GENDER DIFFERENCES IN INTELLIGENCE THEORY, ACHIEVEMENT MOTIVATION AND ATTRIBUTIONAL STYLE: EFFECTS ON CHOICE OF SCIENCE, MATH AND TECHNOLOGY CAREERS

A THESIS

SUBMITTED TO THE DEPARTMENT OF PSYCHOLOGY

OF THE STATE UNIVERSITY OF NEW YORK AT NEW PALTZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE IN MENTAL HEALTH COUNSELING

By

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April, 2007

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ACKNOWLEDGEMENTS

As my personal life has been beleaguered by many difficulties beyond my control during the past year and a half, it began to feel as if this thesis would never see completion. However, my thesis advisor, Dr. Melanie Hill, never gave up on me or the project, and provided invaluable assistance and support during some of the most discouraging times and I would like to extend to her my deepest and most sincere thanks.

I would also like to thank my most patient readers, Dr. Douglas Maynard and Kate Emerson-Hoss, for their most valuable input and guidance, and who expected to be reading this thesis almost two years ago.

I also must deeply thank my husband, John Froehlich, for his unwavering support throughout my educational endeavors and without whom I would have found the past year almost impossible to survive.

Last but not least, I would like to thank my former professor at Columbia University, Dr. Carol Dweck, for introducing me to the concepts in this study, and whose body of research completed over the past 20 years has been both a guide and an inspiration to me.

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ABSTRACT

This study explores potential reasons for why more females become math avoidant than males during middle and high school and tend to skip all but the most necessary math classes in college, leading to a dearth of women who enter careers in mathematics, science, and technology. This web-based study examines gender differences in the way males and females self report views of their own personal math intelligence, their goal orientation in the mathematics learning environment, their demonstration of either mastery or learned helplessness orientation in the face of failure at a difficult math task, and gender differences in math self-efficacy before and after math failure. The author hypothesized that more females than males would demonstrate a learned maladaptive pattern in the mathematical learning environment. Furthermore, it was hypothesized that the above factors will be consistent with females' decision not to enter scientific and math based careers. Contrary to these predictions, the only significant findings were that women did tend to report lower math self-efficacy than men, and that consistent with previous research (e.g. Betz, 1985), low math self-efficacy is predictive of interest in careers in math, science, and technology. The results will be presented and discussed, along with some limitations of the current study and suggestions for future research in this important area.

Introduction

In 1972, the law known as Title IX was passed, which banned sex discrimination in educational institutions that receive federal funds. In the three decades since then there has been a significant increase in the number of women choosing to enter largely male-dominated fields of science, math, and technology (Raloff, 2004). According to a report issued on July 22, 2004 by the Government Accountability Office (GAO), the percentage of female scientists in the United States has increased from 3 percent to 20 percent from 1972 until 2004.

However, in spite of these apparent gains, women continue to be under-represented in many areas in of science (Brush, 1991). For example, although the GAO figures seem to indicate that the gender gap is slowly closing, the report also indicates that much of the increase in numbers is a result of more women entering the life sciences (e.g. psychology, biology), rather than mathematics and engineering (GAO, 2004). According to Matthews (1990), at the end of the 1980s only 4 percent of engineers and 30 percent of scientists in America were women; these figures have not altered significantly since then (Kennedy & Parks, 2000). The same pattern is seen in the academic setting, where male faculty members continue to outnumber female faculty in the domains of mathematics, science, and engineering (GAO, 2004). The American Association of University Women (AAUW) has identified finding ways to increase women's participation in the science-focused fields as a priority concern (1999). This study will utilize past research combined with different applications in order to help identify some possible reasons for women's math avoidance.

The effects of the continuing disparity in numbers between men and women in the fields of science, math, and technology are likely to be substantial, impacting both women as individuals and the greater society in which they live. Owing to the high value placed on science and technology in the current economy, individuals who enter the science and technological fields receive both personal prestige and considerable salaries (AAUW, 1999). However, because women are very poorly represented in the mathematics, computer and engineering fields where salaries and prestige are the greatest, women are losing out on their share of the financial reward, status, and personal satisfaction that a career in science could offer them (National Association of Educational Progress, 1997). On a more global level, the scarcity of visible, successful female scientists and engineers for women to emulate discourages increased female participation and continues the cycle of gender disparity (Kennedy & Parks, 2000). Consequently, many women decide not to enter these traditionally "masculine" fields, choosing instead the socially approved "feminine" fields such as the humanities or social sciences, thus finding themselves restricted to more marginal, less prestigious, and less financially rewarding careers (AAUW,1999). The resulting gender gap in salaries leaves women economically and socially disadvantaged (AAUW, 1999).

