CANADIAN THESES

THÈSES CANADIENNES

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED

LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS REÇUE

THE UNIVERSITY OF ALBERTA

THE EFFECTS OF SEX ROLE ORIENTATION AND MATHEMATICS SELF-EFFICACY ON POST-SECONDARY PROGRAM CHOICE

by

(C) VIOLET OLGA VLCHEK

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF EDUCATION

IN

COUNSELLING PSYCHOLOGY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1986

ISBN 0-315-32348-5

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: VIOLET OLGA VLCHEK

TITLE OF THESIS: THE EFFECTS OF SEX ROLE ORIENTATION AND MATHEMATICS SELF-EFFICACY ON POST-SECONDARY PROGRAM CHOICE

DEGREE FOR WHICH THESIS WAS PRESENTED: MASTER OF EDUCATION

YEAR THIS DEGREE GRANTED: FALL, 1986

(SIGNED) ....

PERMANENT ADDRESS:

13856 - 110 A Avenue

Edmonton, Alberta

T5M 2M9

DATED: May 23, 1986

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled The Effects of Sex Role and Mathematics Self-Efficacy on Post-Secondary Program Choice submitted by Violet Olga Vlchek in partial fulfilment of the requirements for the degree of Master of Education in Educational Psychology.

....

Supervisor

....

....

....

Date: May 23, 1986

DEDICATION

To my mother, Katerina Vlchek, who has shown me the femininity of self-reliance; to my sons, Craig and Vaughn, who have given much to me; and to my family, who have always cared.

ABSTRACT

The Bem Sex-Role Inventory, the Mathematics Self-Efficacy Scale and a questionnaire regarding mathematics and science background were administered to a sample of 111 male and female students at the Northern Alberta Institute of Technology. The purpose of the study was to examine the relationships of sex role orientation and mathematics self-efficacy expectations to the selection of science-based programs at a post-secondary technical institute. The intent was to examine:

1) gender differences in mathematics self-efficacy expectations,
2) the relationship of mathematics self-efficacy expectations to sex role orientation,
3) differences in mathematics self-efficacy expectations and sex role orientation between female science and nonscience students, and,
4) the strength of mathematics self-efficacy in the prediction of science-based program choices.

T-tests were performed to determine the significance of the differences of math self-efficacy scores for males and females, and of math self-efficacy scores and BSRI masculinity scores for females in science and nonscience programs. Males were found to have significantly higher mathematics self-efficacy scores than females on the total scale as well as on the three MSES subscales. Females had significantly higher math self-efficacy expectations than males only regarding six traditionally female courses. Females in science programs had significantly higher mathematics self-efficacy

expectations than females in nonscience programs, but there was no significant difference in the BSRI masculinity scores between these two groups.

Correlation and multiple regression analyses were performed to examine whether mathematics self-efficacy expectations are significantly related to sex-role orientation, and whether mathematics self-efficacy would be a significant predictor in science-based program choice. A positive but moderate correlation was found between BSRI masculinity score and mathematics self-efficacy, but no correlation was found between BSRI femininity and math self-efficacy. Finally, the results of a stepwise multiple regression analysis indicated that mathematics self-efficacy, preceded by mathematics and science performance and achievement, was the third highest predictor of science-based program choice for the total sample.

The results therefore provide support for the hypotheses that males have stronger mathematics self-efficacy expectations than females, except toward traditionally female academic subjects; and that females in science programs have stronger mathematics self-efficacy expectations than do females in nonscience programs. The results also indicated that those students reporting higher masculinity scores on the BSRI were likely to have stronger mathematics self-efficacy expectations, and that mathematics self-efficacy expectations were significantly related to the extent to which students chose science-based programs.

No support was provided for the hypothesis that women in science programs are more psychologically masculine than women in nonscience programs.

In general, the results concur with those of Betz and Hackett's (1983) study. That is, sex role orientation and mathematics self-efficacy were found to be mediational factors affecting the educational choices and career decision-making of both male and female subjects.

ACKNOWLEDGEMENTS

Sincere appreciation is expressed for their assistance in the completion of this study to the following.

To the members of my committee:

Dr. Len Stewin, for his ongoing advice and encouragement,

Dr. Lorraine Wilgosh for her suggestions and attention to detail,

Dr. Murray Smith, for his encouragement and interest, and

Dr. Tom Kieran, for his interest and suggestions.

To Dr. Dwight Harley, for his assistance and unlimited patience in my data analysis, to Kris Magnusson, for his assistance with my data interpretation, and to Vaughn Beakhouse for his assistance in completing the final project.

Finally, the writer gratefully acknowledges the assistance, support and cooperation of the Administration, instructors and students at the Northern Alberta Institute of Technology, without which this study could not have been completed.

TABLE OF CONTENTS

LIST OF TABLES

I. INTRODUCTION

The question "Why don't girls study sciences?" recently addressed by the Science Council of Canada (1982), is one of growing importance to the vocational development and occupation survival of women. Technological advances in all aspects of our society, increasing numbers of women in the work force and of mother-dependent families, and the discrepancies between male and female earning power have drawn attention to women's academic and vocational patterns and the factors which affect women's vocational choices. Menzies (1981) outlined the traumatic impact of microelectronics on traditionally female jobs in the clerical sphere and predicted the vocational obsolescence of thirty-five percent of women employed in this area by 1990. Sells (1980) termed mathematics the "critical filter" which limits post-secondary choices for women, often restricting them to nonscience based programs and to traditionally female occupational choices. Sheinin (1982) stated that without strong backgrounds in mathematics and the "hard" sciences, and the cognitive skills developed through the study of these subjects, women lack the basis for technological adaptation, and are ill-equipped to take advantage of advanced occupational opportunities. At the same time, the attrition of girls in science and mathematics courses in the schools increases as these courses become optional and more difficult (Suderman, 1979), and continues to increase through college and university years.

Much research has been generated by the differences in participation of males and females in mathematics and the sciences. Wittig (1979) stated that in research bearing on the etiology of sex-related differences in cognitive functioning, seventy-five percent of the studies have attempted to establish long-held beliefs about physiologically-based differences in ability, while twenty-five percent examined sociocultural factors. In a comprehensive review of existing literature on sex-related learning differences, Maccoby and Jacklin (1974) analysed 2,000 studies of intellectual performance and social behavior related to male-female learning differences. Their conclusions that sex-related differences are "well-established" in only three areas of ability (verbal, visual-spatial, and mathematical), and that the differences could not be attributed solely to either environmental or biological factors, cast doubt on many previously-held beliefs regarding the innately inferior ability of females to learn mathematics and sciences. Subsequent researchers (Hyde, 1981; Fennema and Sherman, 1977; and Sherman and Fennema, 1977) have challenged the findings regarding "well-established" differences. These researchers concluded that gender-related differences in these areas are not significant, and that they occur in a matrix of relationships which strongly suggests the influence of attitudinal and environmental factors.

Among the sociological factors identified as affecting male-female participation in science and mathematics are: sex-role socialization (Kelly, 1978, 1981; Rossi, 1964); poor self-efficacy and negative attitudes of girls toward math and sciences (Haring and Tyler, 1983; Betz and Hackett, 1981, 1983; Stein, 1971); differential treatment of children by parents (Maccoby and Jacklin, 1974; Ounsted and Taylor, 1972; Rossi, 1964); differential treatment and expectations of boys and girls in schools and lack of role models for girls in science-related areas in the post-secondary and professional world (Pottker and Fishel, 1977; Jay, 1973; Kelly, 1981; Fisher, 1982). Like physiological differences, sociocultural factors are seen as part of a complex interactional system influencing the attitudes and choices of both males and females.

The present study addresses two recent perspectives on the subject of girls and academic choice. First, sex role orientation, defined by Bem (1981) as the degree to which an individual is "attuned to cultural definitions of sex-appropriate behavior and uses such definitions as the ideal standard against which his or her behavior is to be evaluated" (p.4), has been identified as an inhibiting factor for girls in the study of mathematics and the sciences. The belief that math is a male domain (Sherman and Fennema, 1977), and considered of questionable use or appropriateness for females has been found to affect girls' achievement motivation toward, and participation in, mathematics (Stein, Pohly, and Mueller, 1971; Dwyer, 1974; Fennema and Sherman, 1977), while perceived sex role appropriateness was shown to influence both attainment value and expectancy of success. It has been suggested (Bem, 1974, 1975; Forisha, 1978; Spence and Helmreich, 1979), that psychological androgyny, "the integration of both masculinity and femininity within a single individual" (Bem and Martyna, 1976, p.1016), is an ideal alternative to rigid sex role assumptions and the restriction of choices and behaviors considered acceptable only as a function of being male or female.

Second, in an approach to women's career development based on Bandura's (1977) social learning theory, Hackett and Betz (1981) and Betz and Hackett (1981) found "expectations of personal efficacy" to be mediating factor in the career options considered by women, and so to have strong implications for their career development (Hackett and Betz, 1981). In further studies, Betz and Hackett (1983), Hackett and Betz

(1984), and Hackett (1985), found that mathematics self-efficacy expectations, "the perception of performance capability in relationship to math problems, everyday math tasks, and mathematics-related college coursework" (Betz and Hackett, 1983 p.332), were significantly related to students' choice of science-based college majors.

The first study of the relationship of mathematics self-efficacy expectation to the choice of science-based major was by Betz and Hackett (1983). Using their own instrument, the Mathematics Self-Efficacy Scale, as well as the Bem Sex-Role Inventory and a measure of math anxiety, Betz and Hackett found that mathematics self-efficacy expectations were positively related to the degree of science content in students' college majors, and also to the degree to which subjects endorsed traits of psychological masculinity. Mathematics self-efficacy expectations of females were found to be significantly weaker than those of males in all areas of math activity tested. In subsequent studies (Hackett and Betz, 1984; Hackett, 1985), math performance and math self-efficacy were found to be significantly and positively related to masculine sex role orientation and to math related major choice. In each study, mathematics self-efficacy was the strongest predictor of major choice.

A search of the literature did not reveal any other replications of the 1983 study. An objective of the present study is to replicate, in part, Betz and Hackett's procedures to determine if similar results would be obtained with a post-secondary population in a Canadian technical institute. Specifically, the present study addresses the following questions:

1. Do males have higher mathematics self-efficacy expectations than females?
2. Do females in science programs have higher mathematics self-efficacy expectations than females in nonscience programs?
3. Is mathematics self-efficacy related to masculine sex role orientation?
4. Are females in science programs more psychologically masculine than females in nonscience programs?
5. Is mathematics self-efficacy a predictor of science-based program choice?

II. REVIEW OF THE LITERATURE

A. Overview of the Problem

> "...women compared with men may be found, on the average, to do the same things with some variety in the particular kind of excellence. But that they would do them fully as well, on the whole, if their education and cultivation were adapted to correcting instead of aggravating the infirmities to their temperament, I see not the smallest reason to doubt" (Mill, 1867, p.197).

Although John Stuart Mill declared his faith in the intellectual potential of women long before equality was an issue, research on male-female learning differences has continued, well into the twentieth century to search for proof of male intellectual superiority, particularly in mathematics and the sciences. Increasingly, however, since Maccoby and Jacklin's (1974) review of studies, researchers have addressed differences in the attitudes and expectations of parents, teachers, and society toward boys and girls, and examined the effects of these differences on girls' perceptions of the usefulness and role-appropriateness of mathematics and the sciences.

Sheinin (1982) emphasizes that it is time to stop restating the problem, "that there are very few women in Canada in science, engineering and technology" (p.16), and to concentrate instead on identifying which cultural, social and behavioral practices in our society contribute to this problem. Sherman (1982), Fox, Tobin and Brody (1979), Sells (1980), and Fennema (1980) are among the growing number of current researchers who recommend the implementation of specific interventions in the education and socialization of girls. They maintain that these changes would, as Mill suggested, contribute to "correcting, rather than aggravating," whatever differences may exist.

B. Research on Sex-Related Differences in Ability

Maccoby and Jacklin (1974) found sex-related differences in ability to be "well-established" in favor of males after the age of twelve in visual-spatial and mathematical ability and in favor of girls after age eleven in verbal ability. Hyde (1981) questioned whether "well-established" could be interpreted to mean "large". In a reanalysis of twenty-seven studies of subjects eleven years of age and older, Hyde found that gender differences accounted for between 1% and 5% of population variance in verbal ability, quantitative ability, visual-spatial ability and field articulation. She concluded that sex-related differences in these areas are not significant and that gender is a poor predictor of performance in these areas. Fennema and Sherman (1977) noted that no attempt had been made to control prior course-taking in the studies analysed by Maccoby and Jacklin. Controlling this variable in a study of 1,233 females and males in ninth to twelfth grade non-terminal math courses in four schools, Fennema and Sherman found:

- males and females were similar in verbal and general ability in all groups tested
- males always scored higher than females in mathematics with the difference reaching significance in two of the four schools studied
- males tended to score higher than females on spatial visualization with significant differences in male over female ability in two of the four schools studied
- among students with similar backgrounds in mathematics, all tested differences between males and females were small

- in both schools where significant sex-related differences in mathematics achievement were found, five or six sex-related differences in attitudes were also found.

Fennema and Sherman concluded that their study did not indicate that females have lower aptitude than males for mathematics or spatial visualization. Differences were small, and significant only when they reflected the influence of sociocultural factors.

In contrast, Benbow and Stanley (1980), in a study of 9927 intellectually gifted junior high school students tested prior to the influence of differential course-taking, found, on the average, that boys scored higher than girls in all groups tested. They concluded that their studies indicated superior mathematical ability in males; that sizeable sex differences exist in mathematics reasoning ability before differences exist in the number and type of courses taken, and that sex differences in ability increase progressively through the high school years. They suggested a possible relation to greater male ability in spatial tasks, and the influence of both endogenous and exogenous variables.

Several theories attempt to establish biological explanations for sex-related differences in ability. The X-linked hypothesis suggests that genetic inheritance of a recessive gene on the X chromosome determines high potential mathematical and visual-spatial ability, resulting in many more males than females with high ability. Studies by Stafford (1961) and Bock and Kolakowski (1973) supported the proposal that spatial ability exhibits recessive, X-linked inheritance, while a later study by Stafford (1972) and one by Williams (1975) reported findings inconsistent with the hypothesis. Reviewers of research on this hypothesis generally conclude that the findings are too inconsistent to suggest support (Huston, 1983).

