GENDER EFFECTS ON
ATTITUDES AND ACHIEVEMENT IN MATHEMATICS

by

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ABSTRACT

This paper discusses the relevance, rationale, controversies and limits of the question; how does gender affect mathematics attitudes and achievement in the United States? The historical context of this question including efficacy theories, women's educational history and the evolution of gender studies, is explored in chapter two. A critical review of the research on the subject follows, with major findings summarized and threads of commonality highlighted. Five sections are presented in chapter three; student self-efficacy, gender roles, attributions, parents and teachers and classroom environments. The final chapter summarizes the findings, suggests relevant implications for practice, and areas for further research.

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CHAPTER ONE: INTRODUCTION

Research Question

How does gender affect the attitudes and achievement of students in mathematics? Attitudes include self-beliefs about math competence (also called efficacy) and feelings produced when mathematical tasks arise such as anxiety or enjoyment. Achievement in math is usually measured by academic grades, test scores or success in high level math courses.

Relevance

As a student I did not feel positive about or efficacious in math until I reached college. In elementary school I was very successful in art, language, writing and reading but struggled with math and science. Wanting to be a 'good' student in all my subjects, I was surprised by my teachers' and guardians' perceived lack of concern over my fledgling math scores. The women in my family tried to comfort me with stories of their own struggles and failures with math. Many of my teachers echoed similar rationales for avoiding math in the curriculum except during specifically designated 'math time'.

Familial narratives like mine, sometimes reinforced by teachers can produce enduring attitudes about math in children. Some experience anxiety when confronted with math tasks and others simply feel that math is not important for them to master. Both of these negative attitudes about math affect achievement. The low achievement confirms the already existing belief that the student is not a successful math student and a cycle of negative expectations and poor performance is continued.

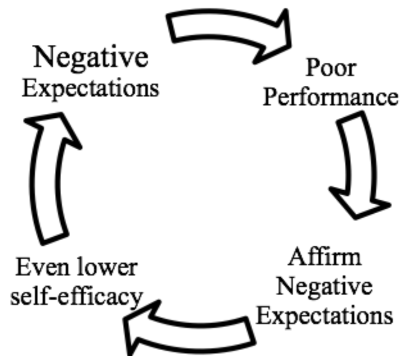

Fig. 1: Cycle of Negative Expectations

Along my journey to earn a Bachelors degree and continuing on to pursue a Masters in Teaching, I have met many very intelligent and capable women who tell me a similar story to my own in regard to their mathematics education. Anxiety, low self-efficacy and avoidance behaviors are all marks of the painful past these women and I experienced at a young age and carry with us into our adulthoods.

Closing the mathematics gender gap has economic and social benefits for both the individual student and the larger community. As teachers find better ways to make math more accessible to both genders, the female student will have a broadened set of opportunities ahead of her with a firm grasp of mathematical skills and confidence. Engineering, physics and medical fields could become stronger and more competitive in the global market if women were joining the workforce in greater numbers. In order for the United States to have the most advanced intelligence, it must also have a wide selection of mathematics experts, and bringing more than half of the population into that arena will provide this.

Much of the research on the gender gap in mathematics suggests that the disparity begins to form as early as elementary school. As an elementary school teacher I have a unique opportunity to promote social justice in my classroom by addressing patterns of inequity like the gap in mathematics achievement. This paper explores how gender affects the math attitudes and performance of students.

Rationale

The need to study gender dynamics in math and math education is apparent from the disproportionately low numbers of females entering into higher-level math courses and their under representation in mathematical occupational fields. It is important to me as an elementary teacher to teach math in a way that maximizes the chance of success for all of my students because math is such an important field for future career opportunities.

Controversies

Researchers in math education disagree as to whether the gender gap in math is achievement or attitude based. For this reason, and because of their inextricable relationship, I have chosen to study both attitudes and achievement in math. Although there is debate about the cause of the gender gap in mathematics, there is general consensus that a gender gap exists. How to go about closing the gap, however, produces a wide range of opinions. There is a division between those who believe the gap exists because of environmentally imposed gender roles, and those that believe it is innate abilities between genders that cause the disparity. Some educators credit the field of mathematics being male-oriented and offer the remedy of increased female math teachers and a re-designed math curriculum. Others argue that integrating math into female-typed subjects like English will help females feel comfortable succeeding in math.

Another controversy surrounds best practices for teachers of math. Some argue that the teacher should ignore any issues of gender in their classroom. Others argue that ignoring gender issues does not mean they do not exist and are not impacting students.

The so-called gender-neutral approach also neglects the teacher as a gendered person whose gender may affect the way they teach math.