Continued male dominance in these prestigious and well paying fields serves to cement women's positions as second-class citizens (Oakes, 1990). According to Kennedy and Parks (2000), if girls observe that women hold positions of inferior social status to men, the girls may conclude that they are inferior to boys. Because math and science careers are stereotypically considered male domains, many girls choose not to continue math and science studies; this choice severely limits their career options (McCormick &

Wolf, 1993). One disturbing consequence of girls' failure to develop their academic potential is the loss of their sense of themselves, which results in lowered self-esteem and lower ability to attain personal satisfaction (Gilligan, 1990; Kennedy & Parks, 2000). Educators and policymakers alike are of the opinion that encouraging women to break away from choosing traditional fields of study and instead to choose science and technological studies is an effective way to lessen the gender gap in science, engineering, and technology (Oakes, 1990).

Lack of equal participation by women in science also impacts society in other significant, but somewhat less obvious, ways. Due in part to the lack of participation by women, the scientific work pool is not increasing at the pace necessary to supply the needs of the industry (Leslie, McClure, & Oaxaca, 1998). According to O'Brien, Martinez, Pons, and Kopala (1999), a shortage of 400,000 workers in science and engineering is projected by 2006 that can only be reduced if more women are induced to enter the field. Lack of equal participation by women in science and engineering not only increases this country's vulnerability in competition with other nations, it also unfairly excludes a large percentage of the population from prestigious, influential and highly paid careers (Campbell & Clewell, 1999).

Furthermore, when women are not adequately represented in science and technology the world loses the benefit of women's unique perspective and input, along with their potential to enrich, expand, and rejuvenate these traditionally male-dominated disciplines (Campbell & Clewell, 1999). For example, starting in the mid- to late-1970s, feminist analyses of science and technology began to appear and have continued as the decades have advanced (Hughes, 1991). Many of these critiques have brought to light numerous long term biases and false assumptions in scientific research that challenge the objectivity of the male dominated scientific community (Hughes, 1991). According to one feminist in science, “The social structure of science , many of its applications and technologies, as modes of defining research problems and designing experiments, ... are not only sexist but also racist, classist, and culturally coercive” (Harding, 1986). Yet most of those working in science, engineering, and technology are neither aware of nor even curious about any feminist critiques of their work (Bleuer, 1986). Many feminists in science believe that until the number of women in the scientific community starts to reach parity with men, scientific thinking and questioning will remain constrained by the limitations that result when one subset of the population (white, middle-class males) controls which research questions may be asked and what are the appropriate answers (Keller, 1985; Kuhn, 1970). Thus, the world may be losing out on potential scientific discoveries due to the inequality of female participation in the sciences.

Researchers are still looking for answers as to why women tend to avoid math and science. Although it was once thought (and still is by some) that males were born with a greater mathematical capability than females, recent studies show no significant differences between boys’ and girls’ elementary school math performance (Feingold, 1988). In spite of this, by the time they are in high school many more girls as compared to boys have stopped taking higher level math courses (Clewell, Anderson & Thorpe, 1992). Researchers have found that parental and teacher expectations that girls will not do as well as boys in math strongly influences girls’ math choices (Eccles, 1989). As a result, many girls have low math self-efficacy; they are not confident of their ability to perform well in mathematics, and attribute success in math to external causes such as luck rather than ability (Ryckman & Peckham, 1987).

Betz (1985) found that self-efficacy in mathematics is predictive of choice of science and math-related college majors for both men and women. Researchers have suggested that lowered mathematics self-efficacy is a contributor to to the low number of women in those fields (Hackett & Campbell,1987; Hyde, Fennema,& Ryan,1990). Self-efficacy has been defined by Bandura (1986) as people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance.

