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Predicting women's persistence in math and science-related college majors

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PREDICTING WOMEN'S PERSISTENCE IN MATH AND SCIENCE-RELATED COLLEGE MAJORS

A Thesis

Presented to the

Faculty of

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by

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ABSTRACT

The current study investigated relationships that may be crucial to women's decisions to persist in math and science-related college majors. Undergraduate, graduate, and alumni women from the majors of mathematics, computer science, physics, chemistry, and biology participated at a university in southern California. The predictors of the study were Math/Science GPA, Beliefs in Academic Stereotypes about women and Vulnerability to Stereotypes. The proposed mediator was Math/Science Self-Efficacy, and the three outcome variables were Intentions to Obtain a Math/Science Degree, Commitment to Major, and Satisfaction with Major. It was hypothesized that Math/Science Self-Efficacy mediated the relationships between the group of independent variables and each dependent variable. Math/Science Self-Efficacy only mediated the relationship between Beliefs in Academic Stereotypes and Commitment to Major. There were also significant correlations between the variables.

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For my mother and grandmother, who were pioneers in their own right and who missed seeing the completion of this work by only a few months. Thank you to Peter and Linda, whose love and encouragement will never fail. Thank you to my Committee, who encouraged my interest in this research area and without whose help I would not have finished my degree. Thank you to the wonderful women who were willing to participate in this study. Last but definitely not least, thank you to Suzanne for helping me collect the data for this study.

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CHAPTER ONE

FEWER WOMEN THAN MEN IN MATH/SCIENCE

Much research has focused on the numbers of women in math and science-related majors in college related to the numbers of men in these majors. It is not unusual to see the number of students decline from high school to college and dip even more when looking at graduate school attendance. This is called the shrinking pipeline, introduced by Berryman (1983). However, the number of women in the science pipeline is shrinking more than expected.

There are several types of statistics that show this decline. Camp (1997) compiled statistics from the National Center for Educational Statistics from the U.S. Department of Education. She found that between 1983 and 1993, the percentage of women across the U.S. obtaining a bachelor's degree in computer science declined steadily from 37% to 28%, although the overall number of bachelor's degrees awarded to women had increased. At the master's level for the past 20 years, differences between the numbers of men and women obtaining degrees in life sciences, physical sciences, computer sciences, and engineering have narrowed. However, in 1996, men were still five times more likely to get a master's degree in computer science and engineering than women (Bae & Smith, 1997).

Like Camp (1997), Hill (1999) found that although more women than men obtained bachelor's degrees, less women received bachelor's degrees in science and engineering-related fields. She also found that the gender gap in science and engineering education had shrunk over the years. From 1966 to 1996, women receiving bachelor's degrees in these areas rose from 25% to 47%; for master's degrees, 13% to 39%; and for doctor's degrees, 8% to 32%. In 1996, out of all the men and women who obtained mathematical and computer science bachelor's degrees, women obtained 34% of those degrees. Out of all the men and women who obtained physical science bachelor's degrees, women obtained 37% of those degrees. Almost the same number of women and men obtained bachelor's degrees in the biological and agricultural sciences.

Hanson, Schaub, and Baker (1996) noted that gender stratification exists in these majors in industrialized countries; in high school, women were not as likely as men to take mathematics, chemistry, and physics courses in most of the countries they studied. However, Baker and Jones (1993) found that in countries that were actively trying to ensure equal opportunities for women and men, there were smaller sex differences in mathematics. They also found that sex differences in mathematics have declined in the United States, and this decrease was related to increased job opportunities for women.

Although there is evidence that not as many women take math and science classes as men, a Research and Development report by the U.S. Department of Education, National Center for Education Statistics (NCES, 2000) found that those women who did take those classes and remained in the science and engineering pipeline were performing equally with men. Women actually completed science and engineering programs more often then men relative to the number who entered those degrees. Chipman and Thomas (1985) found that both men and women drop out of math majors, but the number of women who complete a math degree is actually higher than the number of men who complete a math degree, relative to the entrance rates. The NCES (2000) report also found that 48.6% women completed science and engineering degrees out of all the women that entered those majors, and 40.4% of men completed degrees out of all the men that entered those majors. Of those who switched from science and engineering to other degrees, 19.4% were men, and 11.5% were women. The report concluded that the difficulties those women faced were not that they were poorly prepared academically, but that they faced psychocultural barriers.

Although the numbers of women receiving math and science degrees is increasing, there is still more talent and skills to be developed within the female work force. Ferry (1982) pointed out the problems with society's underdevelopment of women who have scientific and math talent. She stated that society's failure to encourage girls to be scientists is detrimental to the economy, as well as an impediment to girls themselves. Not only do women miss out on rewarding areas of study, they are immediately excluded from critical employment opportunities in a society that is using science and technology and becoming increasingly dependent on them. They will also miss out on the status and/or pay in industries that use science and develop technology.

However, even if women do try to enter science and math-related majors in college to prepare for careers in science or math, they encounter many barriers to their success. Zuckerman and Cole (1975) refer to a "triple penalty" that blocks women who strive for scientific achievement. The first penalty is that science is defined as an inappropriate career for women. This means that women are not recruited to subject areas involving science. The second penalty is that those women who have become scientists are still operating under others' beliefs that women are less competent than men. This belief may interfere with their work, decreasing their motivation and commitment to their careers. The third penalty is the discrimination against women in the scientific community.

Easlea (1986) studied the paradigm under which science operates and described it as a male enterprise. He attributed scientific methods with stereotypical male characteristics—masculine, aggressive, emotionally detached, individualistic, competitive, arrogant, ambitious, and obsessed with manipulation, control, and domination. On the other hand, society encourages and socializes women to develop the stereotypically feminine characteristics of submissiveness, passiveness, intuitiveness, emotional, nurturant, caring, empathetic, communicative, and to be sociable. These characteristics are not valued as highly as masculine characteristics in the paradigm of the scientific method, and society does not afford status to roles and occupations that require these characteristics. Women are encouraged to pursue development of these characteristics, effectively shutting them out of participating in science (Easlea, 1986).

Many methods have been employed to study the barriers that lead to the shrinking pipeline phenomenon for women in math and science. Some of these factors are the cultures of male-dominated fields, gender role socialization, gender role stereotypes, self-efficacy, and educational experiences. Although researchers have used the numbers of men in math/science to serve as a guideline for determining how many women should be in math and science, what should the numbers of women in math and science be? Researchers have not clearly answered the question of how many women should be in math and science and not without mentioning the numbers of men. Researchers are not used to studying women independently. Bleier (1991) has suggested that studying each sex separately reveals more answers than studying differences between the sexes.

In order to address the traditional way of studying women by comparing them to men, many researchers have called for a change in how women are studied. Walsh (1997) and Bem (1996) believe that by focusing on gender differences, researchers ignore the social influences that preceeded and influenced those differences. Eccles (1987) recommends instead of asking, "Why can't women be more like men?" researchers should ask, "Why do men and women choose as they do?" Sex differences can then be looked at from a choice perspective rather than viewing women as having deficits or being victims. Other researchers study men's and women's choices of college majors as indicative of the values that individuals hold. However, they do not necessarily look at the forces that preceeded the development of those values. Eccles (1987) says that science operates under masculine values, but that women hold different values than men.

However, there are women who are attracted to nontraditional, male-dominated fields; perhaps they value the same things as men who enter these fields. For example, Henwood (1990) found that while some women are repulsed by the masculinity of computer science, others are attracted to it because of the status it holds. After all, male-dominated fields contain more status and prestige than female-dominated fields. Women who are successful in masculine fields are respected by men and admired.

In summary, the academic pipeline for women in math and science related majors has been shrinking more than expected, although there is not a definite answer to the question of how many women should be in those majors. Having less women in math and science is detrimental to the economy, as well as education; talent is wasted when it is not being developed. As already mentioned, the way that researchers study women, by using a male standard, could itself become a hindrance instead of an answer to the question. There are many other reasons why women who want to enter math/science majors in college do not do so. The reasons that may keep women from entering those majors may also affect women who do choose to enter those majors. The current study will identify some of those reasons and their effects on women in math/science majors.

CHAPTER TWO

REASONS FOR FEWER WOMEN IN MATH/SCIENCE

Formation of Stereotypes

What women are taught as appropriate roles for women can affect what choices they make as college majors. Research shows how traditional and non-traditional gender role beliefs develop. Mothers' and fathers' gender-typed attitudes, beliefs, and involvement in home activities strongly influence children's beliefs about sex appropriate behavior. There is a plethora of research showing the ways that parents and teachers affect children's beliefs about gender roles as they are growing up (Rubin, Provenzano, & Luria, 1974; Maccoby & Jacklin, 1974; Baruch & Barnett, 1981; Weinraub, Clemens, Sockloff, Ethridge, Gracely, & Myers, 1984; Stein, 1973; Vogel, Broverman, Broverman, Clarkson, & Rosenkrantz, 1970). For example, Maccoby and Jacklin (1974) found that parents expected their sons, more than their daughters, to attend college. Cross (1975) pointed out that women receive less encouragement from their parents and society to achieve at high levels.

For an example of how family-related stereotypes have developed, Baruch and Barnett (1980) pointed out that in the past, men have been the economic providers and women have been the homemakers. Women's roles have been in the home and raising children. At one time it was thought that the roles of homemaker and child-rearing were essential for women's sense of well-being, but research does not support this concept (Sears & Barbee, 1977). Weinraub, Clemens, Sockloff, Ethridge, Gracely, and Myers (1984) found that not only does maternal employment counteract the formation of gender stereotypes in children, but high levels of paternal involvement interacting with maternal employment may strongly predict level and type of gender stereotypes.

Gender role socialization experiences influence children's beliefs about sex-appropriate behavior and choice of behavior. The beliefs women have developed about appropriate behaviors for each sex can influence the choices they make, such as what college majors they choose and what careers interest them. Women who want to enter male-dominated college majors may face the pressures of traditional general role stereotypes. While research shows that society is moving from beliefs in sex roles because of biological differences to roles based on social equality, traditional gender role stereotypes still exist.

Snodgrass (1991) found that even though college students in her study did not believe that gender role stereotypes were still prevalent in their generation, students rated a typical man high on agentic items, and a typical woman as more communal on the PAQ. The PAQ items that did not discriminate between stereotypical characteristics were career-oriented items, which reflected the changes that have occurred as more women enter the work force. In a second experiment, Snodgrass (1991) found that masculinity was associated with task and power orientation, while femininity was associated with social orientation. Masculine women were not liked, and feminine men were not respected. She concluded that the constructs of masculine and feminine were still clearly differentiated, and men and women who did not act according to their appropriate role were not liked, not respected, and perceived as less happy.

In some research it appears that although women perceive they can choose to enter male-dominated careers, they do not choose to do so. Tysse (1982) cited research from the University of Wisconsin's Guidance Institute for Talented Students that indicated elementary age girls believed they could choose to pursue either traditional or nontraditional careers. But later, when those girls reached high school, they chose to enter traditional careers. An unusual finding was that when high school seniors indicated preferences for a "real" career and an "ideal" career, girls chose both traditional and nontraditional careers for both "real" and "ideal" careers. Boys, on the other hand, chose traditionally masculine careers for each category. Girls perceived more career options available to them (Alpert & Tysse, 1982). Perhaps this conflicting research could be explained by factors that may not be visible in childhood, but become apparent in later adolescence.

