Concern about the drop in the number of Americans as well as the percentage of them in relation to other nationals receiving doctorates in the mathematical sciences from U.S. universities prompted a consortium of mathematics organizations to form a committee to study the issue (1st AMS Survey, 1986).

The intent of a slogan contest promoted by The Scientist magazine was to draw attention to the shortage of scientists. After encouraging his students to enter the contest and getting little response, Dr. Connors, professor of mathematics at the University of Massachusetts, Amherst, entered and won. His message, "Sorry, Out of Scientists," was sent as an SOS to Congress, then forwarded to professional science and technological societies in the Washington, D.C. area, as well as research and development corporations. He was given a supply of T-shirts and bumper stickers bearing his slogan to give away and further advertise the shortage (Byrne, 1988).

The Association for Women in Mathematics, Box 178, Wellesley College, Wellesley, MA 02181 is a source for articles and information helpful in promoting an interest in mathematics. They offer memberships ($5 for students, $35 for institutions) which include their bi-monthly newsletter, and their Speakers' Bureau lists women lecturers available in all parts of the United States (Menzin & Goldman, 1987).

Leventman (undated) advises women to join the Society of Women Engineers so that they can benefit from valuable professional networking activities. The Society of Women Engineers also provides information, encouragement, organizes career information days, and administers scholarships.

New student engineers are encouraged by professional women engineers to use them as support systems. In their opinion positive acceptance of women in the field will come slowly over time as a direct result of more women in the profession. They feel valuable coping strategies include going for it if you want it [a career in engineering] by not letting the stereotypes change your behavior, making an effort to blend in with male engineers (make yourself visible) whenever possible rather than going off with whatever few women might be in the class and thereby excluding the men (exactly what you don't want them to do to you), trying to understand the threatened feelings that men express, using the pressure to be better than men (in order to be accepted, recognized, and treated equally) in a positive sense--to be as good as you can be, believing in yourself, and continually striving to grow so that you're not caught up in the negative baggage of others (Elflein, 1985).

The Role of Government and Business in Funding. The role played by government in affirmative action programs connecting the awarding and retention of contracts to a willingness on the part of corporations to seek and hire qualified women has created many well-paid entry level opportunities (Leventman, undated). Dr. Connors gives credit to past government incentives for the successful recruiting of people into certain kinds of teaching and says he would like to see incentives in the form of financial aid to students who would be willing to enter math fields (Union News/Springfield, 1987). Much of the research appearing in this history of literature was funded in 1977 by grants totaling over a million dollars from the National Institute of Education resulting from a conference on Women and Mathematics for further examination of the idea that the lesser abilities shown in math by females was in no way due to their gender (Tobias & Weissbrod, 1980).

A two-year teacher retraining program was conducted at Clark University by Dr. Kevin Cabana with federal funds for the first year and Chapter 188 state funds in the second year (Worcester Sunday Telegram, 1986).

Dr. Connors said corporations and independent research facilities could play an important role in correcting the shortage of math-capable people by creating training opportunities or expanding those they already have for anyone willing to study for advanced degrees in math and create work-study programs to make students aware of opportunities in business (Mass High Tech, 1988).

Interventions in Educational Practice

A wide range of interventions is necessary to correct the inequities that exist. The influence of teacher role and methods, teacher retraining, counselor role, equity-based programs, and evaluation all play a part.

Teacher Role and Methods. Jean Smith (1979) said, "teaching the same math better is not enough" to correct math anxiety. There must be a nonthreatening atmosphere and remediation. The degree of anxiety has to be properly determined before the proper mix of counseling and remediation can be decided or the math anxious student might not experience success. Some examples of a nonthreatening atmosphere: letting students do math in small groups where they will feel free to ask questions or give answers and where they might realize for the first time "math can be a social experience" (Smith, 1979). Allow students to take tests over and over until the desired outcome is achieved to defuse them as anxiety-producing experiences. Let them bring notes and hand calculators to the testing situation. Do word problems daily so they can become more comfortable with them. Have them keep journals about their feelings and frustrations which when reviewed may help them to understand how they create patterns of resistance detrimental to their learning. Help them understand frustration can be viewed on a scale. It can be good (a spur to learning) on one end or bad (shutting the door to trying) on the other end. The first is creative frustration and the latter is destructive frustration. The work of a math clinic concerns itself with having students go in the direction of creative frustration (Smith, 1979). Students should be allowed to spend more time talking, thinking, and writing about the math problems they are solving like a professional mathematician does (Tobias [1987] as cited in Hechinger, 1987). Math textbooks are criticized because they do not reinforce important material through repetitions unlike other subject texts. "They are written like cooking instructions and lack what psychologists call spiral reinforcement: making the same point again at a slightly higher level" (Tobias [1987] as cited in Hechinger, 1987). Tobias (1981) suggests teachers should be looking for persistence rather than speed saying that persistence corrects for the time pressure methods used by teachers and has the added benefit for students that it allows for clearer understanding as well as a solution. Board use can be rewarding to students who perform successfully in front of peers--and will never be humiliating if teachers are careful to never let students sweat it out alone. On the matter of right answers Tobias says students should be rewarded for good thinking as much as for the right answer. If a wrong answer is given and the thinking leading to it is examined valuable learning could take place as well as letting the student know mistakes can be a way of learning, too. She feels it would be much more advantageous to encourage students to work together in small groups, discussing and exploring various ways of solving problems. Focus on process over product allows comparison of answers, learning to experiment, taking risks, and learning new methods--"critical abilities in achieving mathematical understandings." Working or thinking under stress doesn't allow the best climate for doing either one. The teachers who reduce stress in their math programs will help students develop more confidence and help them become better and more capable math performers (Tobias, 1981).

Peterson & Fennema (1985) suggest using activities that are neither competitive nor cooperative, i.e., activities that are gender neutral because they show positive gains for both boys and girls and it would be a way of avoiding the unequal teaching controversy. Other items of importance are recommendations that to maximize female high-level achievement there should be less teacher-approved socialization and to maximize male high-level achievement there should be less off-task time. While both of these activities are nonengagement off-task time is considered disruptive and therefore usually teacher control is attempted whereas socialization is not only permitted it is often promoted by the teacher. Socialization also fits the style of learning of girls more than is the case with boys who already have independent learning styles and therefore are not affected one way or another by teacher allowed socialization (Peterson & Fennema, 1985).

Suggestions to reduce gender-related differences (Fennema & Peterson, 1987) include: spend more time in cooperative activities than competitive ones, increase interactions with girls on high-level cognitive activities and praise them more, keep both sexes equally on task, raise female expectations by encouraging independence, and demanding higher levels of participation and strong performance of high-level tasks. The authors believe if teachers encourage the new behaviors it will lead to changed belief in the girls' self-perceptions and their math will improve.

It will be remembered that Weissglass (1975) emphasizes students will learn better if they feel good. This doesn't mean teachers have to take on the role of counselors but he does feel that to successfully minimize the effects of distress they must be aware not to underestimate how these feelings can hinder learning. He suggests five ways teachers can make students feel good and have confidence.

1. Use peer learning. It dispels fear of criticism and authority. Inadequacy feelings disappear when a student in the role of teacher gets a point across to a peer.
2. Have a friendly classroom. Let students share outside experiences. It refocuses attention away from their own problems and frees their attention up for learning. An added benefit is they get to

know each other better and possibly like each other more.

3. Structure situations to foster the positive verbal expression of each other's contributions to the class to dispel insecurities experienced by even the most capable regarding their abilities. This provides opportunities to correct misconceptions that math is difficult or females can't do math.
4. Let students choose what and when they learn. It dispels frustration and anger associated with something they have no interest in learning.
5. Promote self-evaluation of their progress unless asked to evaluate them. It dispels anxiety they have about being evaluated and enhances their ability to trust their own judgment.

The true learning Weissglass (1985) is concerned with takes place when the student is ready to assimilate the new material being presented with what he/she already knows. If this doesn't occur students who have difficulty understanding new material may recall other experiences when they couldn't grasp something and the two experiences together will lead to depressed feelings about their ability to learn. He has three suggestions for keeping the motivation and attention of the student alive.

1. A learner-controlled rate of presentation of new material is guaranteed through one-on-one learning. This means peer learning, too, since

the teacher couldn't possibly provide this for the whole class.

2. Encourage questions so there will be a quick correction of newly presented material.
3. Supply the missing context (if future elementary teachers have the fundamental mathematical experiences they missed as children then that will provide them with the context needed to understand abstract concepts and help see why it is important not to distress children by asking them to memorize techniques).

Effects of Causal Attribution on Females Can Be Changed. In one study conducted by Cabana (1985) investigating math anxiety and its interaction with perceived control there was no greater anxiety on the part of females as compared to males whereas in nearly all other studies it has proved to be a sex-related difference. It was concluded it might be due to the fact that pressure to perform was more important among these girls than gender because in this private school everyone came from a good socioeconomic level where parents were professionals with high expectations. Social class in this instance seemed to be of greater significance. The anxiety exhibited by both sexes was, therefore, attributable more to issues of perceived control. It would seem parents aware of this information could effectively get higher achievement from their female children by exerting some pressure and having higher expectations.

In another study by Cabana (1986) where he determined the causal attribution patterns of female adult learners and provided the type of learning situation most suitable to their pattern, i.e., more teacher control for those who credited their success to external reasons and less teacher control for those who credited their success to ability, they achieved more and had less anxiety. He proved that teacher awareness of differences in learners needs when put together with methods determined by those needs will result in more success for learners.

<u>Math Improvement Programs</u>. While Peterson and Fennema (1985) conclude sex related differences in classrooms are not easy to see--in their experience they have not been obvious--they do feel classroom activities point to "different influences on girls' and boys' learning of mathematics." They suggest that "experimental studies of the effects on girls' and boys' low-level and high-level mathematics learning when the frequency of certain mathematics activities (e.g., competitive or cooperative) is manipulated" might prove fruitful.

