

DISSERTATION

GENDER DIFFERENCES IN ACHIEVEMENT AND ATTITUDE  
IN COLLEGE MATHEMATICS

Submitted by

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In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

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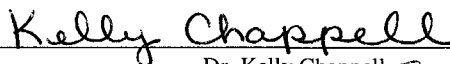
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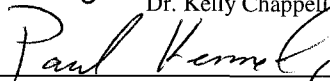
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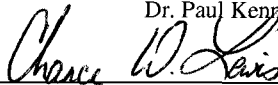
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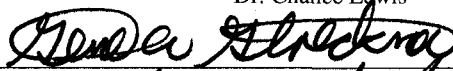
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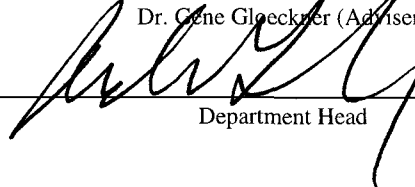
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ABSTRACT OF DISSERTATION  
GENDER DIFFERENCES IN ACHIEVEMENT AND ATTITUDE  
IN COLLEGE MATHEMATICS

The first component of the study tracked 367 freshmen at Colorado State University who had taken calculus in their first semester in either 1991 or 1998. Grades were collected for these students over their next seven semesters in natural science courses and compared. The purpose was to describe the current situation and the trend of gender differences over time in achievement and participation. In addition SAT scores and college GPA were compared. The second component of the study looked at gender differences in attitude toward mathematics. A survey derived from the Fennema-Sherman Attitude Survey was used for 214 students taking second semester calculus in the spring semester of 2004 from Colorado State University. In addition course grade information was requested on the survey, which was used to find relationships with various attitude constructs.

The gender gap is increasing in SAT and Mathematics SAT score in favor of males, while females have an advantage in college GPA. Males outnumbered females by about three to one, but of these students the proportion of male to female participation in mechanical and electrical engineering courses favors males, while remaining the same in chemistry, civil engineering, mathematics, and physics. Achievement in fourteen natural science courses yielded only one significant gender difference in favor of females for the current (1998) sample. Similar findings were found for the early (1991) sample, therefore there was little change in gender differences in achievement from 1991 to 1998.

The results for the attitude portion of the study found significant gender differences in confidence toward mathematics, the level at which mathematics is stereotyped as a male domain, and the level of perceived encouragement from mother and father. Females had more positive responses in each of these areas except the level at which mathematics is perceived as a male subject. When course grades were analyzed with the attitude constructs, only one of the three courses, college composition, showed a significant interaction. Females that were more stereotypical of mathematics as a male domain performed better in college composition than females that were less stereotypical and the opposite was true for males.

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## CHAPTER 1: INTRODUCTION

### *Overview*

For more than three decades gender differences in mathematics have been a major concern for the educational system within the United States and around the world (Rech, 1996). There are an overwhelming number of studies involving achievement and attitude with students ranging from elementary to secondary education. It is accepted knowledge that there are gender differences (in favor of males) in achievement and attitude around the world and that in the past decade the gap has decreased (Flores, 1990; Tapia, 2000). Therefore, it is important now more than ever to continue to show that females are as competent as males in mathematics. If our society believes that mathematics is not a strictly male subject, females may be encouraged to enter the field and ultimately make contributions. Currently our society, which includes peers, teachers, and parents, are guiding females away from the field (Flores, 1990; Schwartz, 1992). Educational, in particular mathematics, reform has been a vital topic for our country as we continue to fall further behind other countries such as Japan and Germany (Stigglers, 1999). But how do we assess what is working and what is not? Too often a reform technique is discarded before it has time to set in. The gender gap is decreasing and researchers are unsure what to attribute it to therefore, it is important to study as many variables as possible as often as possible to help shed light on the issue.

An interesting component found in recent research deals with students in the top ten to twenty percent of secondary school students. Studies have found that these females are at a severe disadvantage (Flores, 1990). "The proportion of boys to girls among 15-year-old pupils obtaining the highest 10 percent of scores on APU

[Assessment of Performance Unit] concepts and skills tests is 61 to 39 percent” (Fennema, 1990, p 13). What makes the top students different? Is it differential treatment from teachers, attitude differences, or could it be differences in cognitive learning styles? The researcher for this study believes that it is not a difference in learning styles, but a difference in societal perspective towards expectations of genders that transcends to student learning.

This study tracked mathematically able students through four years of college at Colorado State University. Achievement in mathematics, physics, engineering, and chemistry were all analyzed. Most of the literature today is based on studies conducted at the elementary and secondary levels. In comparison little research exists on achievement of gender in entry-level college mathematics courses (Rech, 1996). It has been found that females are reluctant to participate in advanced math courses (Fennema, 1990), but how do the females that do opt to take the advanced courses in college compare to males? If it can be shown that females are equal to males in achievement and attitude, it may reduce the social stigma surrounding female participation in mathematics. This study also analyzed attitudes of mathematically talented students at Colorado State University by using parts of the Fenemma-Sherman attitude survey (Fennema, 1976). Areas such as confidence, usefulness, mathematics as a male domain, and students’ perception of father’s attitude toward mathematics were looked at. Grades in various courses were also collected in the survey to determine correlations with attitudinal variables.

It has been shown that peers and adults have guided females away from the independence of mathematics to social/cooperative subjects, which ultimately keeps females out of many trade, semi-skilled and skilled jobs (Friedman, 1995; Fennema,

1990). In a 1996 study, it was found that college courses that prepare students for future mathematics contained more males, while courses for terminal mathematics courses contained more females (Rech, 1996). Mathematics is a vital component to forward progress; therefore we must utilize the talents of all.

“The range across countries is too great for a simple explanation to be advanced as to why such sex differences should have been observed...Nevertheless, it is clear from this evidence that girls tend to be less well-prepared to enter occupations and careers that require a prior knowledge of mathematics and science. To this extent, inequalities between males and females are built into educational systems.” (Fennema, 1990, p 12)

The longer that this trend continues the harder the problem will be to fix. A recent study showed that positive attitudes towards mathematics of females are increasing. In 1999, the Fenemma-Sherman Attitude Survey was re-visited and it showed that students now believe that females are both better at mathematics and more prepared to work hard at it than males (Forgasz, 1999). This finding is rare and many people probably believe it to be a fluke and that is why it is important to continue to research this area.

Here is a list of the current trends that have been observed in the past decade (Rech, 1996):

1. Gender differences in mathematics may be decreasing.
2. Gender differences in mathematics still exist in the learning of complex mathematics, personal beliefs in mathematics, and career choices that involve mathematics.
3. Gender differences in mathematics vary by socio-economic status and ethnicity, by school and by teacher.
4. Teachers tend to structure their classrooms in ways that favor male learning.

5. Interventions can be applied to achieve equity in mathematics.

These findings are optimistic for females, but there are still problems in our current mathematical educational system. This dissertation compared students who are participating in a rigorous mathematical field. It is hoped that the findings will duplicate the current trend that women are as competent as men in mathematics at the college level (Koller, 2001; Casey, 2001; Xin, 1995).

The researcher hypothesized that the results of this study will show that females perform better than or equal to males. This is because of the researcher's belief that only the strongest females make it through the secondary education system in mathematics and continue into college. Thus, the mediocre female student is typically guided away from the field at the first sign of incompetence. On the other hand, there are numerous males who have been encouraged and/or pressured to pursue a mathematical degree, which may be inappropriate for their strengths. Furthermore, it is believed that the attitude survey will depict females with lower scores in such areas as confidence and usefulness. This may be attributed to the belief that females receive less support and encouragement to participate in mathematical fields. Conversely, males are often encouraged regardless of their ability because of the stereotype that mathematics is a male domain and therefore feel the need to fulfill their sex-role congruency.

Ultimately it is hoped that the findings for the study will encourage females to enter mathematical fields and eventually lead them to successful careers. Once this occurs, role-models will be uncovered, which will begin to breakdown the stereotypes our society holds.

### *Research Questions*

1. Are there gender differences in mathematically talented students in regard to achievement and participation in mathematics and mathematics related courses at Colorado State University?
2. Have gender differences in achievement and participation in mathematics and mathematics related courses at Colorado State University changed from 1991 to 1998 within mathematically talented students?
3. Are there gender differences in the attitudes toward mathematics at Colorado State University within mathematically talented students?
4. Are there relationships between achievement and mathematical attitude by gender within mathematically talented students at Colorado State University?

### *Definition of Terms*

1. Attribution Style- refers to the way a student attaches cause for success or failure.
2. Calculus- first semester calculus (single-variable) for engineers.
3. Differential course taking- variation in the elected courses of students.
4. Differential Effectiveness- refers to the processes of the classroom that is geared more to the learning needs of one gender over the other.
5. Differential Treatment- the phenomenon that gender plays a role in determining the experience that is received in the classroom.
6. Fear of Success- a feeling of inadequacy because of the attained success. A common place where this occurs is with females trying to fulfill their sex-role congruency.
7. Internal Belief System- the cause a student places on their ability to learn. The system is comprised of the following attitudinal variables: natural ability, effort, task difficulty, and luck.

8. Learned Helplessness- when a student whom repeatedly fails to succeed comes to the belief that he/she can never learn in the system.
9. Mathematically Talents Students- students taking calculus in their first semester of college.
10. Sex-Role Congruency- refers to an individual trying to parallel the demands set by society, parents etc. on their gender.
11. Spatial Orientation- the ability to comprehend a change that has taken place between two representations.
12. Spatial Visualization- the ability to mentally rotate or transform an object.
13. Survival Rate- refers to the percentage of students who continue to take optional mathematics courses.
14. True Freshman- a non-transfer student registering for the first time in the fall semester.
15. Wait Time- the duration of time between the moment the teacher stops speaking and the moment a student begins to respond or when the teacher begins to speak again.

### *Delimitations*

1. Only students who were true freshman in the fall of 1991 or 1998 and who took calculus their first semester were eligible for the achievement portion of the study. This overlooks the top students who took calculus in high school or students who took calculus later in their college career and excludes transfer students.
2. The attitude survey will be administered to students taking calculus II in the spring semester of 2004. Some of the grade data that will be requested may be unavailable if a student has not elected to take physics, chemistry, or computer programming concurrently with calculus.

3. The data that will be used for the first two research questions will be taken from a prior National Science Foundation study. Therefore, the researcher will restrict the scope of the study and focus on the variables that were selected by the investigators of the prior study.

### *Narrator's Perspective*

The researcher is a single white male 27 years of age. He was raised in a middle class family in Western New York. He was placed in an advanced program early on in his education and continued to study mathematics all through college and graduate school. He had not noticed a problem with gender differences in mathematics until he came to graduate school at Colorado State University in 1999. He was faced with a faculty dominated by men (approximately 4 to 1) and instructed calculus courses where the males outnumbered females by about 3 to 1. Females consistently had done well in his classes, which forced him to question the large disparity in participation rates by gender. He then became involved in a research grant where gender was a variable and started to learn more about the phenomenon.

He is a passionate teacher of mathematics and it was disturbing for him to think that some people might not be getting a chance to study the beauty of mathematics because of gender bias. He wanted to understand if in fact there was a problem and eventually the factors that contribute to the problem.

## CHAPTER 2: LITERATURE REVIEW

### *Overview*

Although it is generally accepted that females are at a disadvantage in mathematics, it should be pointed out that not all data lead to the same conclusion. There are inconsistencies across the board that shows males at an advantage, females at an advantage, or no difference at all. Many variables influence results including content examined, sampling of students, and format of the test. The following results represent a wide range of findings at various levels.

#### *A. Elementary*

At this age, most studies have found little to no gender differences in mathematics (Xin, 1995; Davenport, 1998; Friedman, 1989). Although when first graders were asked about their likelihood to achieve in mathematics males perceived themselves to be more competent than females (Casey, 2001). A study showed that of third and sixth graders taking the Iowa Test of Basic Skills, there was no significant difference in mathematics performance by gender (Navarro, 1989). A perpetual problem that is caused by generation after generation of parents is the stereotyping of males and females into different areas of study. This was researched with first grade students and their respected mothers. The students, as well as the mothers, tended to associate verbal/reading activities with females and mathematics activities with males (Casey, 2001). This would support the theory that gender differences in mathematics are caused by socialization, instead of biological or genetic differences. In 1992 it was found that in students ranging from nine to eleven years old males took three times as many turns speaking as females

and females were less assertive (Schwartz, 1992). Although there does not exist achievement differences, one can easily see the start of future gender problems in mathematics.

### *B. Intermediate / Junior High*

According to many studies, this age group is where the gender differences in achievement begin (Schwartz, 1992). Females were found to have an advantage in number skills, computational abilities, and spatial skills (Becker, 1990; Friedman, 1995). On the other hand, males showed advantages in measurement abilities, geometrical skills, problem solving and abilities of proportionality (Friedman, 1995; Friedman, 1989, Casey, 2001; Koller, 2001; Xin, 1995). In general, findings are inconsistent, but males seem to hold an overall edge (Xin, 1995). In an attitude survey, grades seven through ten, it was found that on average males believed more strongly than females that mathematics was a male domain and females believed more strongly than males that mathematics was a neutral domain. Table 2.1 represents the findings. Notice the main difference in male domain (MD) for males (2.54) compared to females (2.12) (Fennema, 2002). These findings essentially show that males are more apt to believe that mathematics is meant for them, while females are less stereotypical.

Table 2.1

*Means, Standard Deviations And Independent Group t-tests Results By Gender For Each Subscale Of Mathematics And A Gendered Domain*

Subscale	Male		Female		t
	Mean	SD	Mean	SD	
Male Domain	<b>2.54</b>	.68	2.12	.59	9.0*
Female Domain	2.71	.72	2.69	.68	.28
Neutral Domain	3.76	.56	<b>3.92</b>	.54	3.8*

p < .001

### *C. High School*

Males hold an overall advantage in high school, which causes many researchers to refer to mathematics as a “male domain” (Xin, 1995; Koller, 2001). Some researchers believe that differential course taking is a major cause of the gender gap, but there is little variation in the courses taken at this level due to state requirements. There is no difference in the courses taken until the fourth year where the survival rate is much higher for males (Davenport, 1998; Navarro, 1989). This parallels the advantage on the mathematics portion of the SAT exam, which is customarily taken during the student’s third or fourth year. The University of Delaware found that males performed better than females and then tried to account for the advantage. They found that 25% of the difference was attributed by the advantage in the number of courses taken in mathematics, physics, and computer science (Navarro, 1989). Notice in the Table 2.2 that each variable is significant.