Another reason that women may not choose to enter math and science majors is that they believe they cannot be strongly committed to a career and a family. Although women may change their career plans, they may not expect men to sacrifice their career aspirations in deference of current or future family interests. Women may believe that they will have to sacrifice their future careers to have a family, and also believe that the significant men in their lives will bring in the majority of the income. Therefore, women may be choosing majors in college that they already know are compatible with having families.

Tysse (1982) believes that young women postpone planning careers until marriage and family issues are resolved. Fitzgerald and Weitzman (1992) agree, finding that women choose traditionally feminine occupations that are perceived to be easier to combine with home and family responsibilities rather than pursuing their interests into careers. Planning for multiple roles may be a reason why women "settle" for careers that are "good enough" rather than pursuing more challenging careers (Fitzgerald & Weitzman, 1992).

Added pressure to combine career and family comes from the male perspective of gender roles. As mentioned earlier, men tend to be more traditional than women when it comes to gender roles. Fox, Brody, and Tobin (1985) found that most men in their study were not expecting their future wives to have strong commitments to their careers. However, Corder and Stephan (1984) found that women's sex role attitudes were more nontraditional than men's and most women aspired to combine work, marriage and motherhood. The men believed that a man whose wife stayed at home, in a homemaker role, had more status than a man whose wife worked outside the home. Women in the study believed the opposite.

An explanation might be that the adolescent boys still believed in the traditional masculine provider role, and that men whose wives stayed at home indicated that the men made enough money (hence, more prestige) for their wives to stay at home. However, both men and women in the study agreed that women who worked outside the home had more prestige than a women who stayed at home; women in this sample held this view more than the men. They also found that men had a weaker commitment than women for women to balance work, marriage, and motherhood. Herzog, Bachman, and Johnston (1983) also found in a survey of high school seniors that women were less traditional in their preferences for allocating family responsibilities between themselves and their future husbands; more women than men preferred egalitarian arrangements.

To summarize, in childhood, women may believe that both traditional and nontraditional occupations are open to them. However, as they get older and encounter pressure and or become interested in having a family, they choose to pursue more traditional career paths. They may perceive that being committed to a challenging career will preclude having children. Overall, the research shows that women plan on working outside the home and anticipate combining career and family. While they may not identify with traditional sex roles, they also may not feel that commitment to a nontraditional and challenging career is an option for them because of the difficulty of combining career and family.

There are other stereotypes about women that may affect their beliefs about themselves and influence their academic choices. For example, there are negative stereotypes about women's intelligence and cognitive abilities. Women are stereotyped as being less competent than men. If this stereotype is internalized as girls grow up, they may have less confidence in their cognitive abilities (Broverman, Vogel, Broverman, Clarkson & Rosenkrantz, 1972). Deaux and Emswiller (1974) found that performance by a man on a masculine task was attributed more to skill and general intelligence, but when a woman performed equivalently on the masculine task, her success was attributed to luck. Women who performed successfully on feminine tasks were not perceived to be more skillful than men who successfully performed feminine tasks. And regardless of whether the task was labeled as masculine or feminine, men were perceived to be more skillful than women. The men expected to do better on both the feminine and masculine tasks, but the women expected to do better on the feminine tasks.

Feldman-Summers and Kiesler (1974) found that participants in their study expected men to perform significantly better than women on an intellectual task; they also believed that women were more motivated than men. They also proposed that people believe that if women perform at the same level of men, they must be trying harder. They also found that men believed that although a female physician was as successful as a male physician, she was less competent than the male physician. The men also believed that if the female physician asked for and received assistance and was successful, her success had more to do with the help she received. When the male physician asked for and received assistance, his success was less attributed to the help he received. The men in the study believed that the task the female physician received help with was easier than the task with which the male physician received help.

The women in the study did not believe that the male physician was more competent than the female physician. They attributed the male's success to his having had an easier task than the female. But like the men, the women also believed that the female physician was more motivated than the male physician. In conclusion, the researchers thought that maybe the participants in the study did not expect women to be more successful than the men, just only as successful as the men.

Women also encounter stereotypes regarding their educational aspirations and abilities. For example, Parsons, Adler, and Kaczala (1982) found that in a study of children in grades 5-11, both fathers and mothers had different perceptions of their children's math abilities, even though boys' and girls' performance was the same. Parents of daughters believed their daughters had to work harder to do well in math than parents of sons. Parents of sons, more than parents of daughters, believed that advanced math was important for their children. They also found that parents' beliefs about their children's abilities were influencing their children's math self-concepts more than the children's past performance in math. Yee and Eccles (1988) found that parents believed that talent was the cause of boys' math achievement, whereas girls' math success was attributed to effort.

Educational stereotypes also come from male peers. Fennema and Sherman (1977, 1978) found that boys believed mathematics was more of a masculine field than girls. Fennema and Sherman (1977) also found that girls showed less confidence in their abilities to do math, even though they were performing similarly to boys. Girls did not think math was as useful as boys did, and this difference in their attitude became significant in high school. Girls were not less interested in math than boys, and they were just as motivated as boys. They concluded that sex-role attitudes more strongly affected girls learning math than boys learning math. Casserly and Rock (1985) agreed; they found that girls' educational goals were strongly influenced by their perceptions of women's roles in society. When considering how far they wanted to go educationally, tenth-grade girls were more influenced by their egalitarian attitudes rather than their past mathematics performance and self-assessment of their math abilities.

Sherman (1980) found significant correlations between the concept of math as a male domain and girls' math performance, but not boys' math performance. The stereotype of math as a male domain also negatively affected girls' confidence in learning math. They concluded that the sources of differences between boys' and girls' math performance could be attributed to their attitudes. Betz and Hackett (1983) found that boys had more positive attitudes toward math, were more confident in their ability, and tended to view it as more useful than girls viewed it. However, girls viewed math as less of a male domain than boys viewed math.

These stereotypes about women's educational abilities influence their choices of college majors. Dawson-Threat and Huba (1996) studied college seniors and found that while less than half of their sample identified with traditional sex roles, most of their sample had chosen majors that were traditional for their sex. Women were more likely to choose traditional majors than were men. Strange and Rea (1983) found in a study of juniors and seniors in nontraditional majors that regardless of scores on the Bem Sex Role Inventory (BSRI), both men and women chose their major for traditional reasons (male-dominated fields were selected for their status, and female-dominated fields were selected for service and interpersonal skills). They also suggested that men and women chose those majors because they shared the values of those fields.

Women encounter conflicting messages about gender roles. Society pushes them to fit and fulfill roles it has defined for women, but at the same time it devalues the stereotypical feminine characteristics and traditional feminine roles. Stereotypes follow women into their science or math careers. Cole (1981) and Vetter (1981) found that women scientists and engineers were not thought to be as bright or productive as their male peers.

Vulnerability to Stereotypes

As previously mentioned, there are many obstacles that women in math and science-related majors must overcome to achieve successful performance. Another obstacle is the threat from stereotypes that are held about women. For example, Epstein (1970) found that women who "break ground" in traditionally masculine fields have the pressure of feeling that they must perform better than their male counterparts to be taken seriously and that their mistakes will be interpreted as confirming stereotypes of women. Currently, stereotype threat is under investigation in the academic realm; various stereotypes are studied by looking at their effects on academic performance. Steele (1997) defines stereotype threat as "the social-psychological threat that arises when one is in a situation or doing something for which a negative stereotype about one's group applies" and "the event of a negative stereotype about a group to which one belongs becoming self-relevant, usually as a plausible interpretation for something one is doing, for an experience one is having, or for a situation one is in, that has relevance to one's self definition." Stereotype threat has been studied mostly in the academic setting, with the belief that the relationship between a person and his/her academic performance can be disrupted by this threat, especially if the individual strongly identifies with school.

The characteristics of stereotype threat that disrupt good performance are still under investigation. For example, research suggests that an individual does not need to have constant, internalized anxiety for stereotype threat to have a negative impact. It can affect performance simply by an individual realizing that a group stereotype could apply to oneself in a particular situation (Steele, 1997). Other studies have investigated anxiety (Steele & Aronson, 1995) evaluation apprehension, self-efficacy, the strength of students' identification with an academic area, and amount of effort expended on a task, to discover what mechanisms of stereotype threat negatively affect performance. These qualities are later discussed within each research study.

Other characteristics of stereotype threat are that it can affect people of any group for which a negative stereotype exists; however, it may or may not affect a particular person. Whether it does have an affect and the strength of the effect depends on how strongly an individual identifies with and is invested in the academic situation, and that the individual believes that his/her behavior could be interpreted according to a stereotype. The type and degree of stereotype threat varies across groups and settings. Stereotype threat can be experienced even if an individual does not believe that it personally applies. Overcoming stereotype threat can be very difficult, and an individual may have to overcome the same stereotype every time he/she is in a new setting with different people.

Empirical support for the negative effects of stereotype threat comes from several researchers. Spencer, Steele, and Quinn (1999) studied the threat that arose from the stereotype that men are more competent in math than women. They first verified past literature by comparing highly math-competent men and women. On easier math tests, men and women performed equally. But on difficult math tests, men performed better than women. To discover if stereotype threat was a factor in the underperformance of women, all participants were given a difficult math test. In the stereotype condition, participants were told there were known gender differences in the math test they would take; participants interpreted this to mean that women under-performed men. In the control condition, participants were told that the test had never shown gender differences. They found that in the no-gender-differences condition, women performed equally with men. In the gender-differences condition, women performed significantly worse than men.

To further investigate the effects of stereotype threat, they replicated the previously mentioned study with a less-select sample. There were two conditions; in one, participants were told the test showed no gender differences. In the control condition, no mention was made of gender differences. They found that women and men performed equally in the no-gender-differences condition, but women under-performed men in the control condition. In further investigation of what particular characteristics of stereotype threat negatively affected performance, they examined evaluation apprehension, self-efficacy, and anxiety of the women in the sample. While anxiety was higher in women in the control condition, anxiety did not mediate the effects of stereotype threat, but neither could it be ruled out as a mediator. Evaluation apprehension and self-efficacy did not mediate the effects of stereotype threat.

Other researchers have investigated the effects of stereotype threat on individuals with high self-efficacy. Stangor, Carr, and Kiang (1998) found that an activated stereotype negatively influenced individuals' positive expectations about future task performance; the stereotype threat overrode confidence in the participants' own abilities for a task. After a negative stereotype had been activated, participants lowered their expectations of performance on future, similar tasks, even when they had performed well on previous tasks. Even participants who were very confident about their abilities were negatively influenced by stereotype threat.

To further determine the generalizability of stereotype threat to various groups, Aronson, Lustina, Good, Keough, Steele, and Brown (1999) studied Caucasian men with high SAT mathematics scores. In a stereotype threat condition, participants were told that Asian students perform better in math than white students. In the control condition, no stereotypes were mentioned. All participants were given items from the GRE mathematics subject test. They found that the Caucasian men in the stereotype condition solved less questions than men in the control condition; the stereotype threat condition spent more effort on solving the problems. The two conditions did not differ on amount of anxiety, time spent on items, and self-reported difficulty.

The researchers also wanted to know if students' identification with a particular academic domain would mediate the effects of stereotype threat. They wanted to know if those who most strongly identified with math would be most strongly affected by stereotype threat. Their sample consisted of white men in a year-long calculus class who had received high scores on the quantitative section of the SAT. In the stereotype threat condition, participants were told that Asian students perform better in math than white students. In the control condition, no stereotypes were mentioned. The participants took a sample of the practice items on the GRE math subject test. The researcher's results showed that those in the stereotype threat condition who highly identified with math did not perform as well on the test as those in the control condition who also highly identified with math.