Fennema & Peterson (1987) suggested examining teacher behaviors in relation to learning gains for students as a way of eliminating inequities. Teacher behaviors that result in the greatest gains are judged important in increasing learning. In the second stage of the experiment new teachers are taught to use the behaviors and they are observed with a new set of students to see if increases in learning take place.

Dr. Kevin Cabana of Clark University conducted a two-year program for improving math instruction by retraining math teachers and building "their technical awareness of calculus, statistics, and computing" (Worcester Sunday Telegram, 1986).

Worcester teachers from public and private schools who participated in that program examined curricula and methods and returned to their schools with a new sense "of the importance of a strong foundation in mathematics to achieving success in college." After the first session in Dr. Cabana's program, teacher participants from Doherty Memorial High School and South High Community School (two of the eight schools whose teachers attended the seminar) were able to quadruple the numbers of seniors in their respective schools taking senior math classes.

In October, 1987 because of my interest in increasing the numbers of students, especially those who are typically underrepresented, i.e., women and ethnic minorities, I called Dr. Cabana to ask a few questions about his program:

1. When they increased the size of the classes was it in the same proportionate numbers--men to women to minority?
2. If so, what did it accomplish?
3. Did the new participants get good grades?

Dr. Cabana explained that they were not looking expressly for what I was asking about. However, he stated that the increase in numbers did significantly increase the numbers of women and minorities participating. In regard to the question about performance he stated that "performance [on the part of newcomers] was at least as good as those previously in those classes." He indicated that "the support system for extra help in this context [program] was more frequent than in the ordinary situation." He also added that "more onus was put on and accepted by the instructor" for the student's success.

Originally, Eiseman (1986) planned a math improvement program that would start with identifying math teacher behaviors related to high student achievers in secondary math similar to the process-product project of Fennema & Peterson (1987). This approach of linking teacher behaviors was simple, logical and supported by solid research (Good, Grouws, & Ebmeier [1983] as cited in Eiseman, 1986). However, he rejected the idea for several reasons: elementary studies were predominant, connections between behaviors and student achievement were weak, intervening variables weren't considered, and results were of limited usefulness because of complex statistical interaction effects. Other negative considerations entering into his decision were workability of such programs is limited by teachers who resent using behaviors developed by alleged master teachers and there is no guarantee that behaviors originating with excellent teachers can be successfully repeated by average teachers.

As a result of Eiseman's careful and thoughtful scrutiny of prior research he settled on the viewpoint embraced by Leinhardt that cognitive processes--connections between teacher thinking and teacher actions--were more valid in explaining the success of teachers who excel at helping students achieve at high levels than a precise means of achieving the goal by imitating behaviors of other teachers (Leinhardt & Greeno [1986] as cited in Eiseman, 1986). His program's focus, therefore, concentrates on having teachers reflect on their own process as they encourage student learning, thereby increasing their own competence. Another important aspect is that this should be an ongoing "comprehensive" process that implies the "teacher should foster growth along 'all' the highly valued developmental dimensions in 'all' identifiable student populations."

For Eiseman (1986) a change in students in whatever positive directions are determined desirable is central to the idea of excellence in teaching. Ways of measuring the degree of success of a teacher's efforts in the ongoing development of change in students that were determined desirable is also a necessary part of that excellence.

Eiseman's list (1986) of most valued changes in student growth includes that students will:

- view their success as related to their ability
- view math as useful throughout their lives
- have greater degrees of comprehension regarding how the mechanics of math work
- be able to see basic similarities among the various problems they encounter to help them solve new problems
- have competence in skills and problem solving
- use intuition, prior knowledge, creative-deduction reasoning, and careful checking as part of their process
- enjoy the process while improving in math
- show confidence and rely on their own intellects.

Teachers in pursuing excellence will:

- strive to use their skills to achieve growth equally with minority or majority students, the economically disadvantaged or advantaged, whether male or female, and across all ability levels
- have an interest in the literature of what teaching and learning math is about
- review theory and research to keep abreast of significant and/or new material as it might apply to the student growth changes they seek
- be involved in ongoing curriculum development especially as it applies to their own course of study

- have a commitment to ongoing, critical examination of their methods
- rewrite lesson plans to reflect the needs of today's society and the valued changes.

Because Eiseman felt value changes might receive more efforts by teachers than equity goals aimed at equal education of all segments of student populations he devised what he calls a "matrix success pattern." This pattern lists the valued changes down a left column and the populations across the top of the page. As teachers address each of the valued changes with the respective populations they can check off areas of success.

This record serves teachers as a personal evaluation record of their progress toward the excellence in teaching model, i.e., a matrix full of columnar checks would mean 100 percent success has been achieved.

The objective of the program according to Eiseman (1986) is to help teachers come the closest they can to fulfilling the "five criteria of excellence." Starting the program for teachers in the summer would allow for maximum and uninterrupted time to be spent learning the basics of the program. Once school starts in the fall a follow-up series of meetings would be held extending throughout the school year to provide a forum for an ongoing exchange of ideas and sharing of results, feedback, and support. The format of the program also includes teacher self-assessment as well as teacher-peer assessment aspects, i.e., via a participatory form of evaluation using the matrix that is less threatening and more useful. The format also calls for the program's leaders to be responsible for guiding participating teachers through all stages of the program.

Other Education Recommendations. Weissglass' (1975) thesis that learning math should be pleasurable for students implies that their teachers know those pleasurable experiences from firsthand experiences. Therefore, the responsibility for the success of making it possible for elementary and secondary teachers to make mathematics learning a pleasurable experience for their students rests on those who are the teachers of future teachers.

Dr. Connors (Union News/Springfield, 1987) said junior high is the place to start looking for and encouraging talented students to make a decision to study math in high school. And, because they are very underrepresented, women and ethnic minorities should be especially encouraged. While it is not his intention to oversimplify the problem of attracting high school students to study math he suggests a beginning might be made by offering good high school teachers more money and encouragement (Buffalo News, 1987).

Regarding good teachers he says it is as important for them to be inspirational role models as it is for them to be expert if we are to expect high school students to choose math in college as there have been indications that talent in the subject does not seem to be enough (Buffalo News, 1987).

Dr. Lallement suggests that the way to correct the deficiencies of those teaching math on the elementary and secondary level is to require education majors who become teachers of math to take the same courses required of math majors. That way, teachers would know their subject in depth, and therefore, it is assumed, do better teaching it and in inspiring students to study mathematics later in their lives (Fowler, 1988).

Recommendations for Counselors. Hitchner with Tifft-Hitchner (1987) in some of their suggestions see a more than ordinarily active role for counselors--their list of things to do is below:

- point out [to girls] that many tech careers have a great deal of flexibility--flextime, can be part-time, working at home, and, contrary to expectations would fit in very well with family life
- counteract societal pressures, beliefs, suggest girls should be appreciated and rewarded for academics at least as much as for homemaking skills
- foster hope and confidence toward nontraditional careers early on, encourage exploration using sex-fair materials designed to correct age-old discriminatory, biased materials found in the usual visual materials

- develop a course on the dangers of sex-role socialization
- encourage nontraditional shadowing experiences
- develop a speakers bureau of women working in nontraditional occupations
- have in-service experiences that expose counselors to technological careers on a first-hand basis because while studies indicate counselors don't, in general, have bias against women in nontraditional careers exhibiting a neutral or positive attitude alone aren't enough--active encouragement is needed to make a difference
- "Say to bright girls--have you ever thought about a nontraditional career for yourself? Do you know what that means?"

Need for Evaluation. All interventions have to be critically evaluated. If they are not, practices could lead to false conclusions as to their worth contributing to "careless and irresponsible" conclusions about 'math cures' (Tobias & Weissbrod, 1980).

Advice for Students, Parents, and Teachers. In explaining why Asian students achieve better in math than Americans, Tobias (1987) states the differences might be due more to attitudes and effort than ability. She explains that Asians believe they are all about equal in their ability to learn math and that effort is the key to their success--so they are persistent and work hard. Americans believe you either have the ability to do math or you don't. It doesn't matter how hard you try--so they give up without investing much effort. And, Tobias believes the excitement of learning college level math can't be separated from hard work (Tobias, 1987). If four years of math were required of everyone in high school much of the difference in achievement between the sexes would be gone (Fennema [1976] as cited in Tobias, 1978).

If significant adults (teachers, parents) were to take an enlightened position about how the socialized role of females prevents achievement, they could be actively involved in providing awareness and encouragement to girls toward participation in nontraditional subject areas and career exploration because how these people feel is important to a girl's view of self--her dependency needs (Fennema & Peterson, 1985). This doesn't involve changing the socialized role so much as it does changing attitudes that bear upon it. If the people a girl usually seeks the approval of take an active role in encouraging the nontraditional they are saying in effect that it is all right for her to seek validation through what the culture has identified as male--something she needs to help overcome the disadvantageous position for females in a male-dominant culture.

CHAPTER III

METHOD

The major purpose of this study as described in Chapter I was to get a greater level of commitment to study higher levels of math from students exposed to three presentations whose purpose was to increase both their knowledge of specific facts concerning math and their awareness of the importance of math to their futures. Other goals were to assess differences, if any, in six areas: acquisition of factual knowledge, actual levels of math studied, planning soundness (ability to appropriately match minimum math needs to post-high school plans), preferred sources for seeking career information, information about math requirements for various purposes, and career counseling.

