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Mathematical achievement behaviors of female secondary school students.

Joanne Shirley Coutts
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Mathematical Achievement Behaviors of Female Secondary School Students

by

Joanne Coutts

M.A. University of Windsor, 1984

A Dissertation Submitted to the Faculty of Graduate Studies through the Department of Psychology in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy at the University of Windsor Windsor, Ontario, Canada 1988
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ABSTRACT

This research was focused on the mathematical achievement behaviors of female high school students. One hundred and twenty grade 9 students, 60 males and 60 females, participated in this study. These students were all in advanced grade 9 mathematics classes. The first part of the two part study involved having the students fill out a number of rating scales which measured attitudes and expectations towards mathematics. The students also individually completed the mathematics section of the Canadian Achievement Test (1981). The mathematics test was scored and students were placed in high ability or low ability groups based on the median score. Mixed sex dyads of unequal ability were determined, and when the subjects arrived at the second session of the two part study they were given their score as well as their partner's score on the mathematics task.

In the second session the subjects were asked to work cooperatively on a parallel form of the Canadian Achievement Test with their partner. The subjects were asked to indicate on a worksheet who began each problem, how much help they had contributed to the problem, and who had actually solved each of the problems. While the subjects worked, the dynamics of the group were rated by trained
examiners. When the subjects had completed the timed mathematical achievement test, they were asked to fill out a number of questionnaires measuring their attitudes, attributions, and perceptions towards mathematics achievement.

The results indicated that high ability females' mathematical performance was significantly better when they worked on their own than when they worked with a low ability male partner. In fact, with respect to two separate questions, although the high ability females indicated that they had contributed significantly more help than their partner in solving the problems, they did not take significantly more of the credit for solving these same problems. In terms of attitudes and attributions for performance on mathematical achievement tests, the significant differences that existed, for the most part, were between the high ability and the low ability subjects rather than between the male and female subjects. Interestingly, the positive attitudes high ability females expressed towards mathematics did not correspond to their performance in the same way that the positive attitudes of the high ability males corresponded to their performance in the second session. More research is needed to understand the implications of the dynamics of the group and the resulting effects of mathematical achievement behavior among male and female high school students.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I. REVIEW OF LITERATURE</td>
<td>1</td>
</tr>
<tr>
<td>Sex Differences in Mathematical Ability</td>
<td>10</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>11</td>
</tr>
<tr>
<td>Variability</td>
<td>14</td>
</tr>
<tr>
<td>Socio-Cultural Variables and Mathematical Performance</td>
<td>17</td>
</tr>
<tr>
<td>Learning Strategies and Mathematical Performance</td>
<td>20</td>
</tr>
<tr>
<td>Summary</td>
<td>23</td>
</tr>
<tr>
<td>Achievement Motivation Among Males and Females</td>
<td>25</td>
</tr>
<tr>
<td>Differential Course Taking</td>
<td>27</td>
</tr>
<tr>
<td>Between Males and Females</td>
<td></td>
</tr>
<tr>
<td>Factors Influencing Mathematical Achievement</td>
<td>30</td>
</tr>
<tr>
<td>Achievement Behaviors</td>
<td>37</td>
</tr>
<tr>
<td>Motivation Level and Achievement</td>
<td>39</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
</tr>
<tr>
<td>Self-Concept and its Relation to Mathematical Achievement</td>
<td>40</td>
</tr>
<tr>
<td>Attrition and Higher Level Mathematics</td>
<td>42</td>
</tr>
<tr>
<td>Expectations and Values Associated with Mathematics</td>
<td>50</td>
</tr>
<tr>
<td>Locus of Control and Attribution in Mathematics Achievement</td>
<td>56</td>
</tr>
<tr>
<td>Summary</td>
<td>60</td>
</tr>
<tr>
<td>The Mediating Effects of the Situation and Sex-Role Orientation on Performance</td>
<td>61</td>
</tr>
<tr>
<td>Socialization and its Effect on Performance</td>
<td>65</td>
</tr>
<tr>
<td>Fear of Deviance From Sex-Role Standards</td>
<td>68</td>
</tr>
<tr>
<td>Summary</td>
<td>70</td>
</tr>
<tr>
<td>Summary of Literature Review</td>
<td>71</td>
</tr>
<tr>
<td>Limitations</td>
<td>72</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>4</td>
<td>102</td>
</tr>
<tr>
<td>5</td>
<td>111</td>
</tr>
<tr>
<td>6</td>
<td>115</td>
</tr>
</tbody>
</table>

1. Instruments Used in the Data Analyses from Session 1 and Session 2
2. Design of the Two Session Study
3. Percentage of Help Offered and Number of Questions Credited on the Canadian Achievement Test as Examined Across Group Membership
4. Negative and Positive Attitudes Towards Mathematics on the SDI (Student Development Inventory) and the AQ (Attitudinal Questionnaire) as Examined Across Ability Levels
5. Masculine and Feminine Characteristic Scores Among the Subjects from the Personal Attributes Rating Scale According to Sex and Ability Level Groupings
6. Attributions for Mathematical Performance from the Attributional Questionnaire According to Sex and Ability Level Groupings
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Conceptual Framework of Mathematical Development in Relation to Social Learning Theory</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>General Model of Academic Choice</td>
<td>51</td>
</tr>
<tr>
<td>3</td>
<td>Conceptual Framework of Gender Differences in Achievement and Course Taking in Mathematics</td>
<td>55</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

This chapter reviews the literature concerned with mathematical achievement behaviors. Male achievement behavior is presented, but particular thematic attention is given to female achievement behavior. The purpose of this research is to focus on the mathematical achievement behaviors of female high school students. The following sections are discussed in relation to achievement behavior: (a) sex differences in mathematical ability, (b) achievement motivation, (c) self-concept and its relation to performance, (d) and the mediating effects of sex-role orientation on mathematical performance. In examining these sections, Bandura's model (Bandura, 1986), a social learning approach, will be referred to in order to understand better how Bandura's determinants (or factors) are related to mathematical achievement as well as to success avoidance behaviors. These determinants include situational, behavioral, and personality factors. Bandura's (Zimbardo, 1985) social learning approach for understanding personality combines principles of learning with an emphasis on human interactions in social settings. Individuals are neither solely driven by inner forces nor shaped and controlled by external stimuli. Bandura's model
(1986) considers human functioning in terms of these triadic determinants or factors (situational, behavioral, and personality) which act in a reciprocal manner. Bandura's determinants are factors or variables which are thought to account for both the development and the modification of human behavior. A person's unique characteristics may be determined by such factors as social stimuli, social and personal reinforcements, and past learning history (Bandura, 1986).

In Figure 1, a general framework proposed by Jackson and Coutts (1988) presents Bandura's basic factors (enclosed in thin-lined boxes), and also includes additional factors (enclosed in thick-lined boxes). These factors are presented to facilitate the depiction of social learning theory in relation to mathematical development. In Figure 1, mathematical development (MD) is composed of mathematical achievement, mathematical ability, and mathematical aptitude. Mathematical development is shown to be a function of Bandura's three basic factors or determinants (SD, BD, PD). This relationship is depicted by the use of three straight lines with the arrows pointed from each of the following situational, behavioral, and personality determinants to mathematical development. In other words, situational, behavioral, and personality factors impact on a student's mathematical development.

Also included in Figure 1 is self-concept (SC).
Figure 1: General Conceptual Framework of Mathematical Development in Relation to Social Learning Theory by L.M. Jackson and J. S. Coutts.
Self-concept is composed of such variables as self-efficacy, locus of control, achievement motivation, and sex-role orientation. Based on the literature which was reviewed and will be presented later in this thesis, achievement motivation, as listed under self-concept (SC), is considered a multi-dimensional aspect of personality. Achievement motivation is influenced by such personality factors as locus of control and self-efficacy. For example, perceived locus of control is thought to be a relatively stable characteristic which people bring to a situation as a generalized belief about their power and control in various situations. Self-efficacy is an individual's expectation of being effective in a situation and having mastery over a task. An individual who does not believe in his/her mastery of a task and effectiveness in a situation would be low in achievement motivation (Zimbardo, 1985). Locus of control (SC), self-efficacy (SC), and achievement motivation (SC) are considered to be subsumed under personality determinants (PD). This relationship between self-concept and personality is shown by a straight line with the arrow pointed from self-concept to personality determinants. In addition, self-concept (SC) is shown as being in reciprocal relationship with both situational determinants (SD) and behavioral determinants (BD). These reciprocal relationships are depicted by two straight lines with double headed arrows pointed from self-concept to
situational determinants, and from self-concept to behavioral determinants. Thus, Figure 1 indicates that self-concept impacts on situational determinants, and, in turn, situational determinants impact on self-concept. The same process occurs between self-concept and behavioral determinants. In other words, double headed arrows depict relationships of reciprocal influence. Additionally, self-concept (SC) is depicted as affecting mathematical development (MD). This is shown by a straight line with the arrow pointed from self-concept (SC) to personality (PD), and by another straight line with an arrow connecting personality (PD) to mathematical development (MD). Thus, self-concept is conceptualized as influencing mathematical development through personality determinants.

Also listed in Figure 1 is expectations of success or failure (EC). Expectations are reciprocally related to self-concept (SC). Expectations impact on self-concept and, in turn, self-concept impacts on expectations. Due to this reciprocal relationship, expectations, in addition to self-concept, are considered to be subsumed under personality determinants. For example, self-efficacy, as a component of self-concept, helps to define an individual's personal sense of worth. Additionally, self-efficacy is determined through the expectations (EC) of success or failure that an individual attributes to him/her self and/or to the situation. Thus, the expectations that
individuals hold about their degree of self-efficacy help to determine their self-concept, an aspect of personality.

Efficacy-based and outcome-based expectations (EC) are depicted as directly affecting those variables listed as behavioral determinants (BD). This relationship is defined by a straight line with a double headed arrow which shows a reciprocal relationship between expectations of success or failure and behavioral determinants. Thus, according to Bandura, a person's sense of efficacy influences their performance, as well as their perceptions and motivation (Zimbardo, 1985).

This general conceptual framework, as illustrated in Figure 1, has been proposed and will be referred to throughout the thesis in order to understand better women's mathematical achievement behavior, of which there has been much recognition and concern (Becker, 1982). The reasons for this recognition are as follows: a) the influence of the feminist movement, b) increased government attention and funding of sex equity in education, c) the efforts of many people in the mathematics educational community to raise awareness of issues related to sex equity, and d) the work by a number of researchers investigating sex differences in mathematics. For these reasons, women's mathematical achievement continues as an important construct in need of greater understanding and investigation. In this regard, it was thought important to define the mathematical
terms that are used in this thesis.

Definition of Terms

The terms used throughout this thesis are defined as follows:

Mathematical Ability: The currently available power to perform in mathematics (Zimbardo, 1985; p. 428). Ability is composed of the two components of achievement and aptitude (Zimbardo, 1985; p. 446).

Mathematical Achievement: A current evaluation of an individual's competency level in mathematics. (Zimbardo, 1985; p. 446).

Mathematical Aptitude: The potential a person has for acquiring quantitative skills (Zimbardo, 1985; p. 446).

Mathematical Performance: A measure of mathematical ability and achievement in areas such as spatial ability, and problem solving. Performance is an encompassing term which is composed of the components of achievement and ability (Leder, 1982; Lin & Pulos, 1983).

Relationship Between Achievement and Ability: Hopkins and Stanley (1981) stated that there is a 'substantial relationship' between achievement in various subject areas and ability. Thus, it was not considered uncommon to see a description of a standardized achievement test, such as the Canadian Achievement Test (1981), portrayed as a predictor of mathematical ability (Hopkins & Stanley, 1981).

Relationship Between Achievement and Aptitude: Anastasi
(1982) stated that aptitude tests reflect the cumulative influence of a multiplicity of experiences in daily living, and predict subsequent performance. Anastasi reported that the basic difference between achievement and aptitude testing is a difference in the degree of uniformity of relevant antecedent experiences. For example, aptitude tests measure the effects of learning under relatively uncontrolled and unknown conditions, while achievement tests measure the effects of learning that occurred under partially known and controlled conditions. However, according to Anastasi (1982), it is naïve to assume that achievement tests measure the effects of learning, while aptitude tests measure 'innate capacity' independent of learning. Anastasi noted that all psychological tests measure an individual's current behaviors, which inevitably reflect the influence of prior learning.

**Spatial Ability:** The ability to draw on one's capacity to imagine and to visualize objects in space (Tavris & Wade, 1984).

**Understanding Mathematical Achievement**

In understanding the variable called mathematical achievement, relevant literature was examined. It was demonstrated that sex differences in mathematics are important to study. It was found that due to existing cultural beliefs (e.g., male superiority in mathematics) and incon-
sistencies reported in studies (e.g., spatial ability in females), there is still a need to understand how sex differences impact on both mathematical achievement and mathematical ability. For example, one facet of mathematical ability is spatial ability. When spatial ability is tested, sex differences are often observed but with enough inconsistency in the results to suggest cultural influences. These findings will be discussed in more detail in the section on sex differences in mathematical ability.

Mathematical achievement, ability, and skills are viewed as part of a dynamic developmental process. Achievement, ability, and skill need not be thought of as static variables. They are variables that can be influenced by developmental factors as well as by socio-cultural factors. For these reasons, studies which deal with children as well as with late adolescents are reported in the literature review which follows. Thus, developmental and socio-cultural factors are represented.

While mathematical achievement is of interest in this study's review of the literature, it will be noted that the variable of mathematical achievement is a complex one. For this reason the literature review will also include these sections: (a) sex differences in mathematical ability, (b) achievement motivation, (c) self-concept, and (d) sex-role orientation. These sections, either implied or embedded within Figure 1, can be viewed as being directly influenced
by Bandura's three determinants (SD, BD, PD). The literature review begins with a discussion of sex differences in mathematical ability.

**Sex Differences in Mathematical Ability**

Maccoby and Jacklin (1974) defined mathematical ability as involving the complex manipulation of symbols. These symbols can be either mathematical or verbal symbols. Mathematical ability results, in part, from a developmental process. This developmental process begins in childhood and continues into adulthood. For example, the earliest measures of quantitative ability can take place at age three with the measurement of number conservation. Another measure of quantitative ability is enumeration. The mastery of numerical operations and concepts is measured at a later age in children through achievement tests and aptitude batteries such as the Scholastic Aptitude Test.

According to Benbow and Stanley (1980), males, in contrast to females, have superior mathematical ability, which may be related to greater male ability on spatial tasks. Spatial ability is difficult to define because of its close connection with mathematical ability. It is believed that a spatial factor emerges as an element in mathematical ability which, according to Maccoby and Jacklin (1974), appears to enhance males' quantitative performance. Tavris and Wade (1984) defined spatial ability as
drawing on one's capacity to imagine and to visualize objects in space. Maccoby and Jacklin noted that spatial ability is considered one of the primary mental factors found in the early work of Thurstone. Maccoby and Jacklin have found that as a child matures, spatial problems are solved using verbal quantitative and non-quantitative symbols as well as pictorial symbols. According to Maccoby and Jacklin (1974), spatial testing has involved such tasks as: a) drawings of systems of gears, with the subject being asked to determine what motion in one part of the system would be produced by a given motion in another part of the system; b) a two-dimensional representation of a three-dimensional pile of blocks, with the subject's task being to estimate accurately the number of surfaces visible from a different perspective than his/her own.

Benbow and Stanley (1980) concluded that the supposed male superiority in spatial ability probably results from a combination of internal (inherited) and external (situational) factors. However, others such as Maccoby and Jacklin (1974) have not found much evidence of sex differences in tests of field independence, considered an index of spatial ability, until adolescence.

Problem Solving

Problem solving ability is considered a subset of mathematical ability. In this regard, Schaffer (1981) suggested that men emphasize an 'analytic approach' when
solving problems. Women are presumed to emphasize a more 'global approach', and are thought not to be able to separate themselves from a problem. Consequently, according to Schaffer, women may be at a disadvantage in problem solving due to their more global approach. Indeed, Johnson (1984) at the college level found that males appeared to have a distinct advantage over females in problem solving. However, the male advantage was particularly apparent with word problems. Prior experience in solving word problems was found to be unrelated to the sex difference. Perhaps the approach that these males chose to employ when solving word problems was a function of their mathematical ability.

Johnson (1984) found that the sex differences in problem solving were related to similar male advantages in mathematical aptitude and spatial ability. The results of Johnson's study indicated that mathematical aptitude differences between males and females were important in explaining differential problem solving ability. In fact, mathematical aptitude differences were found to be more important in explaining problem solving ability than a subject's attitudes toward mathematics or their mathematical course taking history.

In contrast, Maccoby and Jacklin (1974) reported that no differences were found between the sexes on problem solving tasks which involved ignoring an irrelevant stimulus, such as selective listening and tactual tasks.
These findings are important in that they show that females are capable of problem solving using an analytic approach of restructuring or set breaking. Thus, this analytic approach of inhibiting a well established response while exploring alternative solutions was not found to be more common in one sex than in the other. Supportive evidence presented by Maccoby and Jacklin included studies using measures such as the Stroop Color-Word Test and the Matching Familiar Figures Test. These tests indicated that the sexes were very much alike in their approach and ability to inhibit an early, impulsive response and to engage in an analytic process to find the right answer. Note that the Stroop Color-Word Test requires one to name colors, to read color names, and to name the color of ink in which a color word is printed. The Matching Familiar Figures Test requires one to match the figures that belong together (Maccoby & Jacklin, 1974). Thus, no sex differences in ability or approach were found with this type of problem solving task.

Sherman (1978) has hypothesized that an early female verbal advantage facilitates a preference in women for verbal approaches in problem solving. This predilection to the verbal approach is then thought to be reinforced by the educational system and also by aspects of the female sex role. Sherman also believes, however, that sex-role reinforcement does not encourage the development of spatial-
visualization skills in girls. Of course, Bandura's (Zimbardo, 1985) social learning theory suggests that those behaviors which an individual has been rewarded for will be more readily evidenced than behaviors that have been punished or ignored. According to Sherman, female children, compared to male children, are not likely to receive the same opportunities to explore and manipulate their environment, thus limiting their development of spatial-visualization abilities. However, Sherman concluded that the generalization that females are not as analytic as males with respect to problem solving, is not supported by the available evidence. In fact, it was reported that the mental processes involved in analytical performance and problem solving are not well understood.

When one examines the various aspects of problem solving, the results are ambiguous. Maccoby and Jacklin (1974) have found that on some verbal tasks such as anagrams (which call for restructuring), females perform better than males. On other verbal tasks such as word problems males do better than females. There are also many examples in which the sexes do not differ on tasks which call for restructuring. From the available evidence, researchers such as Maccoby and Jacklin (1974) have concluded that both males and females possess analytic abilities for problem solving.

Variability

There is some evidence to suggest that males, compared
to females, have greater variability in numerical and spatial abilities. Males, in general, however, are not found to have consistently greater variability in verbal abilities (Maccoby & Jacklin, 1974). Similarly, Schaffer (1981) has indicated that it has been assumed, up to the present time, that the female range of intelligence is not that diversified. However, Sherman (1978) concluded that although males may be more variable in performance on intelligence tests than females, this increased variability can be traced to the fact that a greater number of males have various physical, sensory and mental defects. According to Sherman, there is no strong evidence of greater variation in intelligence quotient among normal males than females. Moreover, an indication of a greater number of gifted males than females appears to be attributable, in general, to a number of measurement problems. Sherman (1978) noted that one measurement problem is that of selection bias. For example, boys, because of their gender, may have a higher probability than girls of being considered exceptional in mathematics. Although a similar number of males and females may have the potential to do well in mathematics, more males than females may realize their potential because of the stronger encouragement males apparently receive to do well in their mathematical studies. Thus, Sherman concluded that in terms of sheer quantity, the greater number of gifted males, particularly
in mathematics, is attributable in part to socio-cultural variables such as selection bias.

These findings may be explained in terms of social learning theory and in terms of Bandura's model (1986), which is embedded in a larger conceptual framework (see Figure 1). With respect to social learning theory, an individual who is not rewarded for a behavior or who is punished for the expression of a behavior will likely inhibit the response. On the other hand, an individual who is rewarded for engaging in an activity will pursue it more keenly. According to Bandura's model (1986), as indicated in Figure 1, reward for a mathematical activity would positively influence achievement motivation and self-concept, which are considered to be multidimensional aspects of personality (Zimbardo, 1985). These personality determinants would in turn influence mathematical behavior.

This is not to say that we are controlled strictly by situational determinants or environmental forces, but environmental forces are factors to consider in determining the behaviors that people will engage themselves. For example, there may not be many positively sanctioned opportunities for females to develop spatial-visualization abilities. There may be a stronger emphasis on females to develop their verbal abilities. In addition, an individual is very much influenced by the behaviors of similar others (Bandura, 1986).
Bandura (1986) indicated that children develop their gender and sex-role orientation vicariously through observational learning. In other words, watching someone such as a role model punished for a behavior may help to regulate one's own behavior. Thus, as may be inferred from Figure 1, individuals do not always have to be directly punished for a behavior to know which behaviors are inappropriate. Individuals acquire rules for generating and regulating behavioral patterns without having to actually go through a time consuming trial and error process. An individual gains a considerable amount of information about social norms from observing group members engaged in behaviors that are rewarded and those which are not rewarded. Thus, the role models in a child's environment provide examples of how an individual within a social context is supposed to behave in different situations.