Studies which attempt to establish a hormonal role in the development of cognitive sex differences hypothesize that female performance, facilitated by estrogen, is higher on automatized tasks (well-practiced, over-learned tasks that require a minimum of conscious effort to perform); while males performance is better on cognitive restructuring tasks (those requiring new responses to less obvious stimuli). Broverman (1980) and Petersen (1976) found that males more masculine in secondary sex characteristics (indicating higher levels of testosterone) were better at automated tasks than at spatial ability, while the less physically masculine males showed a reverse pattern. With females, Petersen found that physical variables related only to spatial ability, which related significantly to physical "masculinity". Petersen suggested that this indicates strength in spatial ability among more physically androgynous members of both sexes and skill at automated tasks among more physically masculine males and more physically feminine females.

Attempts to explain how differences in brain lateralization may relate to sex differences in ability propose two opposing hypotheses. Buffery and Gray (1972) and Waber (1977) proposed that bilateral representation results in better spatial ability, while Levy (1976) suggests that bilaterality results in inferior spatial ability. From their review of studies performed on rats, non-human primates, and humans, Buffery and Gray concluded that spatial skill may benefit from a more bilateral cerebral representation which the male brain has a better opportunity to develop because of its less well-lateralized language function. Levy proposed that when verbal and perceptual processes are each confined to a single and separate side of the brain, the two patterns of neural connections underlying these abilities can evolve optimally for the functions they serve. She found that laterally differentiated people had higher perceptual functioning ability than those less differentiated, while verbal abilities were approximately equal. Levy concluded that females, having more bilateral representation of verbal skills, have, therefore, inferior spatial functioning skills. Waber found that late maturers of both sexes performed better on tests of spatial, but not of verbal, ability. Late maturers of both sexes showed greater hemispheric lateralization. Since females mature earlier than males, a lesser degree of lateralization is suggested, indicating support for the theory that greater lateralization indicates greater spatial ability.

In summary, no sound bases have been established for theories of sex-related differences in ability. While some studies show a higher performance of males over females on visual-spatial and mathematical tasks, others question the significance of these findings and the influence of prior course selection and other variables in their results. Attempts to establish biological bases for sex-related cognitive differences present similarly questionable and sometimes conflicting evidence.

C. Sociological Factors in Learning Differences

In general, it is acknowledged by researchers that no study of physiological factors can be considered exclusive of the socio-cultural environment; and that differences in ability, where they exist, are minimal, and often as great within groups as between groups (Huston, 1983). Nash (1979) stated that because the correlations supporting the evidence for biological factors are often low, social, motivational, and attitudinal factors must be considered to be at least as important. A variety of social-psychological factors have been identified as contributing to the disproportionately large differences between the sexes in the study of mathematics and the sciences. Haring and Tyler (1983) identified sex role socialization, poor self-efficacy, negative attitudes toward certain subjects or occupations and counsellor bias in the schools as factors in discouraging women from pursuing non-traditional careers. Maccoby and Jacklin (1974) suggested that differential treatment of children by parents encourages children toward role-appropriate behaviors that are carried into the educational and occupational world. Fisher (1982) stated that such socialization could affect the science involvement of women by two different routes. First, the learning and practice of science may be facilitated by a particular combination of mental abilities and character traits. Social roles imposed on a child may foster or discourage the development of these traits. Second, a female child's image of a scientist may be at odds with her image of the person she wants to become. Socialization may affect either the real abilities required for the practice of science or the child's interest in becoming a scientist. In general, the areas of socialization of girls away from the sciences are identified as the home environment where sex-differentiated roles are encouraged; the school environment where boys and girls are exposed to different academic expectations; and the post-secondary and professional world where subtle prejudice and lack of role models discourage women from entering science-oriented occupations.

Three hypotheses which encompass the variety of sociological factors believed to influence the study of sciences were stated by Kelly (1981). These formed the basis of her extensive investigation of the differences in science achievement among boys and girls in fourteen different countries.

<u>The cultural hypothesis</u>. The cultural hypothesis states that girls do not do well in sciences because of the social expectation that they will underachieve. Kelly found that boys in each country earned higher scores than girls in each branch of science, even where the amount of compulsory science study was the same. However, girls in some countries performed better than boys in other countries. Considered of crucial importance by Kelly was the achievement by Japanese girls of a mean score in physics comparable to that of boys in other countries. She interpreted this to illustrate that, given the right mixture of cultural background, attitude, motivation and teaching, girls can achieve equally with boys. Sex differences in achievement, small for biology (averaging .13 of a standard deviation) and large for physics (.61 SD) were found to be more characteristic of the particular branch of science than of a particular country. The standardized sex differences in science achievement were similar in all countries, suggesting either that these differences are relatively impervious to cultural influences, or that the specific cultural factors which affected the differences were uniform across the countries studied. Kelly further stated that the absence of any relationship between girls' achievement and the proportion of girls studying sciences in each country, suggests that social and cultural factors have more influence on girls' participation in science than on their achievement. In further within-

country analyses, Kelly found that children from high socio-economic groups achieved better in science than those from lower groups, again with variations generally similar for both sexes.

The latter observation is supported by Fennema and Sherman (1977) who found significant differences in achievement for mathematics and spatial visualization only when five or six sex-related differences in attitude were present. Lynn (1972), in a study of determinants of intellectual growth in women, proposed that different cognitive styles are developed in males and females because of parent-child relationships. Boys acquire a cognitive restructuring style which involves defining a goal, restructuring a situation, and abstracting principles of masculine role definition, all of which contribute to the independent thinking required in mathematics and the sciences. Girls acquire a cognitive style which involves a personal relationship with the mother and clearly role-defined lesson learning. The learning occurs in a context where social acceptability is important and there is little opportunity for the development of analytical and problem-solving skills. The parental reinforcement of role definition and sex-appropriate behavior is carried on to course selection and school performance.

Lewis (1972) found parents of both sexes to encourage more autonomous and independent behavior in male than in female infants. Cross-cultural studies examined by Maccoby and Jacklin (1974) indicate that sex differences can be large or small or non-existent, depending upon the cultural conditions involved in the rearing of the two sexes. "Where women are subjugated, their visual-spatial skills are poor; where both sexes are allowed independence early in life, both have good visual-spatial skills" (p.362).

The school hypothesis. In this hypothesis Kelly stated that science is taught in the schools in a way more suited to boys than to girls. Schools are believed to reinforce the differentiation of sex roles in a number of ways:

- sciences and mathematics are perceived by both students and teachers to be masculine in orientation
- girls are encouraged to behave more passively in the educational environment, whereas a more aggressive and independent approach to learning is encouraged in boys
- the importance of mathematics and science to girls is not emphasized
- there is little or no remediation or specialized instruction for those students, primarily girls, who begin to have difficulty grasping scientific and mathematical concepts in the early school years.

A large number of studies relating to the school hypothesis were examined by Pottker and Fishel (1977). In one of these studies, Caite (1972) examined the attitudes of high school teachers toward expected achievement and lifestyle of male and female students. While all male students were expected at age 21 to be in some kind of further education, and at age 31 actively pursuing a career, teachers "rarely" predicted female students going on to further education. Without exception, female students at 31 were described as married, with children, looking after a home. No females were described as engaged in any kind of political activity, or achieving wealth, power or status. Gaite suggested that this differential expectation is indicative of teacher bias which is in turn indicative of their perception of girls' self-expectations. Jay (1973) found that textbooks show men in a far greater number of occupations than women, and actively engaged in learning activities, while girls are depicted in the role of passive observer or recipient of information.

Omerod (1975) suggested that the need to assert gender identity in early adolescence coincides with the time when mathematics and sciences become optional in the schools. "Each sex, when educated with the other, is at puberty almost driven by developmental changes to use subject preference and subject choice as a means of asserting its sex role" (p.102). In a study of fourteen-year-old girls, Omerod found that girls were dropping physics, even though they liked it, because of reluctance to enter a male preserve; anticipated difficulty of the physical sciences; advice from teachers, parents and peer group; and "hidden selection" if the school had limited class or lab space. Other studies (Kelly, 1981) indicated greater attention of science teachers to males, the assignment of more passive roles to females, and the general treatment of girls as an unusual or inferior element in the science class. Kelly found strong awareness amoung female students of this differential treatment. Several studies indicated that school counsellor bias does not strongly influence academic choice. Although some counsellors reinforced the attitude that certain occupations are inappropriate for girls, peers, parents and expectation of employment appeared to be stronger influences in subject choice (Haring and Tyler, 1984).

The attitudinal hypothesis. This hypothesis states that girls' achievement is lower in the sciences because they have a less favorable attitude toward these subjects. The lack of appropriate role models is cited as one factor in discouraging women from entering scientific careers. Girls who are not exposed to attractive and "feminine" women in the sciences tend to perceive scientists as masculine, analytical, and cold. A report by the National Academy of Sciences (1979) found that women are represented in very small percentages in the doctoral labor forces of science and engineering, and that women scientists do not share their male colleagues' advancements in either position or salary. The process of attrition begun in the high schools results in increasingly smaller numbers of women to qualify for post-secondary and graduate work. In relation to the influence of role-modelling, a strong correlation is hypothesized between proportion of women faculty and female student achievement (Tidball, 1977; Carnegie Commission, 1973). Tidball found that women's colleges with over one-half female faculty had graduated a much greater portion of the women in doctoral science and engineering programs than had mixed colleges. Shared values for achievement and success, and insulation from the male-female factor in achievement and competition, were suggested contributing factors, as was the tendency of male and female faculty members to be supportive of same-sex students.

Sex Role Standards and Intellectual Functioning

Sex role as a mediator of intellectual performance has been considered by some researchers as a possible explanation for sex-related differences in academic choice and performance. Nash (1979) stated "For some people, cultural myths are translated into personal beliefs which can affect cognitive functioning in sex-typed intellectual domains" (p.263). The concept of sex role standards "the extent to which the individual considers certain activities to be male or female" (Dwyer, 1974, p.811) was first explored in relation to academic motivation and choice by Kagan (1964) who found that second and third grade children identify objects in the school environment as masculine or feminine. Kagan suggested that a child would be more highly motivated to master tasks viewed as sex-appropriate. Stein and Smithells (1969), Stein (1971) and Stein, Pohly and Mueller (1971) found that the perception of social, verbal and artistic skills as feminine, and of spatial, mechanical and athletic skills as masculine, began in second grade and continued through high school. Stein (1971), Stein and Smithells (1969) and Nash (1975) found that the view of mathematics and science as masculine did not emerge until adolescence. Stein, Pohly and Mueller (1971), Stein and Smithells (1969), Nash (1975) found that attainment value and expectancy of success, two determinants of achievement motivation, were influenced by children's perception of the sex role appropriateness of a task, and were higher on those tasks considered sex-appropriate.

Nash (1979) identifies two prevailing hypotheses in research on sex role as a mediator of intellectual functioning. Studies on the differential effects on performance when cognitive tasks are identified as masculine or feminine are typically based on the hypothesis that "the sex appropriateness of an intellectual domain is related to one's own expectancies for success (i.e., the subjective importance placed on both success and the performance level achieved)" (p.264). Those studies which explore within-group differences in cognitive performance as a function of personal sex role attitudes propose that, both across sexes and within a sex, people differ in sex role orientation, as well as in the importance of sex role to their self-definition. Bem and Lenny (1976) found both male and female sex-typed subjects more resistant to simple sex-inappropriate activities such as hammering a nail or ironing a napkin than were those individuals classified as androgynous. Sex-typed subjects also reported feeling more psychological discomfort and negative feelings about themselves when engaged in cross-sex behavior. This suggests that behavior viewed as appropriate for the other sex is motivationally problematic for sex-typed individuals, and in conflict with the individual's self-image of masculinity or femininity.

The concepts of self-esteem, anxiety, and self-acceptance have been related to sex-typing by a number of researchers. High femininity in females has been found to correlate with high anxiety, low self-esteem and low self-acceptance (Consentino and Heilbrun, 1964; Gall, 1969; Sears, 1970), while high masculinity in adult males was correlated with high anxiety, high neuroticism, and low self-acceptance (Hartford, Willis and Deabler, 1967). Horner (1972) related differences in achievement motivation to a form of anxiety she termed "fear of success". In a study of female college students, 65% of females predicted anxiety, guilt, loss of femininity and social rejection for a woman who excelled in a non-traditional academic program, while very few men projected the same feelings toward male success. Monahan, Kuhn, and Shaver (1974) found both boys and girls, aged 10 to 16, responded negatively to female as compared to male achievement, with females often expressing anxiety over the woman's fate, while males expressed hostility. Winchell, Fenner, and Shaver, (1974) found that with high school seniors, fear of success in females increases with cross-sex competition. In their study, 40.9% of females who had attended coeducational elementary schools indicted "fear of success", while the portion from single-sex schools was 15.8%

Analogous to fear of success is the concept of math anxiety or fear of failure as a factor in poor mathematics performance and the avoidance of mathematics study by females. Richardson and Suinn (1972) defined math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems" (p.551). Betz (1978) found that math anxiety was more prevalent among female than male college students, and was related to inadequate mathematics background and to lower math achievement. Betz suggested that math anxiety in women is due to the influence of sex role socialization and may be a significant factor in vocational and educational choice. Hendel and Davis (1978) found math anxiety in college women to be reduced when participants simultaneously enrolled in a special math course and attended a counselling support group.

Further studies continue to support the concept that sex role is a mediator of intellectual functioning which affects the achievement of women in mathematics and the sciences (Fennema, 1980; Fox, Tobin and Brody, 1979; Nash, 1979; Sherman, 1983; Goldman and Hewitt, 1976; Sells, 1980). More recently, self-perception in relation to mathematics and science ability has been identified as a crucial factor in perceived options in college and career choices (Betz and Hackett, 1981; Betz and Hackett, 1983; Hackett and Betz, 1981; Hackett and Betz, 1984; Hackett, 1985, Hollinger 1983; Ware, Steckler, and Leserman, 1985).