To try to understand what about stereotype threat interfered with performance, the groups were compared on anxiety, effort, confidence, perceived performance, and evaluation apprehension. The only significant finding was an interaction between the groups and evaluation apprehension. Those in the stereotype threat condition who highly identified with math reported more evaluation apprehension. Those in the stereotype threat and control condition who moderately identified with math reported the same amount of evaluation apprehension. The underperformance of those in the stereotype threat condition was not due to participants withdrawing effort. Because the stereotype that Asians do better in math is not one that white men frequently come into contact with, the researchers concluded that an individual did not to be repeatedly exposed to stereotype threat for it to affect his/her performance. In their study, what was necessary for stereotype threat to have an effect was that the participants wanted to perform well and be bothered enough by the stereotype that their performance was negatively affected.

More support for stereotype threat comes from Walsh, Hickey, and Duffy (1999). When they compared equal-ability men and women on math tests, the suggestion that women under-perform men was enough to depress women's performance. They also found that a brief, written reference to a gender stereotype (men do better in math than women) in a testing situation negatively affected women's performance, even though both sexes were similar in performance on a prerequisite math course, perceived that their competence levels were similar, and were interested in math. Steele (1997) believes that it is possible that impaired performance is not triggered by consistent anxiety that women have about their own ability, but comes from anxiety that is triggered by situational pressures.

In summary, although researchers have not established the specific aspects of stereotype threat that negatively affect individuals, there is plenty of evidence that it has a negative effect upon the individual experiencing it. Stereotype threat is an obstacle that has been around for a long time, although it has not until recently been labeled as such. The threat of a stereotype is very real for women who identify with math and science, but feel performance pressures because many math and science-related majors are male-dominated.

Math/Science Self-Efficacy

Another obstacle that women may face, both in and outside of nontraditional college majors, is lack of self-efficacy. Self-efficacy is the belief or expectation that one possesses the abilities to perform a task successfully and achieve what one tries to accomplish (Bandura, 1977). It is already known that women have less self-confidence and self-efficacy in their math abilities than men (Fennema & Sherman, 1977, 1978; Betz & Hackett, 1981). Lack of self-efficacy is an obstacle that may be very salient for women in male-dominated majors.

Self-efficacy is instrumental in women's decisions to even enter math and science-related majors, as well as continue in nontraditional careers (Nevill & Schlecker, 1988).

The Educational Testing Service (Dossey, Mullis, Lindquist, & Chamber, 1988) found that differences between boys and girls in math confidence increased with age. Almost the same percentage of 3rd grade boys (66%) and girls (64%) believed they were good in math, but in 7th grade, 57% of girls said they were good at math, while 64% of boys said they were good at math. By the 11th grade, 48% of girls believed they were good at math, compared with 58% of boys. Fennema and Sherman (1978) found in a study of 6th to 8th graders that boys were significantly more confident than girls of their abilities to learn math. Eccles (1984) found that girls' concepts of their math abilities significantly affected their expectations of performance in future math classes. Because girls thought that math was harder than boys did, their perception of its difficulty, along with their self-concept of their math ability, lowered their expectations for success in future math classes.

There are many studies that link self-efficacy to the choice of a math or science-related college major. For example, Lapan, Shaughnessy, and Boggs (1996) found that math self-efficacy beliefs directly predicted the choice of entering math/science majors; those beliefs also mediated sex differences in those choices. Women with lower self-efficacy did not choose to enter math or science-related majors. They also found that prior achievement experiences were related to self-efficacy; self-efficacy mediated the relationship between prior math/science experiences and interest in those college majors. O'Brien, Martinez-Pons, and Kopala (1999) found that academic performance predicted self-efficacy and that self-efficacy mediated the relationship between academic performance and career interest. Hackett (1985) found that math self-efficacy predicted math-related college major choices, and that those with low math anxiety were more likely to choose a math-related college major. Her results suggested that mathematics self-efficacy was more important in predicting choice of major than actual ability in math.

Nauta, Epperson, and Kahn (1998) created a model that predicted higher level career aspirations among women in math, physical science, engineering, and biology. They found that the relationship between ability and higher-level career aspirations was mediated by self-efficacy. Self-efficacy also mediated the relationship between role model influence and higher-level career aspirations. Although the two groups of female students (those in math, physical science, engineering, and those in biology) did not differ in mean levels of higher level career aspirations, the relationship between ability and self-efficacy and the relationship between positive role models and self-efficacy were significantly stronger for women in math, physical science, and engineering than for biology majors. This may have been because biology is more of a gender-balanced major, whereas the other majors are male-dominated.

More research comes from Betz and Hackett (1983), who found that self-efficacy expectations for mathematics was related to college students' choices of science-based versus non-science based college majors. Students who reported stronger math self-efficacy expectations were more likely to select science-based college majors than students lower in self-efficacy expectations for math. They also found that overall, college women reported lower self-efficacy expectations than men, and men were more confident of their math abilities.

Lent, Brown, and Larkin (1984) found that undergraduates who reported high levels of self-efficacy regarding their ability to complete technical/scientific majors achieved higher grades and persisted longer in these majors than those with low self-efficacy ratings, although the two groups did not differ greatly in their technical/scientific grades. They also found that men and women were comparable in their perceived ability regarding their technical/science majors. This contrasts Betz and Hackett's (1983) results. Again, Lent, Brown, and Larkin (1986) found that self-efficacy was related to academic performance. Self-efficacy predicted grades in technical majors, students' persistence in those majors, and the range of career options students considered. Self-efficacy predicted those things even when math ability, high school achievement, and vocational interest had been controlled.

Multon, Brown, and Lent (1991) conducted a meta-analysis of the reported relationships between self-efficacy and academic performance and persistence. They found that effect sizes were about .38 for academic performance and .34 for persistence. Self-efficacy beliefs accounted for about 14% of the variance in academic performance and about 12% of the variance in persistence. However, the relationship between self-efficacy and performance was moderated by several factors. The relationship between self-efficacy and performance varied with students' achievement status. An unusual finding was that there was a stronger relationship between self-efficacy and performance for low-achieving students than normal achieving students. However, that finding could have been due to methodology rather than substantive factors. Age was another moderating factor. For high school and college students, the relationship between self-efficacy and performance was stronger than for elementary school students. The last mediator they found was the type of performance measure used by researchers. The strength of relationship between self-efficacy and performance depended on whether the performance measure was grades or achievement tests.

They also found that the relationship between self-efficacy and persistence depended on how persistence was measured, whether it was time spent on task, or number of items completed/attempted. There were significantly smaller effect sizes when persistence was measured as time spent on task than when persistence was measured as number of items completed or attempted.

To summarize, the relationship between self-efficacy and choice of science-based major, as well as persistence in these majors has been well-established. Women with low self-efficacy may not even attempt to enter math and science-related majors, even if they are making good grades in their science and math classes.

Equitable Math/Science Performance

There are many factors that affect women's math performance in school, such as parental attitudes, gender socialization experiences, teachers' teaching styles, and women' own beliefs about their math and science abilities. It has been suggested that women' beliefs about their math/science abilities affect their performance more than past performance or ability (Hackett, 1985). While some research has sought to specify the differences in men's and women's math abilities, other research has not found appreciable differences in their math and science performance. There is mixed research regarding boys' and girls' math performance; some research says that both have similar math performance, while other research says that girls' math scores begin to fall behind boys' scores in high school. The National Science Foundation (2000) reported that the gender gap in mathematics achievement in elementary and high school had, for the most part, disappeared. However, the Scholastic Assessment Test (SAT) scores for those who had taken calculus and physics showed that women scored an average of 35 points less than men on math.

Several reasons why girls may be falling behind in certain areas of math is the way that they are taught and if they are encouraged to excel in their math and science classes. Eccles (1987) found that teachers and peers discouraged girls from science and math in elementary school, even though their grades were better than boys' grades. Teachers' teaching strategies for math can differ for boys and girls. In elementary school, Fennema (1990) found that teachers were more likely to encourage girls in the routine computations of math, and give them too much help for cognitively demanding mathematical problems. They found that the teachers also expected the girls to conform and be dependent, which discouraged them from independent thinking in order to solve complex problems.

Grieb and Easley (1984) found that in elementary school math classes, girls excelled at neat papers, correct computations, but became more dependent on the teacher and rule-bound tasks. However, while boys' papers were messy, they did not depend on the teacher for help and became more proficient at problem-solving. Other research to support Grieb and Easley's (1984) findings comes from the Educational Testing Service (Dossey, Mullis, Lindquist, & Chambers, 1988). They reported that girls outperformed boys on math tasks where it was apparent what procedural rule should be followed, but did not do as well as boys when the problem-solving strategy was not clear. They also found that at grades 3, 7, and 11, girls always had more knowledge and skills than boys, whereas in all 3 grades, boys always scored better on the higher-level applications. If teachers are not encouraging girls to develop complex problem-solving skills, their weaknesses may affect their beliefs about how capable they are at doing math; they may begin to believe they are not mathematically-inclined.

Crandall, Katkovsky, and Preston (1962) concluded that women underestimated their abilities to solve math problems. Maccoby and Jacklin (1973) reported that girls underestimated their intellectual abilities more than boys underestimated their own intellectual abilities. Eccles (1984) reported that girls performed as well as boys in math, but they did not believe they would do as well in the future or continue to take math classes.

Despite the Educational Testing Service's report (Dossey, Mullis, Lindquist, & Chambers, 1988), Dweck and Goetz (1978) found that although girls lacked confidence and predicted lower grades for themselves than boys predicted for themselves, girls got higher grades all through elementary school. Dweck, Goetz, and Strauss (1980) found that girls' expectancies of their performance was lower than that of boys', although girls were performing better in school. Wertheim, Wido, and Wortzel (1978) also found that women earned higher grades than men. Hanson (1996) noted that young women and men who did take math and science classes in elementary school obtained similar grades. Maccoby and Jacklin (1974) also found that girls were getting better grades than boys in middle school.

Although women are getting better grades than men in math and science, there is research that shows men receive higher standardized test scores in these areas, which might explain the results of the Educational Testing Service (Dossey, Mullis, Lindquist, & Chambers, 1988). Maccoby (1966) found that although girls got better grades throughout school than boys, boys got higher standardized test scores. Eccles (1984) agreed, finding that even if boys and girls received similar grades in math, boys did better on standardized math achievement tests.

Hanson (1996) looked at when the differences between boys and girls on standardized test scores began. She found that differences between them in math and science scores started approximately at 7th grade. Girls began to score lower in science classes, but their math scores did not fall until 10th grade. Their math scores continued to fall through the end of high school. In high school, girls were less likely to score in the top quartile on standardized math exams. Bae and Smith (1997) compiled data from the National Assessment of Educational Progress and the Longitudinal Study of American Youth and found that boys and girls had similar mathematics and science proficiency standardized scores at about the 3rd grade level. A gender gap in science scores began to appear around the 8th grade. This could not be due to lack of interest, because girls and boys reported similar scores for liking math and science in the 7th and 10th grades. However, on a positive note, Bae and Smith (1997) found that the gender gap in science proficiency scores of college juniors and seniors had narrowed.