The literature suggested that females in general have the ability to do as well as males in mathematics. Inherited differences between males and females may predispose each sex to emphasize different kinds of mathematical abilities. However, it would appear that socio-cultural variables exert a stronger influence over males and females than genetic factors in the area of mathematics (Maccoby & Jacklin, 1974).

Socio-Cultural Variables and Mathematical Performance

Interestingly, cultures which encourage and respect
independence among children tend to produce male and female adults with higher spatial scores than cultures with more restrictive social practices (Sherman, 1978). An extensive international study by Husen (Sherman, 1978) found statistically significant differences between the sexes in mathematical performance in certain countries such as Belgium and Japan, but not in other countries such as Sweden and the United States. Husen (1967) found that students who were above average in quantitative performance in one country, might be considered below average in another country. For example, 13 year olds and students in their final year of high school from 12 countries were tested on a 70 item mathematics achievement test. The range of average scores for 13 year olds went from 31.2 in Japan to 15.7 in Sweden. The range of average scores for high school students in their final year, and continuing in mathematics, went from 36.4 in Israel to 13.8 in the United States. Differences between some of these countries regarding mathematical performance were much larger than differences between the sexes. This finding is interesting in that it shows the varied effects of socio-cultural and possibly out-of-school experiences between countries, rather than a consistent difference between the sexes in general on mathematical tasks (Hanna, 1988).

Mebane and Johnson (Sherman, 1978) reported that sex differences on measures of spatial ability were more
extreme between Mexican boys and girls than between American boys and girls. Thus, the Mexican boys were found to score significantly higher than the Mexican girls on measures of spatial ability. Sex-role divergence, in general, was also found to be more extreme in Mexico than in the United States. According to Mebane and Johnson, these results indicated a social and cultural influence with respect to sex-related differences in mathematics.

Socio-cultural variables, in addition to genetic factors, appear to have a major impact on intellectual development (in this case, mathematical development). These results support the conclusion of Bandura and Walters (1963) that although genetic factors exert an influence on individuals, the environment or situational determinants also play a role in modifying a person's intellectual development. Moreover, the behaviors a child engages in determine intellectual development. Additionally, the personality determinants a child brings into the situation have an influence on intellectual development. For example, Bandura and Walters have found that in societies where formal education is emphasized, a child quickly learns that success in intellectual attainment will be rewarded. The examples set by the role models in a child's environment, help to determine resulting attitudes, beliefs and behaviors. These attitudes, beliefs and behaviors in turn affect societal norms. These various influences on
intellectual development, with respect to mathematical development, are depicted in Figure 1.

**Learning Strategies and Mathematical Performance**

Studies on personality correlates of intellectual performance continue to suggest that intellectual development in girls is fostered by their being assertive and active. It is also important that females have a feeling that they can control, by their own actions, the events affecting their lives. In contrast, although many boys are encouraged to be assertive and aggressive, the personality determinant of assertiveness does not appear to be as important in their intellectual development. Assertiveness may not be all that important in the intellectual development of boys because it is believed that they receive much support and encouragement for their endeavors from the environment (Maccoby and Jacklin, 1974). In fact, Maccoby has concluded that females are more likely to be limited in their intellectual pursuits by too much passivity, while males are more likely to be limited in their intellectual pursuits by too much aggressiveness (Sherman, 1978).

Peterson and Fennema (1985) conducted a study with 36 fourth grade classes. These classes completed a mathematics test containing high level items that involved interpretation and application of mathematical knowledge, and low level items which involved computation, recall and manipulation. The results indicated that the girls and
boys did not differ significantly in either mathematical achievement or in observed engagement/non-engagement in mathematical activities. It was found that in classes where boys had received higher scores than girls on low level items, the classes spent more time engaged in competitive mathematical activities. The boys' low level mathematics achievement was enhanced after participating in competitive mathematical games that emphasized drill and practice of low level skills. In classes where there were no differences in girls' and boys' low level item achievement, the classes spent less time engaged in competition. Moreover, girls' low level and high level mathematics achievement was positively related to participation in cooperative mathematical activities. However, it was concluded that the active participation of females in cooperative activities might result in a lack of independence, limiting higher level thinking in girls. Specifically, Peterson and Fennema indicated that the engagement of girls in cooperative social activities and one to one interactions with teachers were thought to be counterproductive for girls' higher level mathematics achievement. It was believed that these cooperative activities were detrimental for girls in that they emphasized a dependent orientation. Interestingly, the most consistent positive correlations for both males' and females' mathematical achievements were found when students were engaged
in mathematical activities that were neither cooperative nor competitive. Mathematical activities which were more individual and neutrally oriented seemed to be beneficial to both males and females.

Cook and Sloane (1985) used a game-like task to evaluate the cooperative behavior of 10-year-olds placed in same-sex dyads. The dyads were either homogeneous or heterogeneous on a premeasure of external or internal locus of control. It was indicated that those individuals with an external locus of control, believing they have little control over events, come into a situation prepared to be helpless. It was thought that this type of individual would display dependency on others as well as passive cooperation. Individuals with an internal locus of control, in contrast, believe in their own control over events. It was thought that these individuals would be prepared to be effective, in adopting a more aggressive or competitive style of play. The results revealed that, independent of locus of control, the females were relatively more cooperative than the male subjects. However, locus of control of the dyad was found to be more related to the cooperative behavior of the boys than that of the girls. For example, the internal-external heterogeneous male dyad grew less cooperative over time, whereas the internal-internal homogeneous male dyad became more cooperative over time. Thus, Cook and Sloane found that
the structure of the dyad did not seem to influence the cooperativeness of the female students in the same way that it influenced the cooperativeness of the male students.

Begum and Ahmed (1986) conducted a study which examined risk taking behaviors among high school students. The design of the study involved individual and group situations which were a function of cooperativeness or competitiveness among students. In both group and individual situations, the competitive prone subjects were found to take more risks in decision making than the cooperative subjects. In fact, the groups composed of competitive subjects showed a greater shift in risk taking from the individual to the group situation than those groups composed of cooperative prone subjects. In general, the male subjects were found to take greater risks in decision making than the female subjects in the individual situation. Begum and Ahmed have found that risk taking is positively related to masculine associated qualities such as aggression, dominance, and extraversion, while negatively related to feminine associated qualities such as nurturance, deference, and affiliation.

Summary

Socio-cultural variables have been found to play a major role in the development of mathematical achievement behaviors among males and females. According to Figure 1, mathematical achievement behaviors are influenced by a
number of determinants. For example, from the research examined, male children seem to be more actively encouraged to exhibit a competitive orientation, and this orientation appears to have a positive influence on their problem solving and decision making abilities. In contrast, females appear to be rewarded for exhibiting a cooperative orientation (Cook & Sloane, 1985; Begum & Ahmed, 1986). The cooperative orientation of females is thought to have a detrimental effect on females' higher level thinking and their achievement motivation, especially in mathematics (Peterson & Fennema, 1985). This detrimental effect would be especially true in senior mathematics classes, where usually, there is a majority of male students, and a competitive orientation is emphasized in the classroom. One may ask how and why this happens. In a male competitive environment such as mathematics, cooperative females are usually seen as quiet and passive (Becker, 1981). When females are also in a minority, the negative effects can be quite powerful. For a minority person in a competitive environment, remaining quiet and passive may seem a safe strategy; however, if prolonged, this strategy may result in females not seeking help when in fact they are in need of help. Moreover, females using this strategy are not likely to challenge males' thinking with respect to mathematics. Thus, the cumulative effect of little if any reinforcement to be competitive appears to result in
greater passivity and quietness, culminating in learned helplessness for some females and a diminishment of achievement motivation for other females.

Achievement Motivation Among Males and Females

According to Maccoby and Jacklin (1974), it has been assumed by many researchers that boys, in general, have a greater need for achievement and are much more oriented towards achievement than girls. However, Maccoby and Jacklin revealed that girls generally get better grades than boys throughout their school years. Girls have been described as more interested in school related skills from an earlier age. In fact, females are less likely than males to drop out before completing high school. However, according to Maccoby and Jacklin, it is important to note that female students, in general, have not been found to achieve higher aptitude or achievement scores than male students. On the other hand, female students, in general, have not been found to receive lower scores than male students on aptitude or achievement tests. In fact, both males and females exhibit similar degrees of task persistence. Thus, it should not be concluded that female students generally do poorer on aptitude or achievement tests than the male students.

Achievements fall into a number of categories. For example, some of the achievements considered to be suitable
for women, such as wife and mother are less valued than those considered suitable for men, such as mathematician.

Additionally, women are limited in terms of suitable achievements, and this may result in a general lowering of achievement motivation in females. This lowering of achievement motivation may negatively affect female behavior in particular areas such as mathematics, which has been considered a male domain (Sherman, 1978). Social learning theory (Bandura, 1986) would suggest that females are not receiving reinforcement for activities considered masculine in nature. As implied in Figure 1, a lack of reinforcement could have a detrimental effect on achievement motivation. This detrimental effect can be depicted through the direct link between situational determinants (SD) and the self-concept (SC) variables. For example, role models who do not provide reinforcement to female students studying mathematics may negatively affect these female students' achievement motivation. This is further illustrated by the linkage of personality determinants (PD) to situational determinants (SD) and to self-concept (SC) variables. As suggested in Figure 1, personality determinants (PD) could have a negative effect on mathematical development (MD) by way of mathematical achievement behaviors. Further, an example of this negative effect might be related to behavioral determinants (BD), particularly differential course-taking behavior in mathematics between male and
female students.

**Differential Course Taking Between Males and Females**

deWolf (1981) concluded that males are in a better position to do well on mathematical aptitude and achievement tests because they choose more mathematics and mathematics-related courses than females in high school. Mathematical aptitude refers to the potential a person has for acquiring various quantitative skills. Mathematical achievement is a current evaluation of a person's competency level in mathematics (Zimbardo, 1985).

When the amount of coursework taken in mathematics by a representative sample of junior high school students was controlled in deWolf's study (1981), sex differences disappeared on two of the four quantitative achievement tests and on a test of spatial ability. Recent studies (Becker, 1982) of mathematics achievement, controlling for amount studied, do not consistently show sex differences in favor of males. When sex differences did occur, however, they tended to favor high school males exhibiting high mathematical ability. In contrast, sex differences in computational skills favoring females were found in females' early and formative years.

Fennema (1980) noted that because the population of males has traditionally studied mathematics over a longer period of time than females, it is a mistake to compare these obviously unequal groups. The Fennema study found
that at ages nine and thirteen, when the educational backgrounds of boys and girls were similar, their levels of achievement in mathematics were also similar. In fact, no sex-related differences were evident at any level from computation to problem solving at the elementary school level. The differences that did appear in the Fennema study were after the 7th grade, and the differences were in the males' favor, particularly tasks involving mathematical reasoning. There was evidence, however, that the sex-related mathematical differences found in Fennema's study may not have been as great as in previous studies, due possibly to controlling for the number of mathematical courses taken by subjects. According to Fennema (1980), the relationship between teacher behavior and sex-related differences in mathematics is crucial to understanding why females are not motivated to participate in higher level mathematics.

Pallas and Alexander (1983) found, in contrast to the findings of Benbow and Stanley (1980), that female quantitative performance at the beginning of high school was not noticeably inferior to that of males. However, a decided female disadvantage in quantitative skill, as measured on the Scholastic Aptitude Test (SAT-mathematical), was evident at the end of high school. The sizable average difference between the sexes in quantitative SAT performance indicated differences in males' and
females' high school programs. The results helped to support the differential course taking hypothesis which states that females are much less likely than males to take certain higher level mathematics and quantitative science courses. Thus, when the differences in quantitative coursework were controlled, the previously indicated male-female difference in SAT-M performance was reduced by 60 percent. From the results, Pallas and Alexander concluded that the initial difference in SAT-M performance was primarily due to sex-linked differences in students' high school mathematics programs.

Bandura and Walters (1963) noted that although ability is influenced by situational determinants, continuity in ability would be more the norm for an individual than discontinuity. However, as indicated in Figure 1, the ability of an individual in mathematics might be subject to change in the event that socio-cultural variables in the student's environment were to change or to shift abruptly. Thus, according to Bandura's (1986) social learning theory, the differential course taking behavior between males and females may be due more to the effects of socio-cultural variables than to simply a lack of ability. These socio-cultural variables become particularly important in adolescence, and influence the self-concept of an individual. For example, achievement motivation, listed under self-concept (SC) in Figure 1, is thought to strongly influence
behavioral determinants (BD) such as course taking behavior. In addition, other behavioral determinants (BD) are linked to self-concept (SC) and achievement motivation, thereby influencing mathematical development (MD), and in particular mathematical achievement behaviors.

Factors Influencing Mathematical Achievement Behaviors

Ethington and Wolfle (1984) demonstrated that mathematics course exposure was an important factor in explaining variation in mathematics achievement between males and females. However, even after controlling for the effects of parental education, spatial and perceptual abilities, grades, attitudes toward mathematics, as well as exposure to mathematics courses, women scored somewhat lower than men on a combined achievement test of mathematics. Separate analyses by sex indicated that the process of mathematical achievement differs between men and women. This finding may suggest alternative models for males and females. For example, males were found to outperform women with regard to spatial ability, and thus spatial ability had a positive influence on mathematics achievement.

Spatial ability referred to the ability to visualize in three dimensions. On the other hand, women outperformed men with regard to grades, and perceptual ability. Perceptual ability also positively influenced mathematical achievement. Perceptual ability referred to the ability to detect patterns and to see relationships within and between
patterns. Thus, it was discovered that mathematical achievement between the sexes is not simply additive. Interestingly, perceptual ability was found to lead to greater mathematics course exposure among men than among women. In contrast, spatial ability appeared to lead to higher scores in mathematical achievement among women than among men. Thus, Ethington and Wolfe (1984) found that women who exhibited spatial ability were able to convert this ability into mathematical achievement, and were able to do this to a greater degree than men with similar spatial abilities.

Sherman (1981) reached a similar conclusion about the important role spatial-visualization ability plays for females pursuing higher level mathematics. Spatial-visualization scores for females, more so than males, in the 9th grade predicted geometry grades as well as mathematical problem solving scores in the 12th grade. Sherman noted that spatial-visualization is probably an important factor in differentiating mathematical performance among females because many females have not received the same opportunities as males to develop this ability. Socialization practices are not thought to facilitate the expression of spatial ability in girls. For example, it appears that female children are not given the same opportunities to manipulate and explore their environment, and thus do not have the same opportunities to improve their spatial
ability. Behaviors which are not encouraged or rewarded in individuals are not usually pursued by the individual (Bandura, 1986).

Stones, Beckmann, and Stephens (1982) found that when the mathematical background of college students was taken into consideration, there was no real difference between males and females in mathematical ability. Interestingly, males excelled in geometry, probability and statistics, where knowledge of course content was important. In contrast, females excelled in mathematical sentences and mathematical reasoning, in which the ability to reason mathematically was important, but specific course content was not crucial.

Struik and Flexer (1984) found that females outperformed males in two college algebra courses, although the males had done as well if not better on the Scholastic Aptitude Test. From these results Struik and Flexer concluded that these females' higher grades reflected some combination of greater effort, interest, and better work habits than those of the males. Socialization practices would seem to explain many of the differences in achievement motivation in mathematics between males and females.

Booth, Allen and Payne (1985) looked at freshmen and sophomore students with exceptional mathematical ability, as measured by the Scholastic Aptitude Test (SAT), enrolled in introductory mathematics and chemistry courses at Stan-
ford University. Female students constituted 44 percent of the freshmen and sophomore population and were 40 percent of the participants in courses examined for this Stanford University study. It was found that gender had an indirectly negative effect on female performance due to differential course taking behavior between the male and female students. Female students earned lower grades and perceived the mathematics and chemistry courses as more difficult than the males. However, some of the differences in achievement between males and females in these introductory classes were lessened when mathematical background was controlled. Moreover, once enrolled in the courses, females were just as likely as males to continue in mathematics and science. There were, however, differences between the sexes in choice of major. Female students were not as likely as the males to choose to major in subjects considered male oriented such as natural science or engineering. The female students were more likely to choose to major in the life sciences, which may be considered more socially acceptable.

In contrast, Linn and Pulos (1983) investigated the role of aptitude and experience in gender differences in scientific reasoning. Students in grades 7, 9 and 11 were given the Predicting Displaced Volume task. This task involves determining how much water two compared blocks, of varying size and weight, displace in containers filled with
It was found that males succeeded more often on this task than females. The success rate for males also increased with age. In conflict with other studies in this area, measures of spatial ability, field dependence-independence, formal reasoning, and science and mathematical course taking experience did not account for the male-female differences in choice of strategy or performance. The above factors, though, did determine performance in general for both males and females. Further, Maccoby and Jacklin (1974) found that in a study analyzing the mathematical achievement scores of males and females in their senior year of high school (after equating the two sexes on the number of mathematics courses taken), the males still emerged with substantially higher scores.

Armstrong (1981) examined the data from two national surveys conducted in 1978. These surveys were entitled The Women in Mathematics Survey and the National Assessment of Educational Progress. The results of these surveys indicated that 13 year old males and females were similar in mathematical ability. Interestingly, 13 year old females were found to be better at computation and spatial-visualization than their male peers. By grade 12, the females had lost their advantage in computation ability. However, no differences were found between the sexes in spatial-visualization ability. By the end of high school, males showed superior performance on word problems. Even
when course taking background was taken into account, grade 12 males indicated a decided advantage on word problems. Armstrong concluded that there may be differential learning and practice of mathematics between males and females outside of school. The differential learning and practice of mathematics may be facilitated by such personality characteristics as self-confidence, motivation, and perseverance. Males may possess these personality characteristics to a greater degree than females due to situational and behavioral determinants. For example, it may be socially expected and encouraged that males are achievement oriented and perseverant on mathematical tasks (Bandura, 1986).

Hanna (1986) conducted a study to assess sex-related differences in the mathematics achievement of grade 8 students. The boys were found to give slightly more correct responses than the girls on two of the five mathematical tasks. On the mathematical tasks, in general, the girls, compared to the boys, had a higher rate of leaving items blank. It was concluded, however, that both boys and girls had been positively influenced by the mathematical instruction at the grade 8 level. Hanna indicated that informal training outside of class might help to explain why the boys were able to perform slightly better than the girls on two of the mathematical tasks examined. Hanna concluded that social conditioning and different expecta-
tions for boys and girls may explain why more girls than boys omitted responses on the mathematical tasks.

It appears that to some degree, there is a certain amount of difference in the learning and practice of mathematics between males and females (Armstrong, 1981; Hanna, 1986). Such differences may be responsible for some of the variability in mathematical achievement, achievement motivation, and differential course taking behaviors between males and females. However, other socio-cultural variables may be involved in explaining these differences. At this point, Figure 1 is simply a general conceptual framework for understanding mathematical development (MD) for both males and females. Although the development and utility of separate process models for males and females is an intriguing complex research question, it is not the focus of this dissertation to address this question.

In examining other socio-cultural variables, Schunk (1985) has indicated that social comparison is extremely important in determining mathematical achievement, achievement motivation, and differential course taking among students. According to Schunk, social comparison refers to the process of comparing oneself with similar others. As found in the general conceptual framework (Figure 1), social comparison is listed under self-concept (SC), and is thought to influence the skills a student believes he/she is capable of acquiring. The social comparison variable of
comparing oneself to similar others can also be associated with the role model variable. Moreover, the role models a student compares himself/herself with influence the student's motivation level and achievement in mathematics (Bandura, 1986).

Motivation Level and Achievement

Surprisingly, it has been found, according to Maccoby and Jacklin (1974), that it takes stronger effort to motivate males outside of competitive situations. Females, on the other hand, showed a high level of achievement motivation whether given an arousal treatment or not. An arousal treatment consisted of asking a subject to be competitive on a task. Thus, males, compared to females, do not appear to exhibit greater achievement motivation; although, they may show more achievement motivation under directly competitive conditions. Closely related to the question of motivation in competitive situations, male subjects have also been found to put a great deal of energy into a task when in the presence of peers. On the other hand, females have not been found to be more motivated than usual when working on a task in the presence of peers. Maccoby and Jacklin suggested that this indicates a high degree of person orientation for males, in direct contradiction to the prevailing assumption that females are primarily person oriented. According to Maccoby and Jacklin, it has been assumed that females are person oriented
and seek affiliation and approval from others rather than achievement. However, males may also be person oriented in satisfying a need for attention and recognition. In fact, Emmerich (Maccoby & Jacklin, 1974) noted that the oldest, most mature children tend to be both task and person oriented.