Limits

Sex is the biological division between 'male' and 'female'. In the United States, it is a cultural norm to use the terms 'gender' and 'sex' interchangeably. Despite this norm, gender is an identity, often viewed on a spectrum between masculine and feminine. Some of the studies examined in this paper attend to this important difference between gender and biological sex. However, because the gap in mathematics is more easily identified in terms of biological male/female divisions, this is what much of the research bases results on.

This paper's inquiry focuses on public school students of both genders relation to mathematics. Although the androgynous personality is mentioned in a handful of the relevant research, the scarcity of research on the subject made it difficult to draw conclusions. Math anxiety is also discussed as a facet of gender-role expectations and self efficacy in chapter three. However, because math anxiety is a complex and broad field of study in itself, this discussion will be brief and in the context of how anxiety in math is connected with gender role maintenance.

Many of these articles require that students self-identify in terms of gender, competence and comfort level. Depending upon the individual and other important identities they are trying to maintain and protect, the responses could be altered. This paper attempts to uncover how gender affects mathematics attitudes and achievement and what best practices can be adopted to assure gender-equity in math classes.

Summary

The research question, how does gender affect math attitudes and achievement, is explored in this paper. I chose this topic because a sizable gender gap in math achievement exists in my community and I have struggled with math self-efficacy in my own educational history. As an educator, it is important that I am aware of the various affects gender has on my instruction of as well as my students' experience with mathematics in the classroom.

Chapter two introduces the historical context of this question including efficacy theories, women's educational history and the evolution of gender studies. Chapter three provides a critical review of the research on the subject of gender and math attitudes and achievement. Five sections are presented in chapter three; student self-efficacy, gender roles, attributions, parents and teachers and classroom environments. Major findings from each section are summarized and threads of commonality highlighted. Chapter four summarizes and synthesizes the major findings of chapter three and, in the light of the previous two chapters, offers implications for practice. Areas for further research are also offered.

CHAPTER TWO: HISTORICAL BACKGROUND

Introduction

Chapter one presented reasons why the research question, how does gender affect the attitudes and achievement of students in mathematics, is relevant and listed its limits. Chapter one explained that gender equity is important to the stability of the U.S. workforce and upholding the promise of America that equal opportunities should be afforded regardless of sex, gender, race, nation of origin, etc.

Chapter two examines the historical context of the research question to present the reader with possible causes of the gender gap in mathematics attitudes and achievement. The research question is actually situated at the intersection of several histories. The history of mathematics' role in U.S. education, the history of gender differences in education and the history of gender studies are three of these historical narratives especially important to the research question of how gender affects math attitudes and achievement.

Women in Education

Women have played critical roles in the educational system from its very beginnings in the United States. The common school's 'school marm' was central to the very earliest institutions of public education. Although teaching was a job outside the home, teaching was seen as within the moral realm and therefore a suitable social sphere for women to enter. Young mostly unmarried women were entrusted with instilling a moral education in school children in these one-room school houses. Because gender roles were still very rigid, most teachers left the profession once they married in order to fulfill their role as wife and mother on a full-time basis (Spring, 2005).

Throughout most of U.S. history, women held domestic gender roles and worked in the home, in the school or on the family farm. Some women were home schooled by their mothers but few attended college until after the industrial revolution. Women and children alike went to work in factories producing textiles. World War II opened professional possibilities for some women, although not all. With the war effort sapping the work force of men that had previously done most of the jobs away from home, women filled the gaps. Working-class women worked as telephone operators, typists, assembly line workers and more. Despite their contributions, women were not allowed unrestricted access to all professional fields. Despite a 456 percent increase between 1950 and 1974 of females entering college, mathematical fields remained disproportionately male-dominated.

Gender differences in roles and access to education as well as political access are deeply imbedded in the United States' history. Women could not vote until 1912. They did not enter the workforce in large numbers prior to WWII. The most highly regarded Ivy League Universities all began as male-only institutions. Women's groups like the N.O.W. (National Organization for Women), founded in 1966, began to lobby for equal job opportunities and pay for women working in all fields.

Although under title IX women cannot be barred from schools or workplaces by overtly sexist laws, the under representation of females in professional math programs and subsequent job positions persists. Explanations for this disparity are multiple and dependent upon the individual and their particular situation. For many American women who hold roles of mother and care-taker, a historically male-dominated engineering program, for example, may not provide the kind of support she needs. C.M. Kaczala

(1981) calls this the home-career conflict and it could very well be one of the major reasons women who have been successful in school mathematics elect to not pursue careers in the field. It also may strengthen the notion that femininity and math are incompatible, which will be addresses in chapter three. In context of this history of the educational structure being defined by males, it is not surprising that there are some educational arenas in which there are noticeable gender gaps still today.