Research has shown that girls receive higher grades in math and science in school, but that boys get higher standardized test scores in these areas. This difference in grades and standardized test scores continues into high school and college. Cross (1975) found that in a study of high school seniors, that girls had better grade point averages and gained higher grades than boys in traditionally masculine subjects such as math and science. Boys, however, did better on tests in these areas. Hanson (1996) found that in general, women had higher grade point averages than men and were more likely to graduate from college. However, they were not as likely to get jobs within science or math fields.

Other researchers found that women received math grades similar to or better than their male peers in college. DeBoer (1984) followed women over an eight years span and found that while women took less science and math classes than men, they performed at a higher level than men in both high school and college in these subjects. While these women received lower SAT math scores, they achieved higher grades than men in math and science classes in college. DeBoer (1984) concluded that although girls' participation in math and science was less than boys', it was not due to lack of ability.

Sturm and Moroh (1995) looked at computer science students' transcripts over a five-year period and found that women did significantly better in all the pre-calculus and calculus courses than the men did, although most of the men thought they did better than the women. Sturm and Moroh (1994) found that while the there were less undergraduate women than men in computer science, the women were passing prerequisite and major classes at higher rates than their male counterparts. Jagacinski and LeBold (1981) found that women in engineering majors had slightly higher grade point averages than their male peers.

In a review of the research on gender differences in mathematical ability, Fennema (1974) concluded that there were no consistent significant differences between boys and girls from 4th to 9th grade. However, she also concluded there was a trend for girls to perform better in computation and for boys to do better on tests of mathematical reasoning. But other research by Fennema and Sherman (1978) found that in 6th to 8th grades, girls were not superior on computation, and that boys did not perform better than girls on higher-level cognitive tasks as other researcher has suggested. Fennema and Sherman (1977) found that overall, when sex-differences in mathematics from grades 6-12 did appear, those differences were small. They also reported that those small differences did not increase as boys and girls performed higher levels of math.

Hyde, Fennema, and Lamon (1990) conducted a meta-analysis of math performance and found that girls were slightly better than boys in performing computations, but there were no differences between them in their comprehension of mathematical concepts in elementary school. It was not until high school that boys were shown to be better than girls at problem solving. They believed that boys' superior problem-solving ability continued into college. Friedman (1989) also conducted a meta-analysis of studies of gender differences on mathematical performance, and found that the average difference between boys and girls was small. Friedman (1989) also found that the difference favoring boys on math performance has been decreasing over the years.

Maccoby and Jacklin (1972) reviewed research of sex differences on cognitive abilities and pointed out that finding depended on type of sample, grade in school, and method of measurement. Because researchers were measuring children, they could have been measuring the different developmental or maturation rates of girls and boys, rather than inherent ability in math and science. She found that in some grades, girls did better in certain areas on cognitive ability tests, but in other grades, boys performed better on cognitive ability tests. Maccoby and Jacklin (1972) concluded that on measures of total ability, there were no sex differences on the tests. Of component abilities, those differences that did exist were not large.

In summary, the research seems to suggest that the differences between boys and girls in math performance depends on type of sample, type of school, encouragement from authority figures, and whether performance measures consist of standardized tests or school grades. In regard to samples studied, Fennema (1980) pointed out that men choose to study mathematics more than women, so a more mathematically educated group is being compared with a less mathematically educated group. When types and amounts of math courses were controlled, there are few differences between men and women in achievement. Lips, Myers, and Colwill (1978) concluded that while men and women have different strengths and weaknesses, the types and sizes of differences are smaller than sex-role stereotypes advocate.

CHAPTER THREE

JUSTIFICATION FOR CURRENT STUDY AND HYPOTHESES

There are several models that researchers have proposed to help explain the relationships between the various obstacles that may prevent women from entering math and science-related majors in college. These obstacles may also negatively impact women who are already in these majors. Casserly and Rock (1985) proposed occupational stereotyping, equalitarian attitudes, math/science ability and assertiveness to predict persistence in mathematics and career and educational aspirations. They found that women who had equalitarian attitudes were less likely to stereotype occupations and were more assertive. They also found that persistence for mathematics, career, and educational goals was predicted by equalitarian attitudes. Hackett (1985) proposed a model that included gender, math/science self-efficacy, math ability, and the BSRI masculine score to predict choice of math-related college major. She found that gender-related socialization, in combination with previous math classes, predicted math achievement and math self-efficacy. However, masculinity scores did not predict persistence for high school math. Lapan, Shaughnessy, and Boggs (1996) proposed a path analysis with variables such as gender, math ability, math self-efficacy, and math interest to predict choice of math or science college major. They found that math self-efficacy predicted math interest and choice of math/science college major, and that math self-efficacy mediated the relationship between ability/achievement and interest in math.

Nauta, Epperson, and Kahn (1998) also proposed a model that included variables such as ability and self-efficacy to predict higher-level career aspirations. They found that the relationship between ability and higher-level career aspirations was mediated by self-efficacy. Eccles (1987) developed a model that included gender role stereotypes, child socialization experiences, achievement-related experiences and expectations of success to predict achievement-related choices. Fassinger (1990) developed a model that suggested college women's career orientation and choice of major was determined by a combination of ability, agentic personality characteristics, and sex role attitudes. She found that high ability, liberal sex role attitudes, and instrumental personality characteristics predicted high levels of career orientation and a tendency to choose nontraditional careers.

Study Variables

The current study sought to examine the relationships between negative academic stereotypes, women's beliefs in them, women's beliefs that they have been affected by stereotypes, and women's persistence in math and science. More specifically, the study sought to discover whether Math/Science Self-Efficacy mediated the beliefs in and effects of stereotypes on women's persistence in math and science majors. The three independent variables of the study were Math/Science GPA, Beliefs in Academic Stereotypes, and Vulnerability to Stereotypes. The proposed mediator was Math/Science Self-Efficacy, and the three outcome variables were Intentions to Obtain a Math/Science Degree, Commitment to Major, and Satisfaction with Major.

Hypotheses

The hypotheses were that Math/Science Self-Efficacy would partially mediate the relationship between the group of independent variables (Math/Science GPA, Beliefs in Stereotypes, Vulnerability to Stereotypes) and each of the dependent variables (Intentions to Obtain Math/Science Degree, Commitment to Major, Satisfaction with Major). Inherent in the mediation hypothesis are sub-hypotheses that the predictor variables must be related to the outcome variables, the predictor variables must be related to the mediator, and the mediator must be related to the outcome variables.

In further specifying the sub-hypotheses, the directions of the relationships were expected to be that Math/Science GPA was positively related to Math/Science Self-Efficacy; Beliefs in Stereotypes and Vulnerability to Stereotypes were negatively related to Math/Science Self-Efficacy; and Math/Science Self-Efficacy was positively related to Intentions to Persist, Commitment to Major, and Satisfaction with Major. The hypotheses are pictured below.

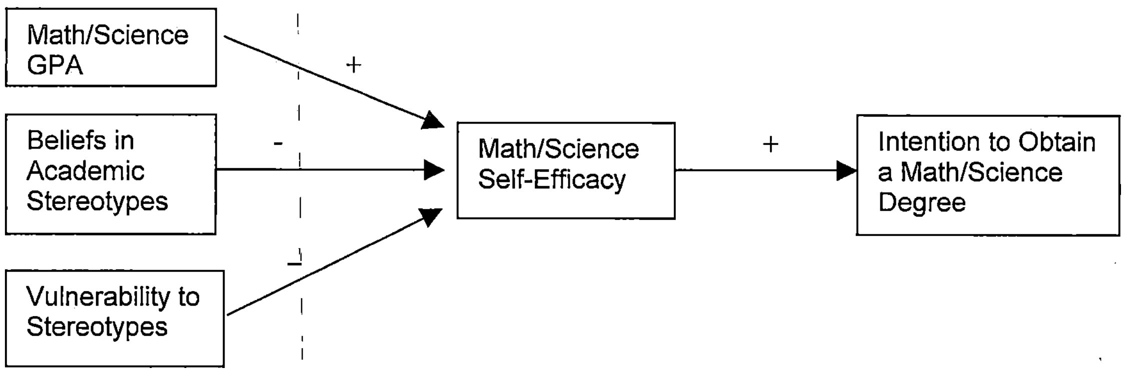

Figure 1. Hypotheses with Dependent Variable Intentions

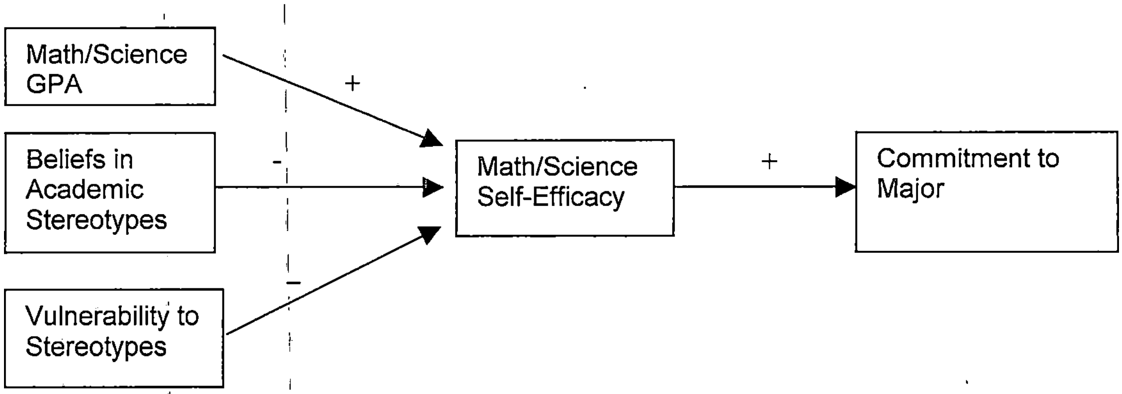

Figure 2. Hypotheses with Dependent Variable Commitment

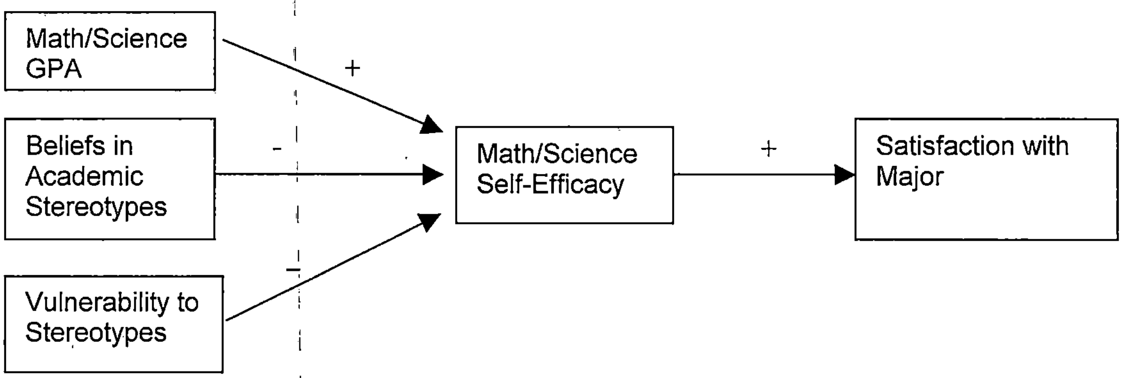

Figure 3. Hypotheses with Dependent Variable Satisfaction

CHAPTER FOUR

DESCRIPTION OF PARTICIPANTS, MATERIALS, AND PROCEDURE

Participants

Ninety-five women from a university in southern California participated in the study and represented the majors of Biochemistry, Biology, Chemistry, Computer Science, Graphic Design, Math, and Physics. Six graduate students, 16 alumni, and 73 undergraduates participated. Ninety-five women met the criteria to find a medium effect size based on Tabachnick and Fidell's (2001) equation of $50 + 8m$, where m is the number of independent variables. The alumni names were provided by the university's department of institutional research. Participants' ages ranged from 18 to 36, with a mean of 27, and a mode of 21. Sixteen ethnicities were represented in the sample. The majority of the participants were Caucasian, and the next highest representation were Mexican American.