Van Hecke, Tracy, Cotler, and Ribordy (1984) found that children in 7th grade when presented with a two choice probability task increasingly chose the more probable stimulus over trials. In fact, more girls than boys chose the correct stimulus across four different conditions. These four conditions included: a) reinforcement for choosing the more probable response, b) reinforcement for choosing the less probable response, c) no reinforcement at all from the experimenter, and d) a neutral condition of working alone which did not address reinforcement. There were no significant differences in initial success expectancies on the task between the boys and the girls. However, the results indicated that girls performed in ways which maximized achievement, more often than the boys, even in the face of limited approval from the experimenter. Importantly, the females in the Van Hecke et al. study were not found to limit their achievement behavior even when it was in conflict with approval from the experimenter. It would seem, with respect to this sample, that socio-cultural variables such as role models have
played a part in encouraging and rewarding the female subjects in Van Hecke et al.'s study to be achievement oriented.

Again, social learning theory (Bandura, 1986), as indicated in Figure 1, would suggest that socio-cultural variables including the role models a person is exposed to are particularly important in reciprocally influencing behavioral (BD), and personality determinants (PD). According to Bandura (1986), we learn vicariously, by watching similar and important others exhibiting the appropriate behaviors. Achievement motivation, listed under self-concept (SC), is affected by watching what similar others do and the consequences that issue from these behaviors (see role models listed under SD). In addition to the influence of role models, the experiences an individual has in various situations are also important in modifying personality determinants (PD) and self-concept (SC), particularly achievement motivation.

Summary

The literature on achievement motivation has suggested that socio-cultural variables are primarily responsible for females choosing not to continue their studies in mathematics. Thus, as illustrated in Figure 1, socio-cultural variables (SD) would seem to be responsible, in part, for determining mathematical development (MD) and self-concept (SC). Implicated in this process is mathematical achieve-
ment, achievement motivation, and behavioral determinants (BD) such as differential course taking behavior among students. It would seem that the reported negative attitudes that many high school and college females hold toward the study of mathematics (Boli, Allen & Payne, 1985) have often been reinforced by social conditions and societal expectations. From the literature reviewed (Sherman, 1978; Peterson & Fennema, 1985; Cook & Sloane, 1985), it appears that the cooperative orientation that many females possess works to their disadvantage and is quite detrimental to their academic career, especially in mathematics.

In contrast, males seem to pursue mathematics competitively because of the reinforcement they receive in their formal and informal training from similar and important others. Perhaps different and more specific process models for males and females is an important research question to consider. Self-concept (SC) is a factor to study when examining mathematical development (MD), particularly mathematical achievement. Mathematics achievement would be strongly influenced by the self-concept individuals have about their ability in mathematics (Zimbardo, 1985).

Self-Concept and its Relation to Mathematical Achievement

Spender (1982) found that girls in elementary school indicated that they like and enjoy mathematics. The boys,
on the other hand, did not believe that girls could do mathematics competently. Spender concluded that somewhere in adolescence the attitudes of many females change and girls begin to state that they are not capable of doing mathematics. Girls repudiate their own experiences and take on the perspective of the boys. This seems to occur when girls reach an age at which boys' opinions are important to them. No doubt many socio-cultural variables (see SD in Figure 1) impact on females' lowered regard for the study of mathematics. Variables such as lack of cultural reinforcements and few female mathematically oriented role models appear to be highly influential factors. Consequently, a technical education is not as equally open to female students as it is to male students. According to Spender, it is assumed that females are not sufficiently good at or trained in technical subjects to be equally represented in educational or employment contexts. Sadly, due to lack of reinforcement and few mathematically oriented female role models, many girls do not realize just how important mathematics is for future careers. Again, the evident lack of interest of females in mathematics in terms of continued participation in either educational or employment contexts does not become apparent until adolescence, indicating more socio-cultural pressures than simply a lack of ability per se. A possible result of a poor self-concept with respect to mathematics is attrition by
females from higher level mathematics courses.

Attrition_and_Higher_Level_Mathematics

Leder (1982) looked at the mathematical performance of students in grades 7, 10, and 11. Only in grade 11 were there no differences in measured performance between males and females. In grades 7 and 10, boys outperformed girls on a mathematical performance measure. The fact that there was no difference in mathematical performance between males and females in grade 11 was explained by the attrition of females from higher level mathematics courses. Female students with low mathematical ability were least likely to continue. For example, Leder found that more females in grades 10 and 11, especially those low in achievement level, than males in the same grade intended to discontinue taking mathematics altogether. More high school males, irrespective of their performance level, than high school females intended to take at least two or more mathematical courses. In contrast, girls high in mathematical performance seemed to experience an increasing amount of anxiety as they went through school. This anxiety was measured by Leder in terms of fear of success (Horner, 1968). Leder (1982) found that high fear of success (anxiety associated with successful performance) (Horner, 1968), and high performance in mathematics become increasingly incompatible for girls as they go through school.

Leder (1982) found that a tendency for these girls
high in fear of success was to get out of taking intensive mathematical courses. On the other hand, although males high in mathematical performance were also found to express an increasing amount of fear of success as they progressed through school, they were not as likely to discontinue taking quantitative courses. It would appear that social conditions and societal expectations are responsible for the fear of success that some high ability females experience. The fact that more females than males discontinue taking higher level mathematics courses suggests that these females may not be receiving many rewards or encouragement in their pursuit of mathematics (Bandura, 1986).

Contrasted to the above results, individuals from Leder’s study (1982), who were found to be high in fear of success as well as high in mathematical performance, indicated that they planned to make non-traditional choices that went opposite to what might be expected. For example, Leder found that females with high fear of success were more likely to express the intention of wanting to take more mathematics courses. In contrast, males with high fear of success expressed the intention of wanting to leave school. Leder resolved some of these inconsistencies by suggesting that females and males may be affected in different ways by the fear of success conflict, and may be affected at different stages of their education. Coming to
terms with this conflict may be a continuing process for males and females. However, the process may be different for males and females. Thus, different process models may be a worthy research endeavor. In terms of the general conceptual framework in Figure 1, the process may be influenced by situational determinants and the personality characteristics of the individual. Clearly, the intentions of males and females are not always realized for any number of reasons. Of course, it is thought that the actions rather than the intentions of the males and females should receive closer inspection.

Becker (1981) found that teachers of both sexes treated grade 9 and grade 10 female and male geometry students differently. Both male and female teachers were found to interact more with their male students than with their female students. This interaction took the form of encouragement, individual help, praise and criticism, open questioning, conversation, and joking. There was a tendency for the female students by the 10th grade to be quieter and to be less active than the male students. Some teachers went so far as to admit that it was fairly easy to ignore quiet females who were able to work on their own. According to Becker, it seemed that the more the females were ignored by their teachers, the more they became quiet and passive. In contrast, males receiving greater attention and encouragement from their teachers became all the
more vocal and active in class. These actions facilitated male-students' understanding of the material. Such trends as described above were, in fact, observed frequently over the course of the study. Becker concluded that some teachers come to class with expectations that seem to reflect the current stereotypes prevalent in society. These expectations, (coming from the results of Becker's investigation), seemed to positively favor the male student, while limiting the female student's pursuit of higher level mathematics. Becker noted that the expectations that a teacher holds toward a student help to determine the student's performance.

Teachers are powerful role models or socializing agents. Their actions affect the choices a student will make with regard to his/her education. As socialization agents, teachers could be instrumental in altering socially prescribed sex-roles. Altering socially prescribed sex-roles is essential if one wants to encourage females to have a positive self-concept and to pursue mathematics. Situational determinants such as the classroom environment, in addition to personality and behavioral determinants, would appear to interact reciprocally in determining mathematics achievement (Bandura, 1986).

Sherman (1982) interviewed 12th grade females who had taken either four, three, or two or less years of mathematics in high school. The groups, having been first
tested in the 9th grade, were equated on cognitive factors such as scores on a vocabulary test and scores on a spatial-visualization test. The groups of students that had taken three or four years of mathematics were also equivalent in scores on a mathematical performance test. It was found that girls who had taken the least mathematics were less ambitious but were somehow more independent in terms of their activities. However, females with three or four years of mathematics were more differentiated in future life goals. These females placed more demands on themselves, and were more ambitious in seeking further education than the females with two or less years of quantitative studies. The girls who had taken four years of mathematics had more pleasant memories associated with this subject and had fewer negative experiences with teachers. However, these same girls considered mathematics more a male domain than the females who had pursued only two or three years of quantitative studies. According to Sherman, by the fourth year of high school, females who continued in mathematics faced classes where the majority of members were male and where the higher level mathematical courses were usually taught by male teachers. Not surprisingly, Sherman found that these females experienced a great deal of conflict about the female sex-role self-concept and appropriate achievements. They felt especially uneasy around males who had become significant in their social
lives, and they felt fearful of the attitudes males might have towards a female with above average ability in mathematics. Sherman concluded that these high school females seemed to continue in mathematics, despite their sex-role conflict, because of their initial positive attitudes.

According to Maccoby and Jacklin (1974), differences in mathematical achievement behaviors do not become apparent between males and females until they reach adolescence. The evidence of mathematics attrition for most females at the senior high school level continues at the university level. Ernest (1980) found that although 55 percent of the 1976 entering freshmen at the University of California at Santa Barbara were female, almost twice as many men as women enrolled in a beginning calculus course. Ernest's study showed that over several years men had consistently made up about 64 percent of the calculus enrollment. Moreover, Ernest found that if there was any tendency at all for women to enroll in mathematics, it was to select a shorter calculus sequence. In addition, the attrition rate was higher for women than men taking mathematical courses.

According to Ernest (1980), the extreme sex differences in enrollment figures were due partly to the fact that females do not take enough mathematics and mathematics-related courses in high school. Ernest concluded that males seem to be much more aware of the fact that mathe-
Mathematical training is a necessary prerequisite for the careers they are interested in pursuing. It was also quite clear that parental, teacher, and peer group attitudes have a major impact on the self-concept of female students. Ernest indicated that results of several surveys reported that a good proportion of teachers, parents, and students themselves expressed the belief that males are better at mathematics than females. In addition, Casserly (1980) has found that for many girls in the 8th grade, admission to an accelerated mathematical program was almost traumatic. This was primarily due to peer pressure, along with limited parental and counsellor support and awareness.

As indicated in Figure 1, one's sense of efficacy in mathematics not only influences the mathematical activities and tasks that an individual will freely engage in, but it also affects the amount of effort he/she will expend. Self-efficacy also determines the lengths to which a person will persevere in an area when faced with difficulty. Thus, self-efficacy is defined as a sense of personal mastery with respect to various tasks (Zimbardo, 1985).

This sense of efficacy or competence may be more important than the amount of ability an individual has when it comes to determining achievement motivation. According to Bandura's social learning theory (Zimbardo, 1985), expectations of success or failure can change in light of feedback from performance, but these expectations are more
likely to create the predicted feedback and become self-fulfilling prophecies. As implied in Figure 1, and from Bandura's theory, expectations of failure or success can take the form of outcome-based or efficacy-based expectations. For example, the negative perceptions an individual holds toward a situation that is considered punishing or unresponsive are referred to as outcome-based expectations. In contrast, the perceptions an individual holds about his/her lack of competency in, for example, mathematics are referred to as efficacy-based expectations.

Bagdura (Zimbardo, 1985) suggested that a person who has low self-efficacy needs to develop competencies to boost his/her perceptions of self-efficacy. An intervention program could be worthwhile for enhancing self-efficacy and for reducing the negative effects associated with outcome-based and efficacy-based expectations of failure. Intervention programs may be instrumental in positively influencing mathematical development. An intervention program could be useful in indicating that certain situations do not have to be punishing or unresponsive. There is also a need to sensitize teachers and counsellors with regard to the possible negative effects that they, as role models, may be having on female students' self-concept and females' pursuit of mathematics. This intervention would appear to be necessary in order to change what many females perceive to be unrewarding situations in senior
high school (Sherman, 1982). Thus, the use of mathematically oriented female role models, as well as provision of a structured supportive situation (by way of an intervention program), could be beneficial in changing the negative expectations females hold toward mathematics (Zimbardo, 1985; Ellis & Cordeau, 1988).

**Expectations and Values Associated with Mathematics**

In trying to understand the expectations and values that students hold toward mathematics, Parsons and her colleagues (Meece, Parsons, Kaczala, Goff, and Putterman, 1982) developed a "General Model of Academic Choice". The "General Model of Academic Choice", illustrated in Figure 2, builds on earlier "Expectation by Value" models of achievement behavior. As can be observed in Figure 2, this "General Model of Academic Choice" assumes that the effects of Past Events (such as grades), and Socializers (such as parents and teachers), are mediated by the student's Interpretation of Past Events. Moreover, the Interpretation of Past Events and the student's Task Specific Beliefs (of ability and task difficulty) are influenced by the Cultural Milieu.

Meece, Parsons, Kaczala, Goff, and Putterman (1982) believe that in making decisions to pursue a particular course of study, ability is just one factor among many factors to be weighed. The final decision is more likely to be a consequence of the student's interpretation of
Figure 2: General Model of Academic Choice by J. Parsons, T. Adler, R. Futtermen, S. Goff, C. Kaczala, J. Meece & C. Midgley.
reality. Thus, the student's decision to enroll in mathematical courses is guided by a set of values such as achievement needs, competency needs, sex-role values, and long-range plans and goals. For example, if taking a mathematics course interferes with other preferred activities, the individual will probably decide not to take a mathematics course. Meece et al. noted that earlier research has shown that girls do as well as boys in mathematics up until early adolescence. However, many adolescent girls do not expect to do as well as adolescent boys in mathematics, and elect not to continue in mathematics at the high school level. Meece et al. indicated that these findings can be explained with the aid of the "General Model of Academic Choice" (Figure 2). Males and females differ in their interpretation of achievement outcomes due to the different information they receive from their cultural milieu and socializers.

In another study, Parsons (1983) took a closer look at the variety of factors which influence mathematical achievement behaviors between males and females. Parsons found that achievement-related behaviors are associated with the following: a) self-concept of abilities, b) expectancies, c) perceptions of task difficulty, d) perceptions of task value, e) personal goals, f) perceptions of parents' and teachers' beliefs and attitudes, g) parents' and teachers' actual behaviors, beliefs and attitudes, and
h) perceptions of cultural stereotypes associated with certain activities. The students' interpretation of reality (such as attributions of success and failure, self-concept of abilities, and perception of beliefs of parents and teachers) were influential mediators of expectancies, values and course plans. Interestingly, these variables were more influential than were objective indices of past reality such as previous grades. Spence and Helmreich (Sherman, 1978) have also found that fathers' attitudes were especially important in relation to girls' achievement attitudes. Thus, returning to Figure 1, it can be inferred that self-concept of one's ability, in addition to situational determinants, is a powerful predictor of subsequent grades in mathematics.

The sex differences that emerged from Parson's study (1983) indicated that females, compared to males, had a less positive self-concept of their mathematical ability. Female students were more likely to attribute mathematical success to effort rather than to ability. Females, compared to males, not only felt that mathematics was more difficult for them, but it was also reported that mathematics was of less value to them in their future lives. It was concluded that sex differentiated course enrollment is a joint function of perceived task difficulty, self-concept of one's ability, and the achievement value of mathematics (Parsons, 1983). Interestingly, in support of Parson's
findings, Mura (1987) found that male students, compared to female students, tended to over-estimate their mathematical performance.

Armstrong and Price (1982) showed that the factors that are important in determining whether or not males and females will continue to participate in mathematics are as follows: a) perceived usefulness of mathematics in relation to career and educational aspirations, b) confidence in mathematics, and c) enjoyment of mathematics. While the influence of parents, teachers and counsellors was thought to be moderately important, peer influence was not viewed to be all that important in deciding whether one would or would not continue in mathematics. The influence of teachers seemed to play a more important role in predicting continued female participation in mathematics, while the influence of parents and counsellors had a stronger effect on male participation.

Kuendiger (1984) has developed a 'Conceptual Framework of Gender Differences in Achievement and Course Taking in Mathematics'. This conceptual framework is depicted in Figure 3. As can be observed, the conceptual framework deals with General Beliefs, and that differences in General Beliefs are caused by sex-role perceptions which subsequently influence the Value System and Achievement. Thus, General Beliefs, and the Value System and Achievement affect Personal Learning Experiences (such as success and
Figure 3: Conceptual Framework of Gender Differences in Achievement and Course Taking in Mathematics by E. Kuendiger
failure and perceived usefulness of mathematics). According to Kuendiger, these factors also influence Classroom Processes (such as the interaction of teachers and students). These Classroom Processes promote content learning and attitudinal factors. Further, these Classroom Processes determine how well students learn and how well students understand the material that is being taught. If the classroom interaction is poor because of the expectations of students and teachers, it is unlikely that the experience will initiate and promote the continued learning in an area such as mathematics. Thus, the Student's Achievement, particularly that of females, and their Course Taking Behavior may be especially limited. Kuendiger noted that when outside expectations and beliefs suggest that mathematics is not a subject for the female to pursue or do well in, females significantly lessen their course taking behavior in mathematics.

Locus of Control and Attribution in Mathematics Achievement

The expectations and values a student has towards mathematics will have an influence on the student's locus of control in mathematics. Locus of control is defined as a relatively stable characteristic which people bring to a situation as a generalized belief about their power and control in various situations (Zimbardo, 1985). Becker (1982) noted that sex typing of mathematics as a male domain may inhibit both female achievement and interest in
mathematics. Becker found that females do not seem to express much confidence in their mathematical ability, especially when they fail. When successful, females attribute their successes in mathematics to effort. Attribution theory is defined generally as the interpretation and understanding of people's actions. Attribution theory is concerned with the underlying regularity in the personality of others. In addition, the effect that the social environment has on the perceptions of one's own behavior is also examined by attribution theory (Shaver, 1975).

In the Pennema-Sherman study (Pennema, 1980) using females and males (grades 6 through 12) enrolled in mathematical courses, it was found that confidence was more highly correlated with mathematical achievement than with any other affective variable. When males and females were asked to rate themselves on a series of characteristics, they expressed equally positive or negative self-images. However, females were found to express less self-confidence about how they would perform on tasks they were about to undertake. Pennema concluded that by college, there is a trend for young women to express an external locus of control and to feel that they have little control, and that luck and chance figure prominently in their lives. In contrast, males, compared to females, are not as affected by the negative feedback that they receive. Moreover, many males react with improved self-ratings to positive informa-
tion about their performance (Fox, 1980). Males, of course, compared to females, appear to exhibit an internal locus of control. Males have been found to believe in their own control over events, and have also been found to express stronger feelings of effectiveness and confidence when undertaking new tasks (Maccoby & Jacklin, 1974).

Agarwal and Misra (1986) studied female university students and their causal attributions to success and failure, both as a function of locus of control and situational contexts. Agarwal and Misra looked at internally controlled female subjects, those females who believe in their own control over events. Agarwal and Misra also looked at externally controlled female subjects, those females who believe they have little control over events. It was found that both internally and externally controlled female subjects attributed success to one's self, (to one's own motivation, and to one's own effort). However, internally controlled females made consistent attributions across both positive and negative outcome situations. Externally controlled females made more situation and context based attributions in the negative outcome situations. It was concluded that externally controlled subjects attributed failure more to external causes. This was hypothesized as an attempt by the externally controlled females to protect their ego and to maintain their self-esteem. In contrast, the internally controlled females
were found to regard themselves as responsible for their outcomes, in both negative and positive outcome situations. Thus, the internally controlled subjects attributed their performance more to effort, irrespective of outcome.

Wolleat, Becker, Pedro, and Fennema (1980) examined the causal attributions of female and male high school students who were enrolled in college preparatory mathematics classes. Wolleat et al. (1980) employed a causal attribution theory which emphasizes that performance that is consistent with expectations will be attributed to stable causes such as ability or task difficulty, whereas performance that is inconsistent with expectations will be attributed to unstable causes such as effort or luck. The results indicated that males attributed their successes in mathematics to ability, irrespective of their level of achievement. Females, especially those at the highest achievement levels, were found to attribute their successes in mathematics to effort rather than to ability. When failure experiences occurred in mathematics, females, regardless of their level of achievement, were more likely than males to attribute this outcome to lack of ability or to task difficulty. Of course, these results are interesting in relation to the area of mathematical achievement and success avoidance behaviors on the part of females. It appears that there may be significant differences in causal attributions between females who performed well in
mathematics compared to those females who did not perform well in mathematics.

Maccoby and Jacklin (1974) noted that school is a relatively structured place facilitating "achievement motivation" but not necessarily "initiative" in female students. According to Maccoby and Jacklin, initiative is the ability to independently set and to pursue goals. Initiative occurs when one believes that his/her successful actions, for the most part, are internally controlled rather than controlled by external forces. Moreover, it is in the workplace where one needs a certain amount of initiative to lead to achievement. According to Bandura's social learning theory (1986), this lack of initiative in some women may be primarily due to limited self-efficacy. Thus, locus of control and attribution of performance are important factors in determining initiative among female students.