The current study will look how mathematics self efficacy is affected by three concepts from the cognitive and motivational domains (i.e., implicit theory of intelligence, achievement motivation, and attributional style) that researchers have found to affect an individual's ability and motivation to learn (Dweck, 1986; Dweck, 1999; Dweck & Leggett, 1988). Research findings also suggest a relationship between these three concepts and individual self-efficacy (Dweck, 1986; Fennema, 1990; Stipek & Gralinski, 1991). Dweck and Leggett (1988) discovered that students motivated by learning goals increased perceptions of self-efficacy and success in their studies. According to Bandura (1993), those with higher self-efficacy persevere and put forth greater effort when faced with failure. Therefore, this study will include an investigation of the relationship of math self-efficacy to career choice. The purpose of the current study is first to explore gender differences in: (a) beliefs about math intelligence, (b) goal orientation in the mathematics learning environment, (c) beliefs about and response to mathematics failure. The study will then look at gender differences in math self-efficacy ratings and identify any significant relationships between implicit beliefs, goal orientation, and failure attribution. Finally, this study will examine the influence of these effects on choice of science-focused careers.

Implicit theory of intelligence

According to the implicit theory of intelligence, learners hold one of two beliefs about intelligence: entity or incremental (Dweck, 1999; Dweck & Leggett, 1988). Holders of the entity view tend to believe that a person is born with a certain fixed amount of intelligence that is uncontrollable and does not change no matter how much he or she learns. Thus, this fixed amount of intelligence determines the challenges that one will or will not be able to master. In contrast, those who hold an incremental view believe that intelligence is malleable and controllable, and increases as learning and study increase. According to this view, intelligence can readily grow and expand to meet any intellectual obstacle. Not surprisingly, research has found that having an entity theory of intelligence results in decreased effort after failure, but having an incremental theory results in increased effort (Dweck, 1999).

Achievement Motivation

Dweck and Leggett (1988) have found that holding an entity or an incremental theory of intelligence tends to result in the pursuit of different achievement goals. Two types of achievement goals have been identified: “performance goals” and “learning goals” (Dweck, 1986; Dweck & Leggett, 1988). Performance goals have also been called “ego-involved goals” (Machr & Nicholls, 1980). Pursuit of a performance goal stems from the wish to be perceived as smart, competent and knowledgeable about a task. Individuals who believe in an entity theory of intelligence tend to pursue performance goals (Dweck, 1999; Dweck & Leggett, 1988). These individuals view intelligence as fixed and do not believe that they can improve it; therefore they are motivated to prove their competence (both to themselves and others) rather than risk learning a new skill. Similar connections have been observed between holding an incremental theory of intelligence and pursuing learning goals (Dweck, 1999; Dweck & Leggett, 1988). Learning goals come from a desire to improve, gain knowledge, and acquire new skills. Since incremental theorists believe that intelligence can always be increased through acquisition of knowledge, they are motivated by the desire to learn and improve.

Attributional Style

Studies have demonstrated that when failures and setbacks occur, individuals will react with either a "helpless" or "mastery" response (Diener & Dweck, 1978; Dweck, 1999; Hong, Chiu, Dweck, Lin, & Wan, 1999). Research has shown that holding an entity theory of intelligence and pursuing performance goals predicts that one will respond with a "helpless" attributional style if failure is encountered (Diener & Dweck, 1978; Dweck, 1999; Hong et.al.,1999). Because individuals who view intelligence as fixed are driven to prove their competence when in an achievement setting, they tend to feel helpless when unable to do so, and experience failure as a threat to their self-image. Because those who hold this view do not believe that improvement is possible, effort decreases after failure. On the other hand, those having an incremental view believe that intelligence can always be increased through acquisition of knowledge, and so are motivated by the desire to learn and improve. Because they view intelligence as malleable, when faced with failure they react with a "mastery" style attributional style that causes them to view failures as challenges and to try even harder at the task (Diener & Dweck, 1978; Dweck, 1999; Hong et al., 1999).

Math Self-Efficacy

According to Bandura (1977), self-efficacy influences individuals' choices of activities, effort, and persistence. Individuals with a low sense of self-efficacy for a task may avoid it, whereas those with a high self-efficacy could be more willing to perform the task, putting forth greater effort and persevering in the face of difficulties (Schunk, 1991). Within the domain of mathematics, self-efficacy of math performance is relevant because skills in math are essential to success in scientific and technological fields (O'Brien, Martinez-Pons, & Kopala, 1999). According to Hackett and Campbell (1987), male college students display significantly more math self-efficacy than female college students, leading more men to become interested in the math and science fields, whereas females with low math self-efficacy typically tend to avoid math and science careers.