Table 2.2

*Means, Standard Deviations, And t-values*

Variables	Gender	Mean	SD	t
Math SAT	Male	<b>576</b>	88.57	12.62*
	Female	525	80.01	
Math Courses	Male	<b>4.0</b>	.48	6.79*
	Female	3.8	.60	
Physics Courses	Male	<b>2.3</b>	1.06	8.09*
	Female	1.9	.96	
Computer Science Courses	Male	<b>0.9</b>	.87	9.08*
	Female	0.6	.60	

\*p&lt;.001

In another study, it was found that males scored significantly better (about 1/2 standard deviation) in each of six years on the mathematics portion of the SAT (Becker, 1990). The Mathematics SAT was also given to seventh, eighth, and ninth graders who scored in the 97<sup>th</sup> percentile of a grade level test. This study attributed the performance difference to bias questions favoring males and numerous questions in the area of geometry, where males hold an advantage. The results are in Table 2.3.

Table 2.3

*Means And Standard Deviations On The Mathematics SAT*

Grade	Male			Female		
	n	Mean	SD	n	Mean	SD
7	814	472	83.2	554	433	65.0
8	610	535	78.7	381	501	65.8
9 / 10	14	641	101.7	9	578	58.4

Worldwide, males have shown to have a significant advantage in achievement in 18 of 21 countries at the twelfth grade (Casey, 2001). “Evidence is clear and overwhelming that achievement differences in favor of boys exist in mathematics” (Koller, 2001, p 452).

*D. College*

Findings are unclear at the college level. Many studies have stated that gender differences narrow over time and become almost non-existent in post-secondary education (Koller, 2001; Casey, 2001; Xin, 1995). But from many perspectives males appear to be continuing their dominance in the field. Males significantly outnumber females in mathematics and quantitatively oriented sciences (Davenport, 1998). Males also tend to outnumber females in calculus and higher level mathematics courses (Koller, 2001). None of these facts represent a difference in performance, but seem to be representative that males are guided into math and females into other areas of study. In general, females elect to take fewer advanced courses than boys (Rech, 1996). It has been found that females that remain in mathematical fields have appeared to diminish the

gap (Koller, 2001; Casey, 2001; Xin, 1995). At the University of Edinburgh, women comprise 50% (compared to the national average of 30%) of the enrollment in mathematics courses (Fraser, 1994). Godfrey (1998) looked into gender differences in attitudes and achievement at the college level. She found a significant correlation for females between attitudes in mathematics and GPA ( $r = .31$ ), while non-significant for males ( $r = .08$ ). These changes could be attributed to the fact that women have started to feel encouraged to continue mathematics at the college level (Fraser, 1994).

### *E. Equality*

We now ask the question of how do we make things equal and what is the definition of equal? The United States Government published a report in 1977 that acknowledged the existence of gender differences in mathematics.

“School administrators should take whatever action is necessary to provide equal educational opportunities for both sexes and to actively oppose sex-role stereotyping which develops within the school and in the larger society... Schools may have to develop programs to inform parents of the need for increased mathematical training for all students. In combination, the school and parents may successfully combat the development of negative mathematics orientations found in many children, orientations which may serve to limit the child’s opportunities as an adult.” (Fennema, 1990, p 11)

One of the problems with trying to achieve equality is to first determine the level of performance that is sought after. Currently schools use male standards as the bar, but this is precisely the root of the problem that is being fought. Rech supports this claim by stating, “conceptions of knowledge and truth have been shaped by men” (Rech, 1996, p 73). Confidence is a crucial variable in learning and with male standards females will be made to feel inferior, while building male confidence. In Mexico City, at a college preparatory bilingual school, 545 students were given the Attitudes Toward Mathematics

Instrument (Tapia, 2000). Researchers found that males scored significantly higher than females on both self-confidence ( $p = .039$ ) and motivation ( $p = .001$ ). Besides these variables, value and enjoyment were measured. Table 2.4 shows the mean scores by gender for each of the attitudinal variables.

Table 2.4

*Comparison Of Means By Gender*

Gender	Self-Confidence	Value	Enjoyment	Motivation
Male	52.60	38.90	37.35	16.78
Female	49.43	37.83	36.10	15.02

Fennema (1990) breaks equality down into three areas: equal opportunities to learn mathematics, equity as educational treatment, and equity as educational outcomes. First, equal opportunities refer to the belief that all students are given the same opportunities to pursue a particular direction in school. In actuality, as stated earlier, males end up taking many more math courses than females. This disparity is believed to have been caused by attitude differences and access differentials that are generated by social pressure (Flores, 1990; Schwartz, 1992). Secondly, equal educational treatment refers to the belief that all students are treated the same in the classroom. The current theory is that differential treatment is present across individuals, but should not exist across gender. In actuality, males receive more interaction from teachers in the form of discipline and praise in the classroom (Fennema, 1990). Another study involving primary and secondary teachers reinforces differential treatment in mathematics across

gender (Becker, 1990). Teachers were surveyed to determine their personal beliefs about how they treat males versus females. The results showed that the teachers believed themselves to be neutral, but these teachers tended to overrate and have higher expectations for males. Rech (1996) found that teachers nominated males more often than females as the best mathematics student in their class. To worsen the problem female teachers have adopted many of society's beliefs and tend to rate mathematics as "less important" than other subjects (Qing, 1999). In 1988, Gross found that women generally receive less encouragement at home and school (Navarro, 1989). In general, a student's experience in a math class is influenced by their gender and females tend to have lower expectations bestowed upon them (Schwartz, 1992). Thirdly, equity as educational outcomes refers to equal achievement for males and females. In actuality, males are at a significant advantage at various levels of education (Fennema, 1990). This will be further uncovered throughout this chapter.

#### *F. Classroom Environment*

Now that guidelines have been drawn for equality what are the responsibilities of the school to reach it? Classroom interaction needs to change, but how can a school benefit both males and females given the theory that they have different cognitive learning processes? Males tend to perform better in independent/competitive situations, while females excel in social/cooperative settings (Fennema, 1990). Schwartz (1992) noted that females work best in situations where there exists conversation, which fosters group consensus and builds ideas on top of each other. Currently, the classroom is geared toward the learning behaviors of males. This in-turn creates a confusing

experience for females. Eighty percent of high school women reported that they were treated strange in math courses, compared to only nine percent of men (Becker, 1990). Furthermore females in eighth grade feel less encouraged, have lower expectations from teachers, and have lower self-confidence than males (Casey, 2001). Females also have higher anxiety toward math, which has a negative correlation with achievement (Ho, 2000). These findings have undoubtedly taken place in traditional classrooms that coincide with male learning styles, but what if the classroom were geared toward female learning styles? Flores performed a study, which included a traditional and experimental (favoring cooperative learning) eighth grade geometry classes (Flores, 1990). Her results showed that females showed advantages in the experimental group, while males held an edge in the traditional setting. In 1985, thirty-six fourth grade classes were studied to determine the relationship between teaching approach and interaction patterns with mathematical achievement (Fennema, 1990). It was found that competitive activities correlated to positive achievement in males and correlated negatively to female achievement. When cooperative activities were practiced there was a positive correlation with female's low-level cognitive achievement, while it correlated negatively to high-level cognitive learning in males. Although in 1981, Fey found that small group work (cooperative environment) does not exist very often in secondary classrooms (Fennema, 1990).

Other variables that play a role in the environment are stereotyping mathematics as a gender domain and sex-role identity. The worst part of the problem is that people often contribute to the problem without knowing it. Teachers make stereotypical remarks in the classroom, which discourages females from attaining a high level of achievement.

One example of this took place when a teacher was discussing SAT results with her high school class.

“Now girls, your English score will be higher than your math score and boys your math score will be higher than your English score. This is because boys are better in math and girls are better in English” (Fennema, 1990, p 129).

Researchers have also analyzed mathematical texts to determine whether or not they were gender biased (Fennema, 1990). They found that in most of the story problems a male’s name was used, especially whenever action was involved. When a problem characterized an engineer or scientist a white male was most often used. Some have also hypothesized that students with the same sex teacher would perform better. Researchers found that there was little, if any, difference in performance (Fennema, 1990). More specifically the student-teacher relationship has been studied. The relationship can be broken down into the following categories.

- a. Type of questions asked.
- b. Who is selected to answer a question.
- c. How the teacher handles incorrect responses.
- d. The amount of praise or criticism that is given.
- e. How the teacher handles a request for help.

Sixteen seventh and eighth grade mathematics and social study classrooms were examined to analyze interaction (Fennema, 1990). It was determined that males and females receive a different experience in the classroom, with males interacting with the teacher more often. Teachers ask males, more often than females, high-level cognitive questions, while the opposite is true for lower level questions. Furthermore males are more apt to initiate contact, “call out” responses, and guess more often. As a result of

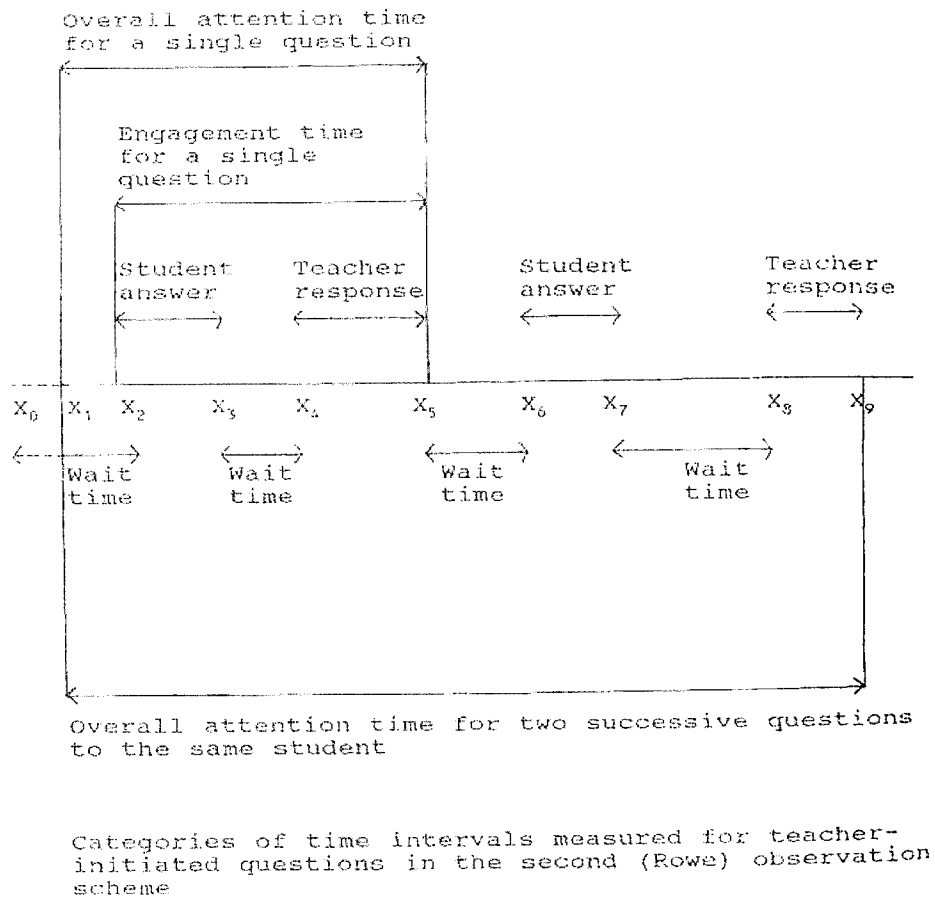
this behavior, it is believed that teachers focus more on males than females. These results were paralleled in thirty-three second grade classrooms in 1979 (Fennema, 1990).

A qualitative study at the secondary level revealed a continuation of gender differences (Fennema, 1990). A geometry class was observed for ten days and it was found that teachers were more likely to call on male volunteers especially when a question involved high-level cognitive ability. Furthermore, 70% of the encouraging remarks were made towards males, while 90% of the discouraging remarks were directed at females.

Another area of study that needs to be mentioned is the “wait time” allotted during teacher-student interactions. Wait time refers to the duration of time between the moment the teacher stops speaking and the moment a student begins to respond or when the teacher begins to speak again (Fennema, 1990). Teachers generally hold higher expectations for males; therefore, it is believed that males should be given longer wait times to respond to a question. In 1983, this was examined by Gore in the Australia public school system (Fennema, 1990). Twenty-six teachers from 14 different schools including 581 students ranging from third to tenth grade participated in the study. Figure 2.5 represents the form in which wait times were calculated.

Figure 2.5

*Sample Form Used To Record Student-Teacher Interaction Time*



The first variable, wait time, consists of the time from  $X_1$  to  $X_2$ . The second variable, subsequent engagement time, consists of the time period starting when the student responds to the time when the teacher ends their subsequent response (i.e.  $X_2$  to  $X_5$ ). Finally, the overall attention per student-teacher interaction would be all of the time that elapses before attention is given to another student (i.e.  $X_1$  to  $X_9$ ). Table 2.6 represents the average times by gender.

Table 2.6

*Mean Time (in seconds) Spent On Interaction, By Gender And Grade Level*

Grade	Wait Time		Subsequent Time		Overall Attention	
	Male	Female	Male	Female	Male	Female
3						
Low-cog. Q	1.9	<b>2.2*</b>	3.9	4.3	6.5	7.5
High-cog. Q	3.4	2.7	6.4	<b>8.9*</b>	11.9	<b>16.6*</b>
Proced. Exch.					15.3	12.2
Discip. Exch.					8.0	4.3
Work-rel. Exch.					12.3	<b>30.7*</b>
6						
Low-cog. Q	2.2	2.0	4.6	4.5	8.0	7.7
High-cog. Q	2.6	2.7	<b>6.8*</b>	4.7	<b>13.4*</b>	8.8
Proced. Exch.					<b>71.7*</b>	35.1
Discip. Exch.					<b>12.6*</b>	4.3
Work-rel. Exch.					34.7	35.2
7						
Low-cog. Q	2.1	2.3	4.7	4.6	7.9	7.6
High-cog. Q	3.7	2.8	<b>8.5*</b>	7.5	12.6	14.0
Proced. Exch.					5.6	<b>6.8*</b>
Discip. Exch.					4.3	3.2
Work-rel. Exch.					19.6	17.2
10						
Low-cog. Q	3.0	3.4	5.0	<b>5.8*</b>	9.9	<b>13.0*</b>
High-cog. Q	3.4	4.3	8.4	7.8	16.4	13.6
Proced. Exch.					9.1	9.3
Discip. Exch.					3.4	4.1
Work-rel. Exch.					22.1	22.9

\* -represents a significant difference

This does not support the hypothesis that males receive more attention from teachers than females. In fact, students are given equal time more often than not. It should be noted that in general, females were given more time on low-level cognitive

questions and males were given more time on high-level cognitive questions. This supports another theory that females are encouraged to master computational mathematics, while males are encouraged to become problem solvers.

In 1985, two above average eighth grade and two below average ninth grade mathematics classrooms that used small groups were analyzed (Fennema, 1990). It was found that males outperformed females in above average performing classrooms. They were given more explanations, while requests for help by females were ignored twice as much as males. Also in the high achieving classrooms females were helpful to all of their peers, while males tended to help other males in the group more often than females. In the low achieving classrooms there did not exist any significant differences in achievement or in the amount of interactions between male and female students. Another area of classroom organization is grouping students according to ability. In 1987, forty-eight classes of fourth through seventh graders were studied and it was found that high achieving females were less likely to be placed in the high aptitude group than males (Fennema, 1990).