**Summary**

The literature suggested that self-concept is an important variable to consider when examining mathematical achievement (Parsons, 1983). In examining self-concept, it has been found that many females: a) exhibit negative attitudes towards mathematics, b) exhibit an external locus of control, and c) attribute their mathematical performance to unstable causes (Becker, 1982; Wolleat, Becker, Pedro & Fennema, 1980). For example, the literature suggested that
many females seem to attribute any success in mathematics to either effort or to luck, while attributing their failures to either a lack of ability or to task difficulty. These factors may be linked directly to a low self-esteem and to a restricted sense of self-efficacy in mathematics. With respect to self-concept and implied in Figure 1, the attitudes and beliefs an individual holds toward mathematics shapes his/her mathematical achievement behavior. In examining self-concept (SC), in relation to mathematical achievement, another important variable to consider is sex-role orientation. It seems that both sex-role orientation (SC) and situational determinants (SD) have mediating effects on a person's performance.

The Mediating Effects of the Situation and Sex-Role Orientation on Performance

It has been found by Swanson and Tjosvold (1979) and Morgan and Mausner (1973) that high ability females cooperating with low ability males on a task, when influenced by self-presentation and compliance concerns, subsequently lowered their performance level. Some women consider achievement and femininity in general to be mutually exclusive (Horner, 1970). Hoffman (1975) indicated that the more feminine and attached a woman is to her mother, the less likely she is to be a high achiever and to excel in mathematics, analytic skills, creativity, and game
strategies. According to Hoffman, too much maternal support limits a girl's independence and achievement. Hoffman found that many girls, having received too much nurturance, lack confidence in their own abilities and seek effectiveness through others as a result. It was noted that these findings tend to go along with the notion of women's assumed affiliative needs and desire to please others. For example, Van Hecke et al. (1984) indicated that some researchers believe that females are interested in achievement primarily as a means of gaining approval rather than the mastery of a task. Van Hecke et al. noted that females are expected to sacrifice achievement or to underachieve when achievement does not lead to approval.

In contrast, Stein and Bailey (1975) found that women are motivated to achieve, but the areas of female achievement are very different from the areas of male achievement because of the cultural definitions of feminine activities and interests. Moreover, Stein and Bailey have indicated that achievement motivation is traditionally defined as a masculine characteristic. Achievement motivation that has been measured in studies unwittingly represents only masculine interests and concerns. With these limitations in mind, Stein and Bailey contended that the social context of females' achievement has been misinterpreted as evidence for affiliation rather than achievement motivation. Further, Stein and Bailey indicated that a major area for
feminine achievement striving is social skill. They feel that the attainment of social skill is different from just seeking affiliation or social approval per se. In fact, the attainment of social skill motivates some women to achieve a standard of excellence in this regard. On the other hand, Stein and Bailey have noted that some women have extended their sex-role constructs to include intellectual achievements, and are thought to identify more with the masculine role.

Hoffman (1975) indicated that outstanding women mathematicians are more attached to and identified with their fathers than with their mothers. Higher masculinity scores for females were related positively to various achievement measures as were specific masculine associated traits, such as aggressiveness. The findings clearly supported the belief that girls who are more impulsive than average have strong analytic thinking styles. However, compliance is mediated by the situation as well as by sex-role orientation.

Other studies have shown that sex-role orientation with respect to masculinity-femininity is important, along with situational factors, in determining the degree of self-presentation concerns and compliance among women (Makosky, 1976). Coutts (1987) has found that although feminine females expressed self-presentation concerns, these concerns did not lead to performance decrements in a
competitive situation. It was concluded that although these feminine females expressed anxiety about performing in a competitive situation, they complied with the experimental instructions and were competitive.

Webb (1984) investigated sex differences in interaction patterns and achievement in small groups. Webb found that even though male and female junior high school students had similar mathematical ability in mixed sex and same sex groups, males outperformed females on a mathematical achievement task. This finding was explained by the fact that males were more successful in obtaining information that would benefit their performance on a test of achievement. The group interaction patterns revealed that females were more positively responsive than males to requests for help from both males and females. In contrast, males responded more to male than to female requests for help, especially in groups that contained only one female. In general, females and males tended to seek help from males more often than from females. Webb suggested that the males might have been perceived, especially by the females, as being more competent in mathematics. Interestingly, increasing the number of females in a group, while decreasing the number of males, resulted in a greater focus on the males in the group and on their requests for help. The females in these groups were found to respond by giving more aid to the male students than the other female stu-
dents. On the other hand, females and their requests for help in male majority groups were largely ignored. However, females and males showed equal achievement and similar interaction patterns when equal numbers of males and females were present. It would appear that a female's mathematical performance may be seriously limited in mathematics classes where female students are in the minority, and are largely ignored.

Makosky (1976) found that women do compete successfully in situations considered sex-role appropriate, but do not compete successfully in situations considered sex-role inappropriate. Thus, in returning to Figure 1, an individual exhibits behaviors he/she knows will be rewarded due to the observation of similar others and due to his/her own past involvement in these activities. One's behaviors are shaped by previous socialization experiences and the role models that are available.

Socialization and Its Effect on Performance

Nash (1979) has found that some female children do not necessarily feel that mathematics and science are masculine areas. It is during adolescence when changes take place, and females conclude that mathematics is a masculine activity, which has very little relevance to their future. Conversely, males become more and more aware of the relevance that mathematics has for their future careers. It appears that once girls enter adolescence, they ex-
perience role conflict with the societal norms and expecta-
tions. These societal norms apparently become all the more
important during the adolescent period. In resolving this
conflict and accepting societal norms, a significant number
of girls choose not to continue taking mathematical
courses. Mathematics becomes a sex-role inappropriate area
for many adolescent females (Fox, Tobin, & Brody, 1979).

Nash (1979) found that role conflict appears to be
quite strong among female high school students who have
chosen to pursue a non-traditional career compared to
female students who want to work in traditional areas.
However, the more sex-typed an individual is, the more
likely that he or she would keep his/her behavior consist-
tent with an internalized sex-role standard. Thus, highly
masculine males or highly feminine females are considered
more rigid and less adaptive in situations calling for the
use of characteristics of both sexes (Nash, 1979). For
example, Bem and Lenney (1976) demonstrated that highly
sex-typed persons will choose sex appropriate tasks rather
than sex inappropriate tasks, (even when the sex inap-
propriate tasks are highly rewarded). Of course, Mischel
(Nash, 1979) has indicated that the maintenance of sex-role
behavior involves the striving for cognitive consistency in
which one's thoughts and beliefs are fairly consistent.
Thus, the maintenance of sex-role behavior involves the
avoidance of cognitive dissonance in which two or more
thoughts or beliefs are psychologically inconsistent. This would be particularly important to people who are sex-typed (Bem, 1975).

Nash (1979) found that the more feminine the adolescent female views herself (with respect to intellectual performance) the higher are her reading scores. Nash found that females who do not incorporate mathematics achievement into their feminine self-concept fail to evidence high mathematics achievement patterns. In contrast, females who accept achievement in mathematics as appropriate to the female sex-role, show high achievement patterns in mathematics. Schildkamp-Kuendiger (1982) found that female mathematics overachievers believe that intellectual achievement is suitable for women.

Campbell and McKain (Nash, 1979) compared adolescents in the 7th through 12th grades. They found that more males than females exhibited an increase in their intelligence quotient level as they progressed through school. Moreover, more females than males exhibited a drop in intelligence quotient level. Campbell and McKain measured the self-concept of the participants in the study and found that females, whose intelligence quotient level had declined, saw themselves as being closer to the passive, non-assertive type of woman, than did females who had not declined in intelligence level. It was concluded that females whose intelligence level had lowered, were comply-
ing with society's sex-role standards by not using their intellectual abilities to full potential (Nash, 1979).

**Fear of Deviance From Sex-Role Standards**

According to Fox, Brody and Tobin (1979), it is likely that the stereotyping of mathematics as a male domain by parents, teachers, and peers results in the acceptance of mathematics anxiety in females as inevitable or, at the very least, irrelevant to their development. As long as competence in mathematics by females is not perceived as useful or necessary by society, girls are not likely to get help in overcoming their fears in this area. These female students will continue to see themselves as having little efficacy in mathematics (Zimbardo, 1985). Although there may be inherited sex-related differences, high ability females, once they reach adolescence, are not pursuing mathematics to the same extent as high ability males.

Outcome-based expectations, related to the situation, in addition to efficacy-based expectations, related to the individual, as identified earlier in the literature review, may be responsible for the attrition of females in senior level mathematics programs. As depicted in Figure 1, mathematical achievement (see MD) is influenced by various situational determinants (SD), behavioral determinants (BD), and personality determinants (PD) (Bandura & Walters, 1963).

Nash (1979) concluded that fear of success is a mis-
nomer and actually should be thought of as fear of deviance from sex-role standards. Fear of deviance is defined as fear associated with overstepping the boundaries of a socially prescribed role. People fear the punishment associated with performing in a sex-role inappropriate area, rather than the success they may achieve in these sex-role inappropriate areas. Bandura (Zimbardo, 1985) has found that outcome-based expectations of a situation viewed as punishing or unrewarding, are powerful factors in determining continued performance in that area.

Depner and O'Leary (Nash, 1979) noted that sex-role orientation in conjunction with other factors might be considered a predictor of both mathematical achievement and success avoidance behaviors. Fear of success may not represent so much an intrapsychic anxiety motive as a culturally learned knowledge of sex-role norms. This belief, of course, would be in accord with social learning theory (Bandura, 1986). In other words, both sexes will avoid success when it conflicts with social norms relating to sex-role, but they will seek success when it is in keeping with sex-role prescriptions. Thus, males may also face sex-role constraints that limit their achievement behaviors. For example, although males are encouraged to achieve in sex-role appropriate areas such as mathematics, their behavior is constrained if they do not have the aptitude to do well in these 'male' areas. Again, the
situational context (SD) along with sex-role orientation (SC) is an important factor in determining the achievement behaviors (MD) of individuals (Nash, 1979). Nash (1979) concluded that it is important to examine the relationship between internalized sex-role standards and the external pressures of the sex-related expectancies of others when studying achievement behaviors.

**Summary**

The literature review demonstrated that sex-role orientation and the situation, in general, work together in mediating task performance. The literature review indicated that compliance and self-presentation concerns seem to have been responsible for the lowering of performance in females working cooperatively with a low-ability male partner (Morgàn & Mausner, 1973; Swanson & Tjøsvold, 1979). It has been documented that socialization processes have emphasized mathematics as a masculine activity. Thus, mathematics is a sex-role inappropriate activity for many females (Nash, 1979; Makosky, 1976). It is apparent that the socialization process for females helps to reinforce negative attitudes as well as an external locus of control which many females appear to hold towards the study of mathematics. Socio-cultural variables would seem to be responsible for encouraging many females to attribute their mathematical achievement behaviors to stable causes such as a lack of ability and/or task difficulty (Becker, 1982).
Summary of Literature Review

Interest in women's mathematics achievement continues. Sherman (1978) has concluded that the idea that males have superior mathematical ability compared to females has not really been proven. Further, the sex differences that are found with respect to spatial tasks, an index of mathematical ability, do not seem to show up until adolescence, indicating the impact of socio-cultural variables (Maccoby & Jacklin, 1974). Moreover, according to Sherman (1978), some researchers have not found any differences between college-age males and college-age females on measures of spatial ability. In addition, various studies have shown that both males and females possess analytic abilities for problem solving (Maccoby & Jacklin, 1974). The finding that there are a greater number of gifted males than females with numerical and spatial abilities appears to be attributable to gender-related measurement problems such as selection bias and socio-cultural variables (Sherman, 1978).

By the time females have reached adolescence they seem to look upon mathematics as a masculine activity. Socio-cultural variables (such as lack of reinforcement and lack of female role models who are mathematically oriented) appear to negatively influence girls' opinions and decisions regarding the study of mathematics. As a result, female students tend to drop out or to choose not to take higher level mathematics courses (Leder, 1982). In keeping
with societal norms, it has been found that some mathematics teachers hold different expectations for male and female students. For example, Becker's study (1981) demonstrated that male students, to a greater degree than female students, were actively encouraged by teachers to participate in class and to pursue the study of mathematics. Female students became quieter and less active as teachers interacted more with male students in these classes. This type of classroom interaction facilitated the understanding of the material for the male students, but had detrimental effects for female students interested in pursuing mathematics.

The achievement behaviors of women appear to be influenced by their sex-role orientation as well as by situational factors. Nash (1979) has found that females who accept mathematics achievement as appropriate to the female sex role, show achievement patterns similar to males. On the other hand, females who were more sex-typed were found to be more rigid in keeping their behavior consistent with an internalized sex-role standard, and tended to limit their achievement, especially in quantitative areas.

Limitations

In reviewing the literature on women and mathematics, a number of limitations and inconsistencies become apparent. Sherman (1978) indicated that some researchers have prematurely concluded that males have stronger
mathematical ability than females. However, contrary to the idea that males have superior ability in mathematics, it is apparent that both males and females have similar problem solving abilities (Maccoby & Jacklin, 1974).

Moreover, cultures which encourage and respect independence among children tend to produce male and female adults with higher spatial scores (a facet of mathematical ability) than those cultures having more restrictive social practices (Sherman, 1978).

A few researchers, however, (Linn & Pulos, 1983; Armstrong, 1981) have found that even after controlling for differential course taking among students, there still exist sex differences between males and females in mathematical performance. It may be that outside of school male students are more involved than female students in differential learning and practice of mathematics. Bandura (Zimbardo, 1985) has indicated that feelings of competency in an area are due to more than measured ability. Factors such as support and reward in a situation help to establish feelings of competency and to positively influence achievement behaviors.

The debate continues as to whether or not females, in general, are achievement motivated. Hoffman (1975) claimed that feminine females are too dependent and conforming, and thereby seek affiliation over achievement. It has also been concluded that feminine females would not be task oriented,
but would more likely be passively cooperative in a group situation (Cook & Sloane, 1985). However, a review of the literature indicated that much depends on the type of situation examined. Makosky (1976) has found that feminine females were achievement oriented in sex-role appropriate situations. A sex-role appropriate situation would be a situation in which feminine females have been rewarded in the past, or in which they have observed similar others being rewarded (Bandura, 1986).

Implications for Research

Socio-cultural variables play a major role in determining the choices a female student will make with regard to career and educational aspirations. It is apparent that differences between males and females in mathematical achievement do not become obvious until adolescence. This strongly suggests that sex-related differences are due more to socio-cultural variables than to ability. For instance, according to Nash (1979), females appear to be fearful of the punishment associated with deviance from traditional sex-role norms. However, some females are able to persevere and to cope in the area of mathematics, irrespective of these constraints.

The review of the literature on mathematics achievement revealed that it would be important to explore how female high school students handle the presumed role conflict which comes from participating in quantitative ac-
tivities. It was thought to be especially important to examine the dynamics of female performance, when working cooperatively with a high or low ability male on a mathematical achievement test. A number of hypotheses were related to a group situation, where females' high or low ability on a mathematical achievement test could be examined. In addition, hypotheses related to the male and female subjects' attitudinal behavior on mathematical tests were proposed. In examining attitudinal behavior, in relation to work orientation and in relation to attributions for performance, it was necessary to consider the mathematical tests as tasks. Thus, the hypotheses were as follows:

**Hypothesis 1**

Hypothesis 1 is composed of two testable conditions:
(a) it is hypothesized that high ability females (Hi-F), working cooperatively with a low ability male (Lo-M), on a revised version of the Canadian Achievement Test (mathematics section-level 19) (1981) will lower their performance level; and, (b) it is also hypothesized that the high ability males (Hi-M) will maintain or possibly improve their mathematical performance level when working with a low ability female (Lo-F) on the revised version of the Canadian Achievement Test (1981).

**Hypothesis 2**

Hypothesis 2 is composed of three testable conditions:
(a) it is hypothesized that low ability females (Lo-F) will endorse more negatively valenced attitudinal statements towards mathematics than either the high or the low ability males (Hi or Lo-M); (b) it is hypothesized that high and low ability females (Hi & Lo-F) will endorse more negatively valenced attitudes towards mathematics than the high and low ability males (Hi & Lo-M); and, (c) it is hypothesized that both high and low ability males (Hi & Lo-M) will endorse more positively valenced attitudinal items concerning mathematics than the high and low ability females (Hi & Lo-F).

**Hypothesis 3**

Hypothesis 3 is composed of two testable conditions:
(a) it is hypothesized that in a group situation high ability females (Hi-F), working with a low ability male (Lo-M), will see themselves as more cooperative and supportive than task oriented; and, (b) it is hypothesized that both low ability and high ability males (Lo & Hi-M) in a group situation will see themselves as task oriented rather than cooperative or supportive.

**Hypothesis 4**

Hypothesis 4 is composed of four testable conditions:
(a) it is hypothesized that high ability females (Hi-F) will attribute any drop in performance level more to a lack of ability or task difficulty than either the high ability males (Hi-M) or the low ability males (Lo-M);
(b) it is hypothesized that low ability females (Lo-F) will attribute any drop in performance level more to a lack of ability or task difficulty than either the high ability males (Hi-M) or the low ability males (Lo-M); (c) it is hypothesized that high ability males (Hi-M) will attribute performance level more to ability than either the high ability females (Hi-F) or the low ability females (Lo-F); and, (d) it is hypothesized that the low ability males (Lo-M) will attribute performance level more to luck than to task difficulty or a lack of ability than either the high ability females (Hi-F) or the low ability females (Lo-F).
CHAPTER II

METHOD

Design of the Study

This chapter describes the methods used in this investigation. The topics discussed include a description of the sample, data collection instruments, testing procedures, data treatment procedures, and analytic methods used in this study.

Sample

One hundred and twenty students, 60 males and 60 females, were drawn from Windsor and Chatham district high schools. These high school students were in grade 9 advanced mathematics classes. Subjects received a monetary payment for their voluntary participation.

Instrumentation

The data collection instruments used in this study included: a) the Demographic Survey which consists of questions adapted from the Tenth-Grade Questionnaire by Brush (1980) and the American College Testing Program (1985) (see Appendix A); b) the Student Development Inventory (SDI) (Jackson, 1985); c) the Attitudinal Questionnaire based on the Tenth-Grade Questionnaire by Brush (1980); d) the Personality Research Form-E (PRF-E) (Jackson, 1984); e) the Canadian Achievement Test (CAT) (math-
matics section-level 19) (1981); f) the Personal Attributes Rating Scale, a modified version of the Personal Attributes Questionnaire (PAQ) (Spence, Helreich & Stapp, 1974); and g) the Attributional Questionnaire based on the Tenth-Grade Questionnaire (Brush, 1980); h) the Group Dynamics form developed from the Interaction Process Analysis (Bales, 1976) (see Appendix E); and i) a mathematics test developed from the Canadian Achievement Test (mathematics section-level 19) (1981). This study is part of a larger research project funded by a Social Science and Humanities Research Council grant (Jackson, 1986). Thus, not all of the instruments were used in the actual data analyses of this study. Table 1 indicates the instruments that were utilized in part for the analyses of this two session study. Table 1 presents all of the dependent variables of this study; however, the results from the Canadian Achievement Test (1981) were used as a measure of the independent variable of ability. In listing the instruments that were employed in the data analyses of this study, our purpose here is to clarify which variables were of interest.
Table 1

Instruments Used in the Data Analyses from Session 1 and Session 2

First Session

Canadian Achievement Test (mathematics section)
This test consists of 45 questions which measured a subject's achievement in problem solving. The achievement scores were used as a measure of the independent variable of a subject's ability level in mathematics.

Student Development Inventory
The thirty items from this 55 item inventory measured self-confidence and enjoyment in mathematics.

Attitudinal Questionnaire
This 25 item questionnaire measured students' attitudes and opinions toward mathematics.

Second Session

Canadian Achievement Test (revised)
This 46 item test was presented to cooperative dyads and measured subjects' achievement in mathematical problem solving. In addition, the subjects were asked to indicate (on a worksheet) who had initiated problem solving, the percentage of help they had offered in problem solving, and who had solved each of the problems on the mathematical achievement test.

Attributional Questionnaire
This 14 item questionnaire measured the attributions subjects made regarding their mathematical performance in this study's two sessions.

Personal Attributes Rating Scale
This 30 item scale measured cooperative-supportive and task orientations among subjects.
The Student Development Inventory

The Student Development Inventory (SDI) (Jackson, 1985) contains seven subscales which measured self-confidence in mathematics, enjoyment of mathematics, smooth communication, self-confidence with superiors, self-confidence with peers, self-confidence in writing, and enjoyment of writing. As indicated in Table 1, thirty items from the 55 item inventory were selected for the present study.

A principal components factor analysis of the intercorrelations of the items in this inventory was conducted (Jackson, Mather & Hood, 1985). Three factors were identified by the pattern of the loadings. These factors are:

a) confidence in one's ability in mathematics, b) confidence in communication, and c) confidence in writing.

The eigenvalues from the principal components analysis were 13.11, 11.53, and 5.20, respectively. Total variation for the three-factor solution explained 45% of the variance.

Jackson, Mather and Hood (1985) concluded that the reasonable stability of the reliability coefficients suggests that the scales may be used as separately based scores. Moreover, the analyses of Jackson, Mather and Hood showed that the scales share a sufficient degree of common variance so that one could interpret a general competency attitude reflecting confidence and enjoyment in quantitative, interpersonal, and communicative areas.
The Attitudinal Questionnaire

The 25 item Attitudinal Questionnaire contains items from the Tenth-Grade Questionnaire (Brush, 1980). These items purport to measure students' attitudes and opinions toward mathematics and, teacher, parent, and peer support. Learning strategies as well as stereotypic thinking with respect to mathematics were also examined with this questionnaire (see Appendix B).