This study had its roots in several separate but related factors. Typically students who enter our high school come from feeder schools with a schedule of courses planned by the feeder school with options (not always taken) for input from them and their parents to review the selections. Traditionally, recommendation for the math course is based on a student's 6th grade achievement test scores and math class performance. Logically, it should be reasonable to conclude that if the selections according to these criteria are well done, a high success rate of students in these prearranged math groupings should result. However, in my position as a high school counselor I observed that while many were successful more than a few barely passed or failed. Since some of the professional readings I had read were critical of the use of tests for this type of placement, citing an unfairness to those who are culturally different, I began to wonder about those who had been denied the opportunity to try because of low scores on achievement tests and/or performance. These thoughts led me to do a pilot study tracing the math history of the North High Class of 1988 to see just how often the traditional criteria were successful determinants of success. My thoughts were that if we are ever going to be able to recruit more females and minority males or increase numbers generally for advanced math classes, we might have to look for ways to include students rather than exclude them. Informal discussions with colleagues that I have been involved in about possibly eliminating the present methods of course selection have usually met with objection. Arguments used to justify retention of the traditional criteria are (a) that they are the best indicators available of a student's ability and readiness and (b) that thoughts of eliminating them in the interests of fairness would mean certain chaos in the selection of class members to group together for the purpose of the most effective teaching and learning in any given math class. Arguments that some students do poorly and/or fail anyway despite the best efforts at proper placement had been met by counterarguments that laid the blame on causes such as failure to do homework, lack of attention, loss of interest, poor motivation, or poor attendance; such counterarguments suggest that it is students themselves who control their success rather than any system that is in place to select them. In any case, students who come close to failing or do fail request a change to a lower level class or stop the study of math if they can. I also discovered that some students who had low scores on achievement tests including female and male minorities did succeed in higher levels of math, some who had high scores and should succeed with ease including white males did not. Furthermore, about half of the Class of 1988 had students studying higher levels of math who came to us from other school systems, in and out of state, from foreign countries, from schools that were parochial, trade and technical, and from other private schools. These students sometimes lacked placement data altogether, or had tests whose results were difficult to compare with our achievement tests and therefore would be pretty meaningless to assist in grouping. Others came from schools where the only apparent criteria used was a desire on their part to take the course. Only some of these passed. It also seems that those who have strong motivation--whether they have low scores or high scores--will succeed, and those who have lower scores would benefit from nurturing and a plan that would increase their motivation. The upshot of this, for me, was that as educators we might be looking for the right answers in the wrong places and we were being unfair to students in the process. The unfairness I am talking about is not associated with absolving students of the responsibility of having a hand in their success, but, rather that we should show more of a responsibility to help them access their motivation.

My approach, therefore, sought to develop strong motivation on the part of the student through knowledge, self awareness, and awareness of the importance of math to their futures. I believe that those who have an internal motivation to do something rather than an external motivation will oftentimes try harder to succeed.

Sample

The original sample for this study (members of the Class of 1990 and the Class of 1991) consisted of 159 students who were studying Algebra 1 or geometry at North High School at the start of school in September, 1987.

Design

I selected a Solomon Four-Group Design which when used with random selection seemed to protect against a variety of threats to internal and external validity (Lehmann/Mehrens, 1971). This design, wherein one experimental group and one control group are given a pretest and all four (two experimental and two control) groups are given a posttest, would allow me to determine if there was a pretest effect of my questionnaire. The first step was to arrange the names of the students in alphabetical order and assign them numbers from 100 to 259 to allow for anonymous and random assignment to one of the four groups of the design. I used the random digits tables from Minium (1970) and Edwards (1972) to come up with all of the numbers assigned to the alphabetical list of students. Their assignment to groups to the Random Selection Worksheet (Appendix A) was completed as follows:

Numbers were assigned from left to right until all numbers came up, i.e., I found 113 and assigned it to Control, Col. 1, then 148 and assigned it to Experimental, Col. 1, then 155 and assigned it to Control, Pretest, Col. 1, then 253 and assigned it to Experimental, Pretest, Col. 1, back to Control, Col. 1 proceeding to 20 students in each Col. 1 before moving on to Col. 2 in each of the groups. This distribution resulted in Table 1.

Table 1

Solomon Four-Group Random Design Totals
By Groups and Subgroups

	Control	Experimental	Control Pretest	Experimental Pretest	Totals
	15WM 5MM 20F	11WM 2MM 27F	15WM 2MM 22F	10WM 6MM 24F	51WM 15MM 93F
Total=	40	40	39	40	159

Key: WM=White Male, MM=Minority Male, F=Female

I then carried the process two steps further because:

1. I needed a stratified sample as I was looking for information specifically regarding females and minority males.
2. I wanted more students in the experimental groups (E and E1) as opposed to the control groups (C and C1) since students who missed either of the panel presentations (one-time only events) had to be dropped from the research.

The adjustment in distribution of numbers as a result of this manipulation was C=34, C1=35, E=45, E1=45 for a total of 159.

To create the stratified sample, I shifted white males, minority males, or females as needed to other groups starting with the first in a category as needed until I balanced the groups. This necessitated shifting a total of 13 students. The stratified sample distribution appears in Table 2.

Questionnaire

The questionnaire (Appendix B) was designed to get responses that test knowledge of the usefulness and importance of math to a student's personal, educational, and career goals. There were questions about values (liking their work versus being well paid for what they do) and the problems that they recalled in their study of math, about how much math they planned to study, and what their plans

Table 2

Solomon Four-Group Random, Stratified, and Balanced Design Totals by Groups and Subgroups

	Control	Experimental	Control Pretest	Experimental Pretest	Totals
	11WM	15WM	11WM	14WM	51WM
	3MM	4MM	3MM	5MM	15MM
	20F	26F	21F	26F	93F
Total=34		45	35	45	159

Changes that were made can be clearly seen by referring to the Random Selection Worksheet (Appendix A).

were beyond high school; and concerning the participant's knowledge of specific math facts, including knowledge of course content, the sequence of study, prerequisites to other math courses and certain science courses, knowledge of requirements for high school graduation, minimum and selective college entrance, and Regents Units for State colleges. Questions also involved the preference and order of use of several readily available resources (people who would provide help) when students needed information regarding their educational and career goals.

Presentations

There were three presentations hereafter referred to as the treatment which was given to the experimental group who did not take a pretest (E) and the experimental group that took a pretest (E1) hereafter referred to as the target group. The intent of the treatment was aimed at getting students to commit to a longer duration of math study; the method for accomplishing this was through a series of three student-centered experiences. These experiences, with their personal focus, were designed to help them develop internal reasons for going further in math than they would otherwise. This was accomplished by providing a knowledge base needed in decision making, focusing on personal awareness issues made relevant through interactions with the career panel, and, finally, by making students aware of methods for achieving their career goals through exposure to the educational panel.

The first presentation, Curriculum Information/ Strategies (Appendix C) was presented by me to the target group. Information was personalized through general discussion, by mentioning sources of student assistance, by comments that helped to sort through the maze of translating the wish for help to the reality of getting help, and through discussions of options available to them given specific problems. In short, the presentations provided essential information needed to maximize a student's high school study of math on a personal level. This gave them information it takes most students their four years in high school to acquire. Each student was given a packet to keep for reference at the end of the presentation. For an abbreviated version of the contents see (Appendix D).

Since it is well known that students more often accept information shared with them by people from outside school, my plan took that factor into consideration through the use of panels consisting of people from outside the school.

The second presentation to the target group was made by the Career/Math Relationship Panel. After being introduced by me, the panel, using guidelines I suggested (Appendix E) presented anecdotal materials about their personal career development and how math fit into that picture. The opportunity for interaction with people students could relate to as role models hopefully provided them with inspiration and meaningful reasons to regard math as important in their lives and careers.

The third presentation to the target group was made by an Educational Goals/Math Relationship Panel. After being introduced by me, the panel, using guidelines I had suggested (Appendix F) presented material about their programs and admissions, and how math related to both. Once again students were given an opportunity to interact with people who shared information with them about how to put it all together to realize the educational goals necessary to accomplish their career goals.

There were three premises underlying the treatment:

1. Students who had a greater knowledge of the specific facts surrounding math study given in the first presentation (Curriculum Information/ Strategies) would do better because they were better informed.

2. Students who heard the second presentation (Career/Math Relationship Panel) would raise their career expectations as a result of being exposed to successful individuals they could identify with as role models.

3. Students who heard the third presentation (Educational Goals/Math Relationship Panel) would decide on more advanced math study and longer schooling especially if they changed career expectations that called for more math preparation as a result of interaction with the Career/Math Relationship Panel.

Plan

Prior to any presentations I met with the students studying Algebra 1 and geometry in June of 1988 at North High School. This meeting was to briefly introduce my project to them and explain that their participation was completely voluntary. They were asked to sign their names and indicate an intention to participate or not to participate on the PARTICIPATION PERMISSION FORM (Appendix G). This resulted in 110 who agreed to participate and 33 who declined to participate for a total of 143. Of the original 159, 16 had either left or changed to other math classes not appropriate to the study.

Students from one control group (C1) and one experimental group (E1) were asked to take the questionnaire as a pretest. Students from the two experimental groups (E, without the pretest and E1, with the pretest), or the target group of students, were given the three presentations for the purpose of increasing the numbers of students (especially female and minority male) who would complete math through calculus.

Students from all four groups (control without pretest (C), control with pretest (C1), experimental without pretest (E), and experimental with pretest (E1) were given the questionnaire as a posttest.

Data Collection

The questionnaire was used as a pretest and as a posttest to collect student responses to knowledge-based questions, intended level of math study, post-high school plans, preferences for career information, and preferences for information about math requirements for high school, college, and career. Responses were then transferred to tally sheets for ease of visual reference. Knowledge-based questions were scored and some items were keyed. These variables were then further coded so that the information could be computer input for statistical analyses.

Data Analyses

The SPSS-X Program was used for analyses of the data collected. An analysis of variance was run to test for a pretest effect of the questionnaire used for data collection. Since the analysis of variance was significant at the .05 level the two groups (C1 and E1) that were given the pretest were excluded from all further analyses. Stratification of the sample was undertaken so that separate analyses of each subgroup could be made. Unfortunately, the minority male sample was not sufficient (N=5) to run any statistical analyses, so no results are reported for this subgroup. However, all hypotheses were analyzed separately for the female subgroup.

For the first three research questions t-tests were run to compare the experimental group in general (including the male minority subgroup and the female subgroup) to the control group in general (including the male minority subgroup and the female subgroup) on each of the variables. This was also done for the female experimental subgroup compared to the female control subgroup. None of the t-tests were significant at the .05 level.