Gender and Choice of Careers in Science

Dweck (1986) found that girls are much more likely than boys to hold an entity view of intelligence. In other words, girls are more likely to believe that they are born with a fixed amount of intelligence that does not change with learning. Therefore, when faced with the expectation that girls do not do as well in math, they are more likely to see this as fixed or innate. In the classroom, rather than risk failure by learning something new, they will choose goals that demonstrate their competence at a task. And when faced with failure, they will respond in a helpless manner.

Based on the research described above, it was hypothesized:

(1) women would report significantly lower scores on the Implicit Theory of Intelligence Questionnaire (indicating an entity theory of mathematics intelligence) than men.

(2) women would report significantly lower scores than men on the Goals Inventory, indicating that they were more likely to pursue performance goals in the mathematics learning environment.

(3) women wouldl report more of a math helpless orientation than men.

(4) participants who report holding an entity theory of math intelligence, pursue performance goals in the mathematics learning environment, and report a math helpless orientation would also report low mathematics self-efficacy.

(5) participants reporting an entity theory of math intelligence would report significantly less math self efficacy in the second half of the math self efficacy survey (after math failure), while the math self-efficacy of those who hold an incremental belief would remain relatively unchanged.

(6) there would be a significant relationship between the following variables: reporting an entity theory of math intelligence, pursuing performance goals in the mathematics learning environment, reporting a math helpless orientation, low math self-efficacy, and a decision not to enter scientific and math based careers.

Method

Participants

Participants were primarily students (173 female, 54 male) recruited from the SUNY New Paltz campus. Recruitment was done through flyers and through an e-mail posting approved by the administration that went out to all SUNY New Paltz students. Participation was voluntary and completely anonymous. Participants who responded were directed to a website link where they completed an on-line survey. They did not receive academic credit or any other compensation for participating in the survey.

Procedures

This study was conducted in online, survey format. The survey contained (a) the Implicit Theory of Intelligence Questionnaire (Dweck Chiu, & Hong, 1995) to categorize an individual as having an entity or incremental theory about math intelligence, (b) the Goals Inventory (Roedel, Schraw, & Plake, 1994) to measure learning and performance goals orientation, (c) the Mastery Orientation Inventory (Reynolds & Miller, 1989) to determine mastery or helpless mathematics attributional style, and (d) the Mathematics Self-Efficacy Scale-Revised (Betz & Hackett,1983) to assess math self efficacy. Participants were also asked to rate their choice or interest in entering math, science, or technological careers by answering (e) the Career Interest Scale (CIS), which was devised for this survey. The survey was taken completely on-line and took approximately 40 minutes to complete.

Instruments

Participants completed a survey that included the following questionnaires, which were modified to be specific to mathematics.

Implicit Theory of Intelligence

Implicit theory of intelligence was measured by The Implicit Theory of Intelligence Questionnaire (Dweck, Chiu, & Hong, 1995), a three item questionnaire that measures implicit theories about the malleability of intelligence. The three questions were modified for this survey to apply specifically to math intelligence. All items present an entity position with items such as "You have a certain amount of *math* intelligence and you can't really do much to change it". Participants responded using a 6 point Likert-type scale (1 = *strongly agree*, 6 = *strongly disagree*). Participants with an average scale value of ≤ 3 are classified as entity theorists, and those with a score of >3 and above are classified as incremental theorists. The sample in the original study consisted of undergraduate college students. Coefficient alphas ranged from .94 to .80 (Dweck, Chiu, & Hong,1995). The test-retest reliability was .80 over a 2-week period (Dweck, Chiu, & Hong,1995). Validity was demonstrated by positive correlations with the Intelligence Theory Measure and the Morality Theory Measure (*Dweck, Chiu, and Hong, 1995).* The coefficient alpha for the modified test in the current sample was .94.