The Canadian Achievement Test

The Canadian Achievement Test (CAT) (mathematics section-level 19) (1981) consists of 45 questions which tested a subject's achievement level in problem solving. Mathematical concepts related to geometry and algebra were examined. The test was individually administered, and required 38 minutes to complete. According to White (1985), the range of skills tested in the Canadian Achievement Test is commendable, particularly in mathematics. Norms were based on a representative sample obtained by:

a) stratified random sampling of school districts by geographical area and degree of urbanization, b) random sampling of schools within districts, and c) achieving a high participation rate. Moreover, White concluded that the development and writing of category objectives played an important part in establishing content validity. The mathematical achievement scores from the first administration of the CAT in this study were used as a measure of
the independent variable of a subject's ability in mathematics.

The Canadian Mathematics Achievement Test (revised form)

A revised form of the Canadian Achievement Test (mathematics section - level 19) (1981) was developed for dyad testing. The questions are very similar to those found on the original test which measured a subject's achievement level in problem solving. The revised form consists of 46 questions and required 30 minutes to complete. In addition to the problems of geometry and algebra, a spatial problem was included in this test (Kuendiger, 1987). The administration of the revised CAT in the second part of this study was used as a dependent measure of a subject's mathematical achievement in a small group situation. This test is similar enough to the Canadian Achievement Test to be generally comparable and to provide an indication of success avoidance on the part of the subjects in a group situation.

The Personal Attributes Rating Scale

The Personal Attributes Rating Scale, derived from the Personal Attributes Questionnaire (PAQ) (Spence, Helmreich & Stapp, 1974) includes 30 items. The Personal Attributes Questionnaire contains three subscales which are: a) male valued items scale; b) female valued items scale; and, c) sex-specific items scale. These scales are explained next.

Spence, Helmreich and Stapp (1974) found that the mean
ratings for the ideal man and woman both fell towards the stereotypic masculine pole on the male valued items scale. An example of a male valued item is, 'How confident was your partner in this situation?'. The mean ratings for the ideal man and woman both fell towards the stereotypic feminine pole on the female valued items scale. An example of a female valued item is, 'How helpful did you feel you were to your partner?'. The mean ratings for the ideal man and woman fell towards sex-specific poles on the sex-specific items scale. An example of a sex-specific item is, 'How much do you like math and science?'.

During the second session of the study, the subjects were asked to rate themselves, their partner, and then the dyad as a team with the Personal Attributes Rating Scale. In addition, the Personal Attributes Rating Scale was used by the group rater during the second session to evaluate each subject as well as the dyad with the same PAQ variables (JSAS Catalog of Selected Documents in Psychology, 1974).

Spence, Helmreich and Stapp (1974) computed alpha reliability coefficients on the PAQ for the Total Self scores as a measure of internal consistency. The reliability coefficients were .73 and .91 for men and women respectively on the Self scale. Test-retest data were available from 31 subjects who took the PAQ again after an interval of 13 weeks. The correlations were .80 and .91
for men and women respectively on the Total Self scale. Spence, Helmreich and Stapp found that the correlations for the individual subscales varied from .65 to .97. Thus, the scales were found to have satisfactory internal consistency and test-retest reliability. Correlations with the Marlowe-Crowne Social Desirability Scale, while occasionally significant, were relatively low: the highest for both sexes being in the .30's and occurring for the female valued items (JSAS Catalog of Selected Documents in Psychology, 1974) (see Appendix C).

The Attributional Questionnaire

The Attributional Questionnaire, adapted from the Tenth-Grade Questionnaire (Brush, 1980), consists of 14 items. This questionnaire examined the attributions subjects made based on their mathematical performance in the two sessions of this study. Attributions of luck, task difficulty, ability, and effort were explored with this rating scale. For example, a) I have performed well on the mathematical tests given during this study; b) My achievement on the mathematical tests given during this study was primarily due to my ability. In addition, enjoyment of mathematical tests while working alone or in a group situation was examined (see Appendix D).

Testing Procedures

First Session

The first session of the two part procedure involved
group testing of subjects. The subjects were tested in groups of 30 students. The first part of this study required approximately two hours for the completion of the test materials. During this time, the subjects individually completed the standardized Canadian Achievement Test (CAT) (mathematics section-level 19) (1981). In the first part of this study, this test measured mathematical concepts and applications, and was considered a premeasure of the subjects' mathematical achievement. The mathematical achievement scores were used as a measure of the independent variable of each subject's ability level in mathematics. In addition, each subject filled out the Demographic Survey, based on the Tenth-Grade Questionnaire and the American College Tests (Brush, 1980; ACT, 1985); the Student Development Inventory (Jackson, 1985); the Attitudinal Questionnaire, derived from the Tenth-Grade Questionnaire (Brush, 1980); and then completed the Personality Research Form/E (Jackson, 1984). The subjects were informed in the first session that they would be given their results from the CAT in the second session. Subjects were thanked for their participation in the first part of the study and were urged to participate in the second session.

**Second Session**

Prior to the second session, the Canadian Achievement Test (mathematics section-level 19) (1981) data were scored
and unequal ability dyads were formed. In the second part of this study, the independent variable of ability was determined by the mathematical achievement scores received from the first part of the study. It is important to note that these subjects were involved in advanced mathematics classes. A subject's low ability was only relative to the other subjects participating in the study. Thus, low ability and high ability male and female subjects, determined by the median score, were paired in two person groups or dyads. These dyads consisted of mixed sex pairs of subjects of unequal ability. A results sheet was developed specially for the second session from the earlier mathematical testing of the first session.

When the subjects arrived at the second session they were introduced to their partner, and they were given their score as well as their partner's score on the Canadian Achievement Test (1981). The second testing session lasted approximately one hour.

The revised form of the Canadian Achievement Test (mathematics section-level 19) (1981) was placed on 8.5" by 11" sheets of paper which were taped to a table. Subjects were given standardized instructions to "work with your partner to see how effectively you can work together". Each subject received either a pen or a pencil so that his/her work was easily identified. The subjects were instructed to use adjacent team worksheets to indicate
approximately the amount of help they contributed to each mathematical problem (e.g., 0%, 25%, 50%, 75%, 100%). They were also asked to decide who started each problem, and to determine who actually solved each of the 46 mathematical questions. The subjects did this by writing down their names in the space provided for each question on the team worksheet. The subjects were given 30 minutes to work together on this mathematical achievement test.

While the subjects were working together, their verbal behaviors were tape recorded for future reference. A rater assessed each subject on both individual and team characteristics using the Personal Attributes Rating Scale, a modified version of the Personal Attributes Questionnaire (Spence, Helmreich & Stapp, 1974), and the Group Dynamics form adapted from the Interaction Process Analysis (Bales, 1976).

In measuring the percentage of rating agreement between the five examiners in the present study, each examiner was introduced to six categories that had been developed specially from Bales' Interaction Process Analysis (1976). The six categories were: a) supportive; b) competitive; c) passive-supportive; d) antagonistic; e) receptive; and f) cooperative. These six categories were defined operationally for the examiners. Next, the examiners were given a paper and pencil task of interpreting a standard set of behaviors which described typical dyad-
type situations. Each examiner was asked to rate the set of behaviors using only one of the six defined categories. When the examiners had completed this task, their work was scored. The mean percentage of agreement was derived from these results. The mean percentage of rater agreement was found to be 96 per cent (see Appendix E).

After the subjects had worked on the mathematical problems in the given time period, they next filled out the Personal Attributes Rating Scale developed from the PAQ (Spence, Helmreich & Stapp, 1974). Subjects rated themselves, their partner, and their team using the Personal Attributes Rating Scale. Finally, the subjects filled out the Attributional Questionnaire based on the Tenth-Grade Questionnaire (Brush, 1980).

When the subjects had completed the second testing session, they were thanked for their participation in the study, and then debriefed as to the nature of the study (see Appendix E). Table 2 summarizes clearly the design of this two part study, and presents the independent variables of ability level and mixed sex dyad composition.

Data Treatment Procedures

Subjects were placed in dyads for the second testing session of this study. These dyads consisted of mixed sex groupings, where participants were of unequal ability. The two critical treatment groups under investigation in the study were: Dyad Type 1: a) high ability male - low
### Table 2

**Design of the Two-Session Study**

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n Individuals</td>
<td>n Dyads</td>
</tr>
<tr>
<td>High Ability</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Males (Hi-M)</td>
<td></td>
<td>Hi-M/Lo-F</td>
</tr>
<tr>
<td>Low Ability</td>
<td>32</td>
<td>Dyad Type 1</td>
</tr>
<tr>
<td>Females (Lo-F)</td>
<td></td>
<td>(32)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Ability</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Females (Hi-F)</td>
<td></td>
<td>Hi-F/Lo-M</td>
</tr>
<tr>
<td>Low Ability</td>
<td>28</td>
<td>Dyad Type 2</td>
</tr>
<tr>
<td>Males (Lo-M)</td>
<td></td>
<td>(28)</td>
</tr>
</tbody>
</table>
ability female, and Dyad Type 2: b) high ability female—low ability male. Thirty-two dyads were composed of (Dyad Type 1) high ability male—low ability female pairings and 28 dyads were composed of (Dyad Type 2) high ability female—low ability male pairings. Thus 60 dyads were examined.

The variables of interest in this study were actual behaviors observed in the dyads as well as self-reported behaviors, attitudes, and opinions of the subjects. The data collection instruments that were used for analyses in this study were as follows.

The Canadian Achievement Test (mathematics section—level 19) (1981) was used in session one to measure the mathematical achievement level of the subjects. The mathematical achievement scores were used as a measure of the independent variable of mathematical ability, which enabled the researchers to place the subjects in mixed sex dyads of unequal ability. The revised form of the Canadian Achievement Test (1981) was used in session two as a dependent measure of mathematical achievement between the high and low ability subjects in a group situation. The Student Development Inventory (Jackson, 1985) and the Attitudinal Questionnaire adapted from the Tenth-Grade Questionnaire (Brush, 1980) helped to measure positive and negative attitudes toward the study of mathematics. Attributions of performance level such as luck, effort, task difficulty, and ability were examined by the Attributional Question—
naire based on the Tenth-Grade Questionnaire (Brush, 1980). The Personal Attributes Rating Scale, adapted from the Personal Attributes Questionnaire (Spence, Helmreich & Stapp, 1974), measured cooperative-supportive and task orientations among the subjects.

Analytic Methods

One-way analyses of variance were used to see if there were any significant differences between the mathematical performance levels of the two partners in each of the two critical experimental groups: Dyad Type 1: high ability males paired with low ability females, and Dyad Type 2: high ability females paired with low ability males. Again, the materials examined included mathematical performance on the first session's Canadian Achievement Test (1981) and the second session's revised Canadian Achievement Test.

One-way analyses of variance were carried out to see if there were any significant differences in attitudes expressed between the four groupings of: a) high ability males; b) low ability females; c) high ability females; and, d) low ability males. The Student Development Inventory (Jackson, 1985), the Attitudinal Questionnaire and the Attributional Questionnaire derived from the Tenth-Grade Questionnaire (Brush, 1980), and the Personal Attributes Rating Scale, adapted from the Personal Attributes Questionnaire (Spence, Helmreich & Stapp, 1974) were used to examine students' expressed opinions and attitudes regard-
ing the study of mathematics.

The significant results from the above analyses of variance were further examined with Scheffe's pairwise comparisons, in addition to Tukey's HSD procedure employing the harmonic mean. These results are given in the Results section, Chapter III of this thesis.
CHAPTER III

RESULTS

This study examined two critical treatment groups: Dyad Type 1 consisted of the high ability male - low ability female pairs and Dyad Type 2 included the high ability female - low ability male pairs. The sample consisted of 28 high ability female - low ability male pairs (called dyads) and 32 high ability male - low ability female pairs (or dyads). These two treatment groups were derived by splitting at the median the males' and females' scores on the Canadian Achievement Test (mathematics section-level 19) (1981). From these two treatment groups, four separate groupings were examined: a) high ability males; b) low ability females; c) high ability females; and, d) low ability males (see Table 2; page 90).

Mathematical Performance

Mathematical performance was measured by a mathematical achievement score. Mathematical achievement of each individual was assessed initially by means of the Canadian Achievement Test (1981). The independent variable of ability was determined by the mathematical achievement scores received from the first part of the study. On the basis of the mathematical achievement scores, the subjects were assigned to mixed sex, unequal ability dyads. As
noted earlier, according to Hopkins and Stanley (1981), there is a substantial relationship between achievement and an individual's measured intelligence or ability. In the second part of the study, the dependent measure of mathematical achievement of each subject was measured by way of a revised form of the Canadian Achievement Test (1981).

**Canadian Achievement Test**

The two critical treatment groups of Dyad Type 1 and Dyad Type 2 were examined. Hypothesis one was composed of two testable conditions. It was hypothesized in condition (a) that high ability females (Hi-F), working cooperatively with a low ability male (Lo-M), on the revised version of the Canadian Achievement Test (mathematics section—level 19) (1981) would lower their performance level. Next, it was hypothesized in condition (b) that high ability males (Hi-M) would maintain or possibly improve their mathematical performance level when working with a low ability female (Lo-F) on the revised version of the Canadian Achievement Test (CAT) (1981).

In developing hypothesis one, with conditions (a) and (b), it was assumed that each student comes to a mathematical task with a certain fund of knowledge, and their individual score on a quantitative test reflects this fund of information. Thus, the first session score each subject received from the Canadian Achievement Test (1981) was thought to be indicative of this fund of knowledge (their
achievement and ability in mathematics. This score was then used as a measure of the independent variable of mathematical ability. Further, the revised Canadian Achievement Test (similar to the original CAT (1981)) was used as a dependent measure of mathematical achievement in the second session.

In the second session, high and low ability subjects worked cooperatively together on the revised Canadian Achievement Test. The fund of knowledge available to the pairs was best estimated by the high performer's score. With this in mind, two paired comparison samples $t$-tests were conducted (see SAS User's Guide Statistics, Version 5, page 799). The first paired comparison samples $t$ test measured the differences in the high ability females' scores between the first and the second mathematical tests. The first paired comparison samples $t$ test indicated that the high ability females performed significantly better $t(27) = -5.93$, $p < .0001$ when they solved mathematical problems on their own (mean = 28.17) than when they worked cooperatively with a low ability male partner (mean = 23.25). The second paired comparison samples $t$ test measured the differences in the high ability males' scores between the first and the second mathematical tests. The second paired comparison samples $t$ test indicated that the high ability males performed significantly better $t(31) = -6.80$, $p < .0001$ when they solved mathematical problems
on their own (mean = 28.96) than when they worked cooperatively with a low ability female partner (mean = 23.90).

Other analyses were conducted on the data from the revised Canadian Achievement Test (1981). One-way analyses of variance were carried out on the mathematical performance data from the second part of the study. Although the two treatment groups of Dyad Type 1 (Hi-M - Lo-F) and Dyad Type 2 (Hi-F - Lo-M) solved approximately the same number of problems correctly on the second mathematical test, the high ability females indicated on the team worksheet that they had contributed a higher percentage of help in problem solving than their low ability male partner, \( F(1, 54) = 11.07, p < .001 \). This result was significant. Next, high ability females appeared to take more credit for solving the mathematical problems than their low ability male partner; however, this result was not significant. In addition, there were no significant differences between the high ability females and their low ability male partner in indicating who initiated problem solving.

Similarly, the high ability males in the high ability male - low ability female group indicated on the team worksheet that they had contributed more help than their low ability female partner on the mathematical test, \( F(1, 62) = 10.96, p < .001 \). This result was significant. However, it is important to note that the high ability males in this group also took credit for solving more of
the problems than their low ability female partner, $F(1, 62) = 16.90, p < .0001$. This result was significant. Thus, the high ability males, in contrast to the high ability females, credited themselves significantly more for mathematical achievement when working in a mixed sex dyad. However, there were no significant differences between the high ability males and their low ability female partner in indicating who initiated problem solving.

Table 3 lists the means and standard deviations, according to group membership, for both the percentage of help offered and the number of questions credited for problem solving on the second mathematical achievement test. From Table 3, it can be seen that the high ability males and high ability females offered a similar percentage (53.7%) of help in problem solving. However, in contrast to Dyad Type 2 (group 2), the high ability males (Dyad Type 1 or group 1) credited themselves significantly more for solving the mathematical problems (mean = 20.0) than their low ability female partner (mean = 14.7). In particular, the high ability males (mean = 20.0), in contrast to the high ability females (mean = 17.5), credited themselves significantly more for problem solving than their respective low ability partner. Thus, the high ability males would appear to have achieved more than the high ability females, in terms of taking more credit on this problem solving task.
Table 3: Percentage of Help Offered and Number of Questions Credited on the Canadian Achievement Test as Examined Across Group Membership

<table>
<thead>
<tr>
<th>Grouping</th>
<th>n</th>
<th>Percentage of Help Offered</th>
<th>Number of Questions Credited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Ability Male</td>
<td>32</td>
<td>53.1%</td>
<td>20.0</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>7.5</td>
<td>6.2</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Ability Female</td>
<td>32</td>
<td>46.9%</td>
<td>14.1</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>7.5</td>
<td>5.3</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Ability Female</td>
<td>28</td>
<td>53.1%</td>
<td>17.5</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>7.1</td>
<td>4.6</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Ability Male</td>
<td>28</td>
<td>46.8%</td>
<td>15.2</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>7.1</td>
<td>4.7</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Spatial Test

In a separately scored spatial problem, high ability males paired with low ability females solved a spatial problem more times correctly than the high ability females paired with low ability males, \( F(1, 118) = 10.97, p < .001 \). This significant result may be due to dyad composition, and therefore helps to support the first hypothesis (condition a) that high ability females in general would lower their performance level when teamed with a low ability male partner. On the other hand, this result may indicate that high ability males, compared to high ability females, have greater spatial ability.

Attitudinal Behavior

Hypotheses two, three and four will be presented next. The attitudinal behavior of each subject towards mathematics was assessed with the aid of a number of rating scales. These rating scales were the Student Development Inventory (Jackson, 1985), the Attitudinal and Attributional Questionnaires based on the Tenth-Grade Questionnaire (Brush, 1980), and the Personal Attributes Rating Scale adapted from the Personal Attributes Questionnaire (Spence, Helmreich & Stapp, 1974).

Student Development Inventory

Two one-way analyses of variance were carried out on data from the Student Development Inventory (Jackson, 1985). The dependent measure for the first one-way ANOVA
was the measured negative attitudes of the subjects towards mathematics. The dependent measure for the second one-way ANOVA was the measured positive attitudes of the subjects towards mathematics. In each of these one-way ANOVA's, the independent variable was the four groupings. These groups were: (a) high ability males; (b) low ability females; (c) high ability females; and (d) low ability males. The results from the Student Development Inventory were used to measure the three testable conditions of hypothesis two. The results from the first one-way ANOVA indicated a significant difference between the four groups in their endorsement of items which reflected a negative view towards mathematics, \( F(3, 116) = 7.85, p < .0001 \). Inspection of the means (see Table 4) indicated higher endorsements of the negatively valenced items on the Student Development Inventory (Jackson, 1985) by both the low ability males (mean = 26.0) and low ability females (mean = 28.1). It is important to note that the higher the mean, the greater the negative/positive attitudes. Post F test analyses (Scheffes) were conducted. The results are given below, and associated with the relevant conditions of hypothesis two. These conditions of hypothesis two are given next.

First, it was hypothesized in condition (a) that low ability females (Lo-F) would endorse more negatively valenced attitudinal statements towards mathematics than either the high or the low ability males (Hi or Lo-M).
Table 4

Negative and Positive Attitudes Towards Mathematics on the SDI (Student Development Inventory) and the AO (Attitudinal Questionnaire) as Examined Across Ability Levels

<table>
<thead>
<tr>
<th>Ability</th>
<th>n</th>
<th>SDI Negative</th>
<th>SDI Positive</th>
<th>AO Negative</th>
<th>AO Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>28</td>
<td>22.5</td>
<td>32.1</td>
<td>15.9</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.4</td>
<td>7.9</td>
<td>3.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Male</td>
<td>32</td>
<td>20.1</td>
<td>36.5</td>
<td>15.3</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.8</td>
<td>7.8</td>
<td>4.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Low Ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>32</td>
<td>28.1</td>
<td>27.7</td>
<td>18.3</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.1</td>
<td>7.4</td>
<td>4.4</td>
<td>4.7</td>
</tr>
<tr>
<td>Male</td>
<td>28</td>
<td>26.0</td>
<td>29.1</td>
<td>17.9</td>
<td>23.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.2</td>
<td>8.4</td>
<td>4.8</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Note: The higher the mean the greater the attitude.
Scheffe's pairwise comparisons of all possible groupings indicated significant differences. Low ability females (mean = 28.1) were found to endorse more of the negatively valenced statements than the high ability males (mean = 20.1; p < .05). This result was significant. Next, significant differences in endorsement of negative attitudinal statements towards mathematics were also found between the low ability females (mean = 28.1) and high ability females (mean = 22.5; p < .05). In addition, it was revealed that the low ability males significantly differed (mean = 26.0) from the high ability males (mean = 20.1; p < .05) in their endorsement of these negative attitudinal statements.