The classroom environment has been shown to place males at an advantage in differential treatment and classroom organization. This has encouraged males to become independent thinkers, meanwhile placing obstacles in the way of female learning. “One might speculate what females might be able to achieve with respect to mathematics if some of the imbalances that now exist in our educational environment were eliminated” (Fennema, 1990, p 146).

### G. Attitudes

In 1983, a two year longitudinal study was conducted involving students in sixth grade (Fennema, 1990). The purpose of the study was to assess gender differences in mathematics achievement, confidence, perception of mathematics as a male domain, and perceived expectations of their teachers. These students were given the Fennema-Sherman Attitude Survey and the Mathematics Basic Concepts Test (achievement). Each student was interviewed about his or her perceptions of mathematics. An example of the type of question that was asked is, "Who will succeed?" which was followed by a picture of a male and a female working independently on a problem. The results in the confidence portion showed what one would suspect. Students with a high level of confidence had significantly higher achievement than students with low self-confidence. Table 2.7 shows the mean averages for achievement and confidence for both years. Each gender is split into two groups based on an initial confidence subscale (high or low).

Table 2.7

#### *Mean Scores For Mathematics Achievement And Confidence By Group*

Gender	Group	n	Achievement		Confidence	
			6 <sup>th</sup> Grade Mean	8 <sup>th</sup> Grade Mean	6 <sup>th</sup> Grade Mean	8 <sup>th</sup> Grade Mean
Female	High	15	30.7	42.8	56.6	52.5
	Low	17	26.7	39.5	38.1	45.5
Male	High	16	29.1	43.6	56.4	51.8
	Low	15	26.9	40.0	37.6	44.8

Females rated as having 'high' initial confidence were ahead of the males in achievement in grade six, but fell behind by grade eight. This could be related to the theory that males are encouraged to develop their problem solving skills, while females are taught to perfect rule-rote arithmetic (i.e. neatness, low-level cognitive etc.). In addition, 27 ANOVA's were calculated to examine the question as whether expectations of success differed by gender. The major difference was that males more often than females chose males to succeed when being compared to females. This supports the trend that males have higher self-confidence in mathematics and/or that males have the perception that they have more ability than females. Studies (discussed later in the chapter) have shown that females attribute their success to effort, rather than given ability. The following are examples of statements that were made by students during the interview (Fennema, 1990, pp 84-85).

1. Male Student- "I read somewhere...that boys are, it's some kind of scientific thing that boys are better in math than girls are."
2. Female Student- "I've seen like studies and they say boys are better (at math)."
3. Question: How would this boy feel about her getting the right answer?

Male Student- "He might...sort of be a little mad because maybe she was a girl and girls usually aren't really supposed to...I don't know, boys, they're supposed to be smarter or something."

4. Question 1: Do you think that teachers tend to call on boys more or on girls more in math class?

Female Student- "Probably on boys more."

Question 2: Why do you think this is?

Female Student- "Well, they'll probably think that, um, since the guy is, um, you know, supposed to be the man of the house and stuff, he should know

how to do a lot of stuff too and learn a lot of math and stuff...understand it better.”

Another area of attitude research has to deal with performance following failure. Many students are intimidated by mathematics because of learned helplessness. This refers to a student whom repeatedly fails to succeed and comes to the belief that he/she can never learn in the system. The way that this has been measured is by giving students difficult mathematics problems, sometimes unsolvable, that result in failure. Then they are given easier problems to determine if the previous experience of failure affected their performance. The theory behind this research is that motivation is closely tied with a student's anticipation for failure or success. If a student feels that the reason for their performance is based on internal factors (i.e. effort, ability) they will persist, but if it based on external factors (i.e. task difficulty, luck) then they will most likely give up. Students with learned helplessness generally attribute success to external factors, for example the task difficulty was low or they were given help. Conversely, their failure is blamed on an internal factor, for example low ability (stable) or low effort (unstable). In 1957, Atkinson tried to explain the reason for a person's motivation (Fennema, 1990). He came up with a measurement called the Test Anxiety Questionnaire, which places individuals along a continuum ranging from motivation to avoid failure to motivation to fulfill high aspirations. He contended that students trying to avoid failure accept mediocrity, while students at the other end of the spectrum will not be satisfied by anything other than perfection. The perfectionist prefers problems that are challenging, but not impossible. These students are generally confident in their ability and are not stressed by thoughts of failure. They feel that they are in control of the learning process

and success is a mere matter of effort because they possess the appropriate ability. The student on the other end of the continuum generally chooses very simple or impossible problems. Therefore, they can be sure that their internal factors do not come into play, rather task difficulty or luck will determine their fate. After repeated failure they may become learned helpless and “withhold effort rather than risk failure and confirm low ability” to retain self-worth (Fennema, 1990, p 105). In the 1970’s, it was found that women showed more characteristics of learned helplessness and that males believed that they were more responsible for their learning (Fennema, 1990). In 1981, Corbitt studied this by giving seventh graders a pre-failure problem, then a failure inducing problem, and then a post-failure problem (Fennema, 1990). The following sequence of problems is an example.

1. Pre-Failure: Vicky is buying a used pair of skates for \$7.49. If the sales tax is 30 cents, how much change should she get from \$10?
2. Failure Inducing: When I arrange the members of a marching band in rows of 2, 3, or 4, there is always 1 person left over. However, when I arrange them in rows of 5, all of the rows are even. There are more than 30 but less than 100 people in the band. How many people are in the band?
3. Post-Failure: Tom bought a record for \$6.53. Tax on the record was 26 cents. How much change did he get from \$20?

The mean score for the 196 males was  $-.54$  (slightly worse on the post-failure versus the pre-failure) and the mean score for the 233 females was  $-.90$ . The results were non-significant ( $t = 1.82, p = .07$ ), but support the trend that females show more learned

helplessness characteristics than males. In the same study, students were measured for mathematical concepts following failure instead of arithmetic computation as in the above example. The seventh grade students were given the Stanford Mathematics Achievement Test. Negative correlations were found between the post-failure items and the achievement test. This means that the students who gave up on the post-failure items quickly actually achieved higher on the achievement test (females  $r = -.28$ ; males  $r = -.30$ ).

In 1975, Nicholls tested fourth graders by manipulating their test results (Fennema, 1990). He placed students in one of two groups, a success group that scored 19 out of 20 or in a failure group that scored 7 out of 20. Males, more often than females, attributed failing to luck (external), while females blamed lack of ability (internal). When students believe that they do not have the ability they will persist less and are less likely to put forth effort, hence creating learned helplessness.

#### *H. Internal Belief System*

There are many factors that influence a student's performance outside of general intelligence. Each student holds an internal belief system, which theoretically consists of a number of variables. Fennema discusses five variables that influence this system; confidence, perception of usefulness of mathematics, sex-role congruency, fear of success, and attribution style. Each of these will be defined and gender differences will be explored in each area.

Confidence is a variable that is usually present in any study that attempts to classify student attitudes towards mathematics. It is defined as part of ones' self-concept

that measures how sure a student is of their ability to learn mathematics and do well. A student's willingness to approach new material or the level that they persist at when difficulty arises are both examples of confidence measurement. The following is a list of results from studies involving confidence (Fennema, 1990):

1. Highly relates to achievement ( $r = .40$ ).
2. Students enrolled in the most number of mathematics courses had the highest confidence.
3. A factor in deciding whether or not to take optional mathematics classes.
4. Females had a significant lower perception of their ability than males.
5. When gender differences occur in achievement in favor of males, they are accompanied by similar differences in confidence.

The next variable that will be studied is perception of usefulness of mathematics. When students have met their mathematical requirement in school and are given the option to continue with more challenging courses, usefulness is a variable that can be crucial in their decision. The following is a list of results from studies involving perception of usefulness (Fennema, 1990; Flores, 1990):

1. If a student feels that the content is useful, regardless of level of confidence, he/she will be motivated to continue.
2. When gender differences were found in participation and achievement, they were accompanied by gender differences in usefulness.
3. After achievement, usefulness has been found to be the best predictor of participation in high school mathematics.

4. Students ranked usefulness as the number one reason to continue to study mathematics.
5. Females have been found to rate mathematics as less useful to their lives than did males.

Teacher expectations of students for usefulness have also been studied. In 1985 Dusek concluded that “teachers do form expectations about their students’ learning and that they are correlated with student learning” (Fennema, 1990, p 173). Teachers showed tendencies to place males more often than females in remedial mathematics programs, which may have been caused by the belief that male students are more likely to need mathematics in their future. This theory is supported by the findings that show that males are encouraged to work on high-level cognitive problems and develop the ability to work independently, while females are encouraged to perfect computational or rule-bound tasks (Fennema, 1990). As a result, females may then become dependent on a procedural style of learning making it difficult to venture into higher-level problems independently. An interesting observation in teacher behavior is that teachers do not feel as responsible for a child’s failure if they feel that the failure was due to the student’s ability. Dweck’s study of reinforcement following performance showed that “males are reinforced (by teachers) in such a way that they come to believe they can control their own learning” (Fennema, 1990, p 177). Fennema supported this claim by her study involving 38 first grade teachers. Each teacher was asked to select their four best students (two males and two females) and four worst students (two males and two females) and then choose the causes of their success or failure in the class. Table 2.8 represents her findings. Notice

the difference in cause for success for ability in the high rated students and effort for low rated students.

Table 2.8

*Percentage of Teacher Attributions for Performance to Various Categories, by Gender and Success Rating (all values represent percentages)*

Success Rating	Attribution Category	Cause for Success		Cause for Failure	
		Female	Male	Female	Male
High	Ability	33	58	8	3
	Effort	37	12	24	25
	Intrinsic motivation	18	25	4	3
	Task difficulty	3	1	40	45
	Teacher helped	7	4	16	16
	Others helped	3	0	0	1
	Other causes	0	0	9	8
Low	Ability	9	8	29	22
	Effort	32	24	28	33
	Intrinsic motivation	12	11	8	12
	Task difficulty	16	21	28	20
	Teacher helped	24	35	3	3
	Others helped	5	1	1	2
	Other causes	2	0	4	7

Sex-role congruency is the variable that measures whether or not an individual finds that studying mathematics is an appropriate choice for their gender. It is believed that students conform to the expectations of others and research has correlated females who study mathematics with unpopularity, abuse, and doubt of femininity (Fennema, 1990). Additionally, it is believed that females compromise their sexual desirability by performing well in mathematics (Schwartz, 1992). An individual may decide to avoid a subject if he/she does not feel that they would adequately fulfill their sex-role identity.

This internal perception may cause the student to believe that their peers and teachers have lower expectations of them causing a contradiction. He/she may then feel that they must pay a price in order to continue in the field. Mathematics has historically been perceived as a male domain, which has forced females into internal conflicts. This perception by society has diminished significantly over the years, but still exists and does not show signs of disappearing any time soon. The following is a list of results of studies involving sex-role congruency (Fennema, 1990).

1. In the late 1970's, it was found that males stereotype mathematics more strongly than did females.
2. In 1984, twelfth grade females were found to be the least likely to stereotype mathematics.
3. In 1980, females that enrolled in a fourth year of mathematics were more likely to stereotype mathematics as a male subject than females who took less than four years.

Fear of success for females is defined as the "...conflict, resulting fear, and decreased performance that many women experience because of the clash they perceive between attaining success and fulfilling (their) role in our society" (Fennema, 1990, p 64). In 1968, Horner identified two negative consequences that females deal with due to success in mathematics (Fennema, 1990). The first is the loss of a sense of femininity and self-esteem, secondly the social rejection that accompanies it. In 1982, Leder found contradicting results that showed that high achieving females who tested high in fear of success expressed intentions to take additional math courses (Fennema, 1990). In view of these mixed results it has been determined that fear of success does not seem to

provide clear explanations for gender differences in mathematics achievement and participation.

Attribution style refers to the way a student attributes success or failure. In 1974, Weiner determined that students define their success or failure in terms of ability, effort, task difficulty, and luck (Fennema, 1990). In 1980, a study was conducted for 647 female and 577 males secondary school students enrolled in college preparatory algebra and geometry in ten high schools (Fennema, 1990). Males attributed their success to ability more strongly than did females, while the opposite was true for success due to effort. Females attributed failure, more strongly than males, to lack of ability or difficulty of task. In the same study, attribution style was used to predict students' plans to take further mathematics courses. A multiple regression analysis was run with achievement as the control variable. It was found that attributing success to ability, for both males and females, significantly related to intentions of taking more mathematics (females,  $r = .31$ ; males,  $r = .41$ ).

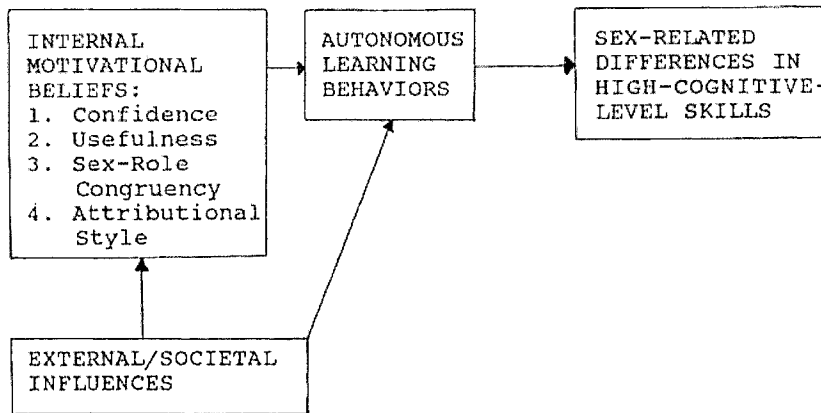
In 1984, a study was conducted of fourth graders, which tested students' attribution style on high-level cognitive mathematics problems (Fennema, 1990). They found that males were more likely than females to attribute their success to ability and their failure to lack of effort. Females were more likely than males to attribute their success to effort and from help from others. This supports the theory that females work better in social, cooperative situations.

Now that a discussion has been given on various affective variables it is time to combine them to analyze the Autonomous Learning Behavior (ALB) model (Fennema, 1990). The ALB model (Figure 2.9) tries to explain gender differences on high-level

cognitive mathematical tasks. High-level tasks were chosen because of the gender differences that have historically been apparent.

Figure 2.9

*Autonomous Learning Behavior Model*



This model combines a students' internal belief system with their external/societal influences and attempts to describe where problems may occur with student learning. A student that is successful with high-level skills takes control of the learning process (autonomous). This type of learner persists when a task proves to be difficult and may prefer to engage independently. These 'choices' are usually accompanied by experiences of success, which strengthens their internal belief system. The internal belief system is made up of four of the variables previously discussed. Males showed a distinct advantage with confidence and attribution style, while the results were mixed for sex-role congruence and usefulness. Males also have an advantage in external/societal influences

which is mainly comprised of variables arising from classroom and social interactions outside of school. It is important that researchers continue to create models that relate the internal belief system with achievement because they build a theoretical basis for future studies.