Achievement Goals

Achievement goals were measured by the Goals Inventory (Roedel, Schraw, & Plake, 1994), an 18 item scale that measures learning or performance goals. All items were on a 5 point Likert-type scale. The items were modified for this survey to apply specifically to mathematics, with items such as "I persevere even when I am frustrated by a *mathematical* task" and "It is important for me to get better *math* grades than my classmates." (1 = *always false*, 5 = *always true*). Scores indicating learning goals range from 12 to 60, while scores indicating performance goals range from five to 25. The original instrument was administered to a sample population of college students. Test-retest reliability estimates for evaluating goals were .73 and .76 respectively (Roedel, Schraw, & Plake, 1994) Coefficient alphas were .80 and .75 respectively (Roedel, Schraw, & Plake, 1994). Validity was demonstrated by comparisons to measure of test anxiety and hope of goal attainment (Roedel, Schraw, & Plake, 1994). The coefficient alpha for the modified survey in the current sample was .82.

Attributional Style

Attributional style was measured by the Mastery Orientation Inventory (Reynolds & Miller, 1989). Attributional style is viewed as continuum with mastery orientation at one end and learned helplessness at the other. The MOI differentiates people along this continuum. The original MOI questionnaire consists of 40 statements (which for purposes of this study was shortened to 10). The 10 statements selected were representative of the 40 in the original study, and revised to reflect either mastery oriented or learned helpless functioning within a *mathematical* context. Examples of questions asked were “In *math* class I give up without trying very hard”, “When *math* class gets more difficult, I try harder”, and “If I can’t get the answer to a *math* problem right away, I know I won’t get it at all.” A three alternative (1= *most of the time, 2= some of the time, 3= almost never*) Likert-type response is utilized with higher scores reflecting greater learned helplessness. The coefficient alpha was .95 in a sample of adolescents (Reynolds & Miller, 1989). Test-retest reliability after a three month period was .77 (Reynolds & Miller, 1989). Validity was demonstrated by significant correlations between the MOI and the three criterion variables: locus of control, depression, and teachers ratings of learned helplessness, as measured by the IAR, RADS and GHRS. Correlations were .49, -.58, and

.52 respectively (Reynolds & Miller, 1989). The coefficient alpha for the modified was .82.

Math Self-Efficacy

Math self-efficacy was measured by the Mathematics Self-Efficacy Scale-Revised (MSES-R, Betz and Hackett, 1983). The original MSES-R originally contained 52 items and three subscales representing three domains of math related behavior: solution of math problems, completion of math tasks used in everyday life, and satisfactory performance in college courses that require knowledge of mathematics. For purposes of this study, only the "solution of math problems" subscale was chosen because it had the most relevance to our investigation of math self-efficacy. This subscale contains 18 items which measure the confidence with which a participant thinks he/she can solve the math problem given. Examples of the items includes " If P = M, then which of the following will be true? I. N=P-M. II. P-N=M. III. N+ M = P", and " If y = 9 + x15, find x when y = 10". Each item was rated on a 5-point Likert scale (1 = *no confidence*, 5 = *complete confidence*). The scale used in this study consisted of two parts: the first 9 questions were presented, followed by a very difficult math problem (which participants were told they got incorrect in order to induce a failure condition), followed by the final 9 questions. The purpose of splitting the scale in half was to obtain a measure of change in math self-efficacy after a math failure. In a sample consisting of college students, the original study had internal consistency of the three subscales was .90 for self-efficacy in math problems, .91 for daily math tasks self-efficacy, and .95 for self-efficacy in mathematics course performance (Kranzler & Pajares, 1997). Cronbach's alpha for the total MSES was .95 (Kranzler & Pajares, 1997). Validity was demonstrated by significant correlations between past MSES scores and past mathematics grades (Kranzler & Pajares, 1997). The shortened Math Self-Efficacy scale had coefficient alpha of .91 in the current sample.

Career Interest Scale

The Career Interest Scale was developed for this study and asked participants to rate their choice or interest in entering a career in math, science, or technology by indicating their interest on a Likert-type scale (1 = *no interest*, 5 = *extreme interest*).

Results

Gender Differences

The first hypothesis was that women would report significantly lower scores than men on the Implicit Theory of Intelligence Questionnaire (Dweck, Chiu and Hong, 1995). An independent groups *t* test was conducted and, contrary to expectations, revealed no significant difference between women's (M = 3.84, SD = 1.28, n =173) and men's (M = 4.16, SD =1.47, n = 54) scores, (t = -1.57, df = 225, p =.118; *See Table 1*).