Materials

Measurement of Independent Variables

The three independent variables were Math/Science GPA, Beliefs in Academic Stereotypes, and Vulnerability to Stereotypes. The first independent variable, Math/Science

GPA, was computed for participants. After receiving permission from the participants, the researcher obtained math/science grades from the university's electronic transcript system. Math/science grade point averages were computed by multiplying the number of units for each class by the grade they received (an abbreviated version is A = 4.00, B = 3.00, C = 2.00, D = 1.00, F = 0). These values from all of their math and science classes were added, then divided by the number of attempted units for these classes, for a math/science grade point average.

The second independent variable, Beliefs in Academic Stereotypes, was a measure of the strength of participants' beliefs in academic stereotypes about women in math and science. It was a questionnaire developed by the researcher and consisted of 13 negative stereotypes about women's math and science abilities. Items for this scale were developed from Spence, Helmreich, and Stapp's (1973) Attitudes Toward Women Scale and Swim, Aikin, Hall, and Hunter's Old-Fashioned Sexism Scale (1995). Two of the items were "Women have less natural math ability than men" and "Typically, women earn worse grades than men in math and science." Participants were directed to express their beliefs about each statement, using a 5-point, Likert-type scale. The extreme ends of the scale were 1 = Strongly

Disagree, and 5 = Strongly Agree. High scores indicated strong beliefs in the negative stereotypes about women's math and science abilities. Because this measure had not been used before, its psychometric properties were studied before the main analyses were performed and its reliability was .87.

The third independent variable, Vulnerability to Stereotypes was a scale composed of 12 items which asked participants how sensitive they were to others' beliefs in academic-related stereotypes about women. It also asked participants if they felt they had been affected by others' beliefs in stereotypes. Items 1-4 and item 12 were adapted from the Stigma Consciousness Questionnaire for Women developed by Pinel (1999). Items 5-10 were adapted from a Stigma Vulnerability scale developed by Swim (1996). Participants were asked to indicate their agreement with each item on a 5-point, Likert-type scale and the extreme ends of the scale were 1 = Strongly Disagree and 5 = Strongly Agree. High scores indicated more vulnerability to stereotypes. Two items were "Stereotypes about women's ability in math and science have not affected me personally" and "When interacting with others, I feel like they interpret my math and science academic performance in terms of the fact that I am a woman." Because this measure had not been used before, its psychometric properties were studied before the main analyses are performed and its reliability was .87.

Measurement of Mediator Variable

The proposed mediator, Math/science Self-efficacy, was measured by an adaptation of an efficacy scale developed by Sherer, Maddux, Mercadante, Prentice-Dunn, and Jacobs (1982). The adapted scale consists of 17 items that participants rated on 5-point Likert-type scale. Some of the items were "I give up on coursework in my math and science classes before completing it" and "I am a self-reliant person when it comes to my math and science homework". The extreme ends of the scale were 1 = Strongly Disagree, and 5 = Strongly Agree. Participants who had already graduated were asked to respond to items based on their beliefs at the time they were taking classes. The psychometric properties of the measure were studied before conducting the main analyses and the reliability was .88.

Measurement of Dependent Variables

The first dependent variable, Intentions to Obtain a Math/Science Degree, was measured with 5 items, rated on a 5-point Likert-type scale. The extreme ends of the scale were 1 = Strongly Disagree, and 5 = Strongly Agree. The five items were "I intend to stay in my major and graduate with a degree in my major", "Even if I am switching majors, I intend to switch to another math or science major and get a degree", "Even if I leave the school I am currently attending and go to another school, I intend to get a degree in math or science", "Even if I have to take time off of school for financial or personal reasons, I intend to finish my degree in a math or science major", and "Even if it takes me longer than four or five years to finish, I intend to get a degree in a math or science major". Because the sample included participants that had already graduated, those participants were given the highest Intention score. Analysis of the measure's psychometric properties indicated a low reliability of .59.

The second dependent variable, Commitment to Major, was measured by Dolen and Schultz' (1998) adaptation of Mowday, Steers, and Porter's (1979) Organizational Commitment Questionnaire. It is called the Academic Commitment Questionnaire (ACQ) and consists of 15 items, measured on a 5-point Likert-type scale. The extreme ends of the scale were 1 = Strongly Disagree, and 5 = Strongly Agree. Two of the items were "For me, this is the best of all possible majors to pursue" and "I am extremely glad I chose this major over others I was considering at the time." The first item was deleted for the purposes of this study because the meaning of the item was unclear, which left 14 items in the scale. The deleted item read, "I am willing to put in a great deal of effort beyond that normally expected in order to help this major be successful." An analysis of the psychometric properties indicated an acceptable reliability of .74.

The third dependent variable, Satisfaction with Major, was measured using the subscales Quality of Education and Compensation, from the College Student Satisfaction Questionnaire (CSSQ), developed by Starr, Betz, and Menne (1971). Thirteen items were measured on a 5-point Likert-type scale; 1 = Strongly dissatisfied, and 5 = Very satisfied. Some of the items were "The chance to prepare well for your vocation" and "The amount of study it takes to get a passing grade." The items were rephrased to reflect the student's major. For example, the item "The amount of study it takes to get a passing grade" was changed to "The amount of study it takes to get a passing grade in your math/science classes." An analysis of the psychometric properties of the measure before main analyses were conducted indicated an acceptable reliability of .86.

Procedure

The researcher recruited participants from math and science classes in the Fall of 2002 and handed out a packet of measures to potential participants, including an informed consent if the women chose to participate. The informed consent form also requested permission for the researchers to access participants' math/science grades. A week after handing out the measures, the researcher returned to the classes to collect the measure and hand out a debriefing form to the participants. The debriefing form briefly explained the purpose of the research, gave them the opportunity to request results, and thanked them for their participation in the study. For the alumni, a packet consisting of an introductory letter, an informed consent, instructions to complete the measures, and a return-addressed, stamped envelope were mailed to them. The researcher did not follow up for alumni who did not respond. A debriefing statement was sent to those alumni who did participate.

CHAPTER FIVE

RESULTS OF THE STUDY

The current research examined the relationships between three independent variables, Math/Science GPA, Beliefs in Academic Stereotypes, Vulnerability to Stereotypes, and three dependent variables that were intended to measure persistence in math/science college majors - Intentions to Persist and Obtain a Math/Science Degree, Commitment to Major, and Satisfaction with Major. The variable Math/Science Self-Efficacy was proposed as a partial mediator between the independent and the dependent variables.

Data Screening

Table 1 contains the means, standard deviations, intercorrelations, and coefficient alpha for each study variable. Prior to conducting the main analyses, the data were screened using SPSS. All six variables were checked for univariate and multivariate outliers, nonlinearity and heteroscedasticity, normality (skewness and kurtosis), missing cases, and multicollinearity. The variables were standardized to obtain z scores and look for univariate outliers, using a critical value of $\underline{F} = 3.29$. Math/Science GPA had one outlier with very low math/science GPA, and

Intentions to Persist contained three low, outlying scores, all of which were removed from the data set.

After the univariate outliers were removed from the data set, the data set was searched for multivariate outliers, using a Mahalanobis Distance critical Chi-square score of 24.32, $\underline{p} = .00$, with 7 df. No multivariate outliers were found. There were no missing cases. To check for normality, the variables were checked for skewness and kurtosis, using a critical value of $z = 3.29$. Intentions to Persist was negatively skewed and leptokurtic, but a logarithmic transformation did not improve the distribution. Therefore, the untransformed variable remained in the data set. There was no evidence of multicollinearity and examination of bivariate scatterplots between all pairs of variables suggested that assumption of linearity was satisfactorily met. After the data were screened, there were 91 records left in the sample on which to conduct the analyses.

Table 1. Means, Standard Deviations, and Correlations of Study Variables

Variables	Mean	St Dev	1	2	3	4	5	6	7
1. Math/Science GPA	2.98	.75	-						
2. Belief in Academic Stereotypes	25.58	8.66	-.25**	.88					
3. Vulnerability to Stereotypes	25.46	8.80	-.15	.35**	.87				
4. Math/Science Self-Efficacy	67.64	8.76	.26**	-.33**	-.13	.88			
5. Intentions to Obtain Math/Science Degree	23.82	1.58	-.02	-.07	.02	.07	.59		
6. Commitment to Major	56.55	5.87	-.07	-.19*	-.13	.36**	.29**	.74	
7. Satisfaction with Major	48.74	7.10	.01	-.10	-.27**	.45**	.18*	.39**	.87

N = 91
Coefficient alphas indicating scale reliabilities (where appropriate) are in bold.
** P < .01
* P < .05

Correlational Analyses

The correlations between the variables are displayed in Table 1. There were several hypotheses regarding the direction of the relationships between the independent variables and the mediator, and the mediator and the dependent variables. To begin, predictor intercorrelations were examined; second, relationships between predictors and outcomes; third, relationships between predictors and the proposed mediator; fourth, relationships between the proposed mediator and outcomes; and fifth, intercorrelations between dependent variables.

First, predictor intercorrelations showed that Math/Science GPA was negatively related to Beliefs in Stereotypes ($\underline{r} = -.25$, $\underline{p} < .01$), but was not related to Vulnerability to Stereotypes ($\underline{r} = -.15$, $\underline{p} > .05$). Beliefs in Stereotypes was positively related to Vulnerability to Stereotypes ($\underline{r} = .35$, $\underline{p} < .01$). Second, Math/Science GPA was not related to any outcome variable. Beliefs in Academic Stereotypes was significantly related to Commitment to Major ($\underline{r} = .19$, $\underline{p} < .05$), but not to Intentions to Obtain a Math/Science Degree ($\underline{r} = -.07$, $\underline{p} > .05$) or to Satisfaction with Major ($\underline{r} = -.10$, $\underline{p} > .05$). Vulnerability to Stereotypes was significantly related to Satisfaction with Major ($\underline{r} = -.27$, $\underline{p} < .01$), but not to Intentions to Obtain a Math/Science Degree ($\underline{r} = .02$, $\underline{p} > .05$) or Commitment to Major ($\underline{r} = -.13$, $\underline{p} > .05$).

Third, the hypothesis that Math/Science GPA will be positively related to Math/Science Self-Efficacy was supported ($\underline{r} = .26$, $\underline{p} < .05$). The hypothesis that Beliefs in Academic Stereotypes will be negatively related to Math/Science Self-Efficacy was supported ($\underline{r} = -.33$, $\underline{p} < .01$). The hypothesis that Vulnerability to Stereotypes will be negatively related to Math/Science Self-Efficacy was not supported ($r = -.13$, $p > .05$). Fourth, the hypothesis that Math/Science Self-Efficacy will be significantly positively related to Intentions to Persist was not supported ($r = .07$, $p > .05$). The fifth hypothesis that Math/Science Self-Efficacy will be significantly positively related to Commitment to Major was supported ($r = .36$, $p < .01$). The sixth hypothesis that Math/Science Self-Efficacy will be positively related to Satisfaction with major was supported ($r = .45$, $p < .01$).