Next, it was hypothesized in condition (b) that high and low ability females (Hi & Lo-Y) would endorse more negatively valenced attitudes towards mathematics than the high and low ability males (Hi & Lo-M). An independent groups t test indicated a significant difference t(118) = 1.73, p < .05 between the females (high and low ability) (overall female mean = 25.3) and the males (high and low ability) (overall male mean = 23.1) in their support of negative attitudinal statements towards mathematics. Thus, the high and low ability females were found to endorse significantly more of the negatively valenced statements than the high and low ability males.

Regarding the second one-way ANOVA, a significant difference was found between the four groups: (a) high
ability males; (b) low ability females; (c) high ability females; and, (d) low ability males in their endorsement of items which reflected a positive attitude towards mathematics, $F(3, 116) = 7.74, p < .0001$. Inspection of the means (see Table 4) indicated higher endorsements of the positively valenced items on the Student Development Inventory (Jackson, 1985) by both the high ability males (mean = 36.5) and the high ability females (mean = 32.1). The Scheffe's pairwise comparisons of all possible groupings indicated significant differences between the high ability males (mean = 36.5) and the low ability males (mean = 29.1; $p < .05$) in their endorsement of positive items found on the Student Development Inventory (Jackson, 1985). The high ability males (mean = 36.5) were also found to endorse the positively valenced items more than the low ability females (mean = 27.7; $p < .05$). This result was significant. In comparing the high ability females and their support of positive items with any of the other groupings, no significant differences were found.

As mentioned earlier, hypothesis two consisted of three testable conditions (a, b, c). It was hypothesized in condition (c) that both high and low ability males (Hi & Lo-M) would endorse more positively valenced attitudinal items concerning mathematics than the high and low ability females (Hi & Lo-F). An independent groups t test revealed a significant difference $t(118) = 2.02, p < .05$ between the
males (high and low ability) (overall male mean = 32.8) and females (high and low ability) (overall female mean = 29.9) in their endorsement of positive attitudinal statements towards mathematics. Thus, the high and low ability males were found to support significantly more of the positively valenced statements than the high and low ability females.

**Attitudinal Questionnaire**

Two one-way analyses of variance were carried out on data from the Attitudinal Questionnaire adapted from the Tenth-Grade Questionnaire (Brush, 1980). The dependent measure for the first one-way ANOVA was the measured negative attitudes of the subjects towards mathematics. The dependent measure for the second one-way ANOVA was the measured positive attitudes of the subjects towards mathematics. In each of these one-way ANOVA's, the independent variable was the four groupings. These groups were: (a) high ability males; (b) low ability females; (c) high ability females; and, (d) low ability males. The results from the Attitudinal Questionnaire were used to measure the three testable conditions of hypothesis two. The results from the first one-way ANOVA indicated a significant difference between the four groups in their endorsement of items which reflected a negative attitude towards mathematics, \( F(3, 116) = 3.61, p < .01 \). Inspection of the means (see Table 4) indicated higher endorsements of the negatively valenced items on the Attitudinal Questionnaire by
both the low ability males (mean = 17.9) and the low ability females (mean = 18.3). Post F test analyses were conducted. The results are given below and associated with the relevant conditions of hypothesis two. These conditions of hypothesis two are given next.

First, it was hypothesized in condition (a) that low ability females (Lo-F) would endorse more negatively valenced attitudinal statements towards mathematics than either the high or low ability males (Hi or Lo-M). Scheffe’s pairwise comparisons of all possible groupings found no significant differences. This result may have been a function of rounding error. Because the group n’s were slightly dissimilar (N1 = 32 and N2 = 28), Tukey’s HSD procedure employing the harmonic mean was used. This procedure revealed that there was a significant difference between the low ability females (mean = 18.3) and the high ability males (mean = 15.3; p < .05) in their endorsement of negatively valenced statements dealing with mathematics. Next, the low ability females (mean = 18.3) also differed significantly from the high ability females (mean = 15.9; p < .05) in their support of negatively valenced statements. The low ability females endorsed significantly more negatively valenced statements than either the high ability males or the high ability females. Using the Tukey's HSD procedure, resulted in no significant differences between the low ability males and the other groupings in their
support of negatively valenced items (see Appendix G).

Next, it was hypothesized in condition (b) that high and low ability females (Hi & Lo-F) would endorse more negatively valenced attitudes towards mathematics than the high and low ability males (Hi & Lo-M). An independent groups t test did not find a significant difference between the females (high and low ability) (overall female mean = 17.1) and males (high and low ability) (overall male mean = 16.6) in their support of negative attitudes towards mathematics.

Regarding the second one-way ANOVA, a significant difference was found between the four groups: (a) high ability males; (b) low ability females; (c) high ability females; and, (d) low ability males in their endorsement of items which reflected a positive attitude towards mathematics. \( F(3, 116) = 5.32, p < .001 \). Inspection of the means (see Table 4) indicated higher endorsements of these positively valenced items on the Attitudinal Questionnaire by the high ability males (mean = 27.7) and high ability females (mean = 26.0). Scheffe's pairwise comparisons of all possible groupings indicated a significant difference between the high ability males (mean = 27.7) and low ability females (mean = 23.6; \( p < .05 \)) in their endorsement of positively valenced attitudinal items towards mathematics. The high ability males (mean = 27.7) were also found to differ significantly from the low ability
males (mean = 23.4; p < .05) in their endorsement of the positively valenced items found on the Attitudinal Questionnaire adapted from the Tenth-Grade Questionnaire (Brush, 1980). It is also worth noting that in comparing the high ability females with any of the other groupings, no significant differences were found.

As mentioned earlier, hypothesis two consisted of three testable conditions (a, b, c). It was hypothesized in condition (c) that both high and low ability males (Hi & Lo-M) would endorse more positively valenced attitudinal items concerning mathematics than the high and low ability females (Hi & Lo-F). An independent groups t test did not find a significant difference between the males (high and low ability) (overall male mean = 25.6) and females (high and low ability) (overall female mean = 24.8) in their endorsement of positively valenced attitudinal items towards mathematics.

Table 4 summarizes the subjects' positive and negative attitudes towards mathematics. As can be seen from Table 4, use of the Student Development Inventory, in contrast to the Attitudinal Questionnaire, provided clearer results in terms of differences between the means of the female and male subjects for both negative and positive attitudes towards mathematics. However, in terms of endorsing positive and negative attitudinal statements, it appears that there were more differences due to ability level than due
to the sex of the subjects.

**Personal Attributes Rating Scale**

Two one-way analyses of variance were carried out on data from the Personal Attributes Rating Scale adapted from the Personal Attributes Questionnaire (Spence, Helmreich & Stapp, 1974). The dependent measure for the first one-way ANOVA was the subjects' endorsement of feminine associated or cooperative/supportive items. The dependent measure for the second one-way ANOVA was the subjects' endorsement of masculine associated or task oriented items (Rosenkrantz et al., 1968). In each of these one-way ANOVA's, the independent variable was the four groupings. These groups were: a) high ability males; b) low ability females; c) high ability females; and d) low ability males. The results from the Personal Attributes Rating Scale were used to measure the two testable conditions of hypothesis three. These conditions of hypothesis three are given next.

First, it was hypothesized in condition (a) that in a group situation high ability females (Hi-P), working with a low ability male (Lo-M), would see themselves as more cooperative and supportive than task oriented. The first one-way ANOVA revealed that there were no significant differences between the groupings of subjects in their support of items characterized as supportive/cooperative or feminine in nature. The second one-way ANOVA revealed, however, a significant difference between the groups of
subjects in their support of masculine or task oriented items, F(3, 116) = 2.91, p < .05. Inspection of the means (see Table 5) revealed that high ability males (mean = 16.5) characterized themselves as possessing more masculine traits compared to the other groupings. In contrast, the high ability females (mean = 14.9) did not characterize themselves as possessing many masculine traits compared to the other groupings. Post F test analyses were conducted. The results are given below, and associated with the relevant conditions of hypothesis three.

The Scheffe's pairwise comparison of all possible groupings revealed no significant differences with respect to masculine traits. This result may have been a function of rounding error. Because the group n's were slightly dissimilar (N1 = 32 and N2 = 28), Tukey's HSD procedure employing the harmonic mean was used. This procedure indicated that there was a significant difference between the low ability females (mean = 15.2) and the high ability females (mean = 14.9; p < .05) in their endorsement of masculine characteristics. The low ability females (mean = 15.2) differed significantly from the low ability males (mean = 15.7; p < .05) in their support of masculine traits. Note, in using Tukey's HSD procedure, treatment totals were used in the computational formula (see Appendix G). The high ability males (mean = 16.5) differed significantly from the high ability females (mean = 14.9; p < .05) in
Table 5

Masculine and Feminine Characteristic Scores Among the Subjects from the Personal Attributes Rating Scale According to Sex and Ability Level Groupings

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Masculine (Task Oriented)</th>
<th>Feminine (Cooperative/Supportive)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grouping</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Perceptions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Perceptions</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group 1

<table>
<thead>
<tr>
<th>High Ability Male</th>
<th>32</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>16.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Ability Female</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>15.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group 2

<table>
<thead>
<tr>
<th>High Ability Female</th>
<th>28</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>14.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Ability Male</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>15.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The higher the mean the greater the attribution.
their support of masculine qualities. In addition, the high ability males (mean = 16.5), also differed significantly from the low ability males (mean = 5.7; p < .05) in their endorsement of masculine characteristics.

Next, it was hypothesized in condition (b) that both low and high ability males (Lo & Hi-M) in a group situation would see themselves as (masculine) task oriented rather than (feminine) cooperative or supportive. The overall high and low ability male subjects' combined mean on the task oriented traits was 16.1. The overall high and low ability male subjects' combined mean on cooperative/supportive traits was 12.3. A paired comparison samples t test was conducted, and the results indicated that the low ability and high ability males significantly endorsed task oriented traits rather than cooperative or supportive traits t(59) = 2.35, p < .01.

Table 5 summarizes the means and standard deviations of the masculine and feminine characteristic scores among the subjects according to sex and ability level groupings. It can be observed from Table 5 that the high ability females (mean = 14.9) were least likely to select masculine associated qualities as characteristic of themselves.

Attributional Questionnaire

Three one-way analyses of variance were carried out on data from the Attributional Questionnaire adapted from the Tenth-Grade Questionnaire (Brush, 1980). In each one-way
ANOVA, the dependent measure was the measured attributions of the subjects. In each of the one-way ANOVA's, the independent variable was the four groupings. These groups were: a) high ability males; b) low ability females; c) high ability females; and, d) low ability males. The results from the Attributional Questionnaire were used to measure the four testable conditions of hypothesis four. Post F test analyses were conducted. The results are given below, and associated with the relevant conditions of hypothesis four. These conditions of hypothesis four are given next.

First, it was hypothesized in condition (a) that high ability females (Hi-F) would attribute any drop in performance level more to a lack of ability or task difficulty than either the high ability males (Hi-M) or the low ability males (Lo-M). Next, it was hypothesized in condition (b) that low ability females (Lo-F) would attribute any drop in performance level more to a lack of ability or task difficulty than either the high ability males (Hi-M) or the low ability males (Lo-M). It was hypothesized in condition (c) that high ability males (Hi-M) would attribute performance level more to ability than either the high ability females (Hi-F) or the low ability females (Lo-F). Finally, it was hypothesized in condition (d) that the low ability males (Lo-M) would attribute performance level more to luck than to task difficulty or lack of
ability than either the high ability females (Hi-F) or the 
low ability females (Lo-F).

The results from the first one-way ANOVA indicated a 
significant difference, F(3, 116) = 3.82, p < .01, between 
the groupings in attributing their performance in the 
present study to luck. Inspection of the means (see Table 
6) revealed that the low ability female group characterized 
their performance on the mathematical achievement tests as 
due more to luck (mean = 2.5) than the other groupings. 
In contrast, the high ability male group's mean attribution 
to luck was the lowest (mean = 1.8). The high ability 
males appeared to be the least likely to attribute their 
performance to luck. Further, Scheffe's pairwise com-
parisons of all possible groupings indicated a significant 
difference between the low ability females (mean = 2.5) and 
high ability males (mean = 1.8; p < .05) in their endorse-
ment of luck to explain their performance. However, 
Scheffe's pairwise comparisons did not indicate significant 
differences between the high ability females and any other 
groupings. Nor were significant differences found between 
the low ability males and the other groupings in their 
endorsement of luck to explain their performance.

The results from the second one-way ANOVA indicated a 
significant difference between the high ability males, low 
ability females, high ability females, and low ability 
males in attributing their performance to ability,
Table 6

Attributions for Mathematical Performance from the Attributional Questionnaire According to Sex and Ability Level Groupings

<table>
<thead>
<tr>
<th>Grouping</th>
<th>n</th>
<th>Luck</th>
<th>Ability</th>
<th>Effort</th>
<th>Task Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Ability Male</td>
<td>32</td>
<td>1.6</td>
<td>8.1</td>
<td>7.3</td>
<td>3.9</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>0.9</td>
<td>1.3</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Low Ability Female</td>
<td>32</td>
<td>2.5</td>
<td>6.8</td>
<td>6.9</td>
<td>5.4</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>0.8</td>
<td>1.1</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Ability Female</td>
<td>28</td>
<td>1.9</td>
<td>7.5</td>
<td>7.9</td>
<td>4.3</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>0.7</td>
<td>1.5</td>
<td>1.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Low Ability Male</td>
<td>28</td>
<td>2.2</td>
<td>6.5</td>
<td>7.1</td>
<td>5.6</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>1.0</td>
<td>1.5</td>
<td>1.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Note: The higher the mean the greater the attribution.
\[ \chi^2(3, 116) = 8.97, \ p < .0001. \] Inspection of the means (see Table 6) indicated higher valenced endorsements of the ability items by both the high ability males (mean = 8.1) and high ability females (mean = 7.5). Further, Scheffe's pairwise comparisons of all possible groupings indicated a significant difference between the high ability males (mean = 8.1) and low ability females (mean = 6.8; \( p < .05 \)) in attributing their performance to ability level. The high ability males (mean = 8.1) were also found to attribute their performance more to ability than the low ability males (mean = 6.5; \( p < .05 \)). This result was significant. In addition, the high ability females supported the attribute of ability more (mean = 7.5) than the low ability males (mean = 6.5; \( p < .05 \)) in explaining their performance level on the two mathematical achievement tests. This result was significant.

The results from the third one-way ANOVA revealed a significant difference between the four groupings in attributing their performance to task difficulty, \( \chi^2(3, 116) = 8.30, \ p < .0001. \) Inspection of the means (see Table 6) indicated higher endorsements of these task difficulty items by the low ability males (mean = 5.6) and low ability females (mean = 5.4). Further, Scheffe's pairwise comparisons of all possible groupings indicated a significant difference between the low ability males (mean = 5.6) and the high ability females (mean = 4.3; \( p < .05 \)) in
attributing their performance level to task difficulty. The low ability males (mean = 5.6) endorsed items of task difficulty more than the high ability males (mean = 3.9; p < .05). This result was significant. In addition, the low ability females endorsed task difficulty items more (mean = 5.4) than the high ability males (mean = 3.9; p < .05). This result was significant.

Table 6 summarizes the means and standard deviations of the subjects' attributions for their mathematical performance. The groupings are listed according to sex and ability. It can be seen that the high ability males and high ability females were more likely than the low ability males and low ability females to attribute their performance to ability rather than to either luck or task difficulty. In terms of performance attributions on the two mathematical achievement tests, it appears that there were more differences due to ability level than due to the sex of the subjects.
CHAPTER IV

DISCUSSION

The purpose of the present study was to investigate mathematical achievement behaviors among female high school students. As noted in the literature review, researchers including Horner (1972) have found that many females are fearful of becoming successful. They perceive success as anxiety provoking and resulting in social rejection and loss of femininity. This type of anxiety, when experienced, is thought to result in success avoidant behaviors or reduced achievement. Success avoidance may be a function of the reciprocal interaction of situational determinants (SD), behavioral determinants (BD), and personality determinants (PD) (Bandura, 1986).

As mentioned in the literature review, reduced achievement may be a function of sex-role perceptions in which females reduce their achievement in order to be perceived as quite feminine and non-competitive. Therefore, sex-role perceptions are also thought to influence achievement and achievement expectations. Kuendiger's (1984) conceptual framework mentioned earlier (see Figure 3; page 55) explores the reciprocal nature of gender differences in achievement in mathematics. This conceptual framework suggests that the sex-role perceptions one holds
influence achievement expectations, attributions of success and failure, and the perceived usefulness of mathematics. These perceptions and expectations in turn influence classroom activity and the subsequent interaction of teachers and students. Thus, a poor or limited interaction between students and teachers due to both teachers' and students' perceptions would not promote the continued learning in an area such as mathematics. These perceptions would, in fact, encourage success avoidant behaviors. For example, researchers such as Spender (1982) have found that by adolescence many girls state that they do not like mathematics and, more importantly, believe that they are not capable of doing mathematics. Spender concluded that socio-cultural pressures in the form of attitudes and sex-role perceptions inhibit many females from doing well in mathematics which is considered a male domain. Several hypotheses were developed in the present study to look at these particular issues. The hypotheses are listed below. In addition, the results from the hypotheses are presented and discussed in greater detail.

Hypothesis 1

Hypothesis one was composed of two testable conditions. The first experimental hypothesis labelled (a) was that high ability females (Hi-F), working cooperatively with a low ability male (Lo-M), on the revised version of the Canadian Achievement Test (mathematics section-level 19)
(1981) would lower their performance level. This hypothesis was supported in the present study. High ability females, working with a low ability male, did not maintain their expected performance level. The high ability females achieved higher mathematics scores when they worked alone than when they worked cooperatively with a low ability male partner.

This type of behavior in a cooperative situation suggests that high ability female students, when working with a male partner, may not be working to their full potential. It may be that high ability female students do not feel comfortable in doing well in mathematics, which is considered to be a masculine area. Perhaps, high ability female students are compelled to be helpful in solving the problems, while being careful not to outperform their low ability male partner. Concerns about not outperforming a low ability male partner have been found in other studies (Morgan & Mausner, 1973; Swanson & Tjosvold, 1979). In particular, the Morgan and Mausner and Swanson and Tjosvold studies reported that high ability females lowered their performance level when working cooperatively with a low ability male partner because of self-presentation and compliance concerns. Related to these findings is the fact that in the present study the high ability females indicated on their worksheets that they had contributed significantly more help than their low ability male partner.
in solving the mathematical problems. However, the high ability females did not take significantly more of the credit for their problem solving. In addition, there were no significant differences between the high ability females and their low ability male partner in initiating problem solving on this second mathematical achievement test.

It would appear that societal norms and expectations deter many high ability females from performing better than males in general, in a subject area such as mathematics. Leder (1982) has indicated that females' high in mathematical ability seem to experience an increasing amount of anxiety as they go through school. Leder concluded that high fear of success, that is, anxiety associated with successful performance (Horner, 1968), and a strong performance in mathematics become increasingly incompatible for high ability girls as they reach senior high school. Horner has concluded that for some females femininity and achievement are mutually exclusive entities. It would seem, however, that many girls are particularly fearful of success in an area such as mathematics. In fact, Leder found there was a strong tendency for female students high in fear of success to get out of taking intensive mathematics courses. Interestingly, Sherman (1982) found that high ability female high school students who had taken three or four years of mathematics still considered mathematics a male domain. This may be understandable in that
many of these females faced high level mathematics classes where the majority of members were male and where the courses were usually taught by male teachers. Sherman concluded that as a result many of these female students experienced a great deal of conflict about their sex-role and their level of achievement in mathematics. This is an example of role conflict and it may be helpful in explaining why in the present study a high ability female would lower her performance level when working cooperatively with a low ability male on a mathematical achievement test.

Another aspect of the first hypothesis labelled (b) was that the high ability males (Hi-M) would maintain or possibly improve their mathematical performance level when working with a low ability female (Lo-F) on the revised version of the Canadian Achievement Test (1981). This hypothesis was partially supported. By partially supported it is meant that the high ability males also achieved a significantly higher score when they worked alone than when they worked with a low ability female partner. However, the high ability males in the present study not only indicated that they had contributed significantly more help, but they boldly took credit for solving significantly more of the problems than their low ability female partner. It would seem from this behavior that male students are not affected by the same concerns, with respect to mathematics, that high ability females experience. Part of the reason
for the sex-role conflict that females experience may be traced to the differential socialization process of males and females.