In 1986, Meyer extended Fennema's prior longitudinal study by tracking the same students over a six year span (Fennema, 1990). Students were tracked from sixth to twelfth grade to see if affective and attitudinal variables in middle school were predictive of mathematics achievement and participation in high school. The attitudinal variables of concern in the study were confidence, mathematics as a male domain, usefulness, teacher attitude, and causal attributions. They were measured at grades 6, 8, and 12 using the Fennema-Sherman Attitude Survey. The affective variables were measured using the Mathematics Attribution Scale, which measure success and failure due to ability or effort, at grades 8 and 12. Achievement for grades 6 and 8 was also collected. The dependent variables were achievement and participation for the twelfth graders. There were no significant differences in male and female achievement in grade 6. In grade 8 males held a significant advantage in achievement. In grade 12 males showed an advantage on high-level cognitive concepts, while there was no difference in low-level cognitive concepts. Significant differences were found in favor of males for likeliness to stereotype at each of the three levels. One optimistic observation that came was that the level at which students stereotyped decreased continuously for both sexes up to grade 12.

The next portion of that study focused on prediction of achievement and participation at grade 12. Achievement and participation variables collected at twelfth grade were treated as dependent variables, while the affective variables and prior

achievement at grades 6, 8, and 12 were used as independent variables. Prior achievement was used as a control variable to help determine if the affective variables had predictive ability. Regression analyses were calculated for each of the 15 affective variables by gender. Five of the variables proved to be predictive for the males, while 12 of the 15 showed predictive ability for the females. For both males and females, confidence was the variable that most frequently predicted achievement. Meyer concluded this portion of the study by using an analysis of linear structural relationships to determine that, "...confidence for both females and males, is more appropriately understood as an outcome of achievement, rather than achievement being an outcome of confidence" (Fennema, 1990, p 91).

### *I. Spatial Skills*

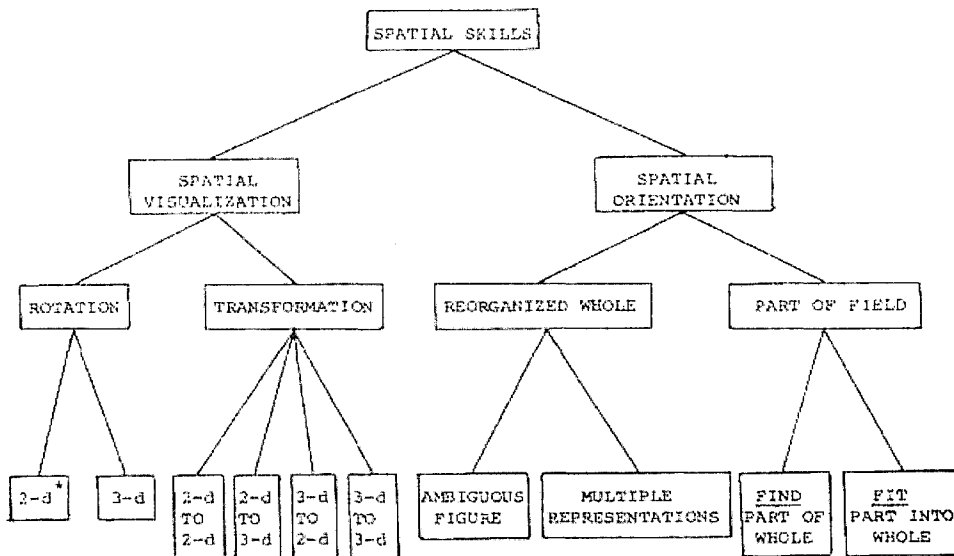
Researchers have often considered spatial skills as a cause of mathematical gender differences. In 1967, Sherman stated that, "space perception...appears to be a relevant variable to control in studies of sex differences in geometric and mathematical problem solving" (Fennema, 1990, p 43). As far back as the 1920's spatial skills have been associated with general intelligence; therefore, researchers wanted to determine if this intelligence factor influenced mathematics achievement. Numerous studies have occurred to help determine any possible significance, but due to the vague definition of spatial ability it is difficult to compare studies.

"In view of the fact that, at present, universally accepted definitions of spatial ability, visual imagery, or even mathematics, do not exist, it is hardly surprising that there is very little direct discussion in the existing literature on why spatial ability, mental imagery and mathematics performance might be expected to be related" (Fennema, 1990, p 57).

More recently two categories have been formed to help make the definition a bit more tangible. The first category is called spatial visualization, which consists of the ability to mentally rotate or transform an object. The second category is called spatial orientation, which is the ability to comprehend a change that has taken place between two representations. The complex nature of this phenomenon can be better understood in Figure 2.10.

Figure 2.10

*Spatial Skills Classification Scheme*



Gender differences in spatial abilities have occurred with students at young ages.

“It has been found with some consistency that boys on the average excel (more than) girls

on spatial tasks and that the spatial functions mature between the ages of 11 and 15” (Fennema, 1990, p 44).

Differences in spatial skills continue into high school with males outperforming females. In 1973, it was found that males had an advantage on the Space Relations portion of the Differential Aptitude Test (Fennema, 1990). Regardless of what definition is used it is clear that males hold an advantage in this area, but is it due to biological or social differences? Many have attributed it to differences in interests. Males have traditionally been into outdoor activities such as hunting and wandering, which are believed to enhance spatial abilities. It was found that females have fewer out of school experiences that lead to the development of their spatial abilities (Casey, 2001). Another interesting theory is that video games have played a role in the development of these skills. In 1984, 58 Harvard students participated in a study that measured their spatial skills (Fennema, 1990). They were given a pretest that involved imagining objects after a rotation of 90 degrees. Then the students were split into two groups; an experimental group, which played video games for 5 hours and a control group that, remained constant. Following the experiment everyone was given a post-test that again measured his or her spatial ability. The men’s scores did not change significantly regardless of which group they were in. Women, on the other hand, that were in the experimental group showed drastic improvements in their scores, scoring as high as the men.

In 1985, a study examined how students with varying levels of spatial skills translated mathematics problems into pictures and used them to solve the problems (Fennema, 1990). It was found that females with low spatial skills consistently put less

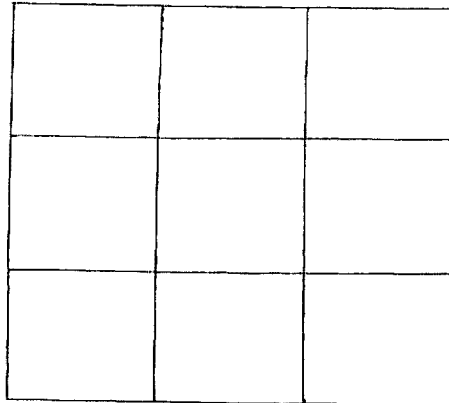
information into pictures and had the lowest mean score on the mathematics problems.

Two problems that were used on the test are given below.

1. A baby came to a staircase; climbed up five steps, climbed down three steps, and then climbed up six steps and was at the top. How many steps were in the staircase? Answer- 8
2. Four people ordered a pizza. One person ate  $\frac{1}{3}$  of the pizza and left before anyone else had a piece. The rest of the pizza was divided equally among the other three people. How much of the whole pizza did each of the three people get? Answer-  $\frac{2}{9}$  (Hints were given, if requested, that depicted circles shaded and divided into thirds and ninths.)

A similar study occurred with tenth graders that focused on spatial orientation (Fennema, 1990). The students were split into four groups by gender and initial spatial orientation ability. The students were asked to solve ten mathematics problems and explain their answers during an interview. The following is an example of a problem that was used on the test.

1. Without counting, do you think there are more squares, or more rectangles that are not squares, in the figure? How many can you find? Answer- 14 squares, 22 rectangles



The females with low spatial orientation ability scored substantially lower than the other three groups (Table 2.11). On the other hand males with low spatial orientation ability made adjustments to increase their performance whereas females did not.

Table 2.11

*Means And Standard Deviations For Mathematics Achievement*

Gender	Spatial Orientation Group	Mean	SD
Female	High	23.08	8.41
	Low	16.12	6.47
Male	High	23.00	8.49
	Low	23.23	10.72

In a 2001 study it was found that among high ability college bound high school seniors that gender difference in the mathematics portion of the SAT is strongly related to spatial skill factors (Casey, 2001). Furthermore it accounted for about twice as much of the difference explained by self-confidence.

*J. Recent Studies and Trends*

The study of gender differences in single gender classrooms has recently been a hot topic. It is believed that if females are separated from males that they will perform better because of the lack of pressure to fulfill their sex-role identity. Another justification for the separation is that males are generally more competitive and females do not excel in that kind of situation. Dunlap (2002) undertook a study that split 50 (25 males; 25 females) fifth graders into single gender classrooms. It should be noted that because of Title IX laws these types of studies are frowned upon. The researcher studied achievement and attitude of the female students. They were given a pre and post-test attitude survey. One additional question was added to the post-test that asked if the

separation helped learning. The results were significant (chi-squared = 14.48) with 6% feeling that it was no different, 8% thought it was harder in the single gender classroom, and 68% benefiting. There was no significant difference in female performance (mean before = 95.27; mean after = 96.29). Table 2.12 summarizes the responses to the pre and post attitude surveys.

Table 2.12

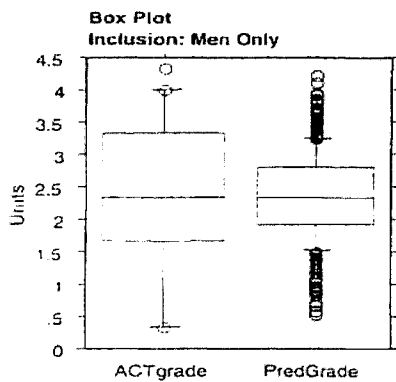
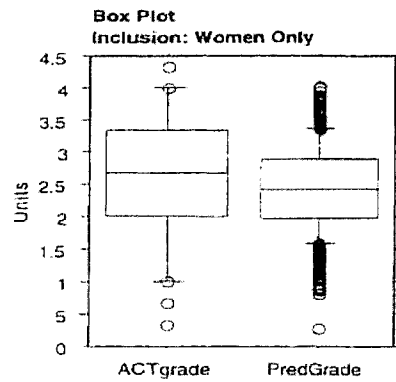
*Female Survey Responses Before And After A Single-Gender Mathematics Class*

Categories	Before (%)	After (%)
Math as favorite class	28	36
Chose traditional careers	68	68
Chose non-traditional careers	32	20
Like math	52	52
Confident in math	12	12

Another area of interest today is the ability of mathematics placement tests to adequately predict performance in college mathematics for men and women. Dorner (1998) examined placement exams at Pacific Lutheran University and the subsequent grades for the students in their freshman math course. She found that in all but one course women were significantly under-predicted. Figure 2.13 represents a visual depiction of the findings. Notice that the ACT is almost perfectly in-line with the placement test for males, while the women are under-predicted on the placement test. This may be an example of a male biased test.

Figure 2.13

*Box Plot Of Overall Actual/Predicted Grades Distributed About The Median For Men And Women*



### *K. Conclusion*

Throughout the literature review there have been studies that have shown advantages for both males and females in both attitudes and achievement. The overall advantages are in favor of males but females are beginning to close the gap. Females that continue to take mathematics courses actually outperform males (Navarro, 1989).

Schartz supports this claim by noting that in 12 of 15 countries females outperformed

males in the twelfth grade (Schwarz, 1992). In 2002, students in grades 7 through 10 in Australia were given an attitude survey, which measured the “gender domain” variable. The results showed that females rather than males expected to be more capable, enjoy the subject, find it interesting and challenging, and whom teachers expect to succeed. On the other hand, males were expected to give up when things got difficult, need more help, and were bored with mathematics. Furthermore, students believe that parents no longer favor their sons in mathematics (Leder, 2002).

Question: Some people say that girls are better in math than boys, and some say the opposite, that boys are better than girls. What do you think?

Student: “I don’t think...It’s not like they’re boys or girls, like, if they want to do stuff, then they can do it. But if they don’t, you know, it’s just, they don’t, then they just don’t really try.” (Fennema, 1990, p 85)

These are examples of findings that are representative of the diminishing gap in gender differences. Studies need to continue to re-examine this trend.

Many of the studies do not apply to the topic of interest of the dissertation research, but are vital in the understanding of the entire picture of gender differences in education. This study is focusing on achievement, participation, and attitude of students at the college level. In order for these results to be meaningful it is necessary to know what differences are occurring at the lower levels in these areas. Similarly each of the studies that focused on gender differences at the college level are crucial to determine if anything is directly changing.

## CHAPTER 3: METHODOLOGY

### *Overview*

This chapter presents an overview of the research approach and design. A discussion of the population is included of undergraduate students for this study and the sampling procedure. The Scholastic Aptitude Test (SAT) was used for a portion of the achievement piece of the study. The instrument used for the attitude segment of the study was a modified version of the Fennema-Sherman mathematics attitude survey (Fennema, 1976). A description of these instruments as well as their validity and reliability are described. This chapter describes the procedure for data collection and the plan for analysis of data.

### *Research Approach*

There are four main research questions and each one shares the same attribute independent variable, which is gender. Each also utilized the non-experimental comparative analysis approach (Gliner, 2000). The four questions are discussed separately.

1. Are there gender differences in mathematically talented students in regard to achievement and participation in mathematics and mathematics related courses at Colorado State University?

This question applies the non-experimental comparative analysis approach. This is due to the fact that participants are not randomly assigned and there is not an active

independent variable. The independent variable (attribute) will be gender, while the dependent variables will be course grades (achievement) and enrollment (participation) in various mathematical courses. Courses were selected based on the number of students that have taken the same course. At least ten males and ten females must have been present for a particular course to be analyzed. It should be noted that the students may not have taken a course during the same semester or with the same instructor. Multiple *t*-tests were used to analyze differences in the dependent variables. The next part of this analysis, participation, compared the number of students of each gender within the selected courses. The researcher had decided that significant differences in participation by department must show a minimum 33% change in ratio by gender when compared to the original ratio of students in the sample.

2. Have gender differences in achievement and participation in mathematics and mathematics related courses at Colorado State University changed from 1991 to 1998 within mathematically talented students?

This question uses the non-experimental comparative approach, which analyzes the differences between groups. There are two independent variables of interest, gender and year, which are both attributes. Comparisons were made by gender and between groups, 1991 and 1998. The statistical design that was used for this question is a 2 x 2 factorial ANOVA. The variables, gender and year, comprised the independent factors, while course grades represented the dependent variables. Participation was also analyzed

over time to determine if gender differences by department exist. As before there must be at least a 33% change in ratio when all factors are taken into account.