For relationships between the dependent variables, Intentions to Persist was positively related to Commitment to Major ($r = .30$, $p < .01$) and Satisfaction with Major ($r = .18$, $p < .05$). Commitment to Major was significantly related to Satisfaction with Major ($r = .39$, $p < .01$).

Regression Analyses

Before conducting the full mediational analyses, various regression analyses using Math/Science Self-Efficacy as an independent variable were run and examined. The purpose was to look at the effects of Math/Science Self-Efficacy in combination with the independent variables on the dependent variables and to see if it added any explanation independent of the other variables. It was used as one of the predictor variables because in the mediational model, it is used to predict the outcome variables. Three multiple regressions were run and the independent variables were Math/Science GPA, Beliefs in Stereotypes, Vulnerability to Stereotypes, and Math/Science Self-Efficacy. In the first regression, the dependent variable was Intention to Persist. The relationship between the independent variables and Intentions to Obtain a Math/Science Degree was not significant $F(4, 90) = .23$, $p = .92$.

In the second regression, the relationship between the independent variables and the dependent variable Commitment to Major was significant $F(4, 90) = .4.59$, $p < .01$. The independent variables and Math/Science Self-Efficacy accounted for 17.6% of the variance in Commitment to Major. Examination of the beta weights showed that the only significant beta weight was Math/Science Self-Efficacy. However, the beta weight for Math/Science GPA approached significance. Table 2 displays the results of the analysis.

Table 2. Predictors of Commitment to Major

Independent Variables	B	SE B	β
Math/Science GPA	-1.56	.81	-.20[1]
Belief in Academic Stereotypes	-.06	.08	-.09
Vulnerability to Stereotypes	-.06	.07	-.09
Math/Science Self-Efficacy	.25	.07	.37*

*$p < .05$; $r = .42$, $R^2 = .1$
[1]$p = .06$

In the third regression, the relationship between the independent variables and the dependent variable Satisfaction with Major was significant $F(4, 90) = 8.41$, $p < .01$. The independent variables and Math/Science Self-Efficacy accounted for 28% of the variance in Satisfaction with Major. Vulnerability to Stereotypes and Math/Science Self-Efficacy had significant beta weights. Table 3 displays the results of the analysis.

Table 3. Predictors of Satisfaction with Major

Independent Variables	B	SE B	β
Math/Science GPA	-1.28	.92	-.14
Belief in Academic Stereotypes	.09	.09	.12
Vulnerability to Stereotypes	-.21	.08	-.26*
Math/Science Self-Efficacy	.40	.08	.49*

*$p < .05$; $r = .53$, $R^2 = .28$

Mediation Analyses

In order to test Math/Science Self-Efficacy as a mediator between the three independent variables and three dependent variables, the main analyses were run according to procedures outlined by Baron and Kenny (1986). To establish a variable as a mediator, the steps are to 1) Show that the independent variables are significantly related to the outcome; 2) Show that the independent variables are significantly related to the mediator; 3) Show that the mediator is related to the dependent variable and 4) Show that the effect of the independent variables on the dependent variable shrinks when adding the mediator to the regression equation. Because it was hypothesized that Math/Science Self-Efficacy was a partial mediator, Step 4 means that when Math/Science Self-Efficacy is added to the regression analyses that already contain the independent variables, the relationship between the independent variables and the dependent variables should decrease. In other words, after Math/Science Self-Efficacy is controlled for by adding it to the regression equation, the relationship between the independent variables and Satisfaction with Major should decrease. The Steps 1-4 were conducted on the study variables, organized by the dependent variables.

To begin testing the mediational relationship for the dependent variable Intentions to Persist, a regression was run with the independent variables Math/Science GPA, Beliefs in Academic Stereotypes, and Vulnerability to Stereotypes. The relationship between the independent variables and the dependent variable Intentions to Obtain a Math/Science Degree was not significant $F(3, 90) = .22$, $p = .88$. None of the beta weights were significant. No further analyses were conducted because the condition of significance to satisfy Step 1 was not met.

To begin testing the mediational relationship for the dependent variable Commitment to Major, a regression was run with the independent variables Math/Science GPA, Beliefs in Academic Stereotypes, and Vulnerability to Stereotypes. The relationship between the independent variables and Commitment to Major was not significant $F(3, 90) = 1.78$, $p = .16$. No further analyses were conducted because the condition of significance to satisfy Step 1 was not met.

To begin testing the mediational relationship for the dependent variable Satisfaction with Major, a regression was run with the independent variables Math/Science GPA, Beliefs in Academic Stereotypes, and Vulnerability to Stereotypes. The relationship between the independent variables and the dependent variable Satisfaction with Major approached significance $F(3, 90) = 2.25$, $p = .09$. The independent variables explained 7.2% of the variance in Satisfaction with Major. Vulnerability to Stereotypes was the only significant beta weight, suggesting it explained most of that variance. The results of this analysis are displayed in Table 4.

Table 4. Predictors of Satisfaction with Major

Independent Variables	B	SE B	β
Math/Science GPA	-.39	1.02	-.04
Belief in Academic Stereotypes	-.02	.09	-.02
Vulnerability to Stereotypes	-.21	.09	$-.26^{*}$

$^{*}p < .05$; $r = .27$, $R^2 = .07$

The researchers felt that although the standard p value of $p < .05$ was not met, meaningful information could still be gained if analysis continued. Because of the significant correlations between some of the variables, further analyses might show that those variables affect women's satisfaction, and as a result, their persistence. Therefore, Step 2 analyses were conducted to find if the independent variables were significantly related to the mediator, Math/Science Self-Efficacy. The independent variables were significantly related to the mediator $F(3, 90) = 4.87$, $p < .05$, meeting Step 2 requirements. The independent variables explained 14.4% of the variance in Math/Science Self-Efficacy. Beliefs in Academic Stereotypes was the only significant beta weight, suggesting it explained most of that variance. The results of this analysis are displayed in Table 5.

Table 5. Predictors of Math/Science Self-Efficacy

Independent Variables	B	SE B	β
Math/Science GPA	2.2	1.2	.19*
Belief in Academic Stereotypes	-.29	.11	-.28**
Vulnerability to Stereotypes	-.00	.12	.00

*$p < .10$; **$p < .05$; $r = .38$, $R^2 = .14$

To test Step 3, a fourth regression was run to find if the mediator, Math/Science Self-Efficacy, was related to Satisfaction with Major. Math/Science Self-Efficacy was significantly related to Satisfaction with Major $F(1, 90) = 23.10$, $p < .05$. Math/Science Self-Efficacy explained 21% of the variance in Satisfaction with Major. The unstandardized beta coefficient, B, was .37, the standard error was .08, and β was .45, $p < .05$. Because the condition of significance was met, Step 4 analyses were performed.

To test Step 4 and find if the relationship between independent variables and Satisfaction with Major decreased after Math/Science Self-Efficacy was controlled, the regression previously run relating the independent variables and Satisfaction with Major was compared to a regression relating the independent variables and Math/Science Self-Efficacy to Satisfaction with Major. In the prior regression, the relationship between the independent variables and Satisfaction approached significance, $\underline{F}(3, 90) = 2.25$, $\underline{p} = .09$. The independent variables explained 7.2% of the variance in Satisfaction with Major. The only significant beta weight was Vulnerability to Stereotypes, suggesting that it explained most of that variance.

After adding Math/Science Self-Efficacy with the independent variables, the relationship was significant, $\underline{F}(4, 90) = 8.41$, $\underline{p} < .01$. The independent variables with Math/Science Self-Efficacy explained 28.1% of the variance in Satisfaction with Major. Math/Science Self-Efficacy and Stereotype Vulnerability were the significant beta weights, suggesting they explained most of that variance. Because Stereotype Vulnerability was the only significant beta weight before and after Math/Science Self-Efficacy was added to the regression equation, it was examined to see if it decreased. It did not decrease, but remained the same, $\beta = -.26$, $p < .05$. If partial mediation had occurred, the beta weights with Math/Science Self-Efficacy added into the equation should have decreased. Thus the hypothesis of partial mediation was not supported. Because Step 4 of Baron and Kenny's (1986) requirements for mediation were not met, no further analyses were conducted. The results of this analysis are displayed in Table 6.

Table 6. Regression for Satisfaction with Major

Independent Variables	B	SE B	β
Regression 1			
Math/Science GPA	-.39	1.01	-.04
Beliefs in Academic Stereotypes	-.02	.09	-.02
Vulnerability to Stereotypes	-.21	.09	-.26*
Regression 2			
Math/Science Self-Efficacy	.40	.08	.49**
Math/Science GPA	-1.28	.92	-.14
Belief in Academic Stereotypes	.09	.09	.12
Vulnerability to Stereotypes	-.21	.08	-.26**

Note: R^2 = .72 for Regression 1; R^2 = .28 for Step 2. N = 91, $p < 05$.
Note: $F(3, 90) = 2.25$, $p < .10$ for Regression 1; $F(4, 90) = 8.41$,
*$p < .01$ for Regression 2.
**$p < .01$

Mediation for Individual Independent Variables

The prior mediation analyses used the group of independent variables in regressions and using this method cannot determine if Math/Science Self-Efficacy mediates the relationship between individual independent variables and dependent variables. Therefore, exploratory analyses were conducted to further examine the role of Math/Science Self-Efficacy as a mediator between individual independent variables and the dependent variables using Baron and Kenny's (1986) steps to determine mediation. The independent variable Math/Science GPA was examined for any significant relationships to the outcome variables. It was not significantly related to Intention to Persist $F(1, 90) = .04$, $p = .84$, to Commitment to Major $F(1, 90) = .38$, $p = .54$, or to Satisfaction with Major $F(1, 90) = .00$, $p = .96$. Because of the lack of significant relationships, further analysis was discontinued.

The second independent variable Beliefs in Academic Stereotypes was significantly related to one dependent variable, Commitment to Major, $F(1, 90) = 3.49$, $p < .10$ and explained 3.8% of the variance in Commitment to Major. Beliefs in Academic Stereotypes was also significantly related to Math/Science Self-Efficacy $F(1, 90) = 10.99$, $p < .01$ and explained 11% of the variance in Math/Science Self-Efficacy. Thus, Baron and Kenny's (1986) first two criteria of showing the independent variable is related to the outcome variable and the mediator were met.

Baron and Kenny's (1986) third criteria was also met; the mediator was significantly related to the outcome variable. Math/Science Self-Efficacy was significantly related to Commitment to Major, $F(1, 90) = 13.31$, $p < .01$, and explained 13% of the variance in Commitment to Major. For the fourth criteria, a regression with Beliefs in Academic Stereotypes and Math/Science Self-Efficacy and the dependent variable Commitment to Major was significant $F(2, 90) = 6.95$, $p < .01$. Beliefs in Academic Stereotypes and Math/Science Self-Efficacy explained 13.6% of the variance in Commitment to Major. The beta weights from this regression were compared with the previous regression relating Beliefs in Academic Stereotypes to Commitment to Major. Examination of the beta weights showed that Commitment to Major became non-significant when Math/Science Self-Efficacy in the regression equation. To determine if the decrease in the beta weight was significant, the unstandardized beta coefficients and standard errors were examined using the Sobel test (Preacher & Leonardelli, 2001; Sobel, 1982). The Sobel test showed that there was a significant decrease in the beta weights, $z = -2.30$, $p < .05$). Thus, Math/Science Self-Efficacy did partially mediate the relationship between Beliefs in Academic Stereotypes and Commitment to Major.