Androgyny

In the early 1970's the concept of androgyny arose as an alternative to rigid adherence to traditional sex roles (Bem, 1974; Block, 1973; Rebecca, Hefner and Oleshansky, 1976; and Spence et al., 1975). Bem (1974) proposed that "whereas a narrowly masculine self-concept might inhibit behaviors that are stereotyped as feminine, and a narrowly feminine self-concept might inhibit behaviors that are stereotyped as masculine, a mixed, or androgynous self-concept might allow an individual to freely engage in both "masculine" and "feminine" behaviors" (p.155). In a study to test this hypothesis, Bem (1975), using her own instrument, the Bem-Sex Role Inventory, found that androgynous individuals were more likely to engage in situationally effective behavior, regardless of the sex-appropriateness of that behavior, than were either masculine or feminine individuals. Androgynous individuals displayed high levels of both "masculine" independence and "feminine" playfulness or nurturance, while masculine males were inhibited in playfulness and feminine males in independence. Masculine and androgynous females displayed greater independence than did feminine females, while feminine females displayed neither independence nor playfulness. Bem and Martyna (1976) similarly found androgynous males and females to be high in both independence and nurturance, and masculine individuals of both sexes to be high in independence but low in nurturance. In this study, however, feminine females as well as feminine males were found to be high in nurturance when interacting with a human baby or fellow student.

Evidence for an androgynous model is provided by Block's (1973) reanalysis of data from the forty-year longitudinal Berkely Growth Study of parents and children. Block found that a group of androgynous individuals with low sex-appropriate and high socialized attitudes did exist. They were the products of parents where neither the mother nor father exemplified typical cultural sex role stereotypes but where both offered a wide range of behavioral and attitudinal possibilities to their children. Rebecca, Hefner, and Oleshansky (1976) disagreed with the dichotomous perception of masculinity and femininity of traditional developmental theories. They proposed a developmental stage of sex role transcendence in which "choice of behavior and emotional expression is not determined by rigid adherence to "appropriate" sex-related characteristics" (p.95). Spence, Helmreich, and Stapp (1975) found support for the dualistic interpretation of masculinity and femininity as well as for the concept of androgyny. Spence et al. proposed the concept of androgyny as the possession of a high degree of both masculine and feminine characteristics. Significant positive correlations were found between masculinity and self-esteem and femininity and self-esteem for both men and women. This suggested that the two factors function additively to determine the individual's self concept and behaviors. Spence et al. also found a categorization of individuals with low masculinity and low femininity which they termed "undifferentiated". This group were found to have the lowest measures of self-esteem.

Measures of Sex Role Orientation

The assumption of bipolarity in the concepts of masculinity and femininity has recently been challenged by Bem (1974), Block (1973), Constantinople (1973), and Spence and Helmreich (1978), who prefer to view masculinity and femininity as two separate, independent dimensions. The characteristics of each dimension are believed to exist to some degree in every individual. In a review of measures of sex-typing, sex role orientation, and of masculinity and femininity, Beere (1979) found that in 25 of 30 measures, masculinity and femininity were scored in a bipolar way. Earlier, widely used measures, particularly the Minnesota Multiphasic Personality Inventory and the California Personality Inventory are also criticized because the masculine scales measure positive attributes e.g. independence, activity, while the femininity scales measure less desirable attributes such as passivity and dependence (Broverman et al., 1972). Recent measures treat masculinity and femininity as two orthogonal dimensions and try to define both masculinity and femininity as positive domains of behavior. Among the most widely used of these measures are the Bem Sex-Role Inventory or BSRI (Bem, 1974), and the Personality Attributes Questionnaire or PAQ (Spence, Helmreich, and Stapp, 1975).

Bem (1974) designed the original BSRI to measure masculinity and femininity as two independent dimensions. An individual could be classified as masculine, feminine, or androgynous, with androgyny representing the difference between the subject's endorsement of masculine or feminine personality characteristics. The original instrument included both a Masculinity and a Femininity Scale, each with 20 personality characteristics. A characteristic qualified as masculine if it was judged by college undergraduates to be more desirable in American society for a man than for a woman, and feminine if judged to be more desirable for a woman than for a man. A Social Desirability scale composed of 20 "neutral" characteristics was also included. Subjects were asked to rate how well each of the 60 items described him or herself on a 7-point scale. The Masculinity and Femininity scores indicate to what extent the individual considers those characteristics to be self-descriptive, while the Androgyny score is the t-ratio between masculine and feminine self-endorsement.

Of similar design is Spence, Helmreich, and Stapp's (1975) Personality Attributes Questionnaire. The PAQ consists of 55 items selected on the basis of college students' ratings of each item as typical of the ideal male or female. These items were classified into three subscales: Male Valued, e.g. independent, active; Female Valued, e.g. emotional, tactful; and Sex Specific, a mixture of expressive (female) and instrumental (male) characteristics. Using their questionnaire to determine the relationship of self-esteem to masculinity and femininity, Spence et al. found highly significant correlations between masculinity and self-esteem and femininity and self-esteem in both sexes. They suggested that those individuals with a high proportion of both masculine and feminine characteristics be classified as androgynous and that a fourth category be created for those with low measures of both masculinity and femininity.

Bem (1977) reanalysed her earlier studies (Bem, 1974, 1975; Bem and Lenny, 1976). She concluded that her definition of an androgynous person as one with about equal scores on masculinity and femininity was incomplete and that a distinction between high scorers on both masculinity and femininity scales and low scorers on both scales was warranted. A fourth classification, labelled Undifferentiated, was added for low-low scorers. Because of questions about the neutrality of items on the Social

Desirability scale, these items are no longer scored and serve only as fillers (Bem, 1981). The final instrument, then, consists of 20 masculine, 20 feminine, and 20 filler items. Subjects are asked to rate themselves on a 7-point scale for each item and are classified as Masculine, Feminine, Androgynous, or Undifferentiated. A short form of 30 items has also been created (Bem, 1981).

Spence and Helmreich (1978) found high correlations between the Masculinity and Femininity scales of the BSRI and the PAQ. Locksley and Colten (1979) and Pedhauser and Tetenbaum (1979) have questioned the desirability of some of the feminine items on the BSRI, and whether instruments based on beliefs can actually be used to measure individual differences. Cook (1985) cautions against viewing androgyny as a desirable final state, based on measures that utilize only the positive aspects of masculinity and femininity.

The Concept of Self-Efficacy

Another area of study addresses the effects of sex role socialization on the career choice processes and options of women. Hackett and Betz (1981) asked, "what are the specific mechanisms by which societal beliefs and expectations become manifested in women's vocational behavior?" (p.327). They stated that this knowledge is needed for the understanding of women's career development as well as for the design of intervention programs which would increase women's status and achievement potential in the academic and professional worlds.

Hackett and Betz (1981) explored the application of Bandura's (1977) self-efficacy theory to women's career development. Based on

Bandura's theory that "behavior and behavior change are mediated primarily by expectations of personal efficacy, i.e., expectations or beliefs that one can successfully perform a given behavior" (p.328), they developed a causal model of career choice in which perceived self-efficacy functions as a major mediator. They postulated that, "largely as a result of socialization experiences, women lack strong expectations of personal efficacy in relation to many career-related behaviors, and, thus, fail to fully realize their capabilities and talents in career pursuits" (p.326). Bandura (1977) distinguished outcome expectation, "the belief that certain consequences will follow a given behavior," from efficacy expectation, "the conviction that one is able to successfully perform the behavior that will lead to the outcome" (p.193). Bandura identifies four sources of information on which self-efficacy expectations are based; performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal. Although all of these have been seen to influence the academic and vocational behavior of women, Bandura suggests that successful performance of a behavior is an especially powerful source of strong self-efficacy expectations, that repeated successes negate the impact of occasional failures, and that established self-efficacy tends to generalize, particularly to related activities.

Hackett and Betz suggest that differential expectations of self-efficacy may be a factor in limiting the range from which women choose career options. In their model postulating the effects of traditional female socialization on career-related self-efficacy expectations, they relate the four sources of information identified by Bandura to the possibility of lower, weaker, and less generalized career-related self-efficacy expectations in women than in men. The sources of information are described below.

<u>Performance Accomplishments</u>. Successful performance of a given behavior tends to increase efficacy expectations regarding that behavior. Sex role socialization, boys' play experiences, and sex differences in attribution of success are likely to enhance perceived self efficacy in performance related to achievements viewed as masculine more strongly for masculine than for feminine individuals.

<u>Vicarious Learning</u>. Self-efficacy expectations are derived from observing others succeed, particularly models of the same sex, (Bandura, 1971). Few role models for females are provided in the media, in textbooks, at home, in schools, and in professions based on mathematics and the sciences.

<u>Emotional Arousal</u>. High levels of anxiety, believed to be debilitating to performance and to efficacy expectations have been shown to be more common in females than in males in relation to academic success, particularly in traditionally male areas (Horner, 1972; Richardson and Suinn, 1972). Bandura (1977b) notes that anxiety not only occurs when expectations of efficacy are low, but also that the presence of anxiety further decreases self-efficacy and the liklihood that a given behavior will be performed.

<u>Verbal Persuasion</u>. Encouragement toward a given behavior tends to increase efficacy expectations. Socialization experiences of females tend to discourage activities and pursuits in traditionally male areas, leading to lower self-efficacy expectations toward many career options.

In the first emperical investigation of the applicability of self-efficacy theory to vocational behavior, Betz and Hackett (1981) found male under-graduates to have equivalent self-efficacy toward traditionally male and female occupations, while females had significantly higher self-efficacy toward traditional occupations than toward non-traditional occupations. Betz and Hackett found that female self-efficacy toward non-traditional careers was negatively related to traditional interests. Significant sex differences in self-efficacy were not paralleled by significant sex differences in ability. Although there was no sex difference in achievement, achievement scores were not significantly related to perceived range of career options for females. For males, however, math achievement was significantly related to range of perceived options.

Hollinger (1983) studied the role of self-perception in the career aspirations of mathematically talented female adolescents. Using the self-estimates of ability in Holland's Self-Directed Search, Hollinger found that those females aspiring to non-traditional (math-related careers) could be differentiated on the basis of seven self-estimates of ability. The highest indicator of aspiration to a career in math or science was the individual's estimate of her science ability. High self-estimates predicted aspiration to nontraditional math and science careers (e.g. accountants, chemists, physicians) while low self-estimates predicted aspiration to non-math careers. Hollinger suggests that "discrimination between math-science career aspiration and non-math career aspiration is a function of self-perception of abilities which are stereotypically viewed as being either masculine or feminine" (p. 56).

Betz and Hackett (1983) investigated the relationship of mathematics self-efficacy expectations in 153 female and 109 male college under-graduates to their selection of science-based college majors. The

Mathematics Self-Efficacy Scale designed by Betz and Hackett, the Bem Sex-Role Inventory, an adapted version of the Fennema-Sherman Mathematics Attitude Scales, and a questionnaire concerning college major choice were used to test two hypotheses, 1) that the mathematics self-efficacy expectations of college males are stronger than those of college females, and 2) that mathematics self-efficacy expectations are importantly related to career decision-making, particularly to the selection of science-based majors. As well, the relationship of math self-efficacy expectations to attitudes toward mathematics and to sex role variables was explored.

The self-efficacy expectations of males were found to be consistently higher than those of females. Males also showed more positive attitudes toward math, greater confidence in their math ability, and a greater tendency to view math as useful. Women showed a greater tendency to view math as a male domain. Students with stronger math self-efficacy expectations had lower math anxiety, more overall confidence, a greater tendency to view math as useful, and greater effectance motivation, which Sherman (1983) describes as "a sort of joy of problem-solving" (p.274). Higher math self-efficacy expecations were related to higher ratings on the BSRI Masculinity scale but were not related to BSRI Femininity Scores. Betz and Hackett concluded that 1) mathematics self-effecacy expectations are related to the choice of science versus nonscience based college majors; 2) students with stronger math self-efficacy expectations showed greater likelihood of choosing a science-based major than students with weaker efficacy expectations; 3) math achievement was not a significant predictor of science choice. The positive relation of self-reported masculinity and the lack of relation of femininity to math self-efficacy expectations supports Spence and Helmreich's (1980) findings that higher levels of masculinity (instrumentality) appear to facilitate confidence and self-esteem.

Hackett and Betz (1984) investigated the relation of mathematics performance, math self-efficacy, attitudes toward mathematics, and choice of science-based (i.e., math-related) college major. A strong positive relationship was found between math performance and math self-efficacy, but women's self-efficacy expectations, compared to men's were not, as Hackett and Betz (1981) hypothesized, found to be unrealistically low. Significant and positive correlations were found between both math performance and math self-efficacy and attitude toward mathematics, masculine sex role orientation, and math-related major choice, with stronger correlations occurring between self-efficacy and the other variables. Hackett and Betz concluded that math self-efficacy was a better predictor of math-related major choice than either performance or achievement variables. Consistent with the 1983 study, the BSRI Femininity scores were not significantly related to any other variables. The Masculinity scores were significantly and positvely correlated with all MSE scales, although not with math performance. Males with higher levels of math self-efficacy and more years of high school math were more likely to have selected science-based majors, supporting the hypothesis that math self-efficacy expectations are stronger predictors of math-related career choice than math performance or math achievement. Hackett and Betz concluded that there was support for their (1983) findings that math self-efficacy and math performance are significantly related to each other and to attitudes toward math and math-related career choices. Gender differences in math self-efficacy were more predictive of gender differences in choice of science-based major than were gender differences in performance.

In a study to test the hypothesis that mathematics self-efficacy mediates the effects of gender and mathematical preparation and achievement on math-related college major choice, Hackett (1985) constructed a causal model of the interrelationships of seven variables in the choice process of math-related careers. In a path analysis, Hackett found significant correlations between gender, years of high school math, math achievement, math self-efficacy, math anxiety, and math relatedness of declared major. Self-efficacy was the variable most highly correlated with math-related major choice, while the BSRI masculinity score did not have a significant correlation. Hackett explained, however, that the necessity of using the masculinity scale only, because the path analysis required interval data, may have accounted for this unexpected finding. Math achievement, math anxiety, and years of high school math had the highest correlations with math self-efficacy. With BSRI scores, significant correlations were found only between masculinity and self-efficacy and gender, indicating that males tended to have higher scores in masculinity and that higher masculinity scores were related to higher math self-efficacy.