The overall results from hypothesis one suggested that males and females may have different ideas concerning cooperative behavior. The significant differences that were found between the high ability males and high ability females appear to involve their perception and their actual style of cooperative behavior. In general, the high ability males and high ability females were found to comply with the instructions and each worked cooperatively with a low ability partner on a mathematical achievement test. However, examination of the worksheet data, which helped to document the working dynamics of the dyad, revealed very different working strategies between the two treatment dyads. In summary, the high ability males and the high ability females were found to indicate that they had offered significantly more help than their respective low ability partners when solving the problems. In contrast, only the high ability males, and not the high ability females, took significantly more credit than their respective low ability partners for solving these problems. Again, Morgan and Mausner (1973) and Swanson and Tjosvold (1979) suggested that compliance and self-presentation concerns are prevalent among high ability females working with a low ability male partner on a cooperative task. It
was concluded that these concerns interfere significantly with the high ability females' performance level and lead to performance decrements on a cooperative group task. 

**Hypothesis 2**

Hypothesis two was composed of three testable conditions. Thus, the second experimental hypothesis labelled (a) was that low ability females (Lo-F) would endorse more negatively valenced attitudinal statements towards mathematics than either the high or the low ability males (Hi or Lo-M). This hypothesis was also supported but only with regard to the high ability males. Thus, low ability females, in comparison to high ability males, endorsed significantly more negatively worded mathematical statements. These endorsements by low ability females reflected a negative attitude towards mathematics. For example, a negatively worded item that low ability females endorsed was, 'I do poorly in math classes'. It was expected that low ability females would endorse significantly more negative attitudes towards mathematics than the low ability males. Contrary to expectation, this was not the case. There was no significant difference between low ability female and low ability male endorsements of negatively worded mathematical statements. Both sexes in the low ability category apparently expressed more negative attitudes towards mathematics than high ability male and high ability female subjects.
The second experimental hypothesis labelled (b) was that high and low ability females (Hi & Lo-F) would endorse more negatively valenced attitudes towards mathematics than the high and low ability males (Hi & Lo-M). This hypothesis was supported. Results from the Student Development Inventory (Jackson, 1985) revealed that high and low ability females endorsed significantly more negative attitudinal items concerning mathematics than the high and low ability males. It would appear that the endorsements of high and low ability females, in comparison to high and low ability males, reflected a more negative attitude towards the study of mathematics.

The second hypothesis labelled (c) was that both high and low ability males (Hi & Lo-M) would endorse more positively valenced attitudinal items concerning mathematics than the high and low ability females (Hi & Lo-F). This hypothesis was also supported. High and low ability males compared to the high and low ability females endorsed significantly more positive Student Development Inventory statements (Jackson, 1985). For example, a positively worded item that high and low ability males endorsed was, 'I enjoy working with numbers'. However, the results also revealed that the high ability males endorsed significantly more of the positive mathematical statements than the low ability males and the low ability females.

Similar to the results of hypothesis two, Nash (1979)
found that many adolescent females, especially those low in ability, viewed mathematics negatively. Not only did the female subjects in Nash's study view mathematics as a masculine activity, but they saw the activity as having little relevance to their own lives. The prevalent societal norms and expectations about mathematics resulted in role conflict and subsequent negative attitudes for high ability as well as low ability female students (Nash, 1979). Parsons (1983) found that females in general had a less positive self-concept of their mathematical ability than the male subjects. The female subjects were more likely to attribute any of their successes in mathematics to effort rather than to ability. Females, compared to males, not only felt that mathematics was more difficult for them, but was not important to their future. Becker (1982) also found that female students did not express much confidence in their mathematical ability, especially when they failed. Moreover, Becker noted that when the female subjects were successful on a mathematical task, they attributed their success to effort rather than to ability.

The overall results from hypothesis two indicated that both high and low ability females endorsed significantly more of the negative statements with respect to mathematics than the high and low ability males. However, contrary to expectation, the low ability males as well as the low ability females were found to support significantly more of
the negative statements toward mathematics than the high
ability males and the high ability females. The high and
low ability males endorsed significantly more of the posi-
tive statements with respect to mathematics than the high
and low ability females. The results also showed that the
high ability males supported significantly more of the
positive statements toward mathematics than the low ability
males and the low ability females.

Hypothesis 3

Hypothesis three was composed of two testable condi-
tions. The third experimental hypothesis labelled (a) was
that in a group situation high ability females (Hi-F),
working with a low ability male (Lo-M), would see them-
selves as more cooperative and supportive than task
oriented. This hypothesis was not supported. The results
of the present study revealed that there were no sig-
nificant differences between the high ability females and
the low ability males in terms of their endorsement of
cooperative or supportive items. Indeed, there were no
significant differences between any of the groupings (high
ability males, low ability females, high ability females,
and low ability males) in terms of endorsing cooperative or
supportive items. The cooperative or supportive oriented
items have been characterized as feminine associated traits
(Rosenkrantz et al., 1968). However, there was a sig-
nificant difference between the groupings of subjects in
their support of task oriented items. The task oriented items have been characterized as masculine associated traits (Rosenkrantz et al., 1968). It is interesting to note that the high ability females, in comparison to the high ability males and the low ability females, did not see themselves as possessing significantly more task oriented or masculine-type traits.

In contrast, it was found that the low ability females, in comparison to the high ability females, characterized themselves as having significantly more masculine traits. The low ability females, compared to the low ability males, were again found to characterize themselves as possessing significantly more masculine qualities. These findings may be explained in the following manner. A female who appears to have less ability in mathematics may also possess fewer self-presentation concerns than those females having more mathematical ability. By having fewer self-presentation concerns, it is meant that females with low mathematical ability may not feel uncomfortable when working on a mathematical task with a high ability male partner. Thus, low ability females, when paired with high ability male partners, may not experience much pressure or the need to inhibit their task oriented traits. In contrast, high ability females may experience more pressure than the low ability females because high ability females have been labelled in front of their partner as individuals
with high ability in a 'masculine domain'. Moreover, high ability females may feel especially uncomfortable when working on a mathematical task with a low ability male partner. On the other hand, high ability males, emphasizing a competitive orientation, may exert a lot of pressure on a low ability partner to be task oriented and to exercise these traits when working together on a project. In contrast, high ability females, emphasizing a more cooperative orientation, may not exert a lot of pressure on a low ability partner to be task oriented. The high ability females, compared to low ability females, would more likely be supportive and cooperative of others working on a task, rather than being task oriented themselves. Thus, self-presentation concerns, in addition to task orientation, could be responsible for inhibiting the expression of task oriented qualities among high ability females.

Few studies report the behavioral differences between high and low mathematical ability females when working with a male partner. However, Cook and Sloane (1985) have found that females, in general, working in a dyadic situation were much more cooperative than the male subjects. In another study, Begum and Ahmed (1986) showed that the male subjects in their study took greater risks than the female subjects as evidenced by task oriented behaviors such as decision making. In addition, this risk taking behavior was found to be positively related to masculine
traits such as aggression, and dominance. Of course, females who have not been rewarded for masculine associated traits such as competitive behavior, or who have, in fact, been punished for the expression of masculine traits, would more readily inhibit competitive behavior (Bandura, 1986). It has been assumed that women have strong affiliative needs and a desire to please others. This may be a direct function of societal conditioning. A need for affiliation, however, would support a more cooperative orientation rather than a masculine task oriented frame of reference in females (Hoffman, 1975).

Hypothesis three (b) stated that both low and high ability males (Lo & Hi-M) in a group situation would see themselves as task oriented rather than cooperative or supportive. This hypothesis was supported. The results revealed that both the low and high ability males endorsed significantly more task oriented traits than cooperative or supportive traits.

However, it is interesting to note that there were no significant differences among any of the groupings (high ability males, low ability females, high ability females, and low ability males) in terms of endorsing cooperative or supportive items. The high ability males, through their particular endorsement of items, indicated that they possessed significantly more masculine or task oriented traits, as compared to the high ability females. In addi-
tion, the high ability males through their particular endorsement of items were found to possess significantly more task oriented traits than the low ability males.

Webb (1984) noted that although male and female subjects had similar mathematical ability, males were still able to outperform females in a group situation on a mathematical task. In this study, male subjects were more successful in obtaining pertinent information to do well on the task. Thus, the male subjects were found to be more task oriented than the female subjects. In fact, the group interaction patterns in Webb's study revealed that females, compared to males, were the more cooperative and responsive subjects. Females were more cooperative in honouring requests for help from the other subjects. Moreover, when the male subjects did respond to the others' requests for help, they responded more to male subjects' requests for help than to female subjects' requests for help.

The overall results from hypothesis three indicated that in a group situation both high ability and low ability males were found to be more task oriented than cooperative or supportive. Further, in the present study it was indicated that the high ability males did not support their low ability female partner in the same way that high ability females supported or cooperated with their low ability male partner. This behavior, of course, may be due to societal expectations that males, in comparison to females, are more
task oriented than supportive and cooperative (Wolleat et al., 1980).

**Hypothesis 4**

Hypothesis four was composed of four testable conditions. The fourth experimental hypothesis labelled (a) was that high ability females (Hi-F) would attribute any drop in performance level more to a lack of ability or task difficulty than either the high ability males (Hi-M) or the low ability males (Lo-M). This hypothesis was not supported. The high ability females, compared to either the high ability males or the low ability males, were not found to significantly attribute their performance level to task difficulty or to lack of ability. The high ability females were found to significantly endorse the attribute of ability to characterize their performance on the two mathematical achievement tests.

The fourth hypothesis labelled (b) was that low ability females (Lo-F) would attribute any drop in performance level more to a lack of ability or task difficulty than either the high ability males (Hi-M) or the low ability males (Lo-M). This hypothesis was supported. The low ability females, in contrast to the high ability males, were found to significantly attribute their performance on the two mathematical achievement tests to lack of ability and task difficulty.

The fourth hypothesis labelled (c) was that high
ability males (Hi-M) would attribute performance level more to ability than either the high ability females (Hi-F) or the low ability females (Lo-F). This hypothesis was supported. The high ability males, in contrast to the low ability females, were found to significantly endorse the attribute of ability in characterizing their performance on the two mathematical achievement tests.

The fourth hypothesis labelled (d) was that low ability males (Lo-M) would attribute performance level more to luck than to task difficulty or a lack of ability than either the high ability females (Hi-F) or the low ability females (Lo-F). This hypothesis was not supported. The low ability males, compared to the high ability females or the low ability females, were not found to significantly attribute their performance on the two mathematical achievement tests to luck. The low ability males were found to significantly endorse the attributes of task difficulty and lack of ability in characterizing their mathematical performance.

In explaining these results, causal attribution theory, according to Wolleat et al. (1980), predicts that performance that is consistent with expectations will be attributed to stable causes such as ability or task difficulty, whereas performance that is inconsistent with expectations will be attributed to unstable causes such as effort or luck.
The results of the present study indicated a significant difference between high ability males and high ability females in comparison to the low ability males and low ability females in attributing their performance level to ability on the two mathematical tests. This is an interesting finding in that it is believed that when females perceive themselves as successful they are more likely to attribute their behavior to effort rather than to ability (Parsons, 1983; Becker, 1982). This attribution is due to the fact that most females do not believe that they have the ability to be successful on a mathematical task (Becker, 1982). However, although high ability females were willing to attribute their performance to ability in the present study, they were still much more sensitive than the high ability male students to the situational demands involved in working cooperatively with a low ability partner. For example, by not taking significantly more credit for problem solving, the high ability females' performance on the mathematical achievement test revealed a cooperative, supportive orientation toward their low ability male partner. This cooperative, supportive orientation was not manifested to the same degree by the high ability male students toward their low ability female partner.

The results of the present study also showed that the high ability males were least likely to attribute their
performance to luck compared to the other groupings. In contrast, the low ability females were significantly more likely than the high ability males to attribute their performance level to luck. It was not surprising that females, in general, would attribute their performance to luck in that they do not usually express much confidence in their mathematical abilities (Becker, 1982).

For example, Pennema (1980) found that there is a trend for young women to feel that they have little control, and that luck and chance figure prominently in their lives. In contrast, males were found to have stronger feelings of both effectiveness and confidence when undertaking new tasks (Maccoby & Jacklin, 1974). Moreover, due to the expectation that mathematics is a masculine activity, male students would be expected to attribute any successful performance to a stable cause such as ability rather than to luck. It would also be expected that male students would attribute an unsuccessful performance to an unstable cause such as bad luck, irrespective of their actual ability levels (Wollett et al., 1980). According to Bandura (Zimbardo, 1985), and indicated in Figure 1, an individual's self-efficacy may be more important than the individual's level of ability when it comes to determining achievement behaviors.

The results of the present study revealed a significant difference between the low ability males and low
ability females in comparison to the high ability males and high ability females in attributing their performance on the mathematics achievement tests to the difficulty of the task in general. Task difficulty was more strongly endorsed by the low ability males and low ability females than the high ability males and high ability females in explaining their performance. According to Wolleat et al. (1980), many females do not expect to succeed on a mathematical task. Thus, it is understandable that especially those females with limited ability in mathematics would be likely to attribute their mathematical performance to a stable cause such as task difficulty.

The overall results from hypothesis four indicated that social expectations are not all that clear-cut, at least as far as attributions go among male and female students for performance on a task. Contrary to expectation, the low ability males attributed their mathematical performance in this study to lack of ability and to task difficulty rather than to luck as predicted. Moreover, both the high ability males and high ability females, for the most part, attributed their mathematical performance to the stable cause of ability. The high ability females were not found to attribute their drop in performance during the second session to stable causes such as lack of ability or task difficulty as expected.
Summary

In summary, the results of the last three hypotheses indicated that, in general, there are more differences in attitudes and attributions between the high and low ability subjects than between male and female subjects. There is an indication, however, from the mathematical performance results that female students, especially the high ability students, will inhibit their performance in mathematics as they go through school. Interestingly, the attitudes of the high ability female students, compared to the high ability male students, did not correspond to their performance on the second mathematical achievement test. Although high ability female students indicated that they enjoy mathematics and that they have ability in the area, they did not seem to work at their expected achievement level on the second mathematical test in the cooperative group situation. Due to their reluctance, many of the high ability females did not receive the credit for problem solving that they should have received, especially when considering their ability levels.

Although both high ability males and high ability females achieved a higher score when they worked alone compared to working in a group situation, the high ability female's working strategy in the dyadic situation seemed to be especially detrimental to her overall performance. The high ability male students, compared to the high ability
female students, did not seem to be as affected by the situational demands of the group situation. Though the high ability males were presented with a cooperative mathematical test to work on with a low ability female partner, many of these high ability males continued to work at their expected achievement level as indicated by the data on the team worksheets. Thus, the high ability males indicated little difficulty in essentially outperforming their low ability female partner. These strategic differences between high ability females and high ability males may be explained by Bandura's (1986) social learning theory which suggests that situational determinants (SD), behavioral determinants (BD), and personality determinants (PD) interact reciprocally rather than as independent determinants of each other. Bandura's (1986) theory takes into account many factors to explain personality and behavior, and theoretically emphasizes the fact that an individual is not solely driven by inner forces nor completely controlled by situational factors. In other words, social learning theory combines the principles of learning with human interaction in social settings as a way of understanding personality and behavior (Zimbardo, 1985).

**Recommendations for Future Research**

It is evident from this research that males and females may have different beliefs and expectations about cooperative behavior in a group situation. The underlying dynamics of cooperative interaction between males and
females should be explored more thoroughly. The differences in both attitudes and perceptions between males and females with respect to cooperative behavior deserve closer investigation. Why is it that a cooperative group situation has a detrimental influence on a female's performance level? Why is it that males and females exhibit different working styles in a cooperative group situation? Morgan and Mausner (1973) and Swanson and Tjosvold (1979) have suggested that compliance and self-presentation concerns interfere with a female's performance when working cooperatively with a low ability male partner.

Self-concept, especially in terms of sex-role orientation, would aid one's understanding of the underlying dynamics of a cooperative group interaction. Sex-role orientation is an important concept in that the negative attitudes some females hold towards mathematics appear to develop during adolescence when sex-role orientation is of significant importance. For example, a feminine female in a cooperative group situation might be more inclined to reduce her performance level than an androgynous female due to different attitudes and sex-role perceptions. Knowledge of the sex-role self-concept of these subjects would help to clarify the stated expectations and aspirations that these students have toward mathematics and toward school in general. Sex-role self-concept could be determined through a rating scale developed to measure the independent constructs of masculinity and femininity.
In addition to self-concept, the attributions, such as luck, effort, ability, and task difficulty, that subjects use to explain their performance may need to be more thoroughly examined. Information as to what the subjects attributed their performance to on the tasks was collected, analyzed, and presented. However, due to the fact that some of the results were contrary to expectation, and indicated that both males and females attributed their performance to stable and unstable causes, suggests that the area of attribution needs further attention. One way to examine attributions in greater detail would be through the use of open-ended questions about subjects' performance on the two mathematical tests. These questions could also be used to explore more directly the possible anxiety associated with performing alone on a test in comparison to working in a small group situation. The attributions that male and female subjects use in describing their performance appear to be an important link to understanding the underpinnings of a cooperative group endeavour.

From the literature reviewed, it seems that there is variability in the learning and practice of mathematics between males and females. This variability appears to influence the mathematical achievement and achievement motivation of males and females. Thus, the development of separate process models for males and females, with respect to mathematical development, may be worthy of investigation.
APPENDIX A

DEMOGRAPHIC SURVEY
Appendix A

Demographic Survey

Q 1. Name:_________________________  Q 2. Sex: M F

Q 3. Age in years:__

Q 4. Grade in school:__  Q 5. Name of school:__

Q 6. Do you wear corrective lenses?  yes no
   Which hand do you write with? (left or right)

Q 7. Ethnic Background (check one)
   Caucasian___  Hispanic___
   Black___  Asian___
   Native American___  Other (please specify)___

Q 8. Father's Occupation_________________

Q 9. Father's Education (check highest level completed)
   Eighth Grade or Less___  College Certificate___
   Some High School___  University Degree Undergraduate___
   High School Graduate___  University Degree Graduate___

Q 10. Mother's Occupation_________________

Q 11. Mother's Education (check highest level completed)
   Eighth Grade or Less___  College Certificate___
   Some High School___  University Degree Undergraduate___
   High School Graduate___  University Degree Graduate___
Q 12. How many older brothers___sisters___?
Q 13. How many younger brothers___sisters___?

Subjects Studied

Q 14. Please write down the number of years you have studied all of the following subjects in high school.

Biology___ Mathematics___
Chemistry___ Physics___
A foreign language___ Social Studies/History___
English___ Other (please specify)___

Q 15. The program of high school courses I take can best be described as (circle one):

Business or commercial.........................1
Vocational-occupational.......................2
College preparatory............................3
Other or general..............................4

Subjects Intended to Study

Q 16. Please write down the number of years you intend to study all of the following subjects in the future.

Biology___ Mathematics___
Chemistry___ Physics___
A foreign language___ Social Studies/History___
English___ Other (please specify)___
Average Mark

Q 17. Please write down the average mark (A, B, C, D, F) you usually receive in each of the following subjects. If you have never taken the subject before indicate N/A.

Biology___ Mathematics___
Chemistry___ Physics___
A foreign language___ Social Studies/History___
English___ Other (please specify)___

Q 18. How would you rate your ability in mathematics?
(please check one)
Excellent___
Very Good___
Average___
Fair___
Poor___

Overall Mark

Q 19. Overall, your average cumulative grade is: (circle)
A, B, C, D, F.

Evaluation of High School Experience

Q 20. Please rate aspects of your high school experience. Use the following scale:
Satisfied, no change necessary.........................1
No strong feelings one way or the other...............2
Dissatisfied, improvement is needed....................3
No experience with this aspect of school.............4
Evaluation of High School Experience Cont'd

a) Classroom instruction with mathematics 1 2 3 4
b) Guidance services provided by the school as a whole (teachers, guidance office, library) 1 2 3 4
c) Provision for students needing special assistance in improving skills in reading, math 1 2 3 4
d) Adequacy of programs in career planning 1 2 3 4

Q 21. How adequate do you feel your high school education has been (please circle):

Very inadequate 1 Good 4
Below average 2 Excellent 5
Average 3

Enjoyment of Subjects

Q 22. Suppose you had to take a course in each of the following subjects. Rate how much you think you would enjoy each subject. Use a scale from 1 to 5, where:

5) I would like it very much.
4) I would like it somewhat.
3) I am indifferent.
2) I would dislike it somewhat.
1) I would dislike it very much.

Biology___ Language___
Chemistry___ Mathematics___
Enjoyment of Subjects Cont'd

English___ Physics___
History___

Q 23. Do you plan to go to college? yes no
Q 24. Do you plan to go to university? yes no

Career Plans

Q 25. What are your career plans? (please be specific)
  first choice_________________
  second choice_________________
  third choice_________________
  Undecided_________________

Q 26. Telephone Number_________________
  The best time(s) to contact you is (are):____________
  __________________
APPENDIX B
ATTITUDINAL QUESTIONNAIRE
Appendix B

Attitudinal Questionnaire

Name: ________________________________

Directions: Use the following scale to answer the items below. Circle one letter per question. Do not skip any questions.