The remaining four research questions were tested by using the chi-square statistic. For questions 4, 5, and 6 the results of the analysis were not significant at the .05 level for the experimental group as a whole or for the female experimental subgroup. The results for question 7 were significant at the .05 level for the experimental group in general. As in every other instance results for the female experimental subgroup were not significant at the .05 level. Results of the data analysis are reported in summary and tabular form in Chapter IV, RESULTS.

Summary

In this chapter, the topics contained in the research questions have been stated. A pilot study leading to this study and the philosophy behind my approach were outlined. The original sample of 159 students studying Algebra 1 and geometry in September, 1987 was described. The Solomon Four-Group Design where one control group and one experimental group could be given the questionnaire as a pretest and all four groups (two experimental and two control) could be given the questionnaire as a posttest was described. The process of random assignment of the 159 students to one of four groups and further modifications to allow for a 7/16 balance of control groups and a 9/16 balance of experimental groups to compensate for those who might miss either panel presentation (one-time events) was detailed. A description of the questionnaire explaining various items used to test student knowledge of specific math facts, intended level of math study, post-high school plans, attitudes, values, and preferences for seeking information for careers, and math requirements for high school graduation, college entrance, and career counseling was provided. The three presentations, their purpose, and the premises underlying them which formed the treatment for the target group were described. The plan detailing the sequence of events from the initial meeting with students to describe the project and their voluntary participation, to pretesting, to presentations, to posttesting was presented.

Treatment of the data collected from the questionnaire as pretest and posttest is described. Finally, the use of three statistical tests: an analysis of variance to test for a possible pretest effect, t-tests for comparison of experimental and control groups on the first three research questions, and the chi-square statistic to test the remaining four research questions was described.

CHAPTER IV

RESULTS AND DATA PRESENTATION

The goal of this study was to increase the numbers of female and minority male students who are underrepresented in advanced mathematics classes as well as the overall total of students who would commit to studying mathematics through calculus.

Seven research questions were investigated to determine the effect of the treatment on the experimental group (E and E1):

1. Will the experimental group have higher scores on knowledge-based questions (specific factual knowledge concerning math) than the control group?
2. Will the experimental group show more intention to study higher levels of math than the control group?
3. Will the experimental group actually study higher levels of math than the control group?
4. Will the experimental group demonstrate greater planning soundness than the control group (as evidenced by their ability to appropriately match minimum math needs to their post-high school plans)?
5. Will the experimental group select counselor as preference for career information more often than the control group?

6. Will the experimental group select counselor as preference for information on required mathematics courses more often than the control group?

7. Will the experimental group select school personnel as preference for career counseling more often than the control group?

The data presented in this chapter was collected on a questionnaire from 110 students studying Algebra 1 or geometry who were randomly assigned to one of four groups in a Solomon Four-Group Design. The questionnaire contained several items that would test specific facts concerning math: knowledge of course content, sequence of and prerequisites for other math courses and some sciences, requirements for high school graduation, Regents Units, and college entrance. Other items were intended level of math study, post-high school plans, and preferences (friends, parents, counselors, teachers, aides, other) when seeking educational and career information or career counseling.

There were three statistical procedures used to analyze the data collected on the questionnaires:

1. An analysis of variance was run to test for a pretest effect of the questionnaire.
2. For the first three research questions t-tests were run to compare experimental and control groups on each of the variables.
3. The remaining four research questions were tested by using the chi-square statistic.

The Solomon Four-Group Design, wherein one experimental group (E1) and one control group (C1) were given a pretest and all four groups--two experimental groups (E and E1) and two control groups (C and C1)--were given a posttest allowed me to determine if there was a pretest effect. An analysis of variance was run in order to test for this effect. Table 3 shows that F for the pretest effect = 2.819, p = .034. Since this is significant at the .05 level, it was concluded that there was a pretest effect. Therefore, the two groups (E1 and C1) who were given the pretest were excluded from all further analyses.

Table 3

Analysis of Variance Testing for Pretest Effect

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Pretest	730.867	15	48.724	2.819	.034*
Group	104.265	1	104.265	6.033	.029
2-Way Interactions					
Pretest by Group	108.652	10	10.865	.629	.766

*Significant at the .05 level.

In addition to random assignment of students to each of the groups in the design, a modification was made to balance the numbers of females and minority males in each group. This stratification of the sample was undertaken so that separate analyses of each of these subgroups could be made.

Unfortunately, the minority male sample was not sufficient (N=5) to run any statistical analyses, therefore, no results are reported for that subgroup. However, all hypotheses have been analyzed separately for the female subgroup.

Discussion of Results

As a direct consequence of presenting factual information about high school and post-high school mathematical course requirements, information on the sequence of courses, and course prerequisites to the experimental group, I hypothesized that this group would have higher scores than the control group when answering the 10 knowledge-based questions on the questionnaire. A t-test was run in order to compare the experimental group (E) and control group (C) on this variable. The results of this analysis are shown in Table 4. The t-test was not significant at the .05 level. Therefore, the treatment did not have the hoped-for effect of increasing the factually useful knowledge of the experimental group in general (including the female subgroup and the minority male subgroup) when compared to the corresponding control group in general.

This hypothesis was also tested for the female experimental subgroup using a t-test. The results are reported in Table 5. This analysis is not significant at the .05 level. Therefore, as with the experimental group in general, this treatment did not increase the factual

Table 4

Comparison of Experimental and Control Groups
on Knowledge-Based Questions

Posttest Group	# of Cases	Mean	Standard Deviation	Standard Error	Pooled Variance Estimate: t Value	Pooled Variance Estimate: Degrees of Freedom	Pooled Variance Estimate: 1-Tail Probability
Experimental	28	13.4286	5.329	1.007	.77	49	.223*
Control	23	12.2609	5.471	1.141			

*Not significant at the .05 level.

Table 5

Comparison of Experimental and Control Groups
on Knowledge-Based Questions Females Only

Posttest Group	# of Cases	Mean	Standard Deviation	Standard Error	Pooled Variance Estimate: t Value	Pooled Variance Estimate: Degrees of Freedom	Pooled Variance Estimate: 1-Tail Probability
Experimental	18	12.3889	5.710	1.346	.98	29	.167*
Control	13	10.5385	4.274	1.185			

*Not significant at the .05 level.

knowledge for the female experimental subgroup when compared to the female control subgroup.

As a second hypothesis, I felt that the experimental group who underwent the three presentations:

- Curriculum Information/Strategies
- Career/Mathematics Relationship Panel
- Educational Goals/Mathematics Relationship Panel

  would make more of a commitment to studying higher levels of mathematics than the control group who received no treatment.

A t-test was run in order to compare the experimental group in general and the corresponding control group on this variable. The results of this analysis are shown in Table 6. Since the t-test is not significant at the .05 level, it was concluded that the treatment had no effect on raising the levels of mathematics that students were willing to study for the experimental group in general compared to the corresponding control group in general.

This hypothesis was also tested for the female experimental subgroup. The results are shown in Table 7. Since the t-test is not significant at the .05 level, the female experimental subgroup did not show any greater inclination than the female control subgroup to commit to the study of higher levels of mathematics.

A major hypothesis was that the experimental group who underwent the three presentations would in fact actually study higher levels of mathematics than the control group

Table 6

Comparison of Experimental and Control Groups
Intention to Study Higher Levels of Mathematics

					Pooled Variance Estimate		
Posttest Group	# of Cases	Mean	Standard Deviation	Standard Error	t Value	Degrees of Freedom	1-Tail Probability
Experimental	28	3.1071	1.100	.208	-.57	48	.284*
Control	22	3.2727	.883	.188			

*Not significant at the .05 level.

Table 7

Comparison of Experimental and Control Groups
Intention to Study Higher Levels of Mathematics Females Only

					Pooled Variance Estimate		
Posttest Group	# of Cases	Mean	Standard Deviation	Standard Error	t Value	Degrees of Freedom	1-Tail Probability
Experimental	18	3.0556	.998	.235	-.08	28	.470*
Control	12	3.0833	.900	.260			

*Not significant at the .05 level.

who received no treatment. A t-test was run in order to compare the experimental group in general and the corresponding control group on this variable. The results of this analysis are reported in Table 8. They are not significant at the .05 level so the treatment was not instrumental in affecting the mathematics-studying behavior of the experimental group in general when compared to the corresponding control group.

As shown in Table 9, the hypothesis that greater numbers of females in the experimental subgroup would actually study higher levels of mathematics than females in the female control subgroup was not significant at the .05 level either. Additionally, it should be noted that the control subgroup in this instance is a bit small which may have affected the stability of the t-test.

As a secondary hypothesis, I was interested to see if the treatment group would have higher scores in planning soundness. I defined planning soundness as the ability to make an appropriate minimum match of intended level of study of mathematics to post-high school plans. This hypothesis was tested using the chi-square statistic. The results of this analysis are reported in Table 10. Since the results were not significant at the .05 level, the treatment group did not demonstrate an ability to more accurately or efficiently plan the amount of mathematics they would need for the educational plans that they had in mind. A glance at the figures in the table indicate, however, that greater

Table 8

Comparison of Experimental and Control Groups
Actual Levels of Mathematics Studied

Posttest Group	# of Cases	Mean	Standard Deviation	Standard Error	Pooled Variance Estimate t Value	Pooled Variance Estimate Degrees of Freedom	Pooled Variance Estimate 1-Tail Probability
Experimental	24	2.9167	1.176	.240	-.92	39	.183*
Control	17	3.2353	.970	.235			

*Not significant at the .05 level.

Table 9

Comparison of Experimental and Control Groups
Actual Levels of Mathematics Studied Females Only

Posttest Group	# of Cases	Mean	Standard Deviation	Standard Error	Pooled Variance Estimate t Value	Pooled Variance Estimate Degrees of Freedom	Pooled Variance Estimate 1-Tail Probability
Experimental	15	2.9333	1.100	.284	-.15	21	.443*
Control	8	3.0000	.926	.327			

*Not significant at the .05 level.