Measures of Attitude Toward Mathematics

The Mathematics Anxiety Rating Scale (Richardson and Suinn, 1972) has been utilized by some researchers to specifically investigate the contribution of mathematics anxiety to math avoidance and related implications for academic and vocational choice (Betz, 1978; Hendel and Davis, 1978). More widely used, however, are the Fennema-Sherman mathematics Attitude Scales (Fennema and Sherman, 1976). These scales were designed for use in schools to measure thos sociocultural factors hypothesized to influence males and females in the study of mathematics. The eight scales include: Confidence in Learning Mathematics; Percieved Usefulness of Mathematics; Perceived Attitudes of Mother, Father and Teacher toward One as Learner of Mathematics; Attitude Toward Success in Mathematics; Mathematics as a Male Domain; and Effectance Motivation in Mathematics. Sherman (1983) states that items on the Math as a Male Domain scale concern opinions that females cannot do math as well as males, and/or that females who do well in math are peculiar or masculine. Betz and Hackett (1978) revised the Fennema-Sherman scales for use with college students. The revised version consists of five 10-item scales to measure math anxiety, confidence in learning math, perceptions of the usefulness of math, math as a male domain, and effectance motivation in math. As in the original, subjects respond on a 5-point Likert scale to statements pertaining to feelings and attitudes toward mathematics. The Mathematics Self-Efficacy Scale was developed by Betz and Hackett (1983) based on Bandura's theory of self-efficacy expectations and their own extension of that theory to career-related behaviors (Hackett and Betz, 1981). The development of the MSES was based on a review of existing measures of math confidence or math anxiety, and the identification from these of three domains of mathematics-related behavior which are relevant to math self-efficacy expectations (Betz and Hackett, 1983b). The three domains are:

1) the solving of math problems, based on Dowling's Mathematics Confidence Scale (unpublished),
2) math behaviors in everyday life, based on the Mathematics Anxiety Rating Scale, and
3) ability to successfully perform college coursework requiring varying degrees of math ability. Item selection was based on students' ratings of courses on Goldman and Hewitt's (1976) science-nonscience continuum.

The initial measure consisted of 7[illegible]ms distributed on three subscales: Math Problems, Math Tasks, and College Courses. Subjects indicate their confidence on a 10-point scale ranging from "0" (no confidence at all) to "9" (complete confidence) in their ability to successfully perform the task, solve the problem, or complete the course with a grade of "B" or better. The final version consists of 18 math tasks, 18 math problems, and 16 math-related courses. An additional six courses in traditionally female areas were included in the courses subscale to examine sex differences in self-efficacy in traditional and non-traditional areas. These are not used in calculating the MSES score (Betz and Hackett, 1983b). A search of literature reveals no critiques of the MSES nor uses by anyone other than the authors.

Conclusion

Although some researchers continue to search for sex-related differences in ability, many recent studies focus on traditional sex role definitions and socialization practices, women's conceptions of their own abilities, the view of mathematics as a male domain, and differential course-taking, to explain differences in achievement and participation between men and women in mathematics and sciences (Ware, et al., 1985).

The socialization of females according to traditional sex role expectations has been identified as a factor strongly inhibiting the development of those characteristics conducive to development of interest and ability in mathematics and the sciences. Bem (1974) proposed that a state of psychological androgyny, a balance between male and female characteristics, gives both men and women the freedom to maintain attitudes and make choices unrestricted by traditional sex role expectations. This hypothesis is supported by research which has shown that high proportions of both masculine and feminine characteristics in the same individual have been related to high self-esteem in both men and women (Spence and Helmreich, 1975), and to independence (Bem, 1975). Female sex-typing has been related to high anxiety, low self-esteem and low self-acceptance (Consentino and Heilbrun, 1964), to fear of success (Winchell, et al., 1974) and to math anxiety (Betz, 1978).

Other researchers have hypothesized that sex role is a mediator of intellectual functioning which affects the achievement of women in mathematics and the sciences (Nash, 1979), while mathematics has been identified as the "critical filter" which restricts women's academic and vocational choices to the traditionally female sphere. Hackett and Betz (1981, 1983, 1984, 1985) developed the concept of mathematics self-efficacy and explored the role of self-efficacy, as well as that of sex role orientation and other variables, in women's academic and vocational behavior.

As the foregoing review indicates, sex role is believed to affect academic development and vocational choice, both directly, as in the identification of mathematics and sciences as male domains, and indirectly, through anxiety, fear of success, and strength of belief in one's ability to perform mathematics-related functions. Particularly, these factors are believed to affect the choices of females regarding the study of mathematics-related subjects, and the choice of mathematics-related occupations. The present study, therefore, attempts to assess the effects of both sex role orientation and mathematics self-efficacy on the choice of a science or nonscience based program in a sample of post-secondary students. The following hypotheses will be tested.

1. Male subjects will have significantly higher self-efficacy expectations toward mathematics than will females.
2. Females in science programs will have significantly higher self-efficacy expectations toward mathematics than females in nonscience programs.
3. Mathematics self-efficacy expectations are significantly related to sex role orientation.
4. Females in science programs will have significantly higher masculinity scores than females in nonscience programs.
5. Mathematics self-efficacy is a significant predictor of science-based program choice.

For the purposes of this study, the terms "sciences", "sex role", "sex-typed", "sex role orientation", "mathematics self-efficacy", "masculinity", "femininity", and "androgyny" will be defined as follows:

1. "Sciences" refers to the natural sciences, e.g., biology, chemistry, physics, and to the applied sciences, e.g., agriculture, engineering, as opposed to the social sciences.
2. "Sex role" refers to those qualities believed to be characteristic of males or females in our society (Block, 1973).
3. "Sex-typed" indicates an individual "who is highly attuned to cultural definitions of sex-appropriate behavior and who uses such definitions as the ideal standard against which his or her behavior is to be evaluated" (Bem, 1981, p.4).
4. "Sex role orientation", sometimes used interchangeably with "sex role identity", indicates an individual's perception, not necessarily conscious, of the extent to which he or she endorses those qualities believed to represent masculinity or femininity in our society (Beere, 1979).
5. "Mathematics self-efficacy", or "mathematics self-efficacy expectations" refers to "the perception of performance capability in relation to math problems, everyday math tasks, and mathematics-related college coursework" (Betz and Hackett, 1983, p.332).
6. "Masculinity" refers to "the personality traits, interests and behaviors that are, or are believed to be, more characteristic of males than of females" (Beere, 1979, p.19).
7. "Femininity" refers to "the personality traits, interests and behaviors that are, or are believed to be, more characteristic of females than of males" (Beere, 1979, p.19).

8. "Androgyny", is commonly used in the literature reviewed to refer to the presence of both masculine and feminine qualities in the same individual. However, the present study uses Bem's definition of an androgynous individual as one who exhibits high levels of characteristics considered desirable for both males and females, as distinguished from "undifferientiated" individuals who exhibit low levels of both masculine and feminine characteristics.

III. RESEARCH DESIGN AND METHODOLOGY

A. The Sample

The sample for the present study consisted of 116 students from four programs at the Northern Alberta Institute of Technology (NAIT). The results from five subjects were removed before the analysis due to incomplete information. The final sample therefore consisted of 111 subjects, a considerably smaller sample than the 262 subjects in Betz and Hackett's (1983) study. All of the subjects, at the time of participation, were registered in either the first or the second year of one of four selected NAIT programs. (See Appendix A for sample breakdown by program, year, and sex). The programs were selected on the basis of science and mathematics admission prerequisites. The questionnaire was administered during class time and students were asked, but not required, to participate.

The sample consisted of 45.9% males (N=51) and 54.1% females (N=60). The age range of the subjects was from 17 years to 34 years (Mean=21, S.D.=3.77). The sample was stratified by sex and choice of science or nonscience-based program. That is, 24.3% were females in a science-based program; 30.6% were males in a science-based program; 29.7% were females in a nonscience program, and 15.4% males in a nonscience program.

Each subject was asked to specify which mathematics and science courses they had taken in Grade 12 and the grades they had obtained in each. Information from academic records provided an additional index of mathematics and science performance. It was found that the females in science had the highest number of science and math courses (Mean=3.9) and the highest achievement (Mean=77.1); males in science had the second highest (3.1; 71.3). The mixed class of males and females in Business Administration had an average of 2.5 math and science courses with 61.7% mean achievement, while the all-female Secretarial group had an average of 1.5 courses with mean achievement of 47.7% (Appendix C). Although three of the four programs were in traditionally "male" or "female" areas, the sample chosen best represented male and female students of about equal academic backgrounds in both science and nonscience areas.

B. The Instruments

Each subject was asked to complete two paper and pencil forms: 1) the Mathematics Self-Efficacy Scale (Appendix G), and 2) The Bem Sex-Role Inventory, and a questionnaire regarding math and science background and achievement. A description of each instrument follows:

The Mathematics Self-Efficacy Scale (MSES)

The Mathematics Self-Efficacy Scale is a 52-item questionnaire. The items are divided into three parts or subscales corresponding to the three domains of mathematics-related behavior identified by Betz and Hackett (1983b) as relevant to math self-efficacy expectations. The subscales are:

1) Math Tasks, 18 items. Subjects are asked to indicate how much confidence they have that they could successfully perform each of 18 everyday tasks requiring some math behavior;

2) Courses, 16 items. Subjects are asked to indicate how much confidence they have that they could successfully complete the indicted courses with a final grade of "B" (65%-79%) or better;

3) Math Problems, 18 items. Subjects indicate how much confidence they have in their ability to successfully solve the math problems listed. Subjects are directed not to solve the problems.

The Courses subscale also includes six courses in traditionally female areas which are not used to compute the total MSES score (Betz and Hackett, 1983b). The actual number of items is therefore 58.

Accompanying the questionnaire is an answer sheet numbered to correspond to the items on the questionnaire. Subjects indicate their confidence in their ability to perform each task or solve each problem on the basis of a 10-point scale ranging from "0" (no confidence at all) to "9" (complete confidence).

For the present study, the six traditionally female courses from the Courses subscale were used to form a fourth subscale, the "F" subscale, for the purpose of determining whether there would be a difference in women's self-efficacy expectations toward traditionally female courses, as opposed to those considered more suited to males. The instrument used by Betz and Hackett was modified by the addition of definitions from Webster (1976) to clarify the meanings of terms used for college courses which may have been unfamiliar to the student population studied. Information was obtained from the authors for the definitions of four course designations (e.g. Algebra I) not used in the Alberta school system. As well, an answer sheet was compiled as none was included in the test materials received from the authors.

Following the procedure outlined by Betz and Hackett, subjects were asked to indicate on the answer sheet their confidence in their ability to successfully perform each item. Scores were calculated for each subscale as well as for the "F" scale. The scores for the six courses in traditionally female areas were excluded from the total calculation as instructed by the authors, and the total mathematics self-efficacy score was calculted as the sum of responses to all items representing math tasks, math problems, and math-related courses.

Reliability. Reliability of the Mathematics Self-Efficacy Scale was tested by administering the original 75-item scale to 115 undergraduate students. Subjects were asked to indicate the degree of confidence they had in their own ability to perform each task, and also the degree of difficuly of the task for the average student, rating difficulty on a scale from "0" (not at all difficult) to "9" (extremely difficult). Analyses of item difficulty, item discrimination (item-total score correlations), and internal consistency reliability of the subscales and total scale were performed. Betz and Hackett reported high internal consistency reliabilities for the three subscales (.90 for Math Tasks; .93 for Courses; and .92 for Math Problems), and .96 for the total scale. Item-total score correlations for the subscales were moderate, ranging from .24 to .63 for Math Tasks; .38 to .68 for Math Problems; and .16 to .70 for Courses.

Validity. Selection of the final 52 items was based on discrimination data and item content, and item difficulty. On the math tasks, eight items with less than 2.0 level difficulty on the 10-point scale were eliminated. Other items having item-total correlations below r_{pb} =.25 were also eliminated.

In developing their instrument, Betz and Hackett first reviewed existing measures of mathematics confidence and math anxiety. From these, they identified three domains of mathematics-related behaviors relevant to the study of self-efficacy expectations toward mathematics. These behaviors are 1) the solving of math problems, 2) the use of mathematics in everyday life, and 3), the ability to successfully complete college courses which require mathematics knowledge in various degrees. The items on the individual subscales of the MSES were chosen to reflect the three domains of math behaviors identified. The Math Problem items were adapted from the Dowling's Mathematics Confidence Scale which consists of 18 math problems. These problems represent three content areas (Algebra, Geometry, and Arithmetic); three types of mathematical operations (computational skill, comprehension, and ability to apply principles of mathematics); and two levels of abstraction (real versus abstract). Betz and Hackett (1983b) stated that all 18 items were selected for inclusion in the Math Self-Efficacy Scale because of the balance of item content and because the Dowling scale provides for the assessment of both performance and self-efficacy expectations. However, in the MSES, the items on the Math Problems subscale are not used for the assessment of performance, but only for the assessment of self-efficacy toward mathematics.

For the Math Tasks subscale, some items were adapted from the Math Anxiety Rating Scale. Items were selected only if they reflected, or could be modified to reflect, math behaviors, e.g., "compute your car's gas mileage", rather than attitudes toward math. Additional items were selected from a pool generated by asking college students for examples of how they, or students in general, use math in everyday life. The 18 Math Tasks subscale items therefore reflect behaviors in which mathematics is utilized in everyday activities.

For the College Courses Subscale, Betz and Hackett selected 8 math courses per se, and eight courses requiring math knowledge and background. For the latter, 32 college majors which represented a range of emphasis on science were identified. These courses had been categorized according to degree of emphasis on science on Goldman and Hewitt's science-nonscience continuum, ranging from level 1 (nonscience) to Level 5 (greatest emphasis on science). To verify whether the students' perceptions of the amount of math required in these courses corresponded to their science classification by Goldman and Hewitt, Betz and Hackett asked students to indicate, on a scale from "None" (0) to "Extensive" (5), how much math coursework they felt was required to complete each course. From the 27 college courses whose perceived math requirement corresponded to their science continuum rating, the eight courses selected for the courses subscale, in addition to the eight mathematics courses were; four level 4 and 5 courses (e.g. physiology, computer science); three level three courses (e.g., accounting); and philosophy, described by the authors as "a level course in a traditionally male area" (1983b. p.5). No explanation is given for the inclusion of philosophy in the total score. As previously mentioned, the Courses subscale also includes six courses from traditionally female areas. These are not included when computing the subscale score nor the total score. The total math self-efficacy score is defined as "the sum or responses to the items representing math tasks, math problems, and math-related courses" (Betz and Hackett, 1983b, p.6). The authors state that further refinements and compilation of normative data are underway.