History of Gender Studies

Because the focus of this paper is mathematics attitudes and achievement, not gender theory, the discussion of gender studies will be limited. However, as gender is one of the variables examined in the research, it is important to briefly note the historical trajectory of the subject in academia. For a majority of Euro-American history in the United States, ‘gender’ has been synonymous with ‘sex.’ Still today in current research, several of the studies used in the literature use biological sex and gender interchangeably.

It is now generally accepted by experts in the field of gender studies that gender is an identity that can operate independently from biological sex. For example, a biological female can identify as masculine or a biological male as feminine. It’s a very important point that often people find themselves more on a sliding scale of masculine and feminine identity as opposed to wholly in one camp or the other. With time, the true complexity and individuality of gender identification may become more appreciated by the larger academic community, but currently it remains largely dichotomous.

Summary

Understanding the history of gender’s impact on math attitudes and achievement requires a basic understanding of several different histories. History of gender studies, women's educational history and the evolution of math education in the United States are all important contributors to the history of this paper's research question. All of these histories are fairly fresh because the United States is a relatively young nation. Women have only in very recent history moved into math and science job markets and become well recognized for their contributions. Dichotomous and rigid gender role expectations are strongly in place in our current cultural climate, preventing the 'androgynous' identity from currently being studied seriously in mathematics gender research.

Chapter three offers a critical review of a selection of available research about gender's affects on math attitudes and achievement. The chapter will divide the findings into five sections; student self-efficacy, gender roles, attributions, parents and teachers and classroom environments.

CHAPTER THREE: CRITICAL REVIEW OF THE LITERATURE

Introduction

Chapter one outlined the relevance, rationale and limits of the guiding question for this paper, how does gender affect math attitudes and achievement. It discussed the importance of mathematics achievement and noted what positive results could come from closing the gender gap in math. Chapter one also discussed the controversies within gender gap research, and presented the reader with limitations for the literature review offered in chapter three.

Chapter two explored the history of differing gender roles and expectations in education for men and women. It also followed the development of women in education throughout United States history. In reviewing the history, it was noted that although great strides towards gender equity have been made, a gap between American men and women in math achievement still persists. This gap is relevant because it weakens the country's potential workforce and competitive edge in a global market. It is also important for elementary school teachers to be aware of gender-related mathematics gaps because they will impact the way they teach students and the way they will learn.

Chapter three reviews a collection of research on the subject of math attitudes and achievement and gender. The research included in this literature review address the question of how gender affects the attitudes and achievement of students in mathematics. Specifically, chapter three examines the effects of student self-perceptions, gender roles, parental and teacher influence and classroom environments. Within each section there is an introductory overview of the research discussed and a brief summary of the findings.

The research sections include; student self efficacy, gender roles, attributions, parents and teachers and classroom environments.

Student Self Efficacy

Introduction

Academic self-efficacy, according to Friedel, Cortina, Midgely and Turner (2007), refers to a child's confidence in their ability to master new skills and tasks, often in a specific academic domain such as mathematics. Because efficacy is subject-specific, the same individual can feel very efficacious in one academic subject and very inefficacious in another. One of the most commonly used methods of collecting data on efficacy is administering questionnaires for participants to fill out about their feelings of competence or efficacy. This self-reporting technique is susceptible to the participants' pride, embarrassment, pressure or a mixture compromising an accurate measure of efficacy.

Pajares (1995) used path analysis to study high school students' (N=329) math self-efficacy, general mental ability and math problem-solving performance. General mental ability was measured by the Raven's Advanced Progressive Matrices, self-efficacy in math was measured with the Mathematics Confidence Scale (MCS), anxiety in math with the Mathematics Anxiety Scale (MAS) and math performance with18 problem-solving math questions. Path analysis techniques were used to examine direct and indirect effects between variables. Boys and girls did not differ in math problem-solving performance, ability or level**.** Eighty-six percent of participants overestimated their math performance. Path coefficients from self-efficacy, ability, anxiety and math level to performance were significant. This analysis found that the direct effect of self-efficacy on performance was as strong (r=.348) as was the effect of ability(r=.321).

A strength of this article was the large size of the participant pool and the administration of several difference measurements, allowing readers to see achievement and attitudes in the same individual. A method weakness was the administration of several of the instruments during math class. The math anxiety scale, for example, when administered during math class, might result in an exaggerated reported level of anxiety.