Table 10

Chi-Square Comparison of Experimental and Control Groups
Planning Soundness Variable

Group	Less Than Minimum Match	Minimum Match	Exceeding Minimum Match	Totals
Experimental	1	16	11	28
Control	3	15	4	22
Totals	4	31	15	50

X2=3.632

Critical value of X2 with 2 degrees of freedom at .05 significance level is 5.99. Since 3.632 does not exceed this value, it is not significant at the .05 level.

numbers were on the side of exceeding the minimum than not meeting it which I consider an error in a positive direction. The fact that the experimental group in general and control group in general do not differ on this variable seems to be the result of the control group performing better than expected rather than the experimental group performing worse than expected.

This hypothesis was tested separately for the female experimental subgroup, again using the chi-square statistic. The results are reported in Table 11. The results were not significant at the .05 level. As in the case of the experimental group as a whole, more erred in the direction of exceeding the minimum mathematics needed for their career

Table 11

Chi-Square Comparison of Experimental and Control Groups
Planning Soundness Variable
Females Only

Group	Less Than Minimum Match	Minimum Match	Exceeding Minimum Match	Totals
Experimental	0	13	5	18
Control	2	8	2	12
Totals	2	21	7	30

X2=3.413

Critical value of X2 with 2 degrees of freedom at .05 significance level is 5.99. Since 3.413 does not exceed this value, it is not significant at the .05 level.

interests than planned for too little when they were compared to the corresponding control subgroup.

Another secondary hypothesis states that the treatment group would choose a counselor to provide career information in preference to teachers, work experience counselor, guidance aide, friends, parents, or the library more often than the control group would. This hypothesis was tested using the chi-square statistic. Results are shown in Table 12. This result was not significant at the .05 level, therefore the treatment was not effective in persuading the experimental group in general to use guidance services for this information when compared to the corresponding control group. Because an emphasis is placed on the role of the guidance counselor in providing career information in the

Table 12

Chi-Square Comparison of Experimental and Control Groups Counselor as Preference for Career Information

Groups	No	Yes	Totals
Experimental	18	10	28
Control	13	10	23
Totals	31	20	51

X2=.318

Critical value of X2 with 1 degree of freedom at .05 significance level is 3.84. Since .318 does not exceed this value, it is not significant at the .05 level.

Curriculum Information/Strategies presentation, it can only be assumed that a good deal more must be done to encourage use of guidance facilities for career research.

Again, this hypothesis was tested for the female experimental subgroup. Results are reported in Table 13. This chi-square statistic is also not significant at the .05 level. This is consistent with the figures reported for the experimental group as a whole in Table 12.

A third secondary hypothesis of interest was that the treatment group would seek a counselor as a source of information regarding mathematics requirements for high school, college, and career needs more often than students in the control group. Again, the chi-square statistic was used to test this hypothesis. Results are shown in Table 14. This statistic is not significant at the .05 level

Table 13

Chi-Square Comparison of Experimental and Control Groups
Counselor as Preference for Career Information
Females Only

Groups	No	Yes	Totals
Experimental	13	5	18
Control	7	6	13
Totals	20	11	31

X2=1.117

Critical value of X2 with 1 degree of freedom at .05 significance level is 3.84. Since 1.117 does not exceed this value, it is not significant at the .05 level.

Table 14

Chi-Square Comparison of Experimental and Control Groups
Counselor as Preference for Information
on Required Mathematics Courses

Groups	No	Yes	Totals
Experimental	6	22	28
Control	3	20	23
Totals	9	42	51

X2=.612

Critical value of X2 with 1 degree of freedom at .05 significance level is 3.84. Since .612 does not exceed this value, it is not significant at the .05 level.

either. The conclusion, once again, is that the experimental group in general was no more apt to seek a counselor for the information than students in the corresponding control group. However, the chart does show that both groups do use the services of guidance counselors for such questions more often than not.

For the female experimental subgroup the results of the chi-square testing this hypothesis are reported in Table 15. Again, this analysis was not significant at the .05 level. As previously noted with the experimental group as a whole in Table 14, however, more students from both the female experimental subgroup and its corresponding female control subgroup would choose a counselor for this information than would not.

Finally, it was hypothesized that the treatment group would preferentially seek out school personnel--i.e. a counselor, teacher, work experience counselor, or guidance aide--as a source for career counseling more often than students in the corresponding control group. The results of this chi-square analysis are reported in Table 16. This result _is_ significant at the .05 level. Viewing the chart, it can be seen that everyone in the experimental group in general when compared to the corresponding control group selected someone from the school personnel pool.

For the female experimental subgroup, the results of this analysis are not significant at the .05 level, therefore, as in all other cases, it was concluded the treatment failed to affect the choice of females when they were compared to their corresponding female control subgroup. This analysis is summarized in Table 17.

Table 15

Chi-Square Comparison of Experimental and Control Groups
Counselor as Preference for Information
on Required Mathematics Courses
Females Only

Groups	No	Yes	Totals
Experimental	4	14	18
Control	1	12	13
Totals	5	26	31

X2=1.183

Critical value of X2 with 1 degree of freedom at .05 significance level is 3.84. Since 1.183 does not exceed this value, it is not significant at the .05 level.

Table 16

Chi-Square Comparison of Experimental and Control Groups
School Personnel as Preference for Career Counseling

Groups	No	Yes	Totals
Experimental	0	28	28
Control	4	19	23
Totals	4	47	51

X2=5.302

Critical value of X2 with 1 degree of freedom at .05 significance level is 3.84. Since 5.302 exceeds this value, it is significant at the .05 level.

Table 17

Chi-Square Comparison of Experimental and Control Groups
School Personnel as Preference for Career Counseling
Females Only

Groups	No	Yes	Totals
Experimental	0	18	18
Control	2	11	13
Totals	2	29	31

X2=2.51

Critical value of X2 with 1 degree of freedom at .05 significance level is 3.84. Since 2.51 does not exceed this value, it is not significant at the .05 level.

Summary

Since an analysis of variance run to determine a pretest effect was significant at the .05 level, the control group (C1) and the experimental group (E1) who were given the pretest were excluded from all further analyses. Stratification of the sample was undertaken so that separate analyses of each subgroup could be made. Unfortunately, the minority male sample was not sufficient (N=5) to run any statistical analyses, so no results are reported for this subgroup. However, all hypotheses have been analyzed separately for the female subgroup.

The first research question examined was whether or not the experimental group (including the minority male subgroup and the female subgroup) would have higher scores on the 10 knowledge-based questions than the control group (including the minority male subgroup and the female subgroup) would. The hoped-for effect of increasing the factually useful knowledge of the experimental group in general was not realized. This result was also obtained in the case of the female experimental subgroup when compared to the female control subgroup.

The second research question investigated was whether or not the experimental group inclusive of the two subgroups would more often indicate an intention to study higher levels of math than the control group inclusive of the two subgroups who received no treatment. The treatment had no effect on increasing the levels of math that students would be willing to study in either the experimental group in general or the female experimental subgroup when compared to the control group in general or the control group female subgroup respectively.

The third research question inquired whether or not the experimental group in general would actually study higher levels of math (as an aftereffect of having received the treatment) than the control group in general who received no treatment. The treatment was not instrumental in affecting the math-studying behavior of the experimental group in general or that of the female experimental subgroup when compared to their corresponding control groups. In the case of the female subgroup, the control group was a bit small, which may have affected the stability of the t-test.

In the fourth research question I wondered whether or not the experimental group in general would be better able to match a minimum amount of math needed to whatever their post-high school plans were than the control group in general would. While neither the experimental group in general nor the female experimental subgroup demonstrated any greater facility in this respect than their corresponding control groups, raw numbers show they did more often choose to exceed the minimum than choose the option not to meet the minimum. This seems to be an error in a positive direction. Also, the fact that the experimental and control group do not differ seems to be the result of the control group performing better than expected rather than the experimental group performing worse than expected.

In the fifth and sixth research questions dealing with a counselor as preference as a source of information on careers or various math requirements, respectively, neither the experimental group in general nor the female experimental subgroup chose that option over others more often than their respective control group members. In the case of career information, this indicates that more should be done to publicize guidance department resources. In the case of information pertaining to math requirements for the experimental group in general and for the female experimental subgroup, the raw numbers indicate that both groups do use the services of guidance counselors for such questions more often than not.

In the seventh research question where it was postulated that the experimental group in general would choose school personnel over other options more often than those in the control group in general, the hypothesis held true for the experimental group in general in comparison to the control group in general. As in all other cases regarding the female experimental subgroup, however, the hypothesis did not hold true when they were compared to the female control subgroup.

Since the analysis of variance showed a statistically significant pretest effect, it could be inferred that the questionnaire used as a pretest was more powerful than the interventions given to the experimental group. However, the apparent pretest effect disappears when examined more closely.

First, those who took the pretest did not start out equally; there was a 1.4 difference between them, demonstrated in Table 18.

Table 18

Pretest Mean Scores

Group	Mean	Standard Deviation	Number
Entire Population	12.4750	4.3204	40
Experimental (E1)	11.7368	4.6648	19
Control (C1)	13.1429	3.9785	21

Second, if the pretest effect had been real, the control group would have done better on the post-test. In fact, their posttest scores were lower--12.5 as opposed to 13.1, and they were only 0.2 points away from those who did not have the pretest--12.5 as opposed to 12.3. These differences can be seen from comparing Table 19 to Table 18.

Table 19

Posttest Mean Scores

Group	Mean	Standard Deviation	Number
Entire Population	13.0220	5.3019	91
Experimental (E)	13.4286	5.3294	28
Experimental/ Pretest (E1)	13.9474	5.4209	19
Control (C)	12.2609	5.4707	23
Control/ Pretest (C1)	12.4762	5.1732	21

The apparent pretest effect appears to be merely a statistical artifact, due to the fact that both the posttest for C_1 was slightly higher than that for C (by only .2 points) and that for E_1 was slightly higher than that for E (by only .5 points). In contrast, the E1 group gained 2.2 points--13.9 as opposed to 11.7 in Table 18.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study assessed the attempt to get a greater level of commitment to study higher levels of math from students, especially female and minority males, who were exposed to three presentations designed to increase their knowledge of specific facts concerning math as well as their awareness of the importance of math to their futures. The study also searched for differences in six areas: acquisition of factual knowledge, actual levels of math studied, planning soundness (ability to appropriately match minimum math needs to post-high school plans), preferred sources for seeking career information, information about math requirements for various purposes, and career counseling.