Bem Sex-Role Inventory (BSRI)

The Bem Sex-Role Inventory (Bem, 1974) was designed to measure masculinity and femininity as separate dimensions rather than as opposite ends of a single continuum, and to identify individuals which may be low (undifferentiated) or high (androgynous) in characteristics of both masculinity and femininity. The scale consists of sixty personality characteristics, twenty of which are considered stereotypically feminine, e.g. gentle, sympathetic; twenty, stereotypically masculine, e.g. analytical, competitive; and twenty neutral or filler items, e.g. friendly, reliable. A shortened version of thirty items is incorporated into the inventory.

Each subject is asked to complete the BSRI by indicating on a 7-point scale, ranging from "1" (never or almost never true) to "7" (always or almost always true) how well each of the adjectives or phrases describes him or herself. Scores are obtained by summing the totals of the Masculinity and Femininity items, respectively, and dividing each total by the number of items on the scale (20).

Medians for both the Femininity and Masculinity scales are calculated for the sample group and subjects are classified as Feminine, Masculine, Androgynous, or Undifferentiated by the median-split method (Bem, 1981). Those subjects who score above the median in Femininity but below in Masculinity are classified as Feminine; those above on Masculinity but below on Femininity are classified as Masculine; those above the median on both Masculinity and Femininity are termed Androgynous; and those below the median on both scales comprise the Undifferentiated group.

Reliability. Psychometric analysis was based on two samples of undergraduate psychology students. The first sample (1973) consisted of 444 males and 279 females; the second (1978) included 476 males and 340 females. Bem (1981) reported high reliability scores for both samples. Internal consistency coefficients ranged from .75 to .78 for the Femininity Score, .86 to .87 for the Masculinity Score, and .78 to .84 for F minus M Difference Score. For test-retest realiability correlations range from .82 to .89 for Femininity, .94 to .96 for Masculinity, and .86 to .88 for F-M. The Masculinity and Femininity scores were shown to be logically independent (Bem, 1974), as well as empirically independent from each other, with correlations ranging from - .14 to .11 (Bem, 1981).

Validity. Bem (1975), Bem and Lenny (1976), and Bem, Martyna, and Watson (1976) provided information which supported the central hypothesis that

> ...non-androgynous individuals restrict their behavior in accordance with cultural definitions of desirable behavior for women and men significantly more often than do androgynous individuals (Bem, 1981, p.16).

In addition the the Bem studies, a number of investigations, included in her (1981) bibliography establish relevant behavioral correlates, supporting the vailidity of the BSRI.

The BSRI has been criticised by Jones, Chernovetz, and Hansson (1978), Locksley and Colten (1979), and Pedhauzer and Tetenbaum (1979), as a valid instrument to measure psychological androgyny. Locksley and Colten questioned whether the endorsement of masculine or feminine traits can be assumed to reflect behavior in accordance with those stereotypes, and whether the adjectives used to describe prototypes are descriptive of actual men and women in our society. Pedhauser and Tetenbaum questioned the desirability of some feminine traits on the BSRI. The lack of an established concept and generally accepted definition of androgyny is also noted (Cook, 1985). The BSRI, however, remains one of the most widely used and accepted measures of sex role orientation at this time.

C. Data Collection

In June, 1985, permission was received from the Executive Committee of the Northern Alberta Institute of Technology to conduct the proposed study. With the cooperation of the Department Chairmen involved, as well as individual instructors, class time in a relevant subject was allocated for the study. The questionnaires were administered during the months of October and November, 1985. A brief explanation of the study was given. Each student was given an envelope containing the The Mathematics Self-Efficacy Scale and answer sheet, the Bem Sex-Role Inventory, and a questionnaire regarding academic background. Verbal as well as written instructions were given for each questionnaire and inquiries were answered before administration. Confidentiality was assured and only students participating in the study were present. One student stated that she would complete the questionnaires but did not wish to include her name or other identifying information. She was allowed to participate in the study but her questionnaire was one of those not included in the final sample due to insufficient information. Subjects were asked to take as much time as needed to complete the questionnaires, which were then placed in the envelope and returned to the investigator.

116 sets of questionnaires were completed and returned. Of these, 5 were not used because of inadequate information regarding math and science background and achievement. The MSES was administered and scored according to information given in the Extended Description received from the authors (Betz and Hackett, 1983b). That is, the scores on each subscale were summed for the subscale scores, and the scores of all items were summed for the total MSES score. The BSRI was administered and scored following directions in the Professional Manual (Bem, 1981). Mean Masculinity and Femininity scores were calculated for each individual by summing the totals of the Masculinity and Femininity items, respectively, and dividing each total by 20, the number of items on each subscale. Median Masculinity and Femininity scores were calculated for the whole sample, a procedure which Bem (1981) indicates as an alternative to using the median raw scores of the normative sample. The sample medians, (M=4.90, F=4.78) were similar to those obtained in the normative sample (M=4.95, F=4.90) (Appendix B). Psychological catergorization of each subject was obtained using the "median split" method recommended by Bem. That is, those subjects who scored above the Femininity median but below the Masculinity median were classified as Feminine; those above the median on Masculinity but below in Femininity were classified as Masculine; those scoring above both medians were classified Androgynous, and those scoring below both medians as Undifferentiated.

Analysis of Data

The Statistical Package for the Social Sciences (SPSSx), a software package designed for analysing social sciences data, and available through computing services at the University of Alberta, was used for data analysis in this study. This program was used to perform a t-test to determine the significance of the differences of the mean self-efficacy scores for males and females in the first hypothesis. Summative statistics and frequency counts were performed using SPSSx for sample breakdown by program, year and sex (Appendix A) and calculation of raw score means, medians, and standard deviations for the BSRI (Appendix B). SPSSx was also used to perform cross tabulations to determine the percentage of subjects in each Bem category (Appendix D).

Two software packages available through the Division of Educational Research at the University of Alberta were also used. ANOV10, which performs t-tests for independent samples, was used to determine the significance of the differences of the means of female science and non-science students' scores in mathematics self-efficacy and BSRI masculinity, for the second and fourth hypotheses. Multiple regressions and correlation analyses for the third and fifth hypotheses were performed using the software package MULR10. Pearson product-moment correlations were used to examine relationships of math self-efficacy to math achievement, math background, and Masculinity and Femininity scores. Subjects program choices at NAIT were classified according to a science-nonscience continuum. Continuum scores of the chosen program were used as the dependent variable in a stepwise multiple regression analysis. Gender, Masculinity, Femininity, MSES total score, math-science achievement and math-science background were utilized as the independent variables.

IV. RESULTS

The intent of this study was to examine five hypotheses relating to the effects of gender and sex role orientation on mathematics self-efficacy expectations; and the effects of gender, sex role orientation and mathematics self-efficacy on students' choice of program at a post-secondary technical institute.

A. Hypothesis 1

Males will have significantly higher self-efficacy expectations toward mathematics than females.

Betz and Hacket (1983) examined sex differences in math self-efficacy expectations on the MSES. Mean scores of males and females were calculated on an item-by-item basis on the subscales, and on the total scale. Item-by-item analysis showed the means of males were higher than those of females on all but three of the 52 items. The three items on which females reported higher, though not statistically significant, self-efficacy expectations were in traditionally female math-related activities, i.e., making curtains, grocery shopping, and calculating quantities for recipes. Examination of means for the math tasks, math problems, and courses subscales, and for the total MSES score showed that self-efficacy expectations of males were significantly higher than those of females on all three subscales of the MSES and on the total scale.

In the present study, means scores were calculated only for each subscale as well as for the total scale score, a procedure followed by Hackett and Betz (1984). T-tests were used to determine the significance of the difference of the means of total MSES scores, of each of the three subscale scores and of the "F" subscale created from the six items representing traditionally female occupations. A significant difference in favor of males was found in the means of the total MSES scores of males and females based on a calculated t-value of 2.63 which was significant at the .01 confidence level. Significant differences in favor of males were also found in the means of scores on all of the MSES subscales with the greatest difference in the Math Problems Subscale (Table 1). While differences in means on the Math Courses subscale ($t=2.08$, $p \leq .04$), indicate that males had higher self-efficacy regarding their ability to successfully complete math-related college courses, comparison of means on the "F" scale (traditionally female college courses) indicates a significant difference in favor of females (t-value -3.11, $p \leq .002$).

The results therefore support Betz and Hackett's findings that males consistently have stronger beliefs in their ability to perform everyday math-related tasks, to correctly perform the calculations for math problems of varying degrees of difficulty, and to complete with a grade of "B" or better, college courses with varying levels of math content. The difference in favor of females on the "F" scale indicates that female students have greater belief in their ability to succeed at role-appropriate college courses than at those with high math content and/or those which are traditionally male-dominated. These results are comparable to Betz and Hackett's (1981) findings that men's occupational self-efficacy is significantly higher than women's toward traditionally male occupations, and that women's self-efficacy is significantly higher than men's toward traditionally female occupations.

TABLE 1

Sex Differences in Math Self-Efficacy Subscale Scores and Total Score

	Males (N=51)		Females (N=60)				
	M	SD	M	SD	t	DF	p
SCALE							
Math tasks	134.4	16.7	127.0	20.1	2.08	109	≤0.040
Courses	98.6	22.4	89.6	23.0	2.08	109	≤0.040
Problems	141.4	17.5	130.9	25.2	2.50	109	≤0.014
"F" Scale	30.3	8.6	35.1	7.3	-3.11	109	≤0.002
Total Score	375.0	51.6	347.2	58.8	2.63	109	≤0.012

Higher scores on the math self-efficacy scale indicate greater confidence in ability to accomplish math-related tasks.
Maximum total score possible = 468.

B. Hypothesis 2

Females in science programs will have significantly higher self-efficacy expectations toward mathematics than will females in nonscience programs.

In their (1981) application of Bandura's self-efficacy theory to career-related behaviors, Hackett and Betz suggested that weak self-efficacy expectations in behavioral domains relevant to career choice, e.g. mathematics, affect career decisions and may be a limiting factor particularly in the career options of women. Betz and Hackett (1983) hypothesized that mathematics self-efficacy expectations are importantly related to career decisions, particularly to the selection of science-based majors in college.

The present study addresses the question of whether women who have chosen a science-based program have higher mathematics self-efficacy expectations than those who have chosen a nonscience program. As shown in Table 2, a t-test to determine the significance of the difference of the means of total MSES scores of science and nonscience females, showed a significant difference based on a calculated t-value of 4.29 which was significant at the .01 confidence level ($p \leq .001$). This is a strong indicator that women in science programs have greater belief in their mathematics-related ability than do women in nonscience programs.

TABLE 2

Differences in Total Math Self-Efficacy Scores

of Female Science and Nonscience Students

	Science (N=27)		Nonscience (N=33)				
SCALE	M	SD	M	SD	t	DF	p
Total Math Self-Efficacy Score	378.9	49.5	321.4	53.3	4.29	58	≤0.001
BSRI Femininity	4.8	.53	5.0	.64	-1.22	58	≤0.226
BSRI Masculinity	4.6	.76	4.6	.63	-0.32	58	≤0.747

Critical value at .05 level = 2.002

Hypothesis 3

Mathematics self-efficacy expectations are significantly related to masculine sex role orientation.

In examining the relationship of mathematics self-efficacy to sex role variables, Betz and Hackett (1983) found higher total MSES scores to be related to higher Masculinity scores on the BSRI (r=.33) but not to Femininity Scores.

In the present study, a Pearson product-moment correlation was used to examine the interrelationship among the predictor variables in the regression analysis. As Table 3 indicates, a positive but not strong correlation (r=.266) was found between Masculinity and mathematics self-efficacy. No correlation was found between Femininity score on the BSRI and math self-efficacy.

TABLE 3

Relationship of Mathematics Self-Efficacy Expectations to Sex Role Variables

	Sex role Variable	
	Masculinity	Femininity
	r	r
Math Self-efficacy	0.266	-0.028

Hypothesis 4

Females in science programs will have higher masculinity scores than females in nonscience programs.

Mathematics self-efficacy expectations were found to be positively related to BSRI Masculinity score in both the present and the previous study. In the present study, females in science programs were also found to have stronger math self-efficacy expectations than females in nonscience programs. It was therefore expected that females in science programs would demonstrate higher levels of masculinity or instrumentality (Spence and Helmreich, 1980) than their nonscience counterparts. In a comparison by t-test of the mean Masculinity and Femininity scores of science and nonscience females, no significant differences were found in the mean scores of either scale between the two groups at either the .05 or the .10 levels of significance (Table 2). This indicates that among those women who are sex-typed, there is no relationship between the strength of their sex-typing and their program choice.

However, very few women in either program were sex-typed as masculine, and fewer women in science programs were found to be sex-typed, either masculine of feminine, than were women in nonscience (secretarial and business administration) programs (Appendix D).

Hypothesis 5

Mathematics self-efficacy is a significant predictor of science-based program choice.

In Betz and Hackett's (1983) study, college major choices were classified according to Goldman and Hewitt's science-nonscience continuum. Scores on this continuum range from 1 (low science content, e.g., theatre) to 5 (high science content, e.g. physical sciences). Continuum scores were used as the dependent variable in a stepwise multiple regression analysis. Independent variables were gender, total MSES score, years of high school math, Fennema-Sherman math anxiety and mathematics confidence scores, math achievement scores, and the BSRI Masculinity score. Of the independent variables, gender, math self-efficacy expectations, years of high school math and math anxiety were significant predictors of college major. That is, subjects with stronger math self-efficacy expectations, more years of high school math, and lower levels of math anxiety had a greater tendency to select science-based majors, as did males over females.