The second hypothesis was that women would report significantly lower scores on the Goals Inventory (Roedel, Schraw, & Plake) than men, indicating that more women would choose performance goals and that men would be more likely to choose learning goals in mathematics subject, even if to do so they choose to be seen as not as intelligent as others. An independent groups *t* test did not support this prediction compared with women's scores (M = 3.26, SD =.46, n = 173) Men scores were (M = 3.35, SD =.42, n = 54, t = -1.28, df = 225, p = .20; *See Table 1).*

The third hypothesis was that women would score significantly higher scores on the Mastery Orientation Inventory (Reynolds & Miller, 1989), which would point toward women having a learned helplessness orientation toward mathematical problems as opposed to men, who would demonstrate a mastery orientation. A *t*-test did not show any significant difference between women's (M = 1.83, SD = .38, n = 173) and men's (M = 1.74, SD = .36, n = 54) scores, (t = -1.59, df = 225, p = .11*; See Table 1*).

The fourth hypothesis was that women would report lower scores than men on the first part (questions 1-9) of the Mathematics Self-Efficacy Scale-Revised (Betz & Hackett, 1983), given before a very difficult math problem was administered in the survey. An independent *t*-test was conducted and the results were significant in this case, indicating that women tend to demonstrate lower mathematics self-efficacy than men. Women's scores were (*M* = 4.031, *SD* = .95, *n*=173) and men's scores were (*M* = 4.32, *SD* = .63, n = 54). Overall, *t* = -2.13, *df* = 225, and *p* = .034 (See Table 1).

Since the unequal sample sizes for female participants (N=173) and male participants (N=54) may have resulted in less power, a post-hoc second *t*-test using randomly selected equal numbers was run. This test found a significant difference between women and men's scores on the Implicit Theory of Intelligence Questionnaire (Dweck, Chiu and Hong, 1995), suggesting that more women hold an entity theory of intelligence than men (*M* = 3.48, *SD* = 1.24, *n* =54, *M* = 4.17, *SD* =1.45, *n* = 54, for women and men respectively; *t* = -2.66, *df* = 106, *p* =.009). These results suggest that the hypothesis that more women hold an entity theory of intelligence than men holds some validity (See Table 4). No other significant differences were found for the other variables.

Mathematics Self-Efficacy Post-Math Failure

The fifth hypothesis was that people (women and men) with entity beliefs (scores <3 on the Implicit Theory of Intelligence Scale) would report a significant decline between the first and second half of the Math Self Efficacy Scale, when an unsolvable mathematical problem in between the two halves. Similarly, it was hypothesized that those with incremental beliefs (high ITI scores) would demonstrate more stability. The results of a paired samples, repeated measures *t*-test supports this prediction for both people with low ITI, (*M* = .230, *SD* = .512, *n* = 76), *t* (75) = 4.93, *p* <. 001, and high ITI (*M* = .432, *SD* = .572, *n* = 153), *t* (152) = 9.32, p <.001 (See Table 2). Consistent with the hypothesis, scores on the math self-efficacy measure declined for those with entity beliefs; however, contrary to the hypothesis, scores on the math self-efficacy measure also declined for those with incremental beliefs.

Self-Efficacy and Career Choice

The sixth hypothesis was that there would be a significant relationship between the following variables: reporting an entity theory of math intelligence, pursuing performance goals in the mathematics learning environment, reporting a math helpless orientation, low math self-efficacy, and a decision not to enter scientific and math based careers. A Pearson's Correlation found no significant correlations between entity theory and career choice, r (226) = .208, p < .01; performance goals and career choice, r (226) = .416, p < .01; and math self-efficacy and career choice, r (226) = .399, p < .01. However, there was a significant correlation between mastery orientation and career choice, r (226) = -.434, p < .01 (See Table 3). These results indicate that reporting a mastery orientation in mathematics may be predictive of interest in entering careers in math science, and technology, while reporting a math helpless orientation correlates with a decision not to enter careers in math, science, and technology, as hypothesized.