A review of the literature provided support for the idea that the differences in female achievement are due to socialization factors peculiar to the role expectations of a male-dominant culture rather than to a difference in ability when compared to males. Theories considered important to learning when used in research studies examining traits related to high achievement, persistence, and performance help readers to understand how socialized role expectations work positively for males and negatively for females in relationship to the subjects they study and the careers they will feel inclined to choose. The problem side of the issue is covered by literature that deals with gender differences, bias and its effects in a personal sense, the inadequacies of educational practice, bias issues due to socialization practices that surface in education, the pressures due to socialized role expectations, and the lack of awareness of parents, educators, and counselors. The positive side of the literature provides hope for the increased performance and achievement of females in the form of studies that show that when the needs of the learner are understood and the proper educational methods meeting those needs are used, anxiety is reduced and achievement is enhanced. Similarly, understanding and enlightened support on the part of parents regarding the effects of the usual socialized role expectations for the female can reverse negative results by letting her know important others are behind her and encourage her to study nontraditional subjects and consider nontraditional careers previously considered male-only areas. Interventions suggested in the literature deal with awareness issues for females, parents, educators, and counselors, many support activities and groups, and the role of parents, educators, and counselors in the necessary changes to assure appropriate, fair, and equal treatment of all learners.

Since the goal of this study was to increase the numbers of female and minority male students who are underrepresented in advanced mathematics classes, as well as the overall total of students who would commit to studying mathematics through calculus, seven research questions were investigated to determine the effect of the treatment on the experimental group:

1. Will the experimental group have higher scores on knowledge-based questions (specific factual knowledge concerning math) than the control group?
2. Will the experimental group show more intention to study higher levels of math than the control group?
3. Will the experimental group actually study higher levels of math than the control group?
4. Will the experimental group demonstrate greater planning soundness than the control group (as evidenced by their ability to appropriately match minimum math needs to their post-high school plans)?
5. Will the experimental group select counselor as preference for career information more often than the control group?
6. Will the experimental group select counselor as preference for information on required mathematics courses more often than the control group?
7. Will the experimental group select school personnel as preference for career counseling more often than the control group?

Data were collected on a questionnaire from 110 students studying Algebra 1 or geometry. The questionnaire contained several items that would test specific facts concerning math: knowledge of course content, sequence of and prerequisites for other math courses and some sciences, requirements for high school graduation, Regents Units, and college entrance. Other items were intended level of math study, post-high school plans, and preferences (friends, parents, counselors, teachers, aides, other) when seeking educational and career information or career counseling.

The Solomon Four-Group Design was used to arrange the original 159 students at the start of the study into four randomly selected groups. The process was carried two steps further because I needed a stratified sample as I was looking for information specifically regarding females and minority males and I wanted more students in the two experimental groups to compensate for any who would have to be dropped from the study if they missed either panel presentation which were one-time only events. This design--wherein one experimental group (E1) and one control group (C1) were given a pretest and all four (the two experimental groups (E and E1) and the two control groups (C and C1) were given a posttest--allowed testing for a pretest effect of the questionnaire.

There were three statistical procedures used to analyze the data collected on the questionnaire:

1. An analysis of variance was run to test for a pretest effect of the questionnaire.

2. For the first three research questions, t-tests were run to compare experimental and control groups on each of the variables.
3. The remaining four research questions were tested by using the chi-square statistic.

<u>Discussion of Results</u>

The analysis of variance run to test for a pretest effect of the questionnaire was significant at the .05 level, therefore, the two groups (E1 and C1) who took the pretest were excluded from further analyses. One factor that could have contributed to this result was the short time span, i.e., less than two weeks, between the pretest and posttest administrations.

The minority male sample was not sufficient (N=5) to run any statistical analyses, therefore, no results are reported for this subgroup. Since the study was conducted at the close of the school year, some students had to choose between coming to my program and being in class for their end-of-year review. Of course, some were also lost if they missed either of the panel presentations. Finally, the original number of 15 was not very large. However, all hypotheses were analyzed separately for the female subgroup.

With respect to the first research question on knowledge-based information, t-tests were neither significant for the experimental group in general (including the female subgroup and the minority male subgroup) nor the experimental female subgroup at the .05 level, therefore, the hoped for effect of increasing their factually useful information did not occur.

It is quite possible that if the material given to students in the knowledge-based presentation had been presented in a different framework, in greater detail, and more time for discussion and questions had been planned in, more would have been retained.

In regard to the second research question, involving students making more of a commitment to studying higher levels of math, t-tests were neither significant for the experimental group in general nor the female experimental subgroup at the .05 level, therefore, the treatment had no effect on raising the levels of mathematics that students were willing to study.

In regard to the third research question, involving the actual math study of the experimental group, neither the experimental group in general nor the female experimental subgroup had t-tests that were significant at the .05 level, therefore, the three presentations were not instrumental in altering the long-term-math-studying behavior of either group.

As I stated in regard to the group acquiring knowledge-based information, a more leisurely approach of spreading the program out with time spent on factual information and awareness issues, career speakers who visit on a monthly or every other month basis, and admissions representatives who present just prior to scheduling in the spring, possibly in the math classrooms, more positive results might have ensued.

The remaining research questions were tested by using the chi-square statistic. For questions 4, 5, and 6 results of the analysis for each question were not significant at the .05 level for the experimental group as a whole or for the female subgroup when compared to the corresponding control groups. Therefore, in regard to question 4 on planning soundness (the ability to make an appropriate minimum match of intended level of study of mathematics to post-high school plans), the treatment was not effective in helping the experimental group in general or the female experimental subgroup more accurately match the amount of math they would need to their post-high school plans. Of note, however, was the fact that greater numbers were on the side of exceeding the minimum match than not meeting the minimum match in the experimental group in general and in the female experimental subgroup, which I consider an error in a positive direction. The fact that the experimental group and the control group do not differ on this variable seems to be the result of the control group performing better than expected rather than the experimental group performing worse than expected.

The treatment was not effective in making the experimental group as a whole or the female experimental subgroup choose a counselor in preference to other options as a source for career information. Because the treatment emphasized the role of the guidance counselor in providing career information, it can only be assumed from this result that a good deal more must be done to encourage the use of guidance facilities for career research.

The treatment was not effective in making the experimental group as a whole or the female experimental subgroup choose the counselor as a source of information regarding mathematics requirements for high school, college, and career needs. However, the tables for this statistic show that both groups do use the services of guidance counselors for such questions more often than not.

Finally, chi-square results were significant at the .05 level for the experimental group in general in reference to their preference of school personnel as a source for career counseling. As in every other instance, results for the female experimental subgroup were not significant at the .05 level.

The pretest effect suggested by the analysis of variance did not bear up under closer scrutiny of the group means. First, the two pretested groups were not equal to begin with (i.e., the control group had more correct answers on the pretest than the experimental group). More important, the control group did worse on the posttest than on the pretest.

The data collection instrument may have shaped the results in unknown ways. The questionnaire was designed solely for this study and its reliability was not assessed. Responses to items on the questionnaire were subject to the student's understanding of the directions as well as the questions themselves. Finally, last minute substitutions of panel members made to replace career panel members who failed to appear fell short in number and diversity, compromising the intent and quite possibly the effectiveness of that presentation.

Implications of the Study

There are no implications from empirical data. Perhaps the interventions would have had a greater effect on student behavior if they had had greater intensity and had been spread out over a longer period of time. Furthermore, the program might have been more successful if it had been a part of students' mathematics classes. Finally, given that ad hoc instruments were used with unknown reliability and validity, time should be taken to develop and field test instruments before using them.

Implications from the Literature Review

The willingness on the part of Peterson & Fennema to accept the idea that schools only reinforce what is already there in relation to alternative learning behavior overlooks the fact that teachers are also socialized in the role expectations of a male-dominant society. They may, therefore, consciously, or if unaware, unconsciously do quite a lot to reinforce their own biases in regard to girls studying math, the sciences, computers, taking shop courses and so on. When these same researchers uncovered the fact that competitive activities are a plus for male math achievement gains and female gains are greater as a result of being involved in cooperative activities, they then postulated that perhaps teaching should be different for girls than it is for boys. However, they quickly concluded that might be unfair to boys as well as opposed to the American philosophy of education that says education must be equal for all learners. These two points are made to emphasize the point that the debates will no doubt continue between researchers who want to be very painstaking about what they do being absolutely correct from all known and acceptable points. The study by Eccles detailing teacher and student interactions showed that teachers do play a major role not only in reinforcing but in maintaining the socialized role expectations of our society, whether consciously or unconsciously, in their treatment of learners, i.e., they had more interactions of a positive nature with males and, in the case of high-level achievement, left the males alone to do their work, whereas they failed to treat high-level achievement girls that way.

Since the causal attribution patterns of females are often mentioned negatively in regard to a girl's high-level math learning as well as contributing to a poor attitude toward math, it is of major significance that these negative effects can be altered if educators are aware of the learning styles of the learner and provide the methods the learner needs for success. Cabana demonstrated in one study that girls had no more anxiety than boys. The results of this one study were thought to be related to the fact that the mostly professional parents of a high socioeconomic level had as high expectations for their daughters as their sons. The anxiety perceived in relation to both sexes had more to do with perceived teacher control, i.e., the pressure to perform put upon them by teachers (expected by parents who send their children to this private school) was different than the usual causal attribution patterns affecting girls in the general school populations. Another study by Cabana meant to provide a model for adult female learners of math demonstrated that if the students are given a learning situation that matches their causal attribution pattern--i.e., if those attributing their success to external causes are given more teacher control and reinforcement of material and if those attributing their success to internal causes are given less teacher control--the result is reduced anxiety and increased achievement.