Goldman and Hewitt's science-nonscience continuum was inappropriate for the present study, as the classification of physical sciences at level 5 and biological sciences at level 4 is incongruent with the math and science prerequisites for NAIT courses. These require a greater number of science courses for admission to the Medical Lab program than to the Electronics Program. A science continuum was therefore developed, patterned after the Goldman-Hewitt model, but categorizing courses on four levels, based on the Grade Twelve math and science prerequisites of NAIT programs. Levels ranged from 1 (no science prerequisite, e.g. secretarial) to 4 (two science and one math prerequisite, e.g. Medical Lab Sciences) (Appendix F).

Table 4 shows the results of the stepwise multiple regression using the science code of program choice on the NAIT continuum as the dependent variable. The independent variables utilized were gender, total MSES score, BSRI Masculinity and Feminity scores, number of math and science courses taken in Grade 12 (Performance), and average achievement score in Grade 12 math and science courses.(Achievement).

In the regression analysis, three predictors contributed significantly to the regression equation. As was expected, given the structure of the science continuum, the strongest predictor of science-based program choice was the number of Grade 12 math and science courses ($r=0.620$, $R^2=.385$). The next strongest predictor was average achievement score ($r=0.549$), followed by Mathematics Self-Efficacy (r=.465). Although achievement was the second highest predictor, math self-efficacy was the second variable to enter the equation (R^2=.462), indicating that mathematics self-efficacy has a greater independent value than achievement. Math self-efficacy accounts for an additional 7.7% of the variance in science code of program choice, as opposed to Achievement which accounted for an additional 3.6% (R^2=.498). Because of its higher correlation with Performance (r=.503), Achievement was the last variable to enter the equation and accounted for the least amount of variance. The obtained multiple regression coefficient was R=.706 and the three predicting variables accounted for a total of 49.8% of the variance.

As in the Betz and Hackett study, BSRI Masculinity and Femininity failed to meet the criteria for inclusion. However, whereas Betz and Hackett found males more likely than females to choose a science-based major, gender was not a predictor of choice of science program in the present study. This is not an unexpected finding considering that there was not a great difference in the number of male and female science students in the total sample (n=34, n=27), and that the group with highest performance was female.

The present study supports Betz and Hackett's (1983) statement that students with stronger self-efficacy expectations regarding mathematics are more likely to select science-based college majors, as are students with more years of high school math. However, whereas mathematics achievement did not contribute significantly to the prediction of science code of major choice in the previous study, this variable did account for a small but significant amount of the variance in the present study. The results [illegible] directly comparable, however, as the present study did not include mathematics anxiety, which contributed significantly to the prediction in the Betz and Hackett study.

TABLE 4

Stepwise Regression Analysis for the Prediction of Value of Program Choice on Science-Nonscience Continuum

Significant Predictors	Multiple R	R-Square	Simple R	B	p
Performance					
Number of Grade 12 Math and Science Courses (Performance)	0.620	0.385	0.620	0.344	≤.0001
Math Self-efficacy Expectations	0.679	0.462	0.465	0.004	≤.0001
Math Achievement	0.706	0.498	0.549	0.014	≤.0001

Constant = 0.688
F = 35.407 df = 3, 107 p 0.001

V. DISCUSSION AND IMPLICATIONS

This study was designed to examine the effects of gender, sex role orientation and mathematics self-efficacy on program choice at a post-secondary technical institute.

The Bem Sex Role Inventory and the Mathematics Self-Effecacy Scale were completed by 111 students from four programs at the Northern Alberta Institute of Technology. Mean differences were examined in BSRI Masculinity, BSRI Femininity, Mathematics Self-Efficacy, Science Performance and Science Achievement. T-tests were used to assess differences in the mathematics self-efficacy expectations of males and females in the total sample, and in female science and nonscience students. A t-test was also used to examine the differences in mean BSRI Masculinity and Femininity scores between science and nonscience females. The relationships of mathematics self-efficacy expectations to Masculinity and Femininity were examined using Pearson product-moment correlations. Finally, subjects program choices at NAIT were classified according to a science-nonscience continuum. Scores on this continuum range from 1, low science prerequisite, to 4, high science prerequisite. The score of 1 is associated with the Administrative Secretarial Arts program, while a score of 4 describes Medical Lab Sciences. The continuum scores were used as the dependent variable in a stepwise multiple regression analysis, with gender, BSRI Masculinity and Femininity scores, total MSES score, number of Grade 12 science and math courses, and average achievement score in Grade 12 science and math courses as the independent variables. All findings were considered statistically significant at the .05 level.

The results of the study supported four of the five hypotheses tested. This chapter will include a discussion of the findings for each hypothesis, conclusions, and suggestions for further research.

A. Hypothesis I

Hackett and Betz (1981) postulated that differential expectations of self-efficacy between women and men are at least in part responsible for the limited range of career options from which most women choose. Sells (1980) identifies mathematics as the "critical filter" which eliminates women from many science-based careers, while Goldman and Hewitt (1976) found that male-female differences in college major are largely mediated by sex differences in math ability. The first hypothesis was examined to determine whether the present study would support Betz and Hackett's (1983) findings that the math-related self-efficacy expectations of college males are significantly stronger than those of college females.

As did the Betz and Hackett (1983) study, the current study showed that males had significantly higher math self-efficacy expectations on all of the MSES subscales and on the total MSES score, indicating that males showed stronger beliefs in their ability to perform everyday math tasks, solve math problems, and successfully complete math-related college courses, than did females. It is interesting to note that, among the four groups compared, males in science had the highest mean MSES score, even though females in science had a higher mean achievement score and had taken a greater number of math and science courses in Grade 12 (Appendix C). Thus, females who had successfully completed a greater number of math-related Grade 12 courses at a higher level of achievement had lower beliefs in their math-related abilities than did males with lower achievement and performance.

On the "F" scale, consisting of six traditionally female college courses, women demonstrated stronger beliefs than men in their ability to successfully complete these courses, and stronger beliefs in their ability to complete these, rather than math-related courses. This is consistent with Betz and Hackett's (1983) findings on the item-by-item analysis where the means of females were shown to be higher than the means of males only on three traditionally female activities of the 52 items assessed.

B. Hypothesis 2

This hypothesis was examined to determine if females who have chosen programs with high science content and high science prerequisites have stronger expectations of their math self-efficacy then females who have chosen programs with low science content and few science prerequisites.

The results of the present study indicate that women in science programs have considerably greater confidence in their ability to perform math-related functions than do women in nonscience programs. This suggests, as Hackett and Betz (1981) proposed, that women who have weak self-efficacy expectations may perceive their career options to be limited to the traditionally female sphere, that attitude toward math is a limiting factor in career choice, and that belief in one's ability in mathematics is, as Betz and Hackett (1983) hypothesized, importantly related to the choice of science-based career.

C. **Hypothesis 3**

Bem and Martyna (1976) found masculine individuals of both sexes to be high in independence, while Spence and Helmreich (1980) found that higher levels of masculinity (instrumentality) appear to facilitate confidence and self-esteem. Betz and Hackett (1983) and Hackett and Betz (1984) found mathematics self-efficacy to be significantly and positvely related to masculine sex role orientation.

The third hypothesis was examined to determine whether the current study would support the contention that subjects reporting higher levels of psychological masculinity would also display stronger math self-efficacy expectations. The findings did indicate that students who had higher Masculinity scores on the BSRI also tended to have stronger efficacy expectations regarding mathematics. No correlation was found between Femininity scores and math self-efficacy.

Hypothesis 4

Since women in science programs were found to have higher self-efficacy expectations than women in nonscience programs, and since math self-efficacy expectations were found to be positively related to BSRI Masculinity score, it was expected that women in science programs would have higher levels of psychological masculinity than women in nonscience programs. The findings did not, however, support such a contention. Females in science programs did not have higher mean masculinity scores than females in nonscience programs.

However, the importance of this finding is questionable since the proportions of women classified as masculine in each group were relatively small (science 14.8%), (nonscience 15.2%). What may be more important to the question of sex role in career-related behaviors is that a high proportion (66%) of females in science were not sex-typed, but were classified as either Androgynous (26%) or Undifferentiated (41%), whereas a large proportion of nonscience women were Feminine sex-typed (51.5%). (Appendix D). Interestingly, the highest percentage of Masculine females were found in the Business Administration program, not in the sciences, as had been expected. A possible explanation is that, despite its high science content, Medical Lab Science is a traditionally "female" occupation, and so may attract women, who, though highly successful academically, have adopted fewer masculine personality characteristics than their business-oriented counterparts.

Hypothesis 5

Betz and Hackett (1983) found mathematics self-efficacy to be a significant predictor of choice of science-based college major, as were gender, years of high school math and math anxiety. Simliarly, Hackett and Betz (1984) found math self-efficacy expectations, gender, and years of high school math to be significant predictors of science major.

The present study supported the hypothesis that mathematics self-efficacy expectations are a significant predictor of math-related program choice. They were not however, the strongest predictor as in both the previous studies. As has been discussed, this is an expected phenomenon related to program classification on the science continuum created for this study. This is, the program with the highest rating on the dependent variable was also the program with the highest number of math and science course prerequisites. It is not surprising, therefore, that the number of Grade 12 math and science courses was the strongest predictor of science-based program choice in this study.

In summary, the present study supports the application of social learning theory to career decision-making, particularly the extension of Bandura's self-efficacy theory to the understanding of women's career behavior (Betz and Hackett, 1981, 1983). The differential scores on the Math Self-Efficacy Scale indicate, as Hackett and Betz (1981) suggest, that women have lower expectations of their own abilities than do men in many career-related behaviors. The present study indicates that women have lower self-efficacy expectations regarding mathematics-related abilities, even when their achievement is higher. The effect of socialization experience on self-efficacy is suggested by the stronger self-efficacy exhibited by females toward traditionally female as opposed to mathematics-oriented or traditionally male college program choices. Women in science programs are shown to have stronger math self-efficacy expectations than women in nonscience programs, and mathematics self-efficacy is shown to be a significant predictor of science-based program choice, again lending support to the theory that mathematics is a "critical filter" in the study and pursuit of science-based careers for women.

Finally, the correlation between masculine personality characteristics as measured by the BSRI and mathematics self-efficacy offers some support for the idea that higher levels of masculinity seem to facilitate self-esteem and confidence. Pershaps of more importance to the understanding of the role of sex role socialization in the career development of women, however, is the finding that a large percentage of women in science were not sex-typed either masculine or feminine, but exhibited equal qualities of both. This is supportive of Bem's original contention regarding the concept of androgyny; that it is a psychological state allowing more versatility of behavior than either the male or the female sex role; a state in which the individual feels free to make choices appropriate to the needs of a situation, rather than according to pre-ordained role expectations.

F. Implications for Further Research

The following observations indicate questions arising from the present study and suggestions for further research.

1. The nature of the sample makes some comparisons between this study and the original study difficult. Specifically, whereas Betz and Hackett had used male and female psychology students, the students in this sample were from traditionally male or traditionally female areas in three of the four programs selected. This may have had biasing effects on the findings. For example, the female sample is drawn largely from traditionally female programs. There is no way to assess to what extent their lower math self-efficacy expectations compared to males may be a reflection of the traditionality their program choices. The questions remains whether same results would occur with female students in traditional occupational fields. Useful information could be gained from further research using subjects, particularly

females in sciences, from less traditional fields such as chemistry or architecture.

2. The number of male nonscience students was disproportionately small (n=14) compared to the number of male science students (n=34). The mean MSES scores for the total male population may have been inflated by the higher proportion of male science students and so affected findings on gender-related differences in math self-efficacy.

3. The question of the BSRI as an appropriate measure of sex role orientation arises, particularly with the use of the median-split method of classification. Although mean scores are computed for masculinity and femininity, the median-split method does not provide for the similar computing of androgyny or undifferentiated scores. The association of undifferentiated scorers with low self-esteem found in previous studies seem incongruous with the high proportion of undifferentiated students in the sample, particularly in the female science students (41%) whose high level of math self-efficacy and math achievement suggests high self-esteem. No explanation is evident for the low self-endorsement of the traits listed on the BSRI for the subjects in this particular sample.

Despite the questions which remain, the study does yeild results congruent with those of previous studies on the self-efficacy approach to the career development of women. The relationship between gender and math self-efficacy is clear, as is that of math self-efficacy to science-based program choice. A direct relationship of sex role orientation to math self-efficacy and to choice of academic program, though evident, is less strongly supported.

Further research is required to address the question of whether the BSRI is indeed an index of sex role socialization, and whether such socialization can be assumed to carry through to academic and vocational choices. In addition, it is recommended that further research address a more general population, e.g., male and female physics, math, and chemistry students in high school. The inclusion of a measure of mathematics anxiety, as well a questionnaire on family background and parental attitudes may provide additional information on factors which mediate the vocational choice process.

Finally, the study has implications for parents, counsellors and educators. As the review of literature indicates, biological explanations for sex differences in intellectual ability can no longer be looked upon as the reason why women do not study sciences. Those sex-related differences in ability which appear to have been supported by evidence are disproportionately small, compared to the male-female differences in science and math study. As well, no difference can be measured irrespective of socialization influences, which have been shown to differ for boys and girls from infancy.

The study suggests, however, that sex role socialization, both directly and indirectly, influences the academic and vocational behavior of women. Female children in role-oriented households are socialized toward passive behaviors such as neatness, compliance and nurturance, which are generally not conducive to the independent thinking, assertiveness, and "joy of problem-solving" attitudes associated with success in the sciences.

Schools have tended to reinforce sex-differentiated behaviors through lack of same-sex, science-oriented role models for girls; acceptance that girls are "not good" at science and mathematics; and lack of encouragement of girls who indicate interest or excellence in non-traditional subjects. Many of those girls who defy role-oriented traditions in childhood succumb, in adolescence, to the need for acceptance and to even greater peer and adult pressure to conform to standards of "femininity". As Suderman (1979) indicated, the process of girls' attrition from mathematics and science study begins in early adolescence and progressively increases throughout the remaining school years. As a result, many women are excluded from college program choices and occupations in the scientific and technological fields.