Scale:

1 = Never characteristic of me
2 = Seldom characteristic of me
3 = Sometimes characteristic of me
4 = Often characteristic of me
5 = Almost always characteristic of me

1. I would trust a woman just as much as I would trust a man to figure out important calculations....1...2...3...4...5

2. Math has been my worst subject throughout high school..................1...2...3...4...5

3. My parents encourage me in the study of mathematics..........................1...2...3...4...5

4. I am sure I could do advanced work in mathematical studies................1...2...3...4...5

5. Mathematics involves a lot of memorization.................................1...2...3...4...5

6. I will use math in many ways as an adult........................................1...2...3...4...5

7. Mathematics gives me a chance to think things out for myself................1...2...3...4...5
8. It would not bother me at all to take
more mathematics courses. 1 2 3 4 5
9. I get anxious when I open a mathematics text
and see a page full of problems. 1 2 3 4 5
10. I find that my mathematics teachers do not encourage
me in the study of mathematics. 1 2 3 4 5
11. I do as little in mathematics as
possible. 1 2 3 4 5
12. My parents do not think I can do well in
mathematical studies. 1 2 3 4 5
13. Boys tend to be better at math than
girls. 1 2 3 4 5
14. My friends do not think I am competent in
mathematics. 1 2 3 4 5
15. Mathematics is not useful for the problems
of everyday life. 1 2 3 4 5
16. My teachers think I can do well in
mathematics. 1 2 3 4 5
17. I usually am at ease during mathematics
tests. 1 2 3 4 5
18. I am challenged by math problems I cannot
understand immediately. 1 2 3 4 5
19. My friends support me in my study of
mathematics. 1 2 3 4 5
20. I would expect a woman mathematician to
be a masculine type of person. 1 2 3 4 5
21. Taking mathematics in school is a waste of time.

22. When a woman has to solve a mathematical problem, it is appropriate to ask a man for help.

23. I can get good grades in mathematics courses.

24. I feel uneasy when I realize I must take a certain number of mathematics courses to graduate from high school/university.

25. Studying mathematics is just as appropriate for women as for men.
APPENDIX C

PERSONAL ATTRIBUTES RATING SCALE
Appendix C

Personal Attributes Rating Scale

Please rate yourself on the following characteristics. Answer each question. Circle the number that best applies.

Q1. How helpful did you feel you were to your partner?

Q2. How aware were you to your partner’s feelings?

Q3. How easily influenced were you by your partner?

Q4. How competitive did you feel you were with your partner?

Q5. How easy was it for you to make decisions?

Q6. How confident were you in this situation?

Q7. How submissive were you in this situation?

Q8. How dominant were you in this situation?

Q9. How needful of approval were you in this situation?
Q10. How much do you like math and science?
1...........2...........3...........4...........5
Not at all  Slightly  Moderately  Very  Extremely
liked      liked      liked      liked      liked

Q11. How much anxiety did you feel in this situation?
1...........2...........3...........4...........5
Not at all  Slightly  Moderately  Very  Extremely
anxious    anxious    anxious    anxious    anxious

Q12. How much anger did you feel in this situation?
1...........2...........3...........4...........5
Not at all  Slightly  Moderately  Very  Extremely
angry      angry      angry      angry      angry

Q13. How much enjoyment did you feel in this situation?
1...........2...........3...........4...........5
Not at all  Slightly  Moderately  Very  Extremely
enjoyed    enjoyed    enjoyed    enjoyed    enjoyed
Please rate your partner on the following characteristics. Answer each question. Circle the number that best applies to your partner.

Q1. How helpful did you feel your partner was to you?
   helpful   helpful   helpful   helpful   helpful

Q2. How aware did you feel your partner was of your feelings?
   aware   aware   aware   aware   aware

Q3. How easily influenced was your partner by you?
   influenced   influenced   influenced   influenced   influenced

Q4. How competitive did you feel your partner was with you?
   competitive   competitive   competitive   competitive   competitive

Q5. How easy was it for your partner to make decisions?
   easy   easy   easy   easy   easy

Q6. How confident was your partner in this situation?
   confident   confident   confident   confident   confident

Q7. How submissive was your partner in this situation?
   submissive   submissive   submissive   submissive   submissive

Q8. How dominant was your partner in this situation?
   dominant   dominant   dominant   dominant   dominant

Q9. How needful of approval was your partner in this group?
   needful   needful   needful   needful   needful
Q10. How much do you think your partner likes math/science?

Q11. How much anxiety did your partner feel in this group?

Q12. How much anger did your partner feel in this group?

Q13. How much enjoyment did your partner feel in this group?
Form C

Please rate you and your partner as a team on the following characteristics.

<p>| | | | | | | | |</p>
<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Not at all cooperative</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Very cooperative</td>
<td></td>
</tr>
<tr>
<td>Q2. Not at all successful working together</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Very successful working together</td>
<td></td>
</tr>
<tr>
<td>Q3. Not at all effective achieving goal</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Very effective achieving goal</td>
<td></td>
</tr>
<tr>
<td>Q4. Much anxiety working together</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Little anxiety working together</td>
<td></td>
</tr>
</tbody>
</table>
01. How helpful did you feel ______ was to his/her partner?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   helpful helpful helpful helpful helpful

02. How aware was ______ to his/her partner's feelings?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   aware aware aware aware aware

03. How easily influenced was ______ by his/her partner?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   influence influence influence influence influence

04. How competitive was ______ with his/her partner?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   competitive competitive competitive competitive competitive

05. How easy was it for ______ to make decisions?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   easy easy easy easy easy

06. How confident was ______ in this situation?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   confident confident confident confident confident

07. How submissive was ______ in this situation?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   submissive submissive submissive submissive submissive

08. How dominant was ______ in this situation?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   dominant dominant dominant dominant dominant

09. How needful of approval was ______ in this situation?
   1. ............2. ..........................3. ..................4. ............5
   Not at all Slightly Moderately Very Extremely
   needful needful needful needful needful
010. How much does ______ like math and science?
1. _______ 2. _______ 3. _______ 4. _______ 5.
Not at all  Slightly  Moderately  Very  Extremely
liked    liked    liked    liked    liked

011. How much anxiety did ______ feel in this situation?
1. _______ 2. _______ 3. _______ 4. _______ 5.
Not at all  Slightly  Moderately  Very  Extremely
anxious   anxious   anxious   anxious   anxious

012. How much anger did ______ feel in this situation?
1. _______ 2. _______ 3. _______ 4. _______ 5.
Not at all  Slightly  Moderately  Very  Extremely
angry     angry     angry     angry     angry

013. How much enjoyment did ______ feel in this situation?
1. _______ 2. _______ 3. _______ 4. _______ 5.
Not at all  Slightly  Moderately  Very  Extremely
enjoyed   enjoyed   enjoyed   enjoyed   enjoyed
APPENDIX D

ATTRIBUTIONAL QUESTIONNAIRE
Appendix D

Attributional Questionnaire

Name: ____________________

Directions: Use the following scale to answer the items below:
Circle one letter per question. Do not skip any questions.
Rate each one.

Scale:
1 = Never characteristic of me
2 = Seldom characteristic of me
3 = Sometimes characteristic of me
4 = Often characteristic of me
5 = Almost always characteristic of me

1. I have performed well on the mathematics
tests given during this study.............1...2...3...4...5
2. It is important to have a good understanding
of math in order to get a good job........1...2...3...4...5
3. Women do just as well in mathematics
as men........................................1...2...3...4...5
4. My achievement on the mathematical tests
given during this study was due primarily
to my ability..................................1...2...3...4...5
5. My achievement level on the mathematical
tests given during this study was due
mainly to luck..................................1...2...3...4...5
6. I put a lot of effort into the mathematics achievement test that was given in the first session of this study. 1 2 3 4 5

7. I put a lot of effort into solving the mathematical problems given in the second session of this study. 1 2 3 4 5

8. I found the achievement test given in the first part of this study to be difficult. 1 2 3 4 5

9. I found the problems given in the second session of this study to be quite difficult. 1 2 3 4 5

10. I enjoy working independently on mathematical tasks. 1 2 3 4 5

11. I enjoy working in a small group situation trying to solve mathematical problems. 1 2 3 4 5
Q12. How much did you like mathematics in elementary school?
1 .......... 2 .......... 3 .......... 4 .......... 5
Not at all Slightly Moderately Very Extremely
liked   liked   liked   liked   liked

Why? (please give a brief statement)

Q13. How much do you like mathematics in high school?
1 .......... 2 .......... 3 .......... 4 .......... 5
Not at all Slightly Moderately Very Extremely
liked   liked   liked   liked   liked

Why? (please give a brief statement)

Q14. Why do you think your team was successful? If your team was not successful, why not? (please answer briefly)
APPENDIX E

GROUP DYNAMICS
**Appendix 2**

**GROUP DYNAMICS**

**Supportive**
Supports partner, shows solidarity, reciprocal relationship—team effort for the good of the group. Harmonious team effort.

<table>
<thead>
<tr>
<th>Extremely</th>
<th>Very</th>
<th>Moderately</th>
<th>Slightly</th>
<th>Not</th>
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</thead>
<tbody>
<tr>
<td>Supportive Supportive Supportive Supportive Supportive Supportive</td>
<td></td>
<td></td>
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</table>

**Competitive**
Competitive frame of mind—not really part of the group, an individual or individuals working counter to group effort. Working to benefit themselves.

<table>
<thead>
<tr>
<th>Extremely</th>
<th>Very</th>
<th>Moderately</th>
<th>Slightly</th>
<th>Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive Competitive Competitive Competitive Competitive Competitive</td>
<td></td>
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</tbody>
</table>

**Passive-Supportive**
Passive support of partner. Gives away information, ideas freely. Supports the wrong course of action knowingly to the detriment of the group. A blind support of the partner rather than supporting the team effort.

<table>
<thead>
<tr>
<th>Extremely</th>
<th>Very</th>
<th>Moderately</th>
<th>Slightly</th>
<th>Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive</td>
<td>Passive</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Antagonistic**
Does not get along with partner. Non productive group. Takes away from individual and/or group effort. Diagreements provide no ultimate value to the team.

<table>
<thead>
<tr>
<th>Extremely</th>
<th>Very</th>
<th>Moderately</th>
<th>Slightly</th>
<th>Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antagonistic Antagonistic Antagonistic Antagonistic Antagonistic Antagonistic</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Receptive**
Seeks help, ideas from the partner. A reciprocal relationship. Elicits opinions and suggestions from partner.

<table>
<thead>
<tr>
<th>Extremely</th>
<th>Very</th>
<th>Moderately</th>
<th>Slightly</th>
<th>Not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptive</td>
<td>Receptive</td>
<td>Receptive</td>
<td>Receptive</td>
<td>Receptive</td>
</tr>
</tbody>
</table>
Group Dynamics Cont'd

Cooperative
A cooperative frame of mind. Trying to develop a group effort or spirit. Characterized by giving help, opinions, suggestions. A sharing of the common resources.

1............2............3............4............5
Extremely Very Moderately Slightly Not
Cooperative Cooperative Cooperative Cooperative Cooperative Cooperative

Success Avoidance
Success avoidance has to do with the avoidance of successful performance. Verbal and non-verbal behaviors may indicate success avoidance. The individual feels uncomfortable about performing well and so limits his/her behavior and performs at a lower level than he/she is capable of. An individual may believe that certain areas are not appropriate for him/her to excel in, especially in a public or group situation.

1. How much success avoidance did the female exhibit?
1............2............3............4............5
Extremely Very Moderately Slightly Not
Success Success Success Success Success
Avoidant Avoidant Avoidant Avoidant Avoidant

2. How much success avoidance did the male exhibit?
1............2............3............4............5
Extremely Very Moderately Slightly Not
Success Success Success Success Success
Avoidant Avoidant Avoidant Avoidant Avoidant
Raters' Training Form

GROUP DYNAMICS

Use the following labels to rate the statements below:
a) cooperative (coop), b) receptive (r), c) passive-supportive (ps), d) supportive (s), e) competitive (comp), f) antagonistic (a). Use one label per statement. Each statement gives some information on an individual in a two person group.

1. A high ability male gives many opinions and suggestions while working on the mathematical task.

2. A low ability male tries to get information and opinions from his partner.

3. A low ability female is very agreeable and allows her partner to answer all the questions.

4. A high ability female compliments her partner's effort and seeks to make him feel at ease.

5. A high ability male answers all of the problems, taking the credit for himself.

6. A low ability male angrily tries to solve the problems without listening to his partner's advice.

7. A high ability female ignores her partner's attempts to give his opinion. She solves most of the problems on her own.

8. A low ability female asks her partner for help in solving the problems.

9. A high ability male seeing that his partner is having trouble solving a problem encourages her to persevere.

10. A high ability female says she doesn't know how to solve math problems very well. She lets her partner complete all the problems.

11. A high ability male states his opinion and offers suggestions to the group situation.

12. A high ability female laughs a lot throughout the session. She states that she doesn't know how to do math very well.

13. A low ability female says she doesn't enjoy working on tasks, especially with a male. She tries to take over the task and ignores her partner's input.
Appendix F

Debriefing Sheet

This study is concerned with mathematical behaviors. There is a high attrition or drop out rate among students, especially female students, in the higher level mathematics courses offered in senior high school and university. Mathematical behaviors are of particular interest to us. We are interested in this area because there is a strong emphasis placed on mathematical and technical skills as prerequisites for employment opportunities in our highly technological society.

In the first session, your quantitative skills were assessed using mathematical questions. Next, you were placed into a two person group. The groups are same and mixed sex groups. For example, in the mixed sex group there would be one male and one female student. In the same sex group, there would be either two males or two females. The purpose of this second session is to see how individuals work together on mathematical problems.

The questions of interest are: 1) How do people perform when working with a partner? 2) Will the performance level increase or decrease? If so why? 3) Will same sex or mixed sex partners have different performance levels? 4) How do males and females cope with a partner in a situation that focuses on mathematics achievement.

Hopefully, our research will shed more information on these
important questions. If you are interested in pursuing further information in this area, here are some references for further information. Do you have any questions?

It is important to this research that you do not discuss the purpose of this study with the other students who have yet to attend the second session. This is because your information could influence their behavior. It is important that we learn more about peoples' actual or natural behaviors rather than artificially prepared behaviors. Are there any other questions?

Thank you for your participation.

Dr. L.M. Jackson

Joanne Coutts
Debriefing Sheet References

Here are some references that you might find useful.


APPENDIX 'G
POST HOC ANALYSES
Appendix G

Post Hoc Analyses

The possibility of a significant F with no post hoc significant differences using the Scheffe procedure is statistically illustrated. Further information is provided by manually employing and calculating Tukey's HSD procedure with the use of the harmonic mean. Significant differences were found and reported on pages 106 and 110 of this thesis.

Variables: Negative Attitudes on the Attitudinal Questionnaire Scheffe Test for Treatment Means

Scheffe's test for treatment means (Horvath, 1985; p. 226) is as follows:

\[ P = \frac{(\bar{T}_2 - \bar{T}_1)^2}{\text{MSError} \left( \frac{1}{n} + \frac{1}{n'} \right) (k - 1)} \]

For the variable NEQAQ (negative attitudes towards mathematics), the four treatment group means are as follows:

- \( \bar{T}_1 = 18.38 \)
- \( \bar{T}_2 = 15.31 \)
- \( \bar{T}_3 = 15.93 \)
- \( \bar{T}_4 = 17.93 \)

1. \( df = (k - 1)/(N - k) = 3/116 \)
2. The critical value for \( P \) at 0.05 level of confidence = 2.70
3. Taking the highest mean (\( \bar{T}_1 = 18.38 \)) and the lowest mean (\( \bar{T}_2 = 15.31 \)), applying by hand the Scheffe test (see below) results in a non-significant difference when compared to the critical value (2.70).

\[ P = \frac{(\bar{T}_1 - \bar{T}_2)^2}{\text{MSError} \left( \frac{1}{n} + \frac{1}{n'} \right) (k - 1)} \]

\[ P = \frac{(18.38 - 15.31)^2}{(18.05) \left( \frac{1}{32} + \frac{1}{32} \right) (3)} = 2.64 \text{ (not significant)} \]

4. However, having a significant overall \( P \) but no significant Scheffe pairwise comparison suggests that using Tukey's HSD procedure and substituting the harmonic
mean as an appropriate alternative may shed further light on the possible differences between the groups.

**Tukey's HSD Procedure Employing the Harmonic Mean**

The harmonic mean is defined as the number of scores divided by the sum of their reciprocals (Horvath, 1985; p. 225). The corrected formula follows (Ruercher & Jackson, 1978):

Harmonic Mean = \[ \frac{1}{\frac{1}{n} \Sigma(1/n)} \]

Harmonic Mean = \[ \frac{1}{(1/32 + 1/32 + 1/28 + 1/28)} \]

Formula and calculation of a critical difference (Horvath, 1985; p. 224) is as follows:

\[ CD = \frac{(q \times \text{df} \times MSerror)}{(1/n \times MSerror)} \]

CD (critical difference) = \[ \frac{(0.05 \times 116)}{(29.87 \times 19.05)} = 0.05 \]

85.53. The following are the treatment group totals:

<table>
<thead>
<tr>
<th>Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>588</td>
</tr>
<tr>
<td>2</td>
<td>490</td>
</tr>
<tr>
<td>3</td>
<td>446</td>
</tr>
<tr>
<td>4</td>
<td>502</td>
</tr>
</tbody>
</table>

The calculations of difference between the groups and the comparison of results to the critical difference is listed below:

- T1 - T2 = 588 - 490 = 98 (significant)
- T1 - T3 = 588 - 446 = 142 (significant)
- T1 - T4 = 588 - 502 = 86 (not significant)
- T2 - T3 = 490 - 446 = 44 (not significant)
- T3 - T4 = 446 - 502 = -56 (not significant)
- T2 - T4 = 490 - 502 = -12 (not significant)

**Variable: Masculine Characteristics on the Personal Attributes Rating Scale**

The same procedure has been applied to the variable MCHAR (masculine characteristics). Four treatment group means are as follows:

- \( \bar{T} = 15.19 \)
- \( \bar{T} = 16.50 \) (highest mean)
- \( \bar{T} = 14.93 \) (lowest mean)
- \( \bar{T} = 15.71 \)
Scheffe Test for Treatment Means

\[ P = \frac{(T - T)^2}{(M_{\text{error}}) \left( \frac{1}{n} + \frac{1}{n} \right) (k - 1)} \]

\[ P = \frac{(16.50 - 14.93)^2}{(5.07) \left( \frac{1}{32} + \frac{1}{28} \right)} = 2.42 \]

1. \( df = (k - 1)/(N - k) = 3/116 \)
2. The critical value for F at 0.05 level of confidence = 2.70.
3. Therefore, the above result is not significant.

Tukey's HSD Procedure Employing the Harmonic Mean:

Harmonic Mean = \( \frac{k}{\sum(1/n)} \)

Harmonic Mean = \( \frac{4}{(1/32 + 1/32 + 1/28 + 1/28)} = 29.87 \)

Critical Difference Procedure:

\[ CD = q \frac{(k, df M_{\text{error}})}{(1/n M_{\text{error}})} \]

\[ CD = q \frac{(4, 116)}{(29.87)(5.07)} = 44.67 \]

Treatment Group Totals:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>486</td>
<td>528</td>
<td>418</td>
</tr>
</tbody>
</table>

Calculation of differences between the groups and the comparison of results to the critical difference is given below:

\[ T_1 - T_2 = 486 - 528 = -42 \text{ (not significant)} \]
\[ T_1 - T_3 = 486 - 418 = 68 \text{ (significant)} \]
\[ T_1 - T_4 = 486 - 440 = 46 \text{ (significant)} \]
\[ T_2 - T_3 = 528 - 418 = 110 \text{ (significant)} \]
\[ T_3 - T_4 = 418 - 440 = -22 \text{ (not significant)} \]
\[ T_2 - T_4 = 528 - 440 = 88 \text{ (significant)} \]
Statement of Agreement

This study is part of a larger research project funded by a Social Science and Humanities Research Council grant (Jackson, 1986). The authorship and copyright of surveys, analyses, and tables are jointly held by Coutts and Jackson (names are listed in alphabetical order).
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176


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January, 1984 - September, 1981
Master's degree Applied Social Psychology
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B.A. Honours degree in Psychology and English
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EMPLOYMENT HISTORY

Occupational Experience
1987-1986 Research Assistant
Dr. L.M. Jackson. Social Science and Humanities Research Council grant: "Mathematical Achievement Behaviors Among High School Students," University of Windsor.

1987-1983 Student Coordinator
Student coordinator for all sections of the Introductory Psychology course offered at the University of Windsor. The coordinator's responsibilities included anticipating the course requirements and needs of approximately 1300 students and 23 teaching assistants. Responsibilities included distribution of all course materials, and preparation of all course information, and student evaluations.

1986-1985 Psychological Examiner
Practicum completed with Children's Aid in Windsor, Ontario. The practicum involved the intellectual and personality assessment of adolescents in the care of the Brian Hyslop Home (preparatory for future placement).

Teaching Experience
1986-1981 Sessional instructor of several Introductory Psychology classes and a Social Psychology course at the University of Windsor. Responsibilities included the dissemination of course material and subsequent evaluation of the students.
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