Furthermore, the study found significant correlations between the Mastery Orientation Inventory and all 4 of the remaining variables. The correlations were: Implicit Theory of Intelligence measure, r (226) = -.397, p < .01; the Goals Inventory, r (226) = - .670, p < .01; the MSE_A, r (226) = -.593, p < .01; and the MSE_B, r (226) = -.582, p < .01 (See Table 3). A comparison of the means of these variables indicates that there are significant correlations between having a mastery orientation and: holding an incremental view of intelligence, pursuing learning goals, possessing high math self-efficacy, and career choice, regardless of gender (See Table 1). These findings suggest that having a mastery orientation in math, regardless of gender, is predictive of the relationships between the variables; finding no correlations between the other variables supports this analysis.

Post-hoc Analyses

A mixed group factorial ANOVA was performed to examine the effects of gender on the math self–efficacy on the two times the Math Self – Efficacy test (MSE-A, MSE-B) was given. Table 5 shows the means for the scores. There was a main effect for gender (F (1, 225) = 5.64, MSE = 1.43, $p < .005$) with men having overall higher scores than women for both the first time and the second time the Math Self-Efficacy Test was given. There was also a main effect in terms of time given (F (1, 225) =72.8, MSE = .153, $p < .05$), with overall higher scores at Time 1 (for both men and women) in comparison to Time 2. There was no interaction between gender and first and second times the MSE was given (F(1, 225) = .025, MSE = .153, p = .665). These results suggest that women's scores on math self-efficacy did not decline to a greater extent than men's after the condition of math failure was induced.

Discussion

This study was conducted as an attempt to bring together research from many previously unconnected studies in order to look at the serious problem of women's math avoidance. The main findings of the current study were: (a) women's endorsement of an implicit theory of intelligence was not significantly different than that reported by men in the original study; however, a post-hoc analysis indicated this might be the result of unequal sample size, (b) women and men were not significantly different in their choice of performance goals versus learning goals in mathematics, (c) women were not significantly more likely than men to report learned helplessness orientation toward mathematical problems, (d) women did tend to report lower math self-efficacy than men, and (e) the scores on math self-efficacy significantly declined after being presented with an insolvable math problem for participants holding entity beliefs; however, this decline was also present for those holding incremental beliefs.

Consistent with previous research, the women in the current study reported lower math self-efficacy than men (Hackett & Campbell, 1987; Hyde, Fennema & Ryan, 1990; Ryckman & Peckham, 1987). Similarly, the current results support previous research (e.g., Betz, 1985) that math self-efficacy is predictive of interest in careers in math, science, and technology. However, in contrast to previous research (Dweck, 1986), the female participants in the current study were just as likely as men to (a) believe that they were born with a fixed amount of math intelligence, (b) report performance goals in mathematics, and (c) report learned helplessness orientation towards mathematical problems. Nonetheless, a second *t*-test consisting of randomly selected equal numbers of men and women indicate that there may be some support to the hypothesis that more women than men were likely to believe they were born with a fixed amount of intelligence. Further research is needed to elucidate these results.

Limitations and Future Research

The failure to establish significant support for the hypotheses presented, while disappointing, also offers the challenge to continue research into this subject. In other words, while it is possible that there are indeed not significant differences, it is also possible that limitations of the current study have clouded any possible results. For example, future research should ensure a more equal number of female and male participants. While 227 participants completed the survey, only 54 were male. Additionally, the participants were survey volunteers and there is a strong possibility that women (or men) with math avoidance simply chose not to respond, prohibiting a truly random sample of participants. In other words, it is possible that gender differences in the belief of the malleability of intelligence exists in the total population, but not in the subpopulation of women who are confident enough in math to complete a survey such as this one. Therefore, the non-significant results found in the current study may not be reflective of what exists in the general population. Similarly, given the anonymous web-based nature of the survey, participants with math avoidance might discontinue their participation without experiencing the social obligation to complete the survey that occurs when surveys are collected in person. It is interesting to note that 609 individuals entered the survey, while only 227 completed it. It seems reasonable that the large amount of those who began the survey, but dropped out when the when the questions began to become more difficult, were exactly the math-avoidant participants the study expected to measure.

Although using a web-based survey was considered the most efficient way to recruit the largest number of participants, besides the drawbacks mentioned above, with web-based surveys there is not a way to limit how many times one participant could take the survey, which also may have caused some skewing of results.