Closely associated with sex role socialization and also strongly influencing academic and career decisions is the belief in one's ability to perform mathematics-related behaviors which Betz and Hackett have termed "mathematics self-efficacy expectations". As the present and previous studies have indicated, males tend to have stronger beliefs in their ability to perform mathematics-related behaviors, even when compared to females who have higher achievement in a greater number of science and mathematics courses. This suggests that even highly successful females tend to underestimate their abilities in mathematics. Evidence is also presented that those students who have personality characteristics generally considered masculine are likely to have higher self-efficacy expectations toward mathematics, while no such relation exists between femininity and math self-efficacy.

The results of the study, then, suggest that changes in parental, societal and educational attitudes may alleviate some of the discrepancy between male and female participation in the sciences. First, perhaps, new social definitions of both femininity and masculinity are required, wherein parents might freely encourage the development of a full range of positive qualities in all children irrespective of biological sex, without fear that independent girls will be viewed as "masculine", nor nurturant boys as "feminine".

Educators and counsellors must be aware of the importance of mathematics, which could well be described as the basis of technological literacy, to the academic and vocational survival of individuals of both sexes. Remedial programs should be instituted from the earliest school years to assist those students who have difficulty grasping mathematical and scientific concepts. The encouragement of children of both sexes to develop to their fullest potential in all subjects, and the removal of sex-appropriate concepts of certain subjects and occupations may provide more female students with the incentive to choose mathematics and science-related options. Teachers need to be aware that female students in "masculine" subjects are embarassed when singled out as different, and discouraged when ignored. Finally, effort should be made for female students to be exposed to role models in non-traditional occupations. Female mathematics and science teachers can serve as examples to female students, as can female accountants, architects, and scientists, who could be visited in the community or brought into schools for career-orientation events. It is important for counsellors, teachers, and parents to be aware that for students without strong backgrounds in mathematics and sciences, increasing numbers of vocational options are eliminated. Equally important is the awareness that females can excel in mathematics and sciences, can choose non-traditional careers, can develop strength, assertiveness, and self-confidence and still retain many desirable aspects of "femininity".

REFERENCES

Bandura, A. (Ed.) (1971). **Psychological modeling: Conflicting theories.** Chicago: Aldine-Atherton.

Bandura, A. (1977). **Social learning theory.** New Jersey: Prentice-Hall. (a)

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behaviorial change. **Psychological Review, 84,** 191-215. (b)

Beere, C. (1979). **Women and women's issues. A handbook of tests and measurements.** San Francisco: Jossey Bass.

Bem, S.L. (1974). The measurement of psychological androgyny. **Journal of Consulting and Clinical Psychology, 42,** 155-162.

Bem, S.L. (1975). Sex-role adaptability: One consequence of psychological androgyny. **Journal of Personality and Social Psychology, 31,** 634-643.

Bem, S.L. (1977). On the utility of alternative procedures for assessing psychological androgyny. **Journal of Consulting and Clinical Psychology, 45,** 196-205.

Bem, S.L. (1981). **Bem Sex-Role Inventory: Professional Manual.** California: Consulting Psychologists Inc.

Bem, S.L. & Lenney, E. (1976). Sex-typing and the avoidance of cross-sex behavior. **Journal of Personality and Social Psychology, 33,** 48-54.

Bem, S.L., & Martyna, W. (1976). Sex typing and androgyny. Further explorations of the expressive domain. **Journal of Personality and Social Psychology, 34,** 1016-1023.

Benbow, C., & Stanley, J. (1980). Sex differences in mathematical ability: Fact or artifact. **Science, 210,** 1262-1264.

Betz, N.E. (1978). Prevalance, distribution, and correlates of math anxiety in college students. **Journal of Counseling Psychology, 25,** 441-448.

Betz, N.E. & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. **Journal of Counseling Psychology, 28,** 399-410.

Betz, N.E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. **Journal of Vocational Behavior, 23,** 329-345. (a)

Betz, N.E., & Hackett, G. (1983). **Development of the mathematics self-efficacy scale: Extended description.** Ohio State University. (b)

Block, J. (1973). Conceptions of sex role: Some cross-cultural and longitudinal perspectives. **American Psychologist, 28,** 512-526.

Bock, R., & Kolakowski, D. (1973). Further evidence of sex-linked major-gene influence on human spatial visualizing ability. **American Journal of Human Genetics, 25,** 1-14.

Broverman, D., Klaiber, E., Kobayashi, Y., & Vogel, W. (1968). Roles of activation and inhibition in sex differences in cognitive abilities. **Psychological Review, 75,** 23-50.

Broverman, I.K., Vogel, S., Broverman, D., Clarkson, F., & Rosenkrantz, P.S. (1972). Sex role stereotypes: a current appraisal. **Journal of Social Issues, 28,** 59-78.

Broverman, D., Clarkson, F., Rosenkrantz, P.S., & Vogel, S. (1980). Gonadal hormones and cognitive functioning. In J.E. Parsons (Ed.). **The psychobiology of sex differences and sex roles.** New York: Mcgraw Hill.

Buffery, A., & Gray, J. (1972). Sex differences in the development of spatial and linguistic skills. In C. Ounstead & D. Taylor (Eds.). **Gender differences: Their ontogeny and significance.** London: Churchills.

Carnegie Commission on Higher Education. (1973). **Opportunities for women in higher education.** New York: McGraw-Hill.

Constantinople, A. (1973). Masculinity-femininity: An exception to the famous dictum? **Psychological Bulletin, 80,** 389-407.

Cook, E.P. (1985). Androgyny: A goal for counselling? **Journal of Counseling and Development, 63,** 567-571.

Cosentino, F., & Heilbrun, A. (1964). Anxiety correlates of sex-role identity in college students. **Psychological Reports, 14,** 729-730.

Dwyer, C.A. (1974). Influence of children's sex role standards on reading and arithmetic achievement. **Journal of Educational Psychology, 66,** 811-816.

Fennema, E. (1980). Sex-related differences in mathematics achievement: Where and why. In L. Fox, L. Brody, & D. Tobin (Eds.). **Women and the mathematical mystique.** Baltimore: Johns Hopkins.

Fennema, E., & Sherman, J.A. (1976). Fennema-Sherman Mathematics Attitude Scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. **JSAS Catalog of Selected Documents in Psychology, 6,** 31. (Ms. No. 1225).

Fennema, E., & Sherman, J.A. (1977). Sex-related differences in mathematics achievement, spatial visualization, and affective factors. **American Educational Research Journal, 14,** 51-71.

Fisher, L. (1982). Science and the environment of young girls. In Science Council of Canada. **Who turns the wheel?** Ottawa: Minister of Supply and Services.

Forisha, B.L. (1978). **Sex roles and personal awareness.** Dearborn: General Learning Press.

Fox, L.H., & Cohn, S.J. (1980). In L.H. Fox, L. Brody, and D. Tobin (Eds.). **Women and the mathematical mystique.** Baltimore: Johns Hopkins.

Gall, M.D. (1969). The relationship between masculinity, femininity, and manifest anxiety. **Journal of Clinical Psychology, 25,** 294-295.

Gaite, A.J. (1977). Teachers' perceptions of ideal male and female students: Male chauvinism in the schools. In J. Pottker and A. Fishel (Eds.). **Sex bias in the schools.** London: Associated University Press.

Goldman, R., & Hewitt, B. (1976). The scholastic aptitude test "explains" why college men major in science more often than college women. **Journal of Counseling Psychology, 23,** 50-54.

Hackett, G. (1985). Role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. **Journal of Counseling Psychology, 32,** 47-56.

Hackett, G., & Betz, N.E. (1981). A self-efficacy approach to the career development of women. **Journal of Vocational Behavior; 18,** 326-339.

Hackett, G., & Betz, N.E. (1984). **Mathematics performance, mathematics self-efficacy, and the prediction of science-based college majors.** Manuscript submitted for publication.

Harford, T., Willis, C., & Deabler, H. (1967). Personality correlates of masculinity and femininity. **Psychological Reports, 21,** 881-884.

Haring, M., & Tyler, K. (1983). Counselling with women: The challenge of non-traditional careers. **The School Counsellor, March, 1984,** 301-308.

Hendel, D., & Davis, S. (1978). Effectiveness of an intervention strategy for reducing mathematics anxiety. **Journal of Counseling Psychology,** 25, 429-434.

Hollinger, C. (1983). Self-perception and the career aspirations of mathematically talented female adolescents. **Journal of Vocational Behavior, 22,** 49-62.

Horner, M. (1972). Toward an understanding of achievement-related conflicts in women. **Journal of Social Issues, 28,** 157-175.

Huston, A.C. (1983). Sex typing. In P.H. Mussen and E.M. Hetherington (Eds.). **Handbook of child psychology (Vol.4) Socialization, personality, and social development.** New York: Wiley.

Hyde, J. (1981). How large are cognitive gender differences? A meta-analysis using w^2 and d. **American Psychologist, 36,** 892-897.

Jay, W. (1977). Sex stereotyping in elementary-school mathamatics textbooks. In J. Pottker and A. Fishel (Eds.). **Sex bias in the schools.** London: Associated University Presses.

Jones, H.J., Chernovetz, M.E., & Hansson, R.O. (1978). The enigma of androgyny: Differential implication for males and females. **Journal of Consulting and Clinical Psychology, 46,** 298-313.

Kagan, J. (1964). Acquisition and significance of sex-typing and sex-role identity. **Child Development, 35,** 1051-1056.

Kelly, A. (1978) **Girls and sciences: An international study of the sex differences in school science achievement.** University of Manchester.

Levy, J. (1976). Cerebral lateralization and spatial ability. **Behavior Genetics, 6,** 171-188.

Lewis, M. (1972). Parents and children: Sex-role development. **School Review, 80,** 229-240.

Locksley, A., & Colten, M.E. (1979). Psychological androgyny: A case of mistaken identity? **Journal of Personality and Social Psychology, 37,** 1017-1031.

Lynn, D. (1972). Determinants of intellectual growth. **School Review, 80,** 241-260.

Maccoby, E. & Jacklin, C. (1974). **The psychology of sex differences.** Stanford: University Press.

Menzies, H. (1981). **Women and the chip: Case studies of the effects of informatics on employment in Canada.** Montreal: Institute for Research on Public Policy.

Mill, J.S. (1869). The subjection of women. In A. Rossi (Ed.). **Essays on sex equality: John Stuart Mill and Harriet Taylor Mill.** Chicago: University of Chicago Press, 1970.

Monohan, L., Kuhn, D., & Shaver, P. (1974). Intrapsychic versus cultural explanations of the "fear of success" motive. **Journal of Personality and Social Psychology, 29,** 60-64.

Nash, S.C. (1975). The relationship among sex-role stereotyping, sex-role preference and the sex differences in spatial visualization. **Sex Roles, 1,** 15-[illegible]

Nash, S.C. (1979). Sex role as a mediatior of intellectual functioning. In M.A. Wittig and A.C. Petersen (Eds.). **Sex related differences in cognitive functioning.** New York: Academic Press.

National Academy of Sciences. (1979). **Climbing the academic ladder: Doctoral women in academe.** Washington: National Research Council.

Omerod, M. (1976). Factors differentially affecting the science subject preferences, choices and attitudes of girls and boys. In A. Kelly (Ed.). **The missing half: Girls and science education.** Manchester: University Press.

Ounsted, C., & Taylor, D. (Eds.) (1972). **Gender differences: Their ontogeny and significance.** Baltimore: Williams and Wilkins.

Pedhauser, E.J., & Tetenbaum, T.J. (1979). Bem Sex-Role Inventory: A theoretical and methodological critique. **Journal of Personality and Social Psychology, 37,** 996-1016.

Petersen, A. (1976). Physical androgyny and cognitive functioning in adolescence. **Developmental Psychology, 12,** 524-533.

Pottker, J., & Fishel, A. (Eds.) (1977). **Sex bias in schools.** London: Associated University Press.

Rebecca, M., Hefner, R., & Oleshansky, B. (1976). A model of sex-role transcendence. In G. Kaplan and J. Bean (Eds.). **Beyond sex-role stereotypes. Readings toward a psychology of androgyny.** Boston: Little, Brown.

Richardson, F.C., & Suinn, R.M. (1972). [illegible] mathematics anxiety rating scale: Psychometric data. **Journal of Counseling Psychology, 19,** 551-554.

Rossi, A.S. (1965). Barriers to the career choice of engineering and medical science among American women. In J.A. Matfield and C.G. Van Aken (Eds.). **Womens and the scientific professions.** Cambridge: MIT Press.

Science Council of Canada. (1982). **Who turns the wheel?** Ottawa: Supply and Services.

Sears, R. (1970). Relationship of early socialization experiences to self-concepts and gender role in middle childhood. **Child Development, 41,** 267-289.

Sells, L.W. (1980). The mathematics filter and the education of women and minorities. In L.H. Fox, L. Brody, and D. Tobin (Eds.). **Women and the mathematical mystique.** Baltimore: Johns Hopkins.

S[illegible]in, R. (19[illegible]. In Science Council of Canada. **Who turns the wheel?** Ottawa[illegible]y and Services.

Sherman, J. (1982). Continuing in mathematics: A longitudinal study of the attitudes of high school girls. **Psychology of Women Quarterly, 7,** 132-140.

Sherman, J. (1983). Factors predicting girls' and boys' enrollment in college preparatory mathematics. **Psychology of Women Quarterly, 7,** 272-281.

Sherman, J., & Fennema, E. (1977). The study of mathematics by high school girls and boys: Related variables. **American Educational and Research Journal, 14,** 159-168.

Spence, J.T., & Helmreich, R.L. (1978). **Masculinity and femininity: Their psychological dimensions, correlates, and antecedents.** Austin: University of Texas Press.

Spence, J.T., & Helmreich, R.L. (1980). Mascu[illegible]tality and feminine expressiveness: Their relations[illegible]ole attitudes and behaviors. **Psychology of Women Qua[illegible]**[illegible]63.

Spence, J.T., Helmreich[illegible]Holahan, C.K. (1979). Negative and positive componen[illegible]hological masculinity and femininity and their relationshi[illegible]orts of neurotic and acting-out behaviors. **Journal [illegible]sonality and Social Psychology, 37**, 1673-1682.