There are a couple extraneous variables that need to be mentioned. First, Colorado State University changed their grading system in the mid-nineties from a straight A, B, C, D, and F course grade to one that includes plusses and minuses. Grades were truncated to make the data uniform from year to year. Secondly, it is very possible that two students taking the same course from different instructors in the same semester received different experiences. A similar problem is encountered when considering the same course taken years apart. Therefore it must be assumed that courses retain their fundamental principles and concepts regardless of when and from whom it was taken. Due to the limitation of the data set, the 1998 SAT scores were adjusted for inflation.

3. Are there gender differences in the attitudes toward mathematics at Colorado State University within mathematically talented students?

Differences in responses based on gender were analyzed under the non-experimental comparative analysis approach. The survey adopted parts of the Fennema-Sherman Attitude Survey (see appendix). A series of independent t-tests were used to analyze differences between genders for each attitudinal variable.

Due to the length of time needed to complete the full version of the survey, five of the nine constructs were analyzed. They are confidence, father's attitude toward one as a learner of mathematics, mother's attitude toward one as a learner of mathematics,

mathematics as a male domain, and usefulness of mathematics. The following represents a brief justification for the selection of these constructs.

Confidence was chosen in part due to the fact that it is a variable that is rarely left out of any attitude study. The researcher also believes that this is the most crucial variable when studying success and participation in mathematics. In a study that involved attitudes of high school students, it was found that confidence was the variable that most frequently predicted achievement (Fennema, 1990). Furthermore females have been found to have lower self-confidence than males (Casey, 2001).

Father's attitude toward one as a learner of mathematics was chosen by the researcher to determine if student perceptions of their father's view of mathematics differ by gender. Mathematics has traditionally been a male subject; therefore, it is possible that a student may receive vastly different levels of encouragement from their father. In 2002, it was determined that students no longer believe that parents favor males in mathematics (Leder, 2002).

The committee selected mother's attitude toward one as a learner of mathematics. It was chosen due to the possibility of situations where only the mother was present. One study analyzed attitudes of first grade students and their respected mothers. The students, as well as the mothers, tended to associate verbal/reading activities with females and mathematics activities with males (Casey, 2001).

Mathematics as a male domain is a logical construct when analyzing gender differences that have long favored men. This data set is an indication of whether or not the students perceive gender as a factor in learning mathematics. It is accepted knowledge that society stereotypes mathematics as a male domain, but ultimately our

concern lies in the views of the current students immersed in the field. In 2002, females rather than males at grades seven through 10 expected to be more capable, enjoy the subject, find it interesting and challenging, and whom teachers expect to succeed (Leder, 2002).

Usefulness was chosen because of the social stigma that mathematical careers are not meant for females. Flores (1990) found that females were less convinced than males that mathematics will be useful to them. After achievement, usefulness was found to be the best predictor of participation in high school mathematics (Fennema, 1990).

4. Are there relationships between achievement and mathematical attitude by gender within mathematically talented students at Colorado State University?

This design uses a combination of the comparative and associational approach (Gliner, 2000). This differs from the previous three questions because relationships were analyzed between attitudes and achievement. Comparisons were made between the attribute independent variable (gender). This question was answered using the data from the attitude survey with the addition of a few of achievement variables. Students taking the survey were asked their grades in calculus (M160), physics (PH 141), introduction to mechanical engineering (ME 192), civil engineering principals (CO 192), and college composition (CC 150). The researcher selected these courses because they generally represent first-year requirements for natural science majors. Correlations between the attitudinal variables and the course grades were compared by gender.

#### *Population*

### *Achievement and Participation*

The registrar data analysis was limited to students at Colorado State University. The students who qualified for the study passed calculus (M160) with a D or better in the fall semester of 1991 or 1998 and were true freshman. A “true freshman” in this study was defined as having no prior college education (i.e. no transfers). The requirement to pass the course limits the study to a high level of student ability and allows for comparisons in advanced mathematics, engineering, physics, and chemistry courses. The seven-year gap is a reasonable amount of time to demonstrate the increase or decrease of gender differences over time.

This sample was chosen due to convenience, as it was used in a prior National Science Foundation (NSF) study. Colorado State University along with six other universities participated in the study. The main objective of that study was to determine if technology advances made a difference in achievement in mathematical courses.

### *Attitude*

Students taking calculus II at Colorado State University in the spring of 2004 were administered the survey. This provided a large sample of mathematically talented students. Furthermore, a majority of these students were majoring in engineering, mathematics, or computer science. This is due to the fact that each of these majors requires two semesters of calculus. Therefore, many of them took similar first-year required courses (i.e. physics, mechanical engineering, civil engineering, college composition).

## *Measurement*

Two instruments utilized in this study for measurement purposes were a portion of the Fennema-Sherman Attitude Survey and the Scholastic Aptitude Test (SAT).

### *Fennema-Sherman Attitude Survey*

The survey was a modified version of the original survey created in 1976. There are nine different constructs that the survey measures:

1. confidence in learning mathematics
2. father's attitude toward one as a learner of mathematics
3. mother's attitude toward one as a learner of mathematics
4. teacher's attitude toward one as a learner of mathematics
5. effectance motivation in mathematics
6. attitude toward success in mathematics
7. mathematics as a male domain
8. usefulness of mathematics
9. mathematics anxiety

Each of the constructs contains 12 Likert-scale items with five responses ranging from strongly disagree to strongly agree (see appendix). Of the 12 items, six were positively stated and six were negatively stated. The following are examples of a positively stated item for the confidence in learning mathematics variable and a negatively stated item for the usefulness variable.

1. I am sure of myself when I do mathematics.

2. I don't expect to use math when I get out of school.

When the survey was administered, items were mixed together from various variables to form a single instrument. Scores range from 12 to 60 for each construct, with higher scores indicative of positive attitudes. For example, a high score for the construct "mathematics as a male domain, indicates a less stereotypic view of mathematics.

In 1976, this survey was administered to 367 students, grades 9-12, suburban/rural high schools, mathematics and non-math oriented students (Fennema, 1976). Split half reliabilities were calculated for each of the nine constructs and are listed in table 3.1.

Table 3.1

*Split-Half Reliabilities For The Nine Scales Of The Fennema-Sherman Attitude Survey*

Scale	Reliability
Attitude Towards Success in Mathematics	.87
Mathematics as a Male Domain	.87
Confidence in Learning Mathematics	.93
Effectance Motivation in Mathematics	.87
Usefulness of Mathematics	.88
Father	.91
Mother	.86
Teacher	.88
Mathematics Anxiety	.89

In 1981, the survey was measured for construct validity, which involved 1541 junior high school students (Fennema, 1990). A factor analysis showed that the items

separated into eight different factors. Fennema (1976) determined that confidence and anxiety correlated at .89, but were left as separate constructs because of different interests of researchers.

It should be noted that the male domain construct was reexamined to determine its overall value (Forgasz, 1999). They found that in past studies males have generally stereotyped mathematics more strongly than females. Furthermore, it showed the largest effect size of all attitudinal constructs. This represents that there is in fact a large separation in the distribution of the scores. The major problem with this construct are the possible interpretations of a participant's response. For example, "Girls can do just as well as boys in mathematics". A response of strongly agree may mean that the student believes that mathematics is a gender-neutral domain or that mathematics is still a male domain but it is possible for some females to achieve at the same level as males. As a result of this study it was determined that the level at which mathematics is stereotyped has actually been underestimated in past studies.

#### *Scholastic Aptitude Test (SAT)*

This test is meant to predict freshman grade point average in college. In 2000-2001 the College Board's Handbook showed that the SAT-Verbal and SAT-Math have a correlation of .47 and .48, respectively, with freshman GPA (SAT, n.d.). Therefore, the predictive ability of the SAT is .22, which means that 22% of the variation in freshman grades is explained by the test. The test has not been very effective in predicting grades beyond the freshman year. It was found that only 4% of the variation in college grades was explained by the test. The University of California conducted a study that analyzed

80,000 students over a four-year period (1996-1999). They found that 12.8% of the variation in freshman GPA was explained by the SAT. It should be noted that the test may under-predict female performance and over-predict male performance. It was found that males on average score 35-40 points higher than females, but receive worse grades in high school and college.

### *Pilot Study*

A pilot study was conducted in the fall of 2003 with two classes of calculus. The survey contained a total of thirty-five questions, six of which pertained to demographics, including gender. Since many of the students were first year freshman they were asked to estimate their calculus grade and whether or not they were currently enrolled in physics, chemistry, or computer programming. In addition, participants were asked to list other courses taken.

The remaining 29 questions were attitude questions relating to confidence (7 questions), father's attitude toward one as a learner of mathematics (4), mother's attitude toward one as a learner of mathematics (4), stereotyping mathematics as a male domain (6), and usefulness of mathematics (7). There were 48 usable responses (30 male, 18 female). Each construct, except mathematics as a male domain, showed significant correlations between each of the statements in their respective categories and clumped together in the factor analysis. The seven statements for the construct 'mathematics as a male domain' revealed that six of the responses were related and one was not. The responses to six of the statements were significantly correlated with each other and 'clumped' together in the factor analysis. Statement number thirty-three, "males are not

naturally better than females in mathematics”, was the one that stood alone. The wording of the statement is believed to have caused the wide range of responses. Therefore, this question was deleted from the final survey. Some of the responses to the statements showed lower levels of correlation and did not hang together as well as others, but due to the short length of the survey the rest of the statements were kept. The results for the demographic variables were probably the most useful. It was initially suspected that many of these students would be taking physics, chemistry and computer programming. Only 8% and 10% were taking chemistry and computer programming, respectively. On the other hand, 40%, 35%, 29%, and 21% reported taking physics, college composition, introduction to civil engineering and introduction to mechanical engineering, respectively. Based on the percentages these four courses will be requested. College composition is obviously not a mathematics related course, but due to the high level of participation it was included.

## CHAPTER 4: RESULTS

The purpose of this study was to investigate gender differences in achievement and attitude in college mathematics. Since this study was split into two different components, two separate discussions will follow, one for achievement and one for attitude. The theoretical population for the achievement portion of the study was students at the university level who took calculus, as true freshman, and passed in the fall semester of 1991 or 1998. The accessible population was students at Colorado State University who passed calculus in the fall semester of 1991 or 1998. The actual sample consisted of 194 students from 1991 and 173 from 1998. The theoretical population for the attitude portion of the study was students at universities taking calculus II in the spring of 2004. The accessible population was students at Colorado State University taking calculus II in the spring of 2003. The actual sample consisted of 214 participants.

### *Description of the Sample Population*

#### *Achievement and Participation*

The data used to analyze achievement was obtained from an existing National Science Foundation (NSF) research grant. Only true freshman (first-year students) that passed calculus with a D or better in the fall semester of 1991 or 1998 qualified for the study. Grades from these students were tracked for seven semesters in mathematics and mathematical related courses. Any course taken from the following departments was included: mathematics, chemistry, chemical engineering, civil engineering, electrical engineering, mechanical engineering, and physics. If a student took a course more than once the highest grade was used. Furthermore college GPA, SAT, and Math SAT were

used from the existing data set. Table 4.1 represents the breakdown of students by gender.

Table 4.1

*Gender Demographics By Year*

Year	Male	Female	Ratio
1991	146	48	3:1
1998	135	38	3.5:1

The gender demographics clearly show that males have consistently held about a 3:1 advantage in calculus participation over females.

*Attitude*

The attitude survey was given to students taking calculus II in the spring of 2004. There were 214 participants (156 male, 58 female) in the survey. A pilot study was conducted in the fall of 2003 with calculus students. Two sections participated, producing 48 surveys. The results helped to create an appropriate survey for the attitude portion of the study. Besides attitudes within five constructs (confidence, usefulness, male domain, father's encouragement, mother's encouragement) gender and grades in selected courses were requested. The courses were calculus (M 160), physics (PH 141), introduction to mechanical engineering (ME 192), introduction to civil engineering (CE192), and college composition (CO 150). All of the students who participated in the study had taken calculus but the level of participation in the other courses varied greatly. Table 4.2 represents the number of participants for each course. Finally students were

asked where they had taken calculus. The responses to this question will not play a role in this study.

Table 4.2

*Number Of Students By Gender That Had Taken Each Course*

Course	Male	Female
Calculus	156	58
Physics I	88	21
Mechanical Eng.	38	6
Civil Engineering	33	11
College Composition	94	33

In each of the courses, the ratio is approximately equal ranging from 3:1 to 4:1 in favor of males. Keep in mind that the overall ratio of males to females that participated in the study was about 3:1; therefore, the participation in each course is consistent with regard to gender. Due to the lack of females in both the mechanical engineering and civil engineering courses these will not be used in the analysis.

### *Examination of Research Questions*

#### *Achievement and Participation*

The first main question is meant to reveal a current snapshot of the “gender gap” in college mathematics while the second investigates the trend of gender differences over the past decade.

1. Are there gender differences within mathematically talented students in regard to achievement and participation in mathematics and mathematics related courses at Colorado State University?

To answer this question gender differences were analyzed from the registrar data for the 173 true freshmen that passed calculus in 1998. To determine initial gender differences of the group, *t*-tests were calculated for College GPA, SAT, and Math SAT (Table 4.3).

Table 4.3

*Gender Differences In GPA, SAT, And Math SAT (1998)*

Grade / Score	Male			Female			t	sig	d
	Mean	N	SD	Mean	N	SD			
GPA	2.76	135	.69	<b>3.02</b>	38	.54	-2.52	.029*	.43
SAT	<b>1179</b>	78	106.5	1106	31	114.7	3.16	.002**	.66
Math SAT	<b>618</b>	78	56.3	570	31	60.6	3.89	.000**	.83

\**p* < .05, \*\**p* < .01

Males hold significant advantages in both SAT and Math SAT scores. The effect sizes for these dependent variables are .66 and .83 respectively. This indicates a medium-large strength of relationship between gender with SAT and Math SAT. Furthermore, the effect size depicts a large magnitude of difference between males and females. On the other hand, females show a significant advantage in overall college performance in grade point average. The effect size shows a small-medium strength of

relationship between gender and college GPA along with a small-medium magnitude of difference between groups.

Participation will be analyzed by considering the number of courses taken within a particular department. For example, chemistry represents enrollment in any chemistry class from the fall of 1998 to the fall of 2001 by any of the 173 students. It should be noted that individuals are counted multiple times if they had taken multiple classes from a department. Table 4.4 represents the breakdown by gender.