In summary, no one would argue that math avoidance by women is caused by merely one or two factors. The subject has been the study of a great body of research, as yet with little effect on the problem. However, it is hoped that the great need to reduce the disparity between females and males in mathematical, scientific, and technological careers will spur further research that will enable continued growth and awareness in this area.

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Table 1. *Means of Major Variables for Male (n = 54) and Female (n = 173) subsamples.*

Variable	Subsample	*M*	Range	*SD*	*t*
Implicit Theory of Math Intelligence (Entity/Incremental Theory)	Women	3.84	-.73 to .08	1.28	-1.57
	Men	4.16		1.47	
Goals Inventory (Performance/Learning goals)	Women	3.26	-.23 to .04	.047	-1.28
	Men	3.35		.042	
Mastery Orientation Inventory (Mastery orientation/ Learned Helplessness)	Women	1.83	-.02 to .21	0.37	1.60
	Men	1.74		0.37	
Math Self-Efficacy-A	Women	4.03	-.57 to -.02	0.95	-2.13*
	Men	4.32		0.64	

Notes. * p<.05, ** p<.01, *** p<.001. Implicit Theory of Math Intelligence- Low score (≤3) = Entity Theory, High Scores (>3) = Incremental Theory. Goals Inventory- Lower scores = Performance Goals, Higher scores = Learning Goals. Mastery Orientation Inventory – Lower Scores = Mastery Orientation, Higher scores = Learned Helplessness. Math Self-Efficacy- Lower scores = low math self-efficacy, Higher scores = higher math self-efficacy.

Table 2. *Paired Samples T-test Comparing Changes in Math Self-Efficacy for Participants with Low (≤ 3) ITI (n = 76) and Participants with High (> 3) ITI (n = 153).*

Subsample	Variable	*M*	*SD*	*t*
Participants with low (≤ 3) ITI	Math Self-Efficacy – A	3.77	0.91	4.93
	Math Self-Efficacy – B	3.48	0.88	
Participants with high (> 3) ITI	Math Self-Efficacy – A	4.27	0.84	9.32
	Math Self-Efficacy – B	3.84	0.89	

Notes. * p<.05, ** p<.01, *** p<.001.

Table 3. *Descriptive Statistics for and Intercorrelations Among Major Variables (N = =297).*

Variable	1	2	3	4	5	6
1. ITI	(.94)					
2. GI	.37	(.82)				
3. MSE-A	.32	.44	(.91)			
4. MOI	-.40*	-.67*	-.59*	(.82)		
5. MSE-B	.27	.44	.81	-.58*	(.90)	
6. CI	.21	.42	.40	-.43*	.46	(N/A)

Notes. * p<.05 , ** p<.01, *** p<.001 ITI = Implicit Theory of Intelligence; GI = Goals Inventory; MSE-A = Math Self-Efficacy (1st half); MOI = Mastery Orientation Inventory; MSE-B = Math Self-Efficacy (2nd half); CI = career interest in math, science or technology.

Table 4. *Means of Major Variables for Male (n = 54) and Female (n = 54) subsamples.*

Variable	Subsample	*M*	Range	*SD*	*t*
Implicit Theory of Math Intelligence Low score (≤3} Entity Theory High score (>3) Incremental Theory	Women	3.49	-.1.20 to - 0.17	1.24	-2.66*
	Men	4.18		1.45	
Goals Inventory Low scores = Performance goals High scores = Learning goals	Women	3.22	-0.31 to .05	0.50	-1.44
	Men	3.35		0.42	
Mastery Orientation Inventory Low score = Mastery orientation High score = Learned Helplessness	Women	1.87	.002 to 028	0.37	2.01
	Men	1.73		0.35	
Math Self-Efficacy-A Low scores = low math self efficacy High scores = high math self-efficacy	Women	3.89	-0.73 to -0.12	0.93	-2.76*
	Men	4.32		0.09	

Notes. * *p*<.05, ** *p*<.01, *** *p*<.001.

Table 5. *Means (Standard Deviations) for scores indicating main effects for gender and time.*

	Time Given	
Gender	MSE-A	MSE-B
Female	4.03 (.95)	3.64 (.90)
Male	4.32 (.63)	3.98 (.85)