Herbert and Stipek (2005) examined when gender differences in children's perceptions of their abilities emerge. In their longitudinal study, kindergarten through fifth grade students (N=300), their parents and their teachers rated their competencies in math and literacy. The following variables were measured; children's competency beliefs, teacher's competency beliefs, parent's competency beliefs and actual achievement scores. Grade (K/1st, 3rd, 5th) by gender (3 × 2) analyses of variance (ANOVAS) were computed for each rater (teacher, parent, child) of children's competency and for achievement test performance. For teachers' ratings of children's literacy skills, the gender main effect, $F(1,191) = 5.61$ ($\eta^2 = .03$), $p < .05$, and the grade main effect, F $(2,190) = 3.34$ ($\eta^2 = .03$), $p < .05$, were significant. Teachers rated girls, $M = 2.98$ ($SE = .09$), higher than boys, $M = 2.69$ ($SE = .09$). For children's own ratings of their math skills, the gender main effect, F $(1,211) = 6.11$ ($\eta^2 = .03$), $p < .05$, and the grade main effect, F $(2,210) = 13.75$ ($\eta^2 = .12$), $p < .001$, were significant. Girls, $M = 3.91$ ($SE = .06$), rated their skills lower than boys, $M = 4.11$ ($SE = .06$).

Two strengths of this study were the large size of the sample and the longitudinal structure of the research. A weakness of this study was the manner in which the researchers collected questionnaire information from teachers by mail. This technique only yielded only a 75% return, meaning 25% of the responses were lost and it reduces the validity by shrinking the sample.

Caporrimo (1990) studied the relationship between gender, confidence and the use of specific problem-solving strategies to math achievement. One hundred twenty two eighth grade students filled out a word problem-solving questionnaire completed a Confidence in Learning Math Scale and took the Iowa Test of Basic Skills. No gender differences were found in standardized scores, problem-solving strategies subtest or confidence questionnaire. Two-tailed T-tests assessed the relationship between standardized math achievement, problem-solving strategies score, Confidence in learning math and gender. No gender differences were found in these variables. A Pearson correlation analysis garnered a significant correlation between problem-solving strategies score and standardized test score ($r=-.19$, $p<.04$).

Strengths of this study included that the participants represented all levels of mathematics achievement; this suggests that findings could be extrapolated to general education classrooms. A weakness of this study was that the analysis of the data collected in this study, the author overlooked the environmental differences that could account for the discrepancy between performance on the Iowa standardized test and the word-problem solving questionnaire. It cannot be determined if a standardized test score reflects the students' mastery of the material or merely their ability to cope with high-stakes test-taking.

Marsh and Tapia (2002) studied the effects of math anxiety and gender on the attitudes and achievement in math of 134 university students. The Attitudes Toward Mathematics Instrument (ATMI) was used to measure attitudes and achievement on a

Likert-type five point scale. A multivariate factorial model with four factors of math attitudes revealed a significant effect of math anxiety on self-confidence, enjoyment and motivation. Students with no math anxiety enjoyed math more. The findings showed that the more anxiety a student has towards math, the less motivated they were and the less they enjoyed math although there was not enough information to determine a two-way multivariate interaction.

A strength of this study was the use of the ATMI to measure attitudes about math. This is a well-developed and widely used tool in this area of research and allows the reader to quickly compare these findings with other research articles in the field. A weaknesses of this study included that the participants had already successfully reached college level. This is a weakness because it is difficult to extrapolate this group of students' attitudes to students who are in elementary school. Additionally, the measurement was administered during math class which might result in higher levels of anxiety than in a non-mathematical environment.

Chouinard, Karsenti and Roy (2007) (N=759) studied the interaction of competence beliefs, utility value and achievement goals in mathematics. The participants were in grades seven-11 and drawn from four public schools. Variables included perception of support from social agents like parents and teachers, competence beliefs, utility value and achievement goals. The five variables were rated on a Likert-type scale from 'strongly disagree' to 'strongly agree.' Structural equation modeling techniques were used to test a model of achievement-related behaviors in mathematics based on support from social agents, competence belief, utility value and achievement goals. No significant relationship was found between gender and utility value, but girls reported higher mastery goals and effort while reporting lower competence beliefs in the subject of math.

A strength of the study included the multi-level design used, taking into account many subsets of variables possibly affecting subject performance and attitudes. A weakness of this study included that cross-sectional analysis was used. If more research was done like this but using longitudinal analysis, it would provide a better idea of how these variables interact with gender over time.

Summary

One of the major findings in this section includes that the gender gap may be more perception or anxiety-based than achievement-based. Pajares' (2005) analysis found that the direct effect of self-efficacy on performance was as strong (r=.348) as was the effect of ability(r=.321). Meelisen and Luyten (2008) suggested a similar conclusion in their study of Dutch students. If actual performance of students is equitable across the board, then the viewpoint that the math achievement gap has closed and there is still a disparity between men and women in mathematics attitudes can be reconciled. If females have the ability to perform at the same level as males in math but do so with anxiety, it's unlikely they will enjoy math and will not pursue it. Marsh and Tapia's (2002) findings showed that the more anxiety a student has towards math, the less motivated they were and the less they enjoyed math although there was not enough information to determine a two-way multivariate interaction.