Spence, J.T., Helmreich, R.L., & Stapp, J. (1975). Ratings of self and peers on sex-role attributes and their relation to self-esteem and conceptions of masculinity and feminity. **Journal of Personality and Social Psychology, 32**, 29-39.

Stafford, R. (1972). Heredity and environmental components of quantitative reasoning. **Review of Educational Research, 42**, 183-201.

Stein, A.H. (1971). The effects of sex-role standards for achievement and sex-role preference on three determinants of achievement motivation. **Developmental Psychology, 4**, 219-231.

Stein, A.H., Pohly, S.R., & Mueller, E. (1971). The influence of masculine, feminine, and neutral tasks on children's achievement behavior, expectancies of success, and attainment values. **Child Development, 42**, 196-207.

Stein, A.[illegible] & Smithells, J. (1969). Age and sex differences in children's sex-role standards about achievement. **Developmental Psychology, 1**, 252-259.

Suderman, M. (1979). Sex differences in high school course choice and achievement. In Science Council of Canada. **Who turns the wheel?** Ottawa: Supply and Services.

Tidball, M. (1977). Baccalaureate origins of American scientists and scholars. **Science, 193**, 646-652.

Waber, D. (1977). Sex differences in mental abilities, hemispheric lateralization, and rate of physical growth at adolescence. **Developmental Psychology, 13**, 29-38.

Ware, N., Steckler, A. & Leserman, J. (1985). Undergraduate women: Who chooses a science major? **Journal of Higher Education, 56**, 73-84.

Webster, M. (1976). **Webster's Third International Dictionary.** Springfield: Miriam Webster.

Williams, T. (1975). Family resemblance in abilities. The Wechsler Scales. **Behavior Genetics, 1**, 405-409.

Winchell, R., Fenner, D., & Shaver, P. (1974). Impact of coeducation on "fear of success" imagery expressed by male and female high school students. **Journal of Educational Psychology, 66**, 726-730.

Wittig, M., & Petersen, A. (1979). **Sex-related differences in cognitive functioning.** New York: Academic Press.

APPENDIX A

SAMPLE BREAKDOWN BY PROGRAM AND SEX

Table A-1 Sample Breakdown by Program and Sex

Program	Number of Students	Male	Female
Administrative Secretarial	19		19
Business Administration	31	17	14
Electronics Technology	34	34	
Medical Lab. Science	27		27
	N = 111	n = 51	n = 60

APPENDIX B

MEANS, MEDIANS AND STANDARD DEVIATIONS FOR BSRI MASCULINITY AND FEMININITY

Table B-1

Total Sample Raw Score Means, Medians and Standard Deviations for the Femininity and Masculinity Scores on the BSRI.

	Mean	Median	S.D.	Minimum	Maximum
Femininity	4.78	4.78	.62	3.35	6.05
Masculinity	4.85	4.90	.7[illegible]	2.60	6.65

Total possible Masculinity or Femininity score = 7.0

APPENDIX C

BETWEEN-GROUP COMPARISON OF MEAN SCORES

Table C-1

Between-Group Comparison of Mean Math Self-Efficacy, Achievement and Performance Scores

GROUP	MEAN SCORES		
	MSES	Achievement	Performance
Secretarial	313.79	47.72	1.53
Business	335.79	61.70	2.45
Electronics	393.14	71.27	3.00
Medical Lab	378.85	77.07	3.93

Achievement = average of Grade 12 math and scince marks
Performance - number of Grade 12 math and science courses
Total possible MSES score - 468.

APPENDIX D

BEM CATEGORY BY GROUP

Table D-1 Bem Category by Group

COUNT ROW% COL% TOTAL%	GROUP 1	 2m	 2f	 3	 4	ROW TOTAL
BEM F	12 46.2 63.2 10.8	2 7.7 11.8 1.8	5 19.2 35.7 4.5	2 7.7 5.9 1.8	5 19.2 18.5 4.5	26 23.4
BEM M	2 7.7 10.5 1.8	4 15.4 23.5 3.6	3 11.5 21.4 2.7	13 50.0 38.2 11.7	4 15.4 14.8 3.6	26 23.4
BEM A	3 10.7 15.8 2.7	5 17.9 29.4 4.5	3 10.7 21.4 2.7	10 35.7 29.4 9.0	7 25.0 25.9 6.3	28 25.2
BEM U	2 6.5 10.5 1.8	6 19.3 35.3 5.4	3 9.7 21.4 2.7	9 29.0 26.5 8.1	11 35.5 40.7 9.9	31 27.9
COLUMN TOTAL	19 17.1	17 15.3	14 12.6	34 30.6	27 24.3	111 100.0

NOTE: 1. Groups 1 and 4 are all female; group 3 is all male; 2m and 2f denote male and female students, respectively, in group 2.

2. Bem categories F = feminine, M = masculine, A = Androgynous, U = undifferentiated.

APPENDIX E

CORRELATION MATRIX

Table E-1

Correlation Matrix for Variables in Regression Analysis

VARIABLES	Gender	Bem M	Bem F	MSES	Perf.	Acht.	Sc.Level
Gender	1.000	-0.362	0.275	-0.244	-0.011	-0.072	-0.040
Bem M	-0.362	1.000	0.043	0.266	-0.079	-0.058	0.002
Bem F	0.275	0.048	1.000	-0.028	-0.122	-0.294	-0.132
MSES	-0.244	0.266	-0.028	1.000	0.327	0.444	0.465
Perf.	-0.011	-0.079	-0.122	0.327	1.000	0.503	0.620
Acht.	-0.072	-0.058	-0.294	0.444	0.503	1.000	0.549
Sc.Level	-0.040	0.002	-0.132	0.465	0.620	0.549	1.000
MEANS	1.541	4.831	4.773	360.003	2.847	65.974	2.622
STANDARD DEVIATIONS	0.498	0.729	0.615	56.788	1.289	17.906	1.032

APPENDIX F

SCIENCE-NONSCIENCE CONTINUUM FOR NAIT PROGRAMS

Table F-1

SCIENCE-NONSCIENCE CATEGORIES OF NAIT PROGRAMS BY GRADE 12 MATH AND SCIENCE PREREQUISITES

	1	2	3	4
PROGRAM	Secretarial	Business Adminis- tration	Electronics	Medical Lab.
MATH-SCIENCE PREREQUISITE	none	one math	one math one science	one math two sciences

Note: The above are minimum prerequisites. Admission is based on a selection process.

APPENDIX G

MATHEMATICS SELF-EFFICACY SCALE
(PERSONAL REACTION INVENTORY)

Personal Reaction Inventory

There are four parts to this instrument. Please read all instructions and respond carefully and completely.

Part I: Please indicate how much confidence you have that you could successfully accomplish each of these tasks by marking your answer sheet according to the following 10-point scale. When you mark your answer sheet, be sure that the number corresponding to the appropriate answer on the confidence continuum is marked.

Confidence Scale:

No Confidence at all		Very little Confidence		Some Confidence		Much Confidence			Complete Confidence
0	1	2	3	4	5	6	7	8	9

Example: How much confidence do you have that you could successfully:

91. Multiply two large numbers in your head.

If your response on the 10-point continuum was #5, "Some confidence", you would mark the number 5 on your answer sheet next to question #91 as follows:

91. 0 1 2 3 4 (5) 6 7 8 9

Revised 2/10/81

No Confidence at all		Very little Confidence		Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

How much confidence do you have that you could successfully:

1. Add two large numbers (e.g. 5379 + 62543).
2. Determine the amount of sales tax on a clothing purchase.
3. Figure out how much material to buy in order to make curtains.
4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14-3/4% interest.
5. Work with a slide rule.
6. Compute your car's gas mileage.
7. Calculate recipe quantities for a dinner for 3 when the original recipe is for 12 people.
8. Balance your checkbook without a mistake.
9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.
10. Figure out how long it will take to travel from Columbus to Chicago driving at 55 mph.
11. Set up a monthly budget for yourself taking into account how much money you earn, bills to pay, personal expenses, etc.
12. Compute your income taxes for the year.
13. Understand a graph accompanying an article on business profits.
14. Figure out how much you would save if there is a 15% mark-down on an item you wish to buy.
15. Estimate your grocery bill in your head as you pick up items.
16. Figure out which of 2 summer jobs is the better offer: one with a higher salary but no benefits; the other with a lower salary but with room, board, and travel expenses included.
17. Figure out the tip on your part of a dinner bill total split 8 ways.
18. Figure out how much lumber you need to buy in order to build a set of bookshelves.

Part II: Please rate the following college courses according to how much confidence you have that you could complete the course with a final grade of "A" or "B". Mark your answer sheet according to the 10-point scale below:

No Confidence at all		Very little Confidence		Some Confidence		Much Confidence			Complete Confidence
0	1	2	3	4	5	6	7	8	9

19. Basic College Math - General Math, First Year University.

20. Nursing - caring for the infirm, the injured, or the ill.

21. Economics - the study of production, distribution, and consumption of wealth.

22. Statistics - the branch of mathematics that deals with the collection and analysis of numerical data.

23. Physiology - the branch of biology that deals with the processes and functions of living organisms and living matter.

24. Education - a study of the principles and methods of teaching or of learning.

25. Calculus - mathematics based on reasoning by computation of symbols. Would follow Math 31.

26. Dietetics - the study of the principles of nutrition in relation to health.

27. Business Administration - a study of principles of business management and operation.

28. Algebra II - mathematics of arithmetic relations using letter symbols to represent numbers. Second Year University Level.

29. Social Work - work with economically and/or socially disadvantaged people.

30. Philosopy - the pursuit of wisdom; the search for truth through logical reasoning.

31. Geometry - the branch of mathematics that deals with measurement, properties and relationships of points, lines and angles.

32. Computer Science - a study of the functions and use of computers.

No Confidence at all		Very little Confidence		Some Confidence		Much Confidence			Complete Confidence
0	1	2	3	4	5	6	7	8	9

33. Accounting - a study of the principles and procedures of recording and analyzing business and financial transactions.

34. Zoology - the branch of biology that deals with the study of animals.

35. Algebra I - First Year University level Algebra

36. Comparative Literature - the comparative study of written works of particular languages, cultures or periods in time.

37. Trigonometry - the branch of mathematics dealing with relations among sides and angles of a triangle.

38. Advanced Calculus - Third Year University level Calculus.

39. Physical Therapy - the treatment of disability or disease by external physical means, e.g. heat, massage, exercise.

40. Biochemistry - the branch of chemistry related to life processes of plants and animals.

Part III: Suppose that you were asked the following math questions in a multiple choice form. Indicate how much confidence you have that you would give the correct answer to the question. Mark the number of your response on the answer sheet. Use the following code:

No Confidence at all		Very little Confidence		Some Confidence		Much Confidence			Complete Confidence
0	1	2	3	4	5	6	7	8	9

Just mark the number of the choice which indicates how much confidence you would have in your answer. Do not work the answers to the problems.

How much confidence do you have that you could give the correct answer to the following problems:

41. 3 - .3/4 - 1/2 =

42. The average of three numbers is 30. The fourth number is at least 10. What is the smallest average of the four numbers?

No Confidence at all		Very little Confidence		Some Confidence		Much Confidence			Complete Confidence
0	1	2	3	4	5	6	7	8	9

43. Write an equation which expresses the condition that "the product of two numbers R and S is one less than twice their sum."

44. Set up the problem to be done to find the number asked for in the expression "six less than twice 4 - 5/6"

45. In Starville, an operation ° on any numbers a and b is defined by a ° b = a x (a + b). Then 2°3 equals ____?____.

46. A living room set consisting of one sofa and one chair is priced at $200. If the price of the sofa is 50% more than the price of the chair, find the price of the sofa.

47. To construct a table, Michele needs four pieces of wood 2.5 feet long for the legs. She wants to determine how much wood she will need for five tables. She reasons: 5 x (4 x 2.5) = (5 x 4) x 2.5. Which number principle is she using?

48. Fred's bill for some househodl supplies was $13.64. If he paid for the items with a $20 bill, how much change should be receive.

49. On a certain map, 7/8 inch represents 200 miles. How far apart are two towns whose distance apart on the map is 3½ inches?

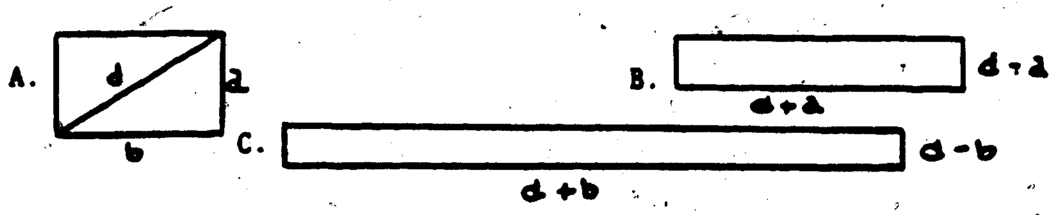
50. Bridget buys a packet containing 9-cent and 13-cent stampsked for in the expression "six less than twice 4 - 5/6"

51. If 3x - 2 = 16 - 6x, what does x equal?

52. There are three numbers. The second is twice the first, and the first is one-third of the other number. Their sum is 48. Find the largest number.

53. The hands of a clock form an obtuse angel at ____________ o'clock.

54. Sally needs three pieces of poster board for a class project. If the boards are represented by rectangles A, B, C, arrange their areas in increasing order. (Assume b>a.).



55. In a certain triangle, the shortest side is 6 inches, the longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches?

56. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the relatiave positions of the points along the line.

57. The Opposite angles of a parallelogram are ________________________.

58. The formula for converting temperature from degrees Centigrade to degrees Fahrenheit is F = 9/5 C + 32. A temperature of 20 degrees Centigrade is how many degrees Fahrenheit?

APPENDIX H

ACADEMIC INFORMATION QUESTIONNAIRE

NAME: ______________________

Part IV:

Academic Information

Please indicate the <u>highest</u> level (e.g. 30, 33) you completed in the following subject areas in high school and the Grade Range you obtained: below 50%, 50% - 60%, 60% -70%, 70% - 80%, above 80%

Subject	**Highest Level Completed**	**Grade Range Obtained**
Mathematics	____________	____________
	____________	____________
Biology	____________	____________
Chemistry	____________	____________
Physics	____________	____________
English	____________	____________