Table 4.4

*Participation By Gender And Department (1998)*

Department	Males	Females	Ratio (M to F)	Gender Diff. (%)
Chemistry	337	111	3:1	-14
Chemical Engineering	78	<b>57</b>	1.3:1	-63*
Civil Engineering	299	92	3.2:1	-6
Electrical Engineering	<b>318</b>	44	7.3:1	109*
Mathematics	462	142	3.2:1	-6
Mechanical Engineering	<b>319</b>	40	8.1:1	131*
Physics	235	58	4:1	29

\* - denotes significant difference, positive in favor of male, negative in favor of female

These results may appear to be very one-sided in favor of males, but the original sample of students was in favor of males with a ratio of 3.5:1. Therefore chemistry, civil engineering, mathematics, and physics each show approximately equal participation by gender within this sample. Both electrical and mechanical engineering depict advantages in favor of males by more than doubling enrollment of female students, 109% and 131% respectively. Females hold an advantage in chemical engineering by taking 63% more courses than males.

Next, females were compared academically to males in specific classes within each department. Due to the small sample of females many of the courses were not available for analysis. A course qualified for comparison if it contained at least ten female and ten male grades. Table 4.5 shows the comparisons of means (*t*-tests) by gender for each course.

Table 4.5

*Academic Achievement Comparisons By Gender In Natural Science Courses (1998)*

Course	Male			Female			t	sig.
	Mean	N	SD	Mean	N	SD		
General Chemistry	2.80	88	.99	2.99	25	.95	-.85	.394
General Chemistry Lab	3.53	78	.62	3.76	21	.54	-1.70	.098
General Chemistry II	2.73	56	1.05	2.66	21	1.08	.26	.793
General Chem. Lab II	3.43	23	.99	3.73	11	.47	-.93	.362
Eng. Mechanics-Statics	2.67	40	1.10	2.97	11	.75	-.85	.398
Intro. to Electrical Eng.	2.88	33	1.02	3.25	12	.97	-1.09	.281
Calculus	2.64	135	.93	2.77	38	.89	-.78	.438
Calculus II	2.33	98	1.17	2.68	25	.86	-1.67	.102
Calculus III	2.48	77	1.22	<b>3.32</b>	19	.75	-3.80	.000**
Matrices / Linear Algebra	2.99	31	.99	3.54	13	.66	-1.83	.075
Differential Equations	2.93	58	.96	3.20	17	.90	-1.01	.314
Intro. to Thermal Sciences	2.51	39	.68	2.67	11	.93	-.63	.532
Physics for Engineers	2.70	105	.90	2.40	27	.84	1.60	.113
Physics for Engineers II	2.54	81	.98	2.40	20	1.10	.57	.568

\**p* < .05, \*\**p* < .01

Of the 14 courses analyzed only one, calculus III, showed a significant difference in achievement. The mean difference was .84, almost one full letter grade, in favor of females. The effect size was large (*d* = .85), which further depicts a strong difference between grades by gender in this particular course. Females held a non-significant advantage in nine other courses, while males held non-significant advantages in three

courses, two of which were in physics. Similar results were found when independent *t*-tests were run on the truncated data set (plusses and minuses dropped) for 1998. The only difference was that all mean differences were non-significant compared to the one significant difference with the non-truncated data.

Retention rates were also analyzed for the calculus sequence. From calculus to calculus II, males retained 73%, while females retained 66%. From calculus to calculus III, males retained 57%, while females retained 50%. These results should be taken with caution due to the small sample size for females.

The analysis for question two will be approached similarly as question one. First a brief description of gender differences for the 1991 group will be analyzed to obtain an overview of the group. Secondly, gender differences will be analyzed between the two groups (1991 and 1998).

2. Have gender differences in achievement and participation in mathematics and mathematics related courses at Colorado State University changed from 1991 to 1998 within mathematically talented students?

Table 4.6 shows a breakdown of the 1991 sample by gender for College GPA, SAT, and Math SAT.

Table 4.6

*Gender Differences In GPA, SAT, And Math SAT (1991)*

Grade / Score	Male			Female			t	sig
	Mean	N	SD	Mean	N	SD		
College GPA	2.86	146	.61	2.99	48	.60	-1.36	.176
SAT	1170	74	97.1	1180	24	136.6	-.35	.731
Math SAT	606	74	60.9	618	24	70.1	-.74	.460

\*p < .05, \*\*p < .01

The statistics shows that there exist no significant gender differences in each of the grades or scores. Females show non-significant advantages in each category, but overall the results represent equality between genders unlike the 1998 sample of students. The only other point that should be noted is that in both SAT and Math SAT males had a smaller standard deviation, which represents more consistency within their group compared to the females. Table 4.7 re-enforces the overall equality of the two groups by showing representation of high and low-end students in each category.

Table 4.7

*Maximum And Minimum Scores By Gender In GPA, SAT, And Math SAT (1991)*

Gender	GPA		SAT		Math SAT	
	Min.	Max.	Min.	Max.	Min.	Max.
Male	1.55	4.00	900	1390	410	800
Female	1.79	4.00	880	1390	460	760

There are considerable performance differences with the background variables when the 1998 group is compared to the 1991 group. It was determined that in 1991

there was essentially no difference between males and females, but by 1998, there were significant differences in all three categories. Males outperformed females in overall SAT score and Math SAT score, while females gained the advantage in overall college GPA.

As with the previous research question, participation will be broken down by various natural science departments. For each department, gender differences in participation are depicted. As with the 1998 sample, students taking multiple courses within a department are counted multiple times. Before participation comparisons are made between the two groups, it is important to analyze the 1991 sample apart from the 1998 group. Keep in mind that the overall ratio of males to females in the 1991 group was exactly 3:1.

Table 4.8

*Participation By Gender And Department (1991)*

Department	Males	Females	Ratio (M to F)	Gender Diff. (%)
Chemistry	319	<b>155</b>	2:1	-33*
Civil Engineering	409	106	3.8:1	27
Electrical Engineering	247	74	3.3:1	10
Mathematics	672	201	3.3:1	10
Mechanical Engineering	<b>418</b>	65	6.7:1	123*
Physics	283	78	3.5:1	17

\* - denotes significant difference, positive in favor of male, negative in favor of female

Due to the fact that in the overall sample, males outnumbered females there were no significant gender differences in civil engineering, electrical engineering, mathematics, and physics. Chemistry is the one subject area where females had an

advantage, while mechanical engineering shows male dominance by taking twice as many courses as females.

Now that a general discussion has been given for both the 1991 group and the 1998 group, it is time to compare differences over the seven-year gap. Remember that the overall ratio of males to females in 1998, 3.5:1, was about the same as the ratio in 1991. Furthermore the overall sample of males dropped 8% from 1991 to 1998 and females dropped 20%, therefore it is expected that participation numbers would decrease for many of the departments for both genders.

Table 4.9

*Participation By Gender And Department Over Time*

Department	Ratio (M to F)		Gender Diff. (%)
	1991	1998	
Chemistry	2:1	3:1	33*
Civil Engineering	3.8:1	3.2:1	-33*
Electrical Engineering	3.3:1	7.3:1	105*
Mathematics	3.3:1	3.2:1	-19
Mechanical Engineering	6.7:1	8.1:1	5
Physics	3.5:1	4:1	-2

\* - denotes significant difference, positive in favor of male, negative in favor of female

Males significantly increased participation over females in chemistry and electrical engineering. Females showed significant advantages only in civil engineering. Due to the fact that the ratio of males to females increased from 1991 to 1998, gender differences in chemistry, physics, and mechanical engineering remained about the same. Chemical engineering was not available for comparison because it was not requested in the 1991 group.

Comparisons will now be given regarding academic achievement of students in the 1991 group. As with the 1998 group only natural science courses with at least ten males and ten females will be used. Seventeen classes met this requirement and *t*-test results are shown in Table 4.10.

Table 4.10

*Academic Achievement Comparisons By Gender In Natural Science Courses (1991)*

Course	Male			Female			t	sig.
	Mean	N	SD	Mean	N	SD		
Intro. to Chem I	2.87	38	.88	2.80	10	.92	.22	.829
Intro. to Chem II	3.13	40	.61	3.20	10	.42	-.37	.715
General Chemistry	2.88	75	.93	2.87	23	.97	.05	.963
General Chemistry Lab	3.19	68	.72	3.56	18	.62	-1.97	.052
General Chemistry II	2.65	63	1.02	2.31	16	1.14	1.16	.250
General Chemistry Lab II	3.11	18	.68	3.18	11	.60	-.28	.778
Eng. Mechanics-Statics	2.85	62	.87	2.50	12	1.24	1.21	.232
Eng. Mech.-Dynamics	3.02	47	.85	3.00	10	.94	.07	.944
Intro. to Electrical Eng.	<b>2.91</b>	43	.72	2.18	11	.75	2.96	.005**
Calculus	2.42	146	.95	<b>2.75</b>	48	.93	-2.12	.035*
Calculus II	2.18	114	1.04	2.45	33	1.28	-1.13	.272
Calculus III	2.47	88	1.14	2.62	26	1.24	-.58	.567
Matrices / Linear Alg.	3.69	74	.60	3.71	24	.55	-.14	.889
Differential Equations	2.86	71	.98	2.73	22	.90	-.58	.567
Intro. Thermal Sciences	2.43	54	1.13	2.88	16	1.03	-1.42	.158
Physics for Engineers	2.70	122	1.00	2.37	26	1.00	1.74	.085
Physics for Engineers II	2.63	110	.94	2.58	26	.86	.25	.803

\**p* < .05, \*\**p* < .01

Only 2 of the 17 courses had significant gender differences. One was introduction to electrical engineering which showed a large advantage for males with a large effect size (*d* = .99). This represents that the male scores, on average, were about one standard deviation ahead of the females. On the other hand females held a slight statistically

significant advantage in calculus with a medium effect size ( $d = .35$ ). The rest of the courses were relatively even in academic performance.

Retention rates were also analyzed for the calculus sequence. From calculus to calculus II, males retained 78%, while females retained 69%. From calculus to calculus III, males retained 60%, while females retained 54%. These results should be taken with caution due to the small sample size for females.

Now that separate descriptions have been given for achievement in 1991 and 1998 it is time to analyze gender differences between the groups. Fifteen 2 x 2 ANOVA's were calculated for each common course. A course qualified for comparison if it contained at least ten females and ten males in each of the two groups. Table 4.11 represents the level of significance for the main effects (gender and year) and the overall interaction. It should also be noted that the 1998 grades were truncated so that it would be consistent with the 1991 data (limitation).

Table 4.11

*Means, Standard Deviations, And Analysis Of Variance (ANOVA) Results For Gender And Year*

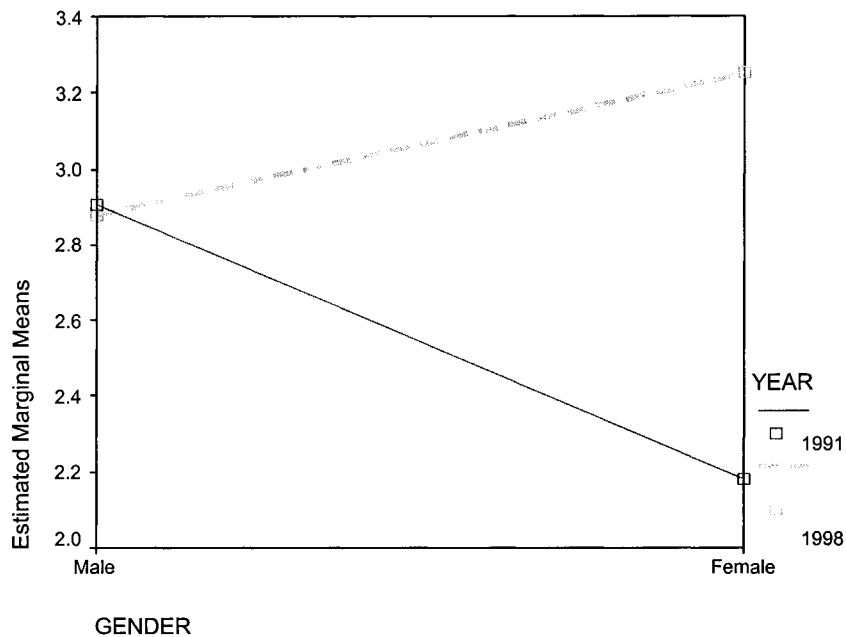
	1991		1998		ANOVA F		
	Mean	SD	Mean	SD	Gender (G)	Year (Y)	G x Y
C111					.41	.01	.51
Male	2.88	.93	2.78	1.00			
Female	2.87	.97	3.00	.96			
C112					6.56*	5.31*	.30
Male	3.19	.72	3.53	.62			
Female	3.56	.62	2.49	.87			
C113					.88	1.57	.57
Male	2.65	1.02	2.75	1.05			
Female	2.31	1.14	2.71	1.10			
C114					.79	4.50	.29
Male	3.11	.68	3.43	.99			
Female	3.18	.60	3.73	.47			
CE260					.01	.56	2.02
Male	2.85	.87	2.70	1.14			
Female	2.50	.62	3.00	.78			
CE261					.51	4.67*	.51
Male	3.02	.85	2.36	1.04			
Female	3.00	.94	2.67	.50			
EE204					.74	6.35*	<b>7.05**</b>
Male	2.91	.72	2.88	1.02			
Female	2.18	.75	3.25	.97			
M160					4.76	1.04	.46
Male	2.42	.95	2.61	.94			
Female	2.75	.93	2.79	.91			
M161					3.43	1.30	.05
Male	2.18	1.04	2.34	1.18			
Female	2.45	1.28	2.68	.85			
M229					3.84	9.11**	3.33
Male	3.69	.60	3.00	1.00			
Female	3.71	.55	3.54	.66			
M261					6.28**	3.31	3.05
Male	2.47	1.14	2.48	1.22			
Female	2.62	1.24	3.32	.75			
M340					.15	2.97	1.27
Male	2.86	.96	2.97	.96			
Female	2.73	1.03	3.24	.90			
ME237					2.31	.02	.29
Male	2.43	1.13	2.51	.68			
Female	2.88	1.03	2.73	1.01			
PH141					5.49*	.03	.00
Male	2.70	1.00	2.72	.93			
Female	2.37	1.00	2.41	.84			
PH142					.50	.47	.16
Male	2.63	.94	2.58	1.02			
Female	2.58	.86	2.40	1.19			

\*p &lt; .05, \*\*p &lt; .01

The analysis will begin with the main effect gender. Three courses showed significant differences when year was not considered. Females held the advantage in both C112 (general chemistry lab) and M261 (calculus III), while males held the advantage in PH141 (physics for engineers). Eta was calculated for each of these courses and were .2, .17, and .14 respectively. Each of these figures represents a small effect size and therefore shows a small magnitude of difference between the genders. The next main effect is year and four courses showed significant overall differences. The 1998 courses that contained an advantage were C112 and EE204 (introduction to electrical engineering). On the other hand, CE261 (introduction to thermal sciences) and M229 (matrices and linear algebra) had higher overall grades in 1991. This essentially shows a level of grade inflation or deflation in these courses over the seven-year gap. The only course to contain a significant interaction was EE204. This interaction represents a significant increase in grades in females from 1991 to 1998 while males remained relatively stable. The interaction can best be seen in the graph of Figure 4.12. Eta squared was calculated to be .07, which explains 7% of the difference just by knowing the year the course was taken.