The third independent variable Vulnerability to Stereotypes was significantly related to one dependent variable, Satisfaction with Major, $F(1, 90) = 6.73$, $p < .05$. Vulnerability to Stereotypes explained 7% of the variance in Satisfaction with Major. However, Vulnerability to Stereotypes was not significantly related to Math/Science Self-Efficacy, so analysis was discontinued.

CHAPTER SIX

DISCUSSION OF RESULTS

Mediation

There were several hypotheses that were explored in the current study. The main hypothesis was that Math/Science Self-Efficacy would partially mediate the relationship between a group of three independent variables, Math/Science GPA, Belief in Academic Stereotypes, Vulnerability to Stereotypes, and three dependent variables, Intentions to Persist, Commitment to Major, and Satisfaction with Major. This hypothesis was not supported. However, Math/Science Self-Efficacy was a partial mediator for one relationship, and the relationships among the variables that were significant will be examined further.

Mediation Found between Beliefs in Stereotypes and Commitment to Major

Math/Science Self-Efficacy partially mediated one relationship, between a woman's beliefs in stereotypes and her commitment to her major. This meant that the strength of the relationship between belief in stereotypes and commitment to major partially depended on math/science self-efficacy. If a woman believed in stereotypes, her self-efficacy decreased, which in turn decreased her commitment to major. This implies that self-efficacy is a key variable in understanding the relationship between a woman's beliefs in stereotypes and her commitment to her major.

The current study's findings that math/science self-efficacy did not mediate most of the hypothesized relationships differs from published literature in which Math/Science Self-Efficacy was found to be a mediator. In the published literature, the outcomes were academic performance, perceived career options and preferences (Betz & Hackett, 1981). O'Brien, Martinez-Pons, and Kopala (1999) found that self-efficacy mediated the relationship between academic performance and career interest in math and science. Lapan, Shaughnessy, and Boggs (1996) also found that self-efficacy mediated the relationship between ability/achievement and interest in math/science. Randhawa, Beamer, and Lundberg (1993) found that self-efficacy mediated the relationship between math attitudes and math achievement. The conclusion can be drawn that self-efficacy is an important variable across studies with different predictors and outcomes, despite the limited support for its mediational role in the current study. The importance of self-efficacy is discussed below.

Mediation Sub-hypotheses of Independent Variables and Dependent Variables

Implicit in the main hypothesis of mediation are sub-hypotheses in the steps of Baron and Kenney (1986), that relationships exist between the independent variables and dependent variables, between the independent variables and the proposed mediator, and between the proposed mediator and the dependent variables. The findings for each step are discussed below.

Relationship between Independent Variables and Intentions to Obtain a Math/Science Degree

The first group of sub-hypotheses was that relationships exist between the independent variables and the dependent variables. There was not a significant relationship between the group of independent variables and Intentions to Obtain a Math/Science Degree, even after self-efficacy was added as an independent variable. No bivariate correlations were significant, either. This finding may have been due to Intentions' lack of variance (see Table 1). Out of a possible score of 25, the mean was 24 and the standard deviation was 1.58. Even a transformation to this variable did not improve the psychometric qualities of the variable. The reliability of the measure was not adequate ($\alpha = .59$). Intentions was significantly related to the other DVs, which was expected because it was assumed that the dependent variable were measuring the same construct. It is believed that the lack of significance was due to measurement problems and not to lack of theoretical support. Therefore, the variable should not be ruled out in further research.

Relationship between Independent Variables and Commitment to Major

The relationship between the group of independent variables and Commitment to Major also was not significant. However, the overall regression model became significant after self-efficacy was added to the group of independent variables and regressed on Commitment to Major. This emphasizes the importance of math/science self-efficacy in affecting a woman's commitment to her major, a component of persistence. Interestingly, efficacy enhanced the relationship between GPA and commitment. Prior to adding self-efficacy, GPA was not significant, but approached significance after efficacy was added to the regression as an independent variable.

The only significant bivariate correlation between beliefs and commitment indicated that if a woman believed in stereotypes about women's math/science abilities, she was less committed to her major. This makes sense; when a woman believes in stereotypes and implicitly believes they are true about women, she likely questions her own competency to achieve in math and science. Guimond and Rousell (2001) point out that gender stereotypes refer not to traits applied to an individual, but to traits applied to groups of people. If women believe that men as a group are better in math and science than women as a group, even if the women are achieving better grades, they may still believe that men are more capable. The women may actually underestimate their performance in order to match the stereotype (Sidanius & Pratto, 1999). A woman may not ever be sure enough of her abilities to be committed to her major if she measures her performance against the stereotypes that men are better in math and science.

Guimond and Rousell (2001) found that women who perceived that men were better in science felt significantly less capable, had lower self-esteem, and reported lower grades. It has already been shown that women's performance expectations are affected by stereotype threat (Stangor, Carr, & Kiang, 1998; Kray, Galinsky, & Thompson, 2002). If women lower their expectations of performance or are not sure of future performance, those factors can decrease commitment because they do not want to confirm the stereotype about women's math/science abilities. Women in math and science encounter the stereotypes and face the threat every day in their classes in which they are the minority and in which their teachers are usually men. Marx and Roman (2002) found that in the presence of a male examiner, women performed worse on a math test than when in the presence of a female examiner. Taken together, this evidence suggests it is likely that the presence of stereotypes and the awareness of being the minority interfere with levels of commitment.

The non-significant correlations indicated that Commitment was not related to GPA or a woman feeling affected by stereotypes. Because beliefs in stereotypes, not GPA or Vulnerability, was related to Commitment, this suggests that beliefs are sufficient to lessen commitment. This is similar to stereotype threat - whether or not a person actually observes the stereotypes affecting him/her, the awareness of a stereotype about her group is enough to diminish performance (Steele, 1997).

Relationship between Independent Variables and Satisfaction with Major

The relationship between the group of independent variables and Satisfaction with Major approached significance. After adding math/science self-efficacy to the group of independent variables and regressed on Satisfaction, the overall equation was significant. Vulnerability was significantly related to Satisfaction before and remained significant after efficacy was added. Both variables explained unique variance in Satisfaction, independently of each other. This emphasizes the importance of self-efficacy in predicting satisfaction.

The bivariate correlations showed that GPA and Beliefs in Academic Stereotypes were not related to Satisfaction. However, Satisfaction was predicted by a woman's belief that stereotypes had affected her. More specifically, the more she felt she had been affected by stereotypes, the less satisfied she was with her major. Steele, James, and Barnett (2002) found that women in male-dominated majors perceived higher levels of discrimination directed at them and other women in their majors. The women also felt more threatened by negative stereotypes about their abilities and were more likely to report changing their majors, similar to the findings in the current study in which perceptions of being affected by stereotypes were related to less satisfaction.

Van den Bos, Wilke, Lind, and Vermunt (1998) found that ratings of satisfaction were influenced not only by expectations, but by social comparison. Persons who received outcomes different than others used both expectations and social comparison to determine their levels of satisfaction. However, expectations were more strongly related to satisfaction than social comparison. Satisfaction may depend more on expectations and/or perception of fair and equitable treatment in specific circumstances than on a woman's lack of belief in stereotypes.

If a woman has certain expectations and those expectations are not met, or if they felt they were being affected by stereotypes when they did not expect to be, it is reasonable to conclude they would be less satisfied. It is possible that in the current study, women are perceiving that they are being affected by stereotypes, may compare their experiences with others, compare that treatment with their expectations, and report less satisfaction.

It is interesting to note that while Beliefs in Stereotypes predicted Commitment, Vulnerability to

Stereotypes predicted Satisfaction. It is not clear why these two independent variables did not predict both of the outcomes. Also, there is mixed support for the lack of relationship between GPA and the outcome variables. Farmer, Wardrop, Anderson, and Risinger (1995) did not find that GPA predicted persistence in science. Farmer, Wardrop and Rutella (1999) also found that GPA did not predict choice of science as a major. However, other studies did find a relationship between GPA and science persistence. Johnson (1987), who included both men and women, found that students' persistence (retention) was predicted by their intentions (students' expectations they would return to classes the following term), GPA, self-concept (similar to self-efficacy), and satisfaction. Mau (2003) also found that academic proficiency (test scores in math and reading) and math self-efficacy were two of the strongest predictors of persistence in math/science career aspirations. Jagacinski, LeBold, and Salvendy (1988) found that GPA predicted persistence in computer science as a major in college.

In the current study, retention was assumed to consist of three components - Intentions to Obtain a Math/Science Degree, Commitment to major, and Satisfaction with Major. GPA did not predict those variables as measured in the current study. As mentioned earlier, maybe a reason that GPA did not predict any outcome variables was because the women had already chosen to enter a math/science major before they even entered college. This is supported by Lapan, Shaughnessy, and Boggs (1996) who found that their participants had already chosen their majors and were determined to obtain a degree regardless of their GPAs. There was no record of women who avoided math/science majors or even switched their majors before data collection, so there might have been a relationship between GPA and the outcome variables had those women been included.

Mediation Between Independent Variables and Proposed Mediator

Sub-Hypothesis Between Independent Variables and Math/Science Self-Efficacy

The second sub-hypothesis examined the relationships between the independent variables and the mediator. The group of independent variables was significantly related to Math/Science Self-Efficacy. The bivariate correlations showed that GPA and beliefs in stereotypes were significantly related to efficacy. If a woman had a high GPA, she had more self-efficacy, and if she believed in stereotypes, she had less self-efficacy. When comparing this study's findings to prior research, there is mixed support. As found in the current study, both Lapan, Shaughnessy, and Boggs (1996) and O-Brien, Martinez-Pons, and Kopala (1999) found that GPA predicted efficacy. Hackett, Betz, Casas, and Rocha-Singh (1992) found that GPA predicted self-efficacy. Santiago and Einarson (1998) also found that prior academic preparation predicted self-efficacy. This seems to be an firmly established relationship in the literature.

It is expected that better academic performance will be related to strong beliefs in one's abilities. Grades are clear and salient feedback about one's performance in a specific area. If one is getting good grades, one would likely believe they have an ability in that area. The significant relationship also emphasizes the importance of having some achievement information to externally reinforce or encourage belief in her abilities. It is also expected that if a woman believes in stereotypes about women, as a member of that group, she may not believe strongly in her abilities.

For the significant correlation between Beliefs in Stereotypes and Math/Science Self-Efficacy, maybe Belief in Stereotypes is more detrimental than being affected by them, as mentioned when discussing the relationship between beliefs and commitment. Believing in stereotypes may be enough to affect self-efficacy. Hackett (1985) found that gender-related socialization factors indirectly predicted self-efficacy. Matsui, Ikeda, and Ohnishi (1989) found that women reported higher self-efficacy for female-dominated occupations than for male-dominated occupations. Schmader (2002) found that when women's gender identity was linked to their performance on a math test, women who identified more with femininity performed worse than men. Other research shows that having role models helps protect women from stereotypes by increasing their self-reported math ability (Marx & Roman, 2002). The research supports that stereotypes do affect women's efficacy for male-dominated domains.