Providing support through math anxiety workshops and remedial work is probably necessary on a high school level to assist those girls who have a capability for math (defined as success in other subject areas by Smith and Tobias) but choose to avoid it. Perhaps high schools should give serious thought to Fennema's advice that if four years of math were mandatory for everyone, much of the difference between male and female achievement would be gone.

All-encompassing programs like the one proposed by Eiseman that involves a commitment on the part of teachers to helping students achieve a set of valued changes while they themselves seek continued professional growth toward excellence are needed if schools are to be successful in their mandate of equal education for all learners.

Recommendations for Further Studies

There is a dire need for research that looks for ways to include more females and minority males in areas of study and activity that will help them to acquire the skills needed to compete in what has become a high technology society. The stickiest problem to arise as a result of this study is the recognition that the tenacity and force of the underlying socialized role expectations that are distinctly disadvantageous for females are not going to change materially by our merely being aware of them. The mandate for teachers and counselors and parents and students is the same: be aware and do whatever you can to work for equal access so you can be the best you can be. It is my hope others will find the challenge of interest and using variations of this study conduct programs of their own that seek to increase the numbers who follow math through four years of high school.

For example, it would be fairly uncomplicated to offer a program of speakers of diverse ethnic backgrounds (one or two each month for seven months) who would discuss their math experiences and career paths with half of the students studying Algebra 1 in another city high school and comparing the numbers who went on to calculus as a whole, as well as for female and minority male subgroups, to the other half of the Algebra 1 group who had no such program. The college admissions representatives component might also be useful--at the conclusion of the program of career/math speakers. I now feel concentrating on awareness issues and role models might accomplish as much if not more in the way of inspiring students to go on for four years in math.

On the junior high level, before student's minds are made up about what math they will study, a similar program of career/math speakers appearing in all math classes might be effective in inspiring students and influencing their intentions regarding their high school math choices. In this instance another junior high might be used as a control if a formal study is desired.

Since it has been discovered that fourth grade is when the first changes in performance for females become evident and losses in confidence start to appear invited speakers could be asked to address those special areas and otherwise share their experiences and serve as role models.

In sixth grade, where boys start to value math more than girls do, speakers could structure their presentations to address the greater need on the part of girls to value math.

Teachers at any grade level can invite speakers and use articles to advance the idea that math is important to everyone--they could use a portion of each week to demystify math--so that girls and boys could see that a teacher's role encompasses helping them be aware.

The foregoing could all be worked out as formal studies but would not necessarily have to be full studies to be of value.

Reflections on the Process

Doing this research has confirmed something I have thought all along: there are no simple problems and no simple solutions. It has humbled me because in my own simplicity, I thought my wonderful idea would make a big difference in the math experiences of the students at North High School. My respect for the many teachers and researchers out there who are presenting ideas and examining them to try to find answers has grown considerably through reading their many studies and articles. I also now know from first hand experience that all they have gone through from the simple inception of the idea to the final phase of evaluating their work is a very satisfying experience but not an easy task. This experience has given me renewed interest in doing what I can to promote an interest on the part of females and minority males in taking all four years of high school math whether they think they need it or not so that their options will be greater. I do not have figures to support it but it is my contention from casual observation that girls need to be convinced more than minority males of the value of persisting in math.

APPENDIX A

RANDOM SELECTION WORKSHEET

Solomon Four-Group Design (Lehmann & Mehrens 1971)
Random Selection Worksheet (Miniumm 1970; Edwards 1972)

Control		Experimental		Control Pretest		Experimental Pretest	
Col.1	Col.2	Col.1	Col.2	Col.1	Col.2	Col.1	Col.2
(113)	104	(148)	150	(155)	249	253	172
163	152	212	145	(127)	236	132	116
(192)	140	199	234	143	188	237	171
141	183	242	227	162	194	107	201
255	117	190	186	(197)	239	118	230
(142)	153	105	112	231	233*	156	243
(220)	122	250	189	204	131	211	164++
165	129	241	246	178	146	137	182
259	161	120	225	(109)	257	223	185
244	198	240	200	139	256	(216)	258
175	179	217	123	(235)	213	103	210
177	151	102	136	215	126	108	180
144	130	168	138	252	158	184	245
(219)	119	206	238	218	195	226	160
(149)	114	228	248	207	221	224	106
232	174	222	157	196	134	209	166
111	181	202	133	135	128	191	124
154	100	193	147	167	125	101	187
205	254	214	110	159	203	170	176
208	115	121	229	173	251	169	247
		219	149	216		148	127
		113	192			155	197
		142	220			109	235

Original Random Distribution

	C	E	C1	E1	Totals
	15WM	11WM	15WM	10WM	51WM
	5MM	2MM	2MM	6MM	15MM
	20F	27F	22F	24F	93F
Totals	40	40	39	40	159

New Stratified Distribution

	C	E	C1	E1	Totals
	11WM	15WM	11WM	14WM	51WM
	3MM	4MM	3MM	5MM	15MM
	20F	26F	21F	26F	93F
Totals	34	45	35	45	159

WM=White Male, MM=Minority Male, F=Female
Note: *number never assigned to anyone; ++moved 5/20/88

- The original random sample is all the numbers appearing above the horizontal line. Each of the four groups had an equal number of students assigned to it.

- Numbers in parentheses were moved to the columns they now appear in (under the horizontal line) to create the stratified sample and a 7/16 (control groups), 9/16 (experimental groups) balance. This particular balance, in favor of greater numbers allotted to the experimental groups, is designed to compensate for any absentees from the two panels which are one-time only events that would necessitate dropping the absent student from the research.

- The original distribution totals under each column indicate the uneven distribution of each category of students (WM, MM, and F). The numbers in parentheses were moved in the order of appearance from columns where they were in excess to columns where they were needed.

APPENDIX B

QUESTIONNAIRE

Name: ______________________________

Mathematics Courses

To the best of your understanding, answer the following questions by placing a check (√) in the column of your choice.	Honors Algebra/9	College Algebra/9-12	Career Pre-Algebra/9-10	Career Basic Competency Mathematics/9	Honors Geometry/10	College Geometry/10-12	Career Math 2/10-12	Honors Algebra 2/ Trigonometry/11	College Algebra 2/ Trigonometry/11-12	Honors Pre-Calculus/12	College Pre-Calculus/12	Advanced Placement Math/ Calculus/12
1. What are the minimum math courses a student must take to graduate from high school?												
2. What are the minimum math courses required for college entrance?												
3. What courses meet the entrance requirements for Massachusetts State Colleges, and Universities, also known as the Regent's requirements?												
4. What math courses do you believe a highly selective college would require?												
5. What math courses are you planning to take during high school?												

	Honors Algebra/9	College Algebra/9-12	Career Pre-Algebra/9-10	Career Basic Competency Mathematics/9	Honors Geometry/10	College Geometry/10-12	Career Math 2/10-12	Honors Algebra 2/ Trigonometry/11	College Algebra 2/ Trigonometry/11-12	Honors Pre-Calculus/12	College Pre-Calculus/12	Advanced Placement Math/ Calculus/12
6. What course(s) are you required to take before you can take geometry?												
7. What course(s) are you required to take before you can take college fundamental applications of mathematics?												
8. What course(s) are you required to take before you can take advanced placement mathematics/calculus?												
9. What course(s) are you required to take before you can take Chemistry I?												
10. What course(s) are you required to take before you can take Physics I?												

11. After high school graduation, I plan to:
Please check (√) only one choice.

____ work
____ go to a 4-year school
____ other training (2 years or less)
____ go to a 2-year school
____ armed services

12. What do you want from your occupation? Divide up 10 points among "liking my work" and "earning a lot of money," depending on how important you expect each to be in your occupation. The more important the item, the more points you should give it, but the total must be 10 points.

Liking my work ____________
Earning a lot of money ____________

Total 10 points

13. Where would you get career information? Indicate the person you would talk to or place you would go first by putting a "1," the person you would talk to or place you would go second by putting a "2," and so on for as many people as you think you would talk to or as many places as you think you would go.

________ my counselor
________ Mrs. Castagna (Guidance Aide)
________ teachers
________ friends
________ the library
________ Mr. Elworthy (Work Experience Counselor)
________ parents
________ reference books
________ other (please specify: ______________________________)

14. Follow the same instructions as in question #13 for this question, only here the question is: Where would you find out about math requirements for high school, college, and careers?

________ my counselor
________ Mrs. Castagna (Guidance Aide)
________ teachers
________ friends
________ the library
________ Mr. Elworthy (Work Experience Counselor)
________ parents
________ reference books
________ other (please specify: ______________________________)

15. Describe in as much detail as you can any problems you have had in math courses.

16. If you do well in math, but don't plan to continue taking more than you absolutely need, please explain why as fully as possible.

APPENDIX C

CURRICULUM INFORMATION/STRATEGIES

Look around at the people in this room. Everyone here is either taking Algebra 1 or geometry. There are approximately 70 more students taking those two subjects in this school this year. I don't know how many are doing well or how many are doing not so well but I do know that someone in middle school thought you did well enough on tests and in classwork to recommend that you take Algebra 1 here in high school. The same is true of students studying geometry.

How many will be taking calculus in grade 12?
How many will be taking precalculus?
How many will study math through Algebra 2/Trig?

This past year there were 7 students taking calculus, about 11 taking precalculus, and about 25-30 taking Algebra 2/Trig.

Each of those total numbers of students is but a small fraction of the students who start out as Algebra 1 or geometry students. What happens to this large original group of students so that it ends up that only a handful study calculus, precalculus, or even Algebra 2/Trig?

Math is a career filter so it is very important to everyone's future plans. What that means is that if a person stops taking math too soon or doesn't take as much math as he or she is capable of certain careers in which math is important won't be available to them. This is also true in regard to certain programs in colleges where math is considered necessary for the program. Of course, college is where a lot of people go to prepare for their career so if they haven't taken enough math the doors start to close early on their choices and possibilities.