Figure 4.12

*Estimated Marginal Means Plot Of Introduction To Electrical Engineering*



Additionally 2 x 2 ANOVAs were calculated using Math SAT as a covariate. But due to the fact that many students had not taken the SAT the sample size was too small to analyze the data with meaningful results.

The retention rates from calculus to calculus II and calculus III, as seen in Table 4.13, show that for each category males hold a 6-9% advantage over females. This difference was approximately maintained over time and thus there was no change in gender differences from 1991 to 1998.

Table 4.13

*Retention Rates (all numbers in percentages) From Calculus To Calculus II And Calculus III*

Course Sequence	1991		1998	
	Male	Female	Male	Female
Calculus to Calculus II	78	69	73	66
Calculus to Calculus III	60	54	57	50

*Attitude*

The third main research question is meant to investigate the current situation in attitude differences by gender. The fourth question explores the relationships in gender differences between mathematical attitude and achievement.

3. Are there gender differences in the attitudes toward mathematics at Colorado State University within mathematically talented students?

To best analyze each attitude construct, questions were grouped together and responses were summated to produce individual scores in each of the five areas. Negatively worded question responses were reversed to make the data set uniform. Table 4.14 lists each construct along with each possible score. A score of 35 in confidence represents a student that strongly agreed with each question regarding their confidence in mathematics.

Table 4.14

*Attitude Constructs*

Attitude Construct	Number of Questions	Possible Score
Confidence	7	7-35
Usefulness	7	7-35
Stereotype	6	6-30
Perception of Father	4	4-20
Perception of Mother	4	4-20

A factor analysis was calculated (refer to chapter 3) for the pilot study that contained most of these questions. It was determined that each question in the survey accurately described the construct it was intended to and was grouped together with questions measuring the same construct. Table 4.15 analyzes gender differences in each of the attitude constructs.

Table 4.15

*Gender Differences In The Means Of Summated Attitude Constructs*

Attitude Construct	Male			Female			t	sig	d
	M	N	SD	M	N	SD			
Confidence	27.54	153	4.7	<b>29.07</b>	54	4.2	2.1	.036*	.34
Usefulness	29.09	153	4.0	30.27	55	4.1	1.7	.090	
Stereotype	<b>12.70</b>	148	3.7	9.60	55	2.6	-6.7	.000**	.99
Father	15.04	151	2.5	<b>17.00</b>	54	2.8	2.4	.019*	.37
Mother	16.07	151	2.3	<b>16.84</b>	55	2.5	2.1	.041*	.32

\*p < .05, \*\*p < .01

The statistics show gender differences in four of the five attitude constructs. Females show significant advantages in their confidence in mathematics, their perception of the

encouragement that they receive from their fathers and mothers. Although the differences are statistically significant, the effect size for each construct was small to medium in strength. This represents that the magnitude of difference between genders was fairly small. On the other hand, males believed that mathematics was more of a male subject (labeled stereotype). The effect size was large ( $d = .99$ ), which represents a full standard deviation difference in scores by gender.

4. Are there relationships between achievement and mathematical attitude by gender within mathematically talented students at Colorado State University?

Research question number three only analyzed attitude, but question four investigates the relationship between achievement and attitude. To obtain an overview of the sample, *t*-tests were calculated to analyze gender differences in commonly taken freshman courses. Two of the five courses requested, civil engineering and mechanical engineering, produced samples that were too small to analyze. Table 4.16 depicts the gender differences in the three remaining courses.

Table 4.16

*Gender Differences In Selected Courses*

Course	Male			Female			t	sig	d
	M	N	SD	M	N	SD			
Calculus (M160)	2.93	156	.84	2.80	58	.80	1.1	.290	
Physics (PH141)	2.53	88	.92	2.45	21	.87	.4	.708	
College Comp. (CO150)	3.29	94	.62	<b>3.59</b>	33	.46	-2.6	.010**	.57

\* $p < .05$ , \*\* $p < .01$

Only college composition showed significant gender differences in grades.

Females held three tenths of a point advantage over males with a medium effect size.

A student was rated high or low in each attitude construct if their score fell above or below the mean for their gender. Then for each attitude construct, along with gender, 2 x 2 ANOVAs were calculated for grades in calculus, physics, and college composition.

Each attitude construct was analyzed separately. Any significant differences found for the main effect of gender will not be discussed in detail because it essentially represents the findings in the *t*-tests calculated in Table 4.16. College composition was the only course that contained a significant difference across gender, which explains the significant gender main effect for each of the attitude constructs in the following tables.

Table 4.17 analyzes gender differences in the relationship between achievement and confidence.

Table 4.17

*Means, Standard Deviations, And Analysis Of Variance (ANOVA) Results For Gender And Confidence*

	High Confidence		Low Confidence		ANOVA F		
	Mean	SD	Mean	SD	Gender (G)	Confidence (C)	G x L
Calculus (M160)					1.46	24.97**	2.22
Male	3.29	.73	2.52	.75			
Female	2.97	.71	2.56	.82			
Physics (PH141)					.11	.13	1.12
Male	2.65	1.02	2.32	.72			
Female	2.33	.81	2.49	.87			
College Comp. (CO150)					6.85**	.57	3.74
Male	3.46	.53	3.14	.65			
Female	3.54	.53	3.68	.39			

\*p < .05, \*\*p < .01

The only main effect for confidence was found in calculus. This seems rather straightforward because students that are confident in mathematics would be expected to

perform better than less confident students. Furthermore eta squared (.11) shows that 11% of student's grades in calculus can be predicted just by knowing their level of confidence in mathematics. Surprisingly, there was no difference in high and low mathematically confident students and their grades in physics. There were no significant interactions.

Table 4.18 analyzes gender differences in the relationship between achievement and usefulness.

Table 4.18

*Means, Standard Deviations, And Analysis Of Variance (ANOVA) Results For Gender And Usefulness*

	High Usefulness		Low Usefulness		ANOVA F		
	Mean	SD	Mean	SD	Gender (G)	Usefulness (U)	G x U
Calculus (M160)					1.35	5.23*	.59
Male	3.12	.82	2.73	.80			
Female	2.87	.80	2.68	.80			
Physics (PH141)					.02	.22	2.63
Male	2.73	.92	2.25	.85			
Female	2.39	.83	2.66	.99			
College Comp. (CO150)					6.77**	.03	1.15
Male	3.35	.60	3.24	.63			
Female	3.53	.43	3.68	.49			

\*p < .05, \*\*p < .01

As with confidence, usefulness contained one significant main effect in calculus. Students who predict that mathematics will be useful in their future achieved significantly higher grades. Only 3% of student's achievement in calculus can be determined by knowing their level of mathematics usefulness (eta squared = .03). Attitudes about the usefulness of mathematics did not carry over to make a difference in physics or college composition. There were no significant interactions.

Table 4.19 analyzes gender differences in the relationship between achievement and stereotype.

Table 4.19

*Means, Standard Deviations, And Analysis Of Variance (ANOVA) Results For Gender And Stereotype*

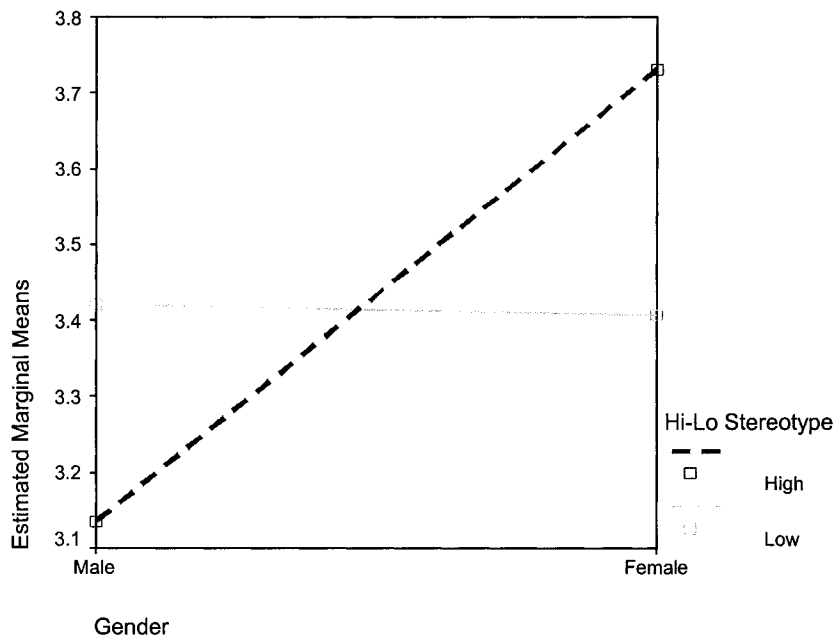
	High Stereotype		Low Stereotype		ANOVA F		
	Mean	SD	Mean	SD	Gender (G)	Stereotype (S)	G x S
Calculus (M160)					1.25	1.01	1.81
Male	2.95	.82	2.91	.85			
Female	2.63	.77	2.94	.80			
Physics (PH141)					.01	1.34	2.26
Male	2.48	.77	2.56	.98			
Female	2.84	.95	2.25	.77			
College Comp. (CO150)					5.91**	.03	<b>6.45*</b>
Male	3.14	.65	3.42	.58			
Female	3.73	.35	3.41	.54			

\*p < .05, \*\*p<.01

There were no significant main effects based on the level at which students stereotype mathematics. Thus regardless of whether or not the attitude of students re-enforce the stereotype in mathematics, course grades are not significantly affected. There was a significant interaction with regard to college composition. Essentially this means that females who believe mathematics is more of a male domain do much better in college composition than females who are less stereotypical of mathematics. Males on the other hand perform worse in this course when they stereotype mathematics as a male subject. Figure 4.20 depicts a graphical representation of this ordinal interaction. Furthermore 5% of female grades in composition can be predicted by their level of stereotype in mathematics (eta squared = .05).

Figure 4.20

*Estimated Marginal Means Plot For College Composition And Stereotype*



The graph shows the disparity in grades for each gender by the level that they stereotype mathematics.

Table 4.21 analyzes gender differences in the relationship between achievement and father's encouragement.

Table 4.21

*Means, Standard Deviations, And Analysis Of Variance (ANOVA) Results For Gender And Father's Encouragement*

	High Father		Low Father		ANOVA F		
	Mean	SD	Mean	SD	Gender (G)	Father (F)	G x F
Calculus (M160)					1.64	5.81*	.46
Male	3.15	.79	2.75	.83			
Female	2.90	.77	2.67	.82			
Physics (PH141)					.07	.79	.02
Male	2.60	.94	2.42	.90			
Female	2.57	.92	2.33	.89			
College Comp. (CO150)					6.87**	.26	.09
Male	3.23	.59	3.33	.64			
Female	3.59	.48	3.61	.46			

\*p < .05, \*\*p < .01

The only main effect of father's level of encouragement was in calculus. Students who have higher levels of encouragement do better than students with less supportive fathers. About 3% of student grades in calculus can be determined solely on the level of encouragement that they receive from their father (eta squared = .03). There were no significant interactions.

Table 4.22 analyzes gender differences in the relationship between achievement and mother's encouragement.

Table 4.22

*Means, Standard Deviations, And Analysis Of Variance (ANOVA) Results For Gender And Mother's Encouragement*

	High Mother		Low Mother		ANOVA F		
	Mean	SD	Mean	SD	Gender (G)	Mother (M)	G x M
Calculus (M160)					2.45	5.60*	.01
Male	3.10	.85	2.80	.80			
Female	2.91	.81	2.59	.75			
Physics (PH141)					.03	.14	.09
Male	2.60	.99	2.45	.87			
Female	2.49	.90	2.47	.88			
College Comp. (CO150)					6.46*	.02	.23
Male	3.31	.45	3.27	.71			
Female	3.57	.48	3.64	.46			

\*p < .05, \*\*p < .01

The findings for mother's level of encouragement were similar to those in father's level of encouragement. The only main effect was in calculus. In general students who have higher levels of encouragement from their mothers do better than students with less support. About 3% of student grades in calculus can be determined solely on the level of encouragement that they receive from their mother (eta squared = .03). These findings represent that students receive very similar support from each of their parents.

## CHAPTER 5: DISCUSSION

For the past few decades, the phenomenon of gender differences in mathematics has inspired many researchers to try to determine if in fact there are differences, and if so, where those differences are. It has become accepted knowledge that gender differences, in favor of males, are present in achievement and attitude, but are decreasing (Tapia, 2000; Flores 1990). Numerous descriptive studies have added to the wealth of knowledge in the field and each one is vital in revealing the status of gender differences, which helps to give direction to reforms such as single-gender classrooms or cooperative learning.

This study provides a picture of gender differences in achievement and attitude within mathematically talented students at the college level. There were two main components of the study. First, students from two groups in the 1990's were tracked for achievement and participation over a seven-semester period. The analysis begins by analyzing gender differences in background variables, achievement variables, and participation for the current (1998) sample. Then the early (1991) sample was compared to the current sample to determine the trend in gender differences over time for the same variables mentioned above. The second component of this study analyzed current attitudes of mathematically talented students at the college level. In addition, various course grades were collected so that connections and contrasts could be made between achievement and attitudes for each gender.

The hope was not only to help depict the current state of gender differences in college mathematics, but also to raise the level of awareness to encourage females to enter into mathematical fields.

The researcher hypothesized that females would show advantages in achievement and attitude, but severe disadvantages in participation. This theory was created by the belief that only highly competent females enter into mathematics because of the negative social stigma that surrounds their presence. Whereas many males enter into mathematics to satisfy their gender role identity when in reality their talents lie in areas outside of mathematics. The participation gender differences were easy to predict because of the researchers experiences within the college mathematics classroom. The hypothesis that females would be at an advantage in attitude was created by a similar rationale as above. In order for females to be successful within mathematics, they must be very confident in their presence and ability or they probably would have been scared off by societies underlying belief that mathematics is more of a male subject.

#### *Overview of Findings and Relationship to the Literature*

The discussion of the results will be broken into three parts. First, a discussion will be given in regard to the first two research questions. These questions dealt with gender differences currently (1998-2001) and over time (1991-2001) in achievement and participation. The second part will discuss research questions three and four. These questions dealt with current (2004) gender differences in attitudes and relationships between attitudes and achievement. Finally, an overview of the entire study will be given in the conclusion portion that compares and contrasts the two main components.

### *Achievement and Participation*

Within the mathematically talented students in 1998 males held a significant advantage in SAT and Mathematics SAT scores. On the other hand, females showed a significant advantage in overall college performance in grade point average. These findings are ironic because the SAT is meant to predict first year college performance, but coincide with previous studies that found that males scored significantly higher on average than females on the SAT (Navarro, 1989; Becker, 1990). The same background variables were analyzed for gender differences for the 1991 sample. Unlike the 1998 sample there were no significant gender differences in regard to college grade point average, SAT score, or Mathematics SAT score. Therefore gender differences increased over time in for each of the three background variables. Males gained an advantage in both SAT and Mathematics SAT scores, while females gained an advantage in overall college grade point average.

The participation ratio for the 1998 sample was 3.5 males for every one female. This ratio re-enforces Davenport's observations of college students that depicted males significantly outnumbering females in mathematics courses (Davenport, 1998). But it contradicts findings at the University of Edinburgh that showed that women comprise half of the enrollment in mathematics courses (Fraser, 1994). A closer look at participation by department was done next. In four of the seven departments analyzed; chemistry, civil engineering, mathematics, and physics, the participation of males to females stayed relatively proportional to the original sample of students. Therefore these departments did not attract a higher percentage of females or males. But in both mechanical and electrical engineering males were drawn to the subject about twice as

much as females. Koller offers a possible solution for this by showing that males performed better than females in tasks dealing with problem solving (Koller, 2001). Another possible explanation is the stereotype that appears within mathematics text books. Researchers found that in most story problems involving an engineer a white male was used (Fennema, 1990). Chemical engineering was the only department that attracted a higher relative percentage of females.

As with the 1998 group, participation was analyzed for the 1991 sample in all of the same natural science departments except chemical engineering. The proportion of enrollment in civil engineering, electrical engineering, mathematics, and physics each were relatively proportional to the overall sample of students (three to one in favor of males). Females were found to take more chemistry classes, while males enrolled in more mechanical engineering courses.

Now the analysis of the trend of gender differences in participation over the seven-year period from 1991 to 1998 will begin. The participation rates remained similar between the two groups in chemistry, physics, and mechanical engineering. Participation rates for males in electrical engineering increased for males when compared to females, while female participation increased at a higher rate in both civil engineering and mathematics. The increased participation by females over-time coupled with the overall male dominance in participation supports prior research. In 1996, Rech found that females elect to take fewer advanced courses in mathematics, but the bigger picture reveals that females are closing the gender gap (Flores, 1990; Tapia, 2000).

The next area that was analyzed was gender differences in achievement within courses offered through the natural science departments previously mentioned. Of the

fourteen courses analyzed only one, calculus III, showed a significant difference in favor of females. Furthermore females held a non-significant advantage in nine other courses, while males held non-significant advantages in only three, two of which were in physics. These findings initially may appear to show females outperforming males, but due to the significance level set at five one-hundredths, the researcher would expect by pure probability that about one in twenty *t*-tests would show a significance. The researcher could have reduced the significance level, but in most cases the significance level was far less than .01. It would be possible to try to account for this with a post-hoc test (i.e. Bonferroni), but the aim of the research was purely exploratory. Therefore caution should be used throughout the achievement findings. One slight gender difference was found in the standard deviations. They depict that in most courses females tend to score closer to the overall mean thus having a smaller range of abilities, whereas the male sample contains more extreme high and low cases.

Of the 17 courses analyzed in 1991 only two showed significant gender differences. Females held the advantage in one course, calculus, while males showed an advantage in introduction to electrical engineering. The advantage in calculus is interesting because it is an entry level course and all of the students in the study were first semester freshman when they took it. Therefore, females appeared to be better prepared to succeed at the start of college, but their advantage does not continue into later mathematics courses or in other natural science courses. This also goes against the gender differences found within the Mathematics SAT scores, which showed males at an advantage. Another overlap in findings occurs within electrical engineering. Males were found to have a strong advantage in participation in courses offered through that

department and also show a significant advantage in achievement in a fundamental course within that department.

To analyze gender differences in achievement over time, 15 courses were compared. The only course that showed a significant interaction effect was introduction to electrical engineering. In this course males showed relatively no change in achievement from 1991 and 1998, 2.91 and 2.88 respectively. Females on the other hand showed an enormous increase in performance jumping from 2.18 to 3.25. It was surprising that there were no significant interactions in either calculus or calculus III. In 1991 there was no gender difference in calculus, but by 1998 females held a significant advantage. Similarly in calculus III female average dropped off considerably over-time (3.3 to 2.6) while males maintained a 2.5 average. Due to the lack of statistical significant differences it is concluded that gender differences have remained constant over-time. This contradicts earlier research that depicts females closing the gender gap (Flores, 1990; Tapia, 2000).

#### *Attitude*

Of the five attitude constructs that were analyzed four of them showed significant gender differences. Only usefulness of mathematics did not prove to have a significant gender difference.

Confidence showed significant advantages for females, which contradicts prior research that showed high school males have more self-confidence than females (Tapia, 2000; Casey, 2001). The level of encouragement from parents (both mother and father) that is perceived by the student is also in favor of females. This refutes the trend found in

the late 1980's and 1990's that depicted women receiving less encouragement at home (Navarro, 1989; Casey, 2001). Also in 1977 the United States Government acknowledged the presence of favoritism by parents and set an initiative to "...actively oppose sex-role stereotyping...and to develop programs to inform parents of the need for increased mathematical training for all students" (Fennema, 1990, p11). This shows that finally after 25 years parents have received the message that their daughters deserve the same opportunities as their sons. One construct that showed males at an advantage was the level at which mathematics is stereotyped as a male domain. They agree more strongly than females that mathematics is a male domain, which support Fennema's study (2002). Furthermore a recent study showed that these differences in stereotyping may actually be underestimated due to the ambiguity of the statements (Forgasz, 1998). For a further discussion of this theory refer to the literature review.

The one construct that did not show significant gender differences was how useful mathematics would be to their career, which shows progress from a past study that showed that females were less convinced than males that mathematics would be useful to them (Fennema, 1990). In that study it was found that males are encouraged to work on high-level cognitive problems, while females are encouraged to focus on rule-bound computational skills. Thus males were exposed to problems that have real world applications while females were given less 'important' mathematics problems.

The second portion of the attitude component was limited due to the lack of overlap in the sample's first semester coursework. Only three courses had sufficient participation, one of which was college composition. The results in this course are relevant because the content in this class focuses on verbal and reading skills which are

traditionally viewed as the opposite of mathematical skills. Females held an overall significant advantage in the course. This is ironic because most of the students in this study are on a career path that leans toward mathematics and therefore should perform similarly. This supports Casey's (1999) study that showed that mothers of first graders tended to associate verbal/reading activities with females and mathematics activities with males. The other two courses, physics and calculus, showed no significant gender differences. This supports the trend that females are decreasing gender differences in attitude and to a lesser extent achievement.

To connect attitudes with achievement each participant was labeled either high or low depending on if his/her ratings were above or below the mean for each construct. The findings for the stereotype construct along with the college composition class proved to be the most interesting result. Each gender showed inverse results in achievement when high and low stereotyping was factored in. Therefore, females that are more stereotypical of mathematics as a male domain perform better in college composition than females who are less stereotypical and the opposite is true for males. This again supports Casey's study (1999) that equated mathematical skills with males and verbal skills with females.

### *Conclusions*

The overall conclusions of this study show that females are continuing to close the gender gap in achievement and in their attitudes. The biggest issue was that in both components of the research females were severely outnumbered. The females that have

chosen to study mathematics and mathematics related courses have fared as well as males academically and are engrained with positive attitudes towards mathematics.

Many believed these results should be expected due to the fact that the students involved in this study are the “best of the best”. It would seem logical to analyze gender differences in achievement where they first occur (i.e. elementary, junior high), but it is also important to study levels the differences are less apparent. Therefore the results support past studies that predict that gender differences narrow, as students get older (Casey, 2001; Koller, 2001; Xin, 1995).

The major similarity between the two components was that there existed little to no gender difference in performance. Females did however show achievement advantages in the non-mathematical variables. They held significant advantages in college grade point average and in college composition.

There are also visible trends between the two components. Females are decreasing the participation ratio and making achievement gains. The ratio of students that qualified for the registrar part of the study in 1998 was 3.5:1 in favor of males and then it decreased to 2.7:1 in the sample that participated in the attitude survey in 2004. Also between 1998 and 2001 male mean score in calculus dropped three tenths of a point while females dropped only three one hundredths of a point.

Society’s view is a major factor in erasing gender differences in mathematics. Although ultimately the challenge of learning is up to the individual, success often times hinges on the level of support they receive from the people around them. This study supports the theory that gender differences in mathematics are purely cultural. The main difference occurred in participation but there was essentially none in achievement. The

researcher believes the findings from this study parallel a story of a female engineer who had to overcome herself for success (Turk, 2004). She realized that one of the biggest problems in the struggle for success is not in ability but in effort and attitude.

Mathematics is a very demanding subject and regardless of gender a student will eventually become overwhelmed and frustrated. When females hit this point often times the natural reaction is to give up because the realization meets the stereotype that she cannot succeed in mathematics. When a male reaches this point he fights through the problems, which is ultimately fueled by the confidence that society instills in him. The female engineer "...worried that (her) gender was holding (her) back, until (she) realized the boys were studying just as hard (as her)" (Turk, 2004, p 12). This is a perfect example of a student who contained the ability, but had to overcome her internal beliefs before success was reached.

#### *Assumptions and Limitations*

1. Many issues arose with regard to the Scholastic Aptitude Test scores in the archive data set. In this dissertation the variable was used as a dependent variable but could not be used as a covariate variable in the analysis of achievement. Only about half of the students that were selected for this study had taken the SAT. Due to the lack of information SAT was not used as a covariate variable. Another problem with the SAT scores dealt with score inflation. The NSF investigators were concerned with this issue and adjusted the scores. The researcher for this study was unable to find the justification for these adjustments.

2. Another limitation with the archive data set is that the grades from the 1998 sample were truncated to make the grades uniform with the 1991 sample. Therefore caution should be exercised when interpreting the results. One last issue with the data is the lack of information for the chemical engineering department for the 1991 sample. It may have been mistakenly un-requested in the NSF study.
3. It is assumed that courses with the same titles that were taken from different instructors or at different times are relatively equivalent. Furthermore, it is assumed that course curriculum remains similar over time and that course instructors used similar grading criteria.
4. The attitude survey was administered during the week before spring break at the middle of the semester. Also the second of four exams, which covered the hardest (traditionally) material of the semester in calculus II, was given at the end of that week. Therefore the responses to the attitude survey may have been influenced by the pressures of a very challenging time period. As a result constructs such as confidence or stereotypical beliefs may have been altered.
5. Another concern with the attitude survey was the choice of descriptor words for male and female. The survey was originally created to measure high school students and therefore gender was referred to as boy or girl. One participant left her survey incomplete. She expressed written concern that she was a mother and did not feel the survey applied to her.

6. The attitude survey will ask for grades in prior courses. Students may have taken the same course at a different institution. The researcher assumes a course is similar in content regardless of where or when it was taken.

### *The Next Logical Research Questions*

1. Test the predictive power of the SAT, ACT, and/or other college placement exams with first year college grade point average. Furthermore analyze gender differences with the verbal and mathematics scores in each test. Determine whether or not there are bias questions, in particular in geometry, which favors males. In 1990, Becker found that when seventh, eighth, and ninth graders took the SAT males had a significant advantage. The researcher attributed the difference in scores to biased questions in geometry. In 1998, Dorner found that females taking their mathematics entrance exam were under-predicted in comparison to their actual grades. Students should be tracked after their placement exam to determine if the field they enter correlates with their score and how well they ultimately do. Check specifically for females with high placement exam mathematics scores that enter and/or excel in non-mathematical fields and males with low scores that go into a mathematical field. These students may hold the answers to the social stigma that creates unnecessary gender differences.
2. In the 1998 group relative participation (percentage compared to the overall sample) levels in mechanical and electrical engineering favored males. On the other hand females were more apt to take more chemical engineering courses. Therefore a study should analyze the marketing strategies within these fields to

determine what draws one gender over the other. The researcher should probably take a qualitative approach to understand the social atmosphere of the department and careers offered within.

3. The Fennema-Sherman attitude survey has been a vital tool in numerous studies since 1976. The researcher suggests a meta-analysis be conducted to attempt to synthesis the various results.
4. There was an overwhelming advantage for males in participation in mathematics and mathematics related courses. Furthermore, many females in this study eventually left the various departments (i.e. electrical engineering) as they progressed through college. A qualitative study should be conducted to analyze the potential issues that would be gender biased. A few examples might include issues with guidance counselors, teachers, and marketing schemes in college departments.

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## APPENDICES

## ATTITUDE SURVEY

1. Gender
  - Male
  - Female
2. Where did you take Calculus I (M160 or equivalent)?
  - Colorado State University
  - High School
  - Community College
  - Four-Year University other than Colorado State University
3. What was your grade in Calculus I (M160 or equivalent)? (Circle one)  
A    A-    B+    B    B-    C+    C    C-    D    F
4. If you have taken Physics I (PH 141), what was your grade?  
A    A-    B+    B    B-    C+    C    C-    D    F
5. If you have taken Introduction to Mechanical Engineering (ME 192), what was your grade?  
A    A-    B+    B    B-    C+    C    C-    D    F
6. If you have taken Civil Engineering Principles (CE 192), what was your grade?  
A    A-    B+    B    B-    C+    C    C-    D    F
7. If you have taken College Composition (CO 150), what was your grade?  
A    A-    B+    B    B-    C+    C    C-    D    F
8. I am sure that I can learn mathematics.
  - strongly agree
  - agree
  - neutral
  - disagree
  - strongly disagree
9. I'll need a firm mastery of mathematics for my future work.
  - strongly agree
  - agree
  - neutral
  - disagree
  - strongly disagree

10. Girls who enjoy studying math are a bit peculiar.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

11. My mother thinks I need to know just a minimum amount of math.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

12. I don't think that I could do advanced mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

13. Knowing mathematics will help me earn a living.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

14. Girls can do just as well as boys in mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

15. My mother thinks I'll need mathematics for what I want to do after I graduate from college.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

16. I'm not the type to do well in mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

17. I see mathematics as a subject I will rarely use in my daily life as an adult.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

18. I would expect a woman mathematician to be a masculine type of person.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

19. As long as I have passed, my father hasn't cared how I have done in math.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

20. I can get good grades in mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

21. Taking mathematics is a waste of time.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

22. Males are naturally better than females in mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

23. My father thinks that mathematics is one of the most important subjects I have studied.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

24. For some reason even though I study, math seems unusually hard for me.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

25. I'll need mathematics for my future work.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

26. Females are as good as males in geometry.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

27. My mother has strongly encouraged me to do well in mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

28. I think that I could handle more difficult mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

29. I expect to have little use for mathematics when I get out of school.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

30. Studying mathematics is just as appropriate for women as for men.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

31. My father thinks I'm the kind of person who could do well in mathematics.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

32. I have a lot of self-confidence when it comes to math.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

33. Mathematics is a worthwhile and necessary subject.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

*-Go on to the next page-*

34. My father has shown no interest in whether or not I take more math courses.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

35. My mother wouldn't encourage me to plan a career which involves math.

- strongly agree
- agree
- neutral
- disagree
- strongly disagree