Herbert and Stipek (2005) found that beginning in third grade; girls rated their math competencies lower than boys even though the teacher's competency rating and the actual math achievement remained the same. Parents also rated boys' math competencies higher than girls in the third and fifth grades actual achievement and teacher's ratings. For teachers' ratings of children's literacy skills, the gender main effect, $F(1,191) = 5.61$ ($\eta^2 = .03$), $p < .05$, and the grade main effect, $F(2,190) = 3.34$ ($\eta^2 = .03$), $p < .05$, were significant. Teachers rated girls, $M = 2.98$ ($SE = .09$), higher than boys, $M = 2.69$ ($SE = .09$). For children's own ratings of their math skills, the gender main effect, $F(1,211) = 6.11$ ($\eta^2 = .03$), $p < .05$, and the grade main effect, $F(2,210) = 13.75$ ($\eta^2 = .12$), $p < .001$, were significant. Girls, $M = 3.91$ ($SE = .06$), rated their skills lower than boys, $M = 4.11$ ($SE = .06$). This findings suggest that gender stereotype not only affects students' self-efficacy but the perception their teachers have of them. This is explored further in the section concentrating on parents and teachers.

Several of the studies did not find significant gender differences in math attitudes and achievement despite hypotheses that they would. Caporrimo (1990) found in a Pearson correlation analysis that a significant correlation between problem-solving strategies score and standardized test score existed ($r=-.19$, $p<.04$), but no gender differences were found in these variables. Chouinard (2007) found no significant relationship was found between gender and utility value, but girls reported higher mastery goals and effort while reporting lower competence beliefs in the subject of math.

Gender Roles

Introduction

Depending upon the difficulty of the mathematics task assigned, students seem to react in different ways depending upon their gender. The task's difficulty may encourage (as seen in Neuville and Croizet (2007) or discourage students by triggering stereotype threat. High-difficulty tasks may also prompt students to use coping mechanisms designed to preserve a students' self identity as efficacious or inefficacious in math.

Stereotype threat is a type of confirmation bias, also called a 'self-fulfilling prophecy'. Claude Steele (as cited in Osborne 2007) argued that many of the academic achievement gaps between groups are results of stereotype threat. The basic operation is that an individual belonging to a group that is stereotyped as inferior experiences anxiety and distress. Stereotype threat is sometimes tested in educational research by reminding a member of a group-stereotype before distributing a test. The test results are often abnormally lower than for control groups, as seen in Neuville and Croizet's (2007) study.

Math anxiety has been described as an irrational dread of mathematics that interferes with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations (Lazarus, 1974; Richardson and Suinn, 1972, as cited in Buckley and Ribordy, 1982). Anxiety is commonly measured in this research with the Mathematics Anxiety Scale. Math anxiety can be related to gender and math because of gender-role identity maintenance. Math anxiety is discussed as a facet of gender-role expectations and self efficacy in chapter three. However, because math anxiety is a complex and broad field of study in itself, this discussion will be brief and in the context of how anxiety in math is connected with gender role maintenance.

Kaczala (1981) investigated the relationship between the value of a task and self-perception in regards to sex-role typed activities and success in them. There were 50 students in sample one and 850 students in sample two. PAQ (personal attributes questionnaire) and a new tool that uses ratings of sex-typed activities were used to measure sex-role identity and salience. Participants were divided into the following categories; feminine male, masculine male, undifferentiated male, androgynous male, feminine female, masculine female, undifferentiated female and androgynous female. Boys felt it more important for either a girl or a boy to engage in same-sex types activities than did girls. Boys perceived math as less difficult than girls ($t=3.93$, $p<.001$) requiring less effort ($t=3.78$, $p<001$). Males also held higher expectancies of their success in math ($t=3.86$, $p<.001$). Girls' attitudes about English were significantly more positive than boys. Girls perceived English as less difficult ($t=4.49$, $p<.001$) and requiring less effort ($t=3.59$, $p<.001$) than did boys.

Strengths of this study include that attitudes about both masculine-typed and feminine-typed subjects were measured. This allows the reader to see if there is a gender-gap in all academic subjects, or if the low math efficacy is math-specific. A weakness of this study is that all participants were from white middle-class populations, the findings cannot be extrapolated to other ethnic and socio-economic groups.

Bandura, Barbaranelli, Capara and Pastorelli (2001) investigated the network of socio-cognitive influences that shape children's career aspirations and trajectories. The method was a longitudinal multiple cohort design. Two hundred seventy two children (142 males and 130 females) ranging from 11-15 year old were administered the set of scales measuring the variables of theoretical interest in their classrooms. Academic achievement was measured by two evaluations by the teacher over the year, one mid-year and one end of year. Participants were presented with 69 occupational options and rated for each pursuit how seriously they could consider choosing it for their lifework. A year later they rated their occupational choices on a three point scale to indicate how seriously they would consider it as their career choice. Boys had a higher sense of efficacy for mathematics ($F = 6.29$, $p < .02$) and geographic science ($F = 4.13$, $p < .05$) whereas girls judged themselves more efficacious for language coursework ($F = 9.05$, $p < .01$). Girls also judged them-selves more efficacious to regulate different aspects of their own learning activities. Girls surpassed boys in their scholastic activities and to abstract instructional material, ($F = 11.13$, $p < .001$).

A strength of the study included its longitudinal design. By following the same participants as they mature, the researchers could see how the initial attitudes about career choices and efficacies had changed over time. Weaknesses of this study included that the participants were so young that measuring their personal career and academic aspirations is difficult to accurately tap. Participants were asked to rate for themselves how likely they were to follow a specific career path, but at eleven to fifteen years old, it's possible the answers will be the values of the parents. It's also undetermined how predictive these early attitudes about careers are for these participants' adult lives.

Brewer and Blum (1979) used a panel survey with University of California Santa Barbara students. All participants were volunteer freshmen. The initial pool was 195 students. Initial testing was conducted with a questionnaire and two follow-ups with two subsets of the initial pool. The Bem scale was administered. Respondents also rated their comfort and enjoyment in four academic areas, including mathematics, on a 4-point Likert-type scale. Of the 124 female respondents, 55% had taken a math/physical science course during their last year in high school, but only 41 (33%) enrolled in a math/physical course their first quarter in college. The pattern for the 71 male respondents was the reverse: 85% had taken a M/PS course during their last year in high school and 50 (70%)

were enrolled in a M/PS course during the first quarter of college. Controlling for enrollment, there were no significant differences between male and female respondents in degree of liking for M/PS (M = 2.24, and 2.44, respectively)"or non-M/PS courses (M = 1.82 and 1.76), or in feelings of competence in M/PS (M = 2.27 and 2.35) or non-M/PS areas (M = 1.65 and 1.72).

A strength of this study was that freshmen were chosen for the subject population. The researchers assumed that, as a result of initial experiences in a new academic environment, their self-perceptions and attitudes toward academic subjects would be more open for change. As students enter into majors in their junior and senior year, their attitudes about math's utility would be more or less fixed because they have a career trajectory set. A weakness of this study was that it did not produce easily measurable quantitative results and therefore provides little that can be easily extrapolated to other situations.

Wulff and Steitz (1997) investigated psychological androgyny among 40 high school girls, 20 girls from a college preparatory upper-level mathematics class and 20 from a vocational track cosmetology class. Masculine and feminine personality traits were measured using a short, 30-question version of the Bem Sex-Role Inventory. Wulff and Steitz hypothesized that the choice of curricular track would correspond to traditional sex-role stereotypes and that there would be a significant difference between the two groups in terms of feminine orientation. Neither was supported by the findings. The chi-square analysis of the distribution of feminine and androgynous girls in both courses was significant (chi^2 (1) =468, $p<.03$). The cosmetology group demonstrated higher levels of androgynous identification than the math course students. These findings are contradictory to the findings in Bandura et al (2001) article in regard to gender-type dictating professional path. It appeared that feminine gender-identification did not determine, in this sample, the selection of feminine gender-typed curricular paths.

A strength of this study was use of the Bem inventory to determine gender identification. This tool provides for more meaningful information about student attitudes and potential relationships with math than a simple male/female distinction. A weakness of this study was the small size of the sample. Findings from only 40 participants cannot be extrapolated to other communities.

Osborne (2007) tested the theory that stereotype threat increases individual anxiety levels thus affecting performance. Forty-three students recruited from an undergraduate psychology pool participated. Subjects were randomly assigned to either high or low stereotype threat conditions involving a challenging mathematics task while physiological measure of arousal were recorded. Stereotype threat was activated by instructions given before the evaluation. These high-stakes instructions were omitted in the control group. Performance on the achievement test was significantly related to sex and condition ($p<.02$), meaning there was a large gap in achievement between the sexes in the high stress condition that did not appear in the low stress condition.

Strengths of this study include that many efforts were made to create a ‘control’ situation for both groups prior to treatment. This was referred to as an acclimatization period where students read magazines. A major weakness of this study included that despite best efforts, isolating gender stereotype threat as the cause of poor performance in the study is very difficult. Heightened physical reaction could have been caused by seemingly endless variables that it would be difficult to make the same in both the experimental and control group. For example, personal past experiences with psychology classes, temperature in the room, what the participants' ate that morning or sitting next to someone they like or dislike.

Buckley and Ribordy (1982) investigated mathematical performance as a function of anxiety. Forty nine male and 52 female undergraduate students were pretested with MARS and BEM measures. The stress condition group (N=20) was given pre-test instructions emphasizing the importance of performing well. Subjects in the low-stress treatment (N=20) were told their results would be anonymous. Both groups took the Numerical Ability subtest of the standardized Differential Aptitude Tests. High math anxious students reported significantly higher levels of state anxiety ($p<.05$) Analyses of variance revealed that high math anxious students performed significantly poorer than low math anxious students ($p<.001$).

A strength of this study included that the control and experimental groups were very similar except for the variable in question, their math anxiety level. This allows the reader to feel confident that the performance on the math task is related to the level of anxiety. A weakness of this study was its' limited scope and therefore it is not easily extrapolated to other populations.

Neuville and Croizet (2007) compared the math achievement on a short test of seven-eight year olds with a control group that experienced no gender activation and a group that had their gender identity activated. Both groups of seven-eight year olds (N=79) were asked to color a picture prior to taking a short math assessment with questions varying in degree of difficulty. All members of the control group colored a landscape. Gender salience in the experimental group was activated by having boys color a picture of a boy holding a ball and girls color a picture of a girl holding a doll. The researchers' questions were; can the salience of gender identity affect the math performance, and can this phenomenon occur at age seven to eight? The ANOVA performed on the performance score revealed a main effect for task difficulty ($p<.001$). The interaction between children's gender, gender identity activation and difficulty was significant ($p<.05$). The ANOVA performed on the difficult items revealed a significant gender by identity activation interaction ($p<.05$). The findings suggested that gender salience can affect student math performance. According to these findings, stereotype threat undermined performance on difficult tasks but facilitate it on easy tasks.

Strengths of this study include that children were randomly assigned to one of two gender identity activation conditions. They were also the same age, which avoids issues of maturation. Weaknesses include that the control activity may not be truly gender neutral. Coloring the pastoral scene may have inadvertently activates gender identity in members of the control group, consequently skewing the results. The labels of "difficult" or "easy" when referring to questions students were asked seems relative.

Summary

Anxiety produced by breaking gender expectations was an important focus of set of studies. Buckley and Ribordy (1982) found that subjects who were given high-stakes instructions prior to taking a math assessment experienced higher levels of anxiety and that those heightened levels of anxiety negatively affected their performance.

Osborne's (2007) results showed significant physiological reactance (skin conductance, skin temperature, blood pressure) as a function of a stereotype threat condition. Performance on the achievement test was significantly related to sex and condition ($p<.02$), meaning there was a large gap in achievement between the sexes in the high stress condition that did not appear in the low stress condition.

Neuville and Croizet (2007) offer the possibility of behavioral priming as a cause for gender achievement gaps in math. Behavioral priming occurs when a person becomes aware of stereotypes of a group they belong to and then let their behavior emulate memories of stereotypes they have heard. This research suggests that *femininity*, as opposed to the female sex, seems to be mentally linked to low math achievement and a predisposition for areas like language arts.

Kaczala (1981) found that boys felt it more important for either a girl or a boy to engage in same-sex types activities than did girls. Boys perceived math as less difficult than girls ($t=3.93$, $p<.001$) requiring less effort ($t=3.78$, $p<001$). Males also held higher expectancies of their success in math ($t=3.86$, $p<.001$). Girls' attitudes about English were significantly more positive than boys. Girls perceived English as less difficult ($t=4.49$, $p<.001$) and requiring less effort ($t=3.59$, $p<.001$) than did boys.

Bandura, Barbaranelli, Capara and Pastorelli (2001) found that boys had a higher sense of efficacy for mathematics ($F = 6.29$, $p < .02$) and geographic science ($F = 4.13$, $p < .05$) whereas girls judged themselves more efficacious for language coursework ($F = 9.05$, p s< .01). Girls also judged them-selves more efficacious to regulate different aspects of their own learning activities. Girls surpassed boys in their scholastic activities and to abstract instructional material, ($F = 11.13$, $p < .001$).

Bandura et al (2001) presented findings that supported their theory that gender role expectations will affect student's curricular and career choices. Two of the articles did not support these findings. Brewer and Blum (1979) found that of the 124 female respondents, 55% had taken a math/physical science course during their last year in high school, but only 41 (33%) enrolled in a math/physical course their first quarter in college. Controlling for enrollment, however, there were no significant differences between male and female respondents in degree of liking for M/PS (M = 2.24, and 2.44, respectively). Wulff and Steitz (1997) hypothesized that the choice of curricular track would correspond to traditional sex-role stereotypes and that there would be a significant difference between the two groups in terms of feminine orientation. Neither was supported by the findings. The cosmetology group demonstrated higher levels of androgynous identification than the math course students.

Attributions

Introduction

Attributions are the inferences that individuals make about why they succeed or fail (Graham, 1991, Weiner, 1986). Attributing success or failure in mathematics is an important part of feeling efficacious or not. In most attributional research, attributions are examined in two distinct categories; external and internal. The following set of studies suggested that the way females and males attribute positive or negative experiences in math differ, resulting in different attitudes about math and different levels of efficacy in the subject.

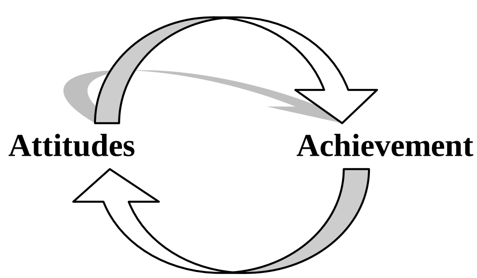

Fig.2: Cycle of Attitudes and Achievement

Rogers (1991) explored the causes cited by 157 seven, nine and 11 year old students for their academic success and failure in a free-response setting. Two math activities and a reading activity were used to attribute. The researchers found that the children were most likely to explain success and failure in terms of performance ability, specific competence ability, effort and interest, behavior and speed. No child explained success or failure in terms of chance. As children got older, they were less likely to answer "don't know/ no response" or to attribute success and failure to performance ability. Gender was found to have no effect on attribution patterns.

Strengths of this study include the careful attention to where the interview took place, away from the whole class but in an area of the school familiar to the student. If a student is interviewed within ear shot of their peers or teacher, the answers they give could be influenced by these external factors. A weakness of this study included that the participants were making attributions about someone else's performance. The finding that gender didn't affect attribution patterns may have been different if students had been attributing their own performance.

Gilbert (1996) researched the difference between how much boys and girls like and how hard they rate various subjects especially math and science. They also analyzed attributional patterns regarding success and lack of success in math. In this quantitative study fifth to seventh grade students (361) filled out a questionnaire about their views of school subjects including math, science, social studies and language arts and their attributions about success and lack of success on a math test. The students selected their favorite subject and why they liked this subject, and they then rated the difficulty of each subject on a 5-point Likert-type scale. Two-way analyses of variance show that girls and boys were not significantly different in their perception of math and science in grades five through seven. Both sexes rated math among the hardest subjects all three years. The two-way ANOVAs showed that girls and boys had similar attributional patterns when it came to a lack of success on a math test. While girls attributed success in math to effort, boys attributed success to ability ($p<.001$).

A strength of this study was the full-participation of the large sample. This helps the reader extrapolate findings to other populations in a similar age range. One weakness of the study was that random sampling was not used; the classrooms used were selected to represent diversity in socio-economic, racial and ethnic backgrounds.

Eccles, Wigfield, Harold and Blumenfeld (1988) examined the dynamics of student self and task perceptions on math achievement. Eight hundred sixty five children between the ages of seven and 10 filled-out questionnaires tapping their beliefs about academic subjects, specifically mathematics and reading. Confirmatory factor analyses found that boys had more positive competence beliefs and values than did girls for sport activities and more positive competence beliefs for mathematics. Girls had more positive competence beliefs and values than did boys for reading and music activities (p.001). According to these results, children do hold differentiated self and task perceptions in the skill linked activity domains studied herein, even at the first grade.

A strength of the study included that it is a longitudinal study and confirmatory factor analyses were used. A weakness of this study was that the findings cannot be extrapolated to other racial or ethnic groups as 95 percent of the participants were Caucasian.

Lloyd, Walsh and Yailagh (2005) examined whether or not sex differences exist in mathematics achievement and if they are related to boys' and girls' differing achievement-related beliefs. Participants (N=161) included 62 fourth graders and 99 seventh graders. Math report card grades, 2001 FSA (foundational skills assessment) score, performance attributions and levels of self-efficacy were measured. Results from the MANOVA analysis suggested that the significant main effect of student's grade level on the composite variable was related to three variables; attributions of effort for success, attributions of teacher's help for success and total self-efficacy. The results revealed that males and females differed significantly in only two measures; attributing failure to lack of teacher help ($p<.01$) and relative self-efficacy ($p<.05$).

A strength of this study included that the researchers sampled from a fourth grade participant pool as well as a seventh grade pool. This helps the reader extrapolate the findings to students who fall within the mid to upper elementary age range. A weakness of this study included the relatively small sample size, limiting what conclusions can be extrapolated to other groups.

Krauser and Ballif (1988) studied the dynamics of achievement attributions along self-schemas for gender, expectancy for success and math achievement. Two hundred ninety nine tenth and eleventh grade female students participated in the study. A Personal Attributions Questionnaire (PAQ) was used to measure self-schema for gender. A Mathematics Attribution Scale (MAS) was used to determine students' attributions for their success and failure in math. A Likert-type scale questionnaire was used to