My program is about making students aware of these facts and hoping somehow that what you learn will influence you to think more before you decide to abandon the study of math. If a student thinks math is important and makes a personal commitment to study it even though it may be hard at times to complete a course then more students will succeed simply because they will be refusing to be quitters. "Where there is a will there is a way," is a saying that applies to people who won't accept less than success. It is my hope that after this program this group won't accept less than success in relation to math.

I have prepared packets of materials for each student. These are for you to keep. I will be going over some of the material and talking about how you can use the various parts and pieces.

The first eight pages are course descriptions of the math available in the Worcester Public Schools. The following page is a chart showing the sequence of math study. If you look at this chart the math courses will be in order of their recommended study so you can understand what courses are prerequisites to more advanced courses. Information on prerequisites is also written into the course descriptions.

In regard to sciences it is preferred that you have algebra and geometry before you take Chemistry 1, that you have Algebra 1, geometry, and Algebra 2/Trig before you take Physics 1. Also, if you are interested in electronics it is helpful and easier if you have had Algebra 1 first.

Two years of math is required for high school graduation as a minimum requirement. From the easiest to the hardest would be Basic Competency Math and Prealgebra, or Prealgebra and Career Math 2, or Algebra 1 and geometry. If you look at the back of the selection sheet included with your packet you will notice that in all of the college tracks three years of math is the minimum requirement. In all cases those three years should be on a college level. Basic Competency Math, Prealgebra, and Career Math 2 would not be considered acceptable. The three acceptable math courses are Algebra 1, geometry, and Algebra 2/Trig. This agrees with the Regents requirements which you should read over carefully if you plan to qualify for admission to a state college or university. In fact, they have additional comments about other math that they want you to have in certain instances. These standards are recommendations for preparation and it should be understood that the admissions boards of each college may admit a student who doesn't meet all the recommendations on certain occasions. Prestigious schools may want four years of high-level math and students who can present that may have an edge over those who don't. Engineering schools in particular want as much math as possible. It is always best to do individual research about the colleges you are thinking about and what subjects they want you to take in high school. Your counselor will be glad to help you start this if you haven't done any research yet.

In the May 19 <u>Evening Gazette</u> section on business there was an article on the best and worst jobs. Out of the ten best jobs eight would require a good deal of math. The full article is posted in the guidance office for anyone who would like to read it. Also, Mr. Elworthy has it posted in his office area. I will read excerpts if there is time at the end.

Resources that will help you succeed include peer tutors. Mrs. Belevick is in charge of these student volunteers who do well in math and are available to help others. To arrange to have a tutor you should start with your counselor. We all know about after school help on Tuesdays being available. Some students will go to see a teacher they have had before and I'm sure most teachers wouldn't mind helping you even if you are not their student that particular year. There are college students and other professional tutors available to help you if you or your parents don't mind paying a fee. One should always see a counselor and/or teachers before it becomes an impossible situation. Delaying asking for help with something you don't understand is the worst possible thing you can do.

Planning your whole high school program and updating it should be done when you are making a new schedule each year. This can be done by using the selection sheet or a four-year plan sheet whichever you prefer. Sit down with your counselor when it is schedule time or even before to discuss plans. Start to research if you are planning on college or any other post-high school training to see what those schools want you to have. Read up on or get a computer printout about careers you are possibly interested in to see what courses they mention as important. Also, look over the Regents requirements that are included with your packets.

Teachers and counselors are valuable resource people. If you ask for their help they can suggest ways for you to accomplish your goals. You don't have to wait for them to call on you. You should make the moves. Just drop in early in the morning to say you would like to have an appointment. If you want to see a teacher mention it and they will probably tell you when they would have available time. Don't give up if at first you don't succeed. Don't take it personally. Be persistent. It is like studying math--you have to be persistent.

Anyone who is interested should ask his or her counselor to review their test record so that they can add that information to their understanding of where they are in regard to their tested ability in math. Many students don't realize they test well in the math area. Likewise, some students perform better than their tested ability shows. I just believe people are helped by having all parts of the picture available.

As a last item I'd like to discuss strategies that could help you succeed in math. Remember that everyone's case is different. When someone is experiencing difficulty the first thing is to be honest about how much effort is being put into learning the subject. Once that has been determined you might want to try to get tutoring help, (peers, teachers, an outside tutor) or you may want to drop a level (if you are honors), or you may want to stay in the class you are in even if that seems to mean you will fail (especially if you need math for future plans) as you will get something more out of that class than a general math class, and repeating it should be that much easier. When repeating it consider taking the next math along with it. This means you must be willing to work hard but this would mean you wouldn't fall behind in the total amount of math you could take. Consider repeating a course if you have a D and math is important to your future by taking a sixth course to make up for the credit you lose (can't get credit for a course you take twice). Consult with your counselor--two heads are better than one to explore the possibilities that exist for you.

Everyone at this session will be invited to two more presentations. The first is a Career/Math Panel on Wednesday. On Thursday a panel of admissions representatives from our area colleges will discuss getting into colleges, educational goals, and math requirements in regard to their schools. Please listen carefully as they present their material. I am sure they will be happy to answer any questions you may have at the end of each panel presentation and I would encourage that you do so in whatever time is left.

APPENDIX D

PACKET

Course descriptions

All of the math courses available in the Worcester Public Schools at the time of the study were described. Descriptions included topics covered, whether courses were honors, college, or standard level, prerequisites were mentioned when applicable, skills one could expect to gain, and how courses might fit future plans. A course sequence sheet showing the progression of courses of varying levels from grade 7 through 12 added visual reinforcement to the descriptions enabling students to track their own intended path of courses with understanding and accuracy. Additional clarifying and numbered notes keyed to the same numbers on the sequence chart gave examples of math sequences appropriate to a low level student and a high level student.

Regents Units

The leaflet, Plan Now for College Success, printed by the Board of Regents of Higher Education Commonwealth of Massachusetts in 1985 containing a letter to parents and students and describing the new unit requirements for public colleges and universities that would be phased in over several years starting with the 1984-85 school year and ending with the 1987-88 school year was the second piece in the packet. In addition to a chart showing the added units year by year the leaflet contained information about the admissions eligibility index describing how class rank and Scholastic Aptitude Test scores combined with the Regents Units to arrive at whether or not a student would be considered for admission. Exemptions were explained and a Question and Answer section detailing everything in the leaflet was included.

Course Selection Sheet

The same course selection sheet given to students each year when they plan their program for the coming year was given to them so that they could plot their math choices through their years of high school. Using the courses listed under Mathematics the reader can picture how the student could use the list for planning through graduation. It should be noted also that students take only 1 math class per year unless there are special circumstances where he/she would be encouraged to take 2 classes. Since classes have the year possibilities listed, i.e., Gr.9, Gr.9-12, Gr.10-12, it is quite easy to make selections.

Mathematics

010721 Algebra (Honors) Gr.9
010832 Algebra (College) Gr.9-12
010933 Prealgebra (Career) Gr.9-10
011033 Basic Competency Math (Career) Gr.9
011131 Geometry (Honors) Gr.10
011232 Geometry (College) Gr.10-12
011343 Mathematics 2 (Career) Gr.10-12
011441 Algebra 2 & Trigonometry (Honors) Gr.11
011552 Algebra 2 & Trigonometry (College) Gr.11-12
012252 Fundamental Applications of Mathematics (College) Gr.11-12
011751 Precalculus (Honors) Gr.12
011862 Precalculus (College) Gr.12
012060 Advanced Placement Mathematics-Calculus Gr.12

The back of the selection sheet also contains a chart outlining the Four Year Requirements and Electives and sets the requirements up under four Program headings: Scholars, Classical, College, and Career with typical requirements to meet the standards for each program--the math requirements for the first three programs is 3 years and for Career 2 years. Minimum requirements for high school are stated at the bottom of the sheet--that math requirement is 2 years.

Four-Year Plan Sheet

A four-year plan sheet was given out because it is an alternative to the selection sheet for planning purposes. The main difference is students would have to write in their selections because they are not listed by name. The same chart that appears on the selection sheet outlining requirements and electives with four program headings is used as a visual aid to students trying to figure out what program they are in.

APPENDIX E

CAREER/MATH RELATIONSHIP PANEL

Dear Career/Math Relationship Panel:

I feel it is important for students to be able to share in the personal experiences of successful people

1) by listening to them as they relate the ways in which math was a part of their educational and career paths;

2) by being able to interact by asking questions; and

3) by being able to identify with panel members as role models.

The following comments are meant only as examples of what panel members might wish to include and should not be understood as limits:

1) Did the amount and kind of high school math you took prepare you to go into the programs and colleges of your choice or did you have to make up deficiencies?

2) Did you take math because the career you had in mind demanded it?

3) Did math come easy to you or was it a difficult subject that you managed to make into a positive experience?

4) What important ideas relating to math would you like to leave with students for them to think about?

Thank you for sharing your experiences with us.

APPENDIX F

EDUCATIONAL GOALS/MATH RELATIONSHIP PANEL

Dear Educational Goals/Math Relationship Panel:

I feel it is important for students to hear firsthand from admissions representatives about math requirements as they relate to:

1) admissions in general

2) the various programs offered at your school

3) the ways in which math deficiencies can be eliminated

4) supportive services offered at individual schools

5) what students can do while they are still in high school to prepare themselves in the best possible way

Thank you for being a part of this panel presentation.

APPENDIX G

PARTICIPATION PERMISSION FORM

I, Loretta Morelle, am conducting a research project about the effectiveness of presentations dealing with the use of math in various careers. Students in the ninth and tenth grades taking Algebra 1 and geometry at North High are being asked to participate in this study. During this study about 70 students will take pre-presentation questionnaires, about 90 students will hear three presentations, and all students will take post-presentation questionnaires. Your participation is encouraged regardless of whether you plan to take any further courses in math or use math ever again in your life.

To the best of my knowledge there are no risks whatsoever to students who take part in this study.

Student participation in this study is completely voluntary and if a student begins to participate but wishes to withdraw before the study is completed he or she may do so.

Using a check (✓) mark, please indicate whether you will or will not participate below in the space provided.

( ) I will participate

( ) I will not participate

__________ ______________________________

date Student signature

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