The good news about the non-significant correlation between Vulnerability to Stereotypes and Math/Science Self-Efficacy is an indication that even if a woman believed she had been affected by stereotypes, she could still possess high self-efficacy. It could also mean that because most of the sample had overcome enough barriers to choose math and science majors, they were not as vulnerable to stereotypes. Another reason could be that there were women on the faculty who could serve as role models, as buffers against stereotypes. Although there were about twice as many male faculty as female faculty in math and science departments at the university, the women's presence might have had a powerful effect in enhancing the self-efficacy of the participants and decreasing their feelings of vulnerability to stereotypes.

Although the relationship between stereotypes and math/science self-efficacy has not been studied in depth, Spencer, Steele, and Quinn (1999) did not find a relationship between stereotype threat and self-efficacy. The relationship between beliefs in and the effects of stereotypes and math/science self-efficacy needs further study.

Mediation between Proposed Mediator and Dependent Variables

Sub-hypotheses Between Math/Science Self-Efficacy and Dependent Variables

The third sub-hypothesis examined the relationship between the proposed mediator and dependent variables. The correlations indicated that the strength of a woman's Math/Science Self-Efficacy was not related to her intent to obtain a degree, probably due to the lack of variance in the latter variable. However, it is conceivable that a woman could have strong self-efficacy and not be interested in obtaining a math/science degree, for reasons such as perceived career opportunities or interest. Interest in math/science was not measured in the current study; interest was assumed because the women had already declared their majors in math and science.

The strength of a woman's self-efficacy did predict the strength of her commitment to and satisfaction with her major. Both correlations were of moderate strength. This is consistent with the researcher's expectation that if a woman believes in her abilities and competence, it is likely she will be more committed to and satisfied with her major. If a woman believes in her abilities, it is more likely she will choose to remain within a comfortable area, studying a subject she enjoys. The measures of self-efficacy, commitment, and satisfaction consisted of items related to current events and their classes. That all the measures contained items that measured current academic events might have artificially enhanced the strength of the relationships, a potential form of method bias.

The current findings that efficacy was related to commitment and satisfaction is supported by prior literature. Multon, Brown, and Lent's (1991) meta-analysis found that self-efficacy was related to performance and persistence across a wide variety of participants, experimental designs, and assessment methods. Lent, Brown, and Larkin (1984) also found that self-efficacy was positively related to persistence and performance. Those rating high on their ability to complete technical/scientific majors received better grades and persisted longer than those rating low on their abilities. Brown, Lent, and Larkin (1989) also found that self-efficacy, measured by beliefs about obtaining specific academic milestones, facilitated academic performance (grades) and persistence (retention) for both low and high aptitude students. Students with less aptitude but high self-efficacy had higher retention than those with low self-efficacy.

Lent, Brown, and Larkin (1986) also found that self-efficacy contributed significant unique variance to prediction of grades, persistence and perceived career options after variance for math ability, high school achievement, and career interests had already been explained. Although the current study did not examine the dependent variables the way the literature did, the importance of self-efficacy in predicting various measures of retention and persistence is clear. The relationships still exist, even though the current study used GPA as an independent variable and although persistence was measured by commitment and satisfaction.

When comparing math/science self-efficacy's predictive ability with GPA's predictive ability, it is seen that GPA did not predict any outcome variables. As mentioned earlier, a high GPA is not enough to elicit commitment or satisfaction. This emphasizes self-efficacy's importance in retaining women in math and science and encouraging their persistence, despite or along with their GPAs. GPA affects self-efficacy, but it is self-efficacy that is related to commitment and satisfaction. Although a woman may have a high GPA in math and science, it is her beliefs in herself that need examination when predicting retention in those majors.

While Math/Science Self-Efficacy predicted both Commitment and Satisfaction, it predicted them more strongly than the independent variables. Beliefs predicted Commitment only, and Vulnerability predicted Satisfaction only. This again underscores the important of a woman's belief in her abilities. This also provides further evidence that efficacy could have been an independent variable in the current study, rather than a mediator.

CHAPTER SEVEN

ADDITIONAL FINDINGS

Patterns in the Bivariate Correlations

The significant bivariate correlations were checked for patterns, starting from the independent variables to the proposed mediator and the dependent variables. First, a woman with a high GPA was less likely to believe in stereotypes, and if she believed less in stereotypes, she was likely to have higher self-efficacy and be more committed to and satisfied with her major. Secondly, a woman with stronger beliefs in stereotypes was likely to have less self-efficacy and less commitment to her major. Lastly, a woman who believed that she had been affected by stereotypes was less likely to be satisfied with her major.

Overall, when looking for medium effect sizes in the significant bivariate relationships, the strongest relationships were between the independent variables Beliefs in Academic Stereotypes and Vulnerability to Stereotypes, and between Beliefs in Academic Stereotypes and Math/Science Self-Efficacy. The strongest relationships were also between Math/Science Self-Efficacy and both Commitment to Major, and Satisfaction with Major, and between Commitment to Major and Satisfaction with Major.

Properties of the Measures

The main finding of the study is that Math/Science Self-Efficacy was a partial mediator between Beliefs in Stereotypes and Commitment to Major but not for the other hypothesized relationships. It did have strong relationships with the dependent variables. When examining the measures to explain the lack of significant findings, perhaps the hypothesized relationships with Vulnerability to Stereotypes were not found because Vulnerability to Stereotypes was a measure that required women to believe that stereotypes existed, and also to believe that those stereotypes had affected them. Although similar to Stereotype Threat (Spencer, Steele, & Quinn, 1999) it differed in that the study did not evoke a stereotype condition in which participants were unaware that their performance was affected by the given stereotype. The measure in the study might have been at a disadvantage to measure vulnerability to stereotypes because it relied on the participants' beliefs and perceptions rather than on a performance measure. To be politically correct in this society, people are often forced to hide their true beliefs about stereotypes; the effect of stereotypes may be covert and not noticeable to the women themselves.

The measure Intentions to Obtain a Math/Science Degree also relied on participants' beliefs that they would persist in their major long enough to achieve a degree. Perhaps a more effective indication of their persistence would have been to look at the actual retention of the women in those majors.

CHAPTER EIGHT

IMPLICATIONS, LIMITATIONS, CONCLUSIONS, AND RECOMMENDATIONS

Implications

Because Math/Science Self-Efficacy was not a mediator for the current study's variables, it may be better to study it as a mediator the way past research has done so, for women who are deciding their majors, as a mediator between ability and interest, achievement and interest, or attitude and achievement. Math/Science Self-Efficacy may be a mediator for women who are considering math/science majors, as Betz and Hackett (1983) and Hackett (1985) indicate, and as a "critical filter" (Sells, 1978) for women considering math/science majors, but may play a different role for women who are already in those majors. It may increase their performance, commitment, and satisfaction with their majors. Whether or not it acts as a mediator, efficacy is required for women to choose a math/science major, as well as to enhance their performance and retention.

The relationship between stereotypes and efficacy needs further study. Although Beliefs in Stereotypes was related to efficacy, the women's feelings that they had been affected by stereotypes was not related to their efficacy. It was also clear that Belief in Stereotypes was related to Commitment and feeling affected by stereotypes was related to lower Satisfaction with Major. Math/science retention programs and women's studies need to address the stereotypes; women may be their own worst enemies if they still believe they are not as logical and intelligent as men, have less aptitude for math and science and have to work harder to obtain the same goals. It is not clear from the current study that women's beliefs in stereotypes and feeling affected by them are enough to prevent them from entering math/science majors or that the combination of high GPA, high self-efficacy, high commitment and satisfaction are enough to ensure their persistence.

Although prior research indicates that achievement predicts persistence and performance, this study's findings also indicated that GPA does not predict women's satisfaction, commitment, and intentions to obtain a math/science degree. Strong ability or grades may not be sufficient to ensure satisfaction and commitment to math/science majors. Perhaps measuring academic performance prior to entering college would have been a better predictor of the outcome variables.

Limitations

Variables and Measures

One of the limitations of the study was that there was no variance in the dependent variable Intentions to Obtain a Math/Science Degree. This limited any chance of finding significant relationships. The good news about the variable not having any variance was that the women all intended to obtain a math/science degree.

A second limitation was that Vulnerability to Stereotypes relied on the participants' perceptions and beliefs instead of measuring the effects of stereotypes on their performance. In the literature, stereotype threat is typically measured by activating a stereotype and then measuring performance on a measure, such as a test. Stereotype threat (Spencer, Steele, & Quinn, 1999) measures the effect of stereotypes in a way in which participants are not necessarily biased to answer a particular way. Therefore, the construct of threat from stereotypes may not have been measured accurately or appropriately with the survey used in the current study.

Also, the current study's method requires participants to be consciously aware of their feelings and reactions. Having become aware, they might have over- or underestimated the effects of stereotypes. Response bias, including social desirability, could have affected the lack of relationship between Vulnerability to Stereotypes and the dependent variables. Also, the women might not have felt comfortable admitting they were still being affected by stereotypes. The women's movement was supposed to have gotten rid of stereotypes; admitting being affected by stereotypes means the women's movement did not accomplish its purposes.

Sample Size

A third and final limitation was the sample size. The first concern about sample size was that it was small, and the second was that because it was small, less male-dominated majors and less math-intensive majors were included. The assumption underlying the use of math-intensive, male-dominated, majors is that women who choose those majors respond differently than other science majors. Because this sample included women from majors that were not as math-intense and contained more women, the anticipated findings might have been concealed.

Conclusions

Several themes emerge from the current study. One is that women need some achievement information to reinforce their beliefs in their abilities, which will then positively influence their commitment and satisfaction. However, a good GPA is not enough to ensure commitment to and satisfaction with their major. A second theme is that a woman's belief in stereotypes is enough to hinder her commitment to her major. A third theme is that women who believe in stereotypes are more likely to feel they have been affected by them and also feel less self-efficacious. A fourth theme is that a woman who feels she has been affected by stereotypes in her classes will be less satisfied with her major. A fifth theme is that self-efficacy is extremely important to influence women to be committed to and satisfied with their majors, two components of persistence.

Because the women in the current study were already in math and science majors, they had already encountered and dealt with barriers that could have occurred while growing up (socialization, educational experiences, and stereotypes). The sample was very select because they were women who had chosen, entered, and persisted in science majors. However, the findings indicate they were and are affected by stereotypes about women's abilities.

Recommendations

This study indicated that Math/Science Self-Efficacy was a partial mediator between Beliefs in Academic Stereotypes and Commitment to Major. Based on the prior research, Math/Science Self-Efficacy might be a mediator for women who have not already chosen a math or science major in college, but who are interested. Future research could focus on increasing women's Math/Science Self-Efficacy, studying its relationship to Vulnerability to Stereotypes, and identifying how it differs between women already in math/science majors, and those who want to enter but do not feel that they can.

This study's results also indicated that Math/Science Self-Efficacy has better predictive ability as an independent variable than as a mediator. Future research could compare two models - one with self-efficacy as a mediator, and a second model with self-efficacy as a predictor. Future research could also examine whether math/science self-efficacy mediates the relationship between beliefs in stereotypes and the how strongly a woman feels affected by stereotypes. Academic institutions would probably strengthen women's retention and persistence in math and science by finding ways to counteract the effects of stereotypes and increase self-efficacy. The findings could also be used to increase recruitment in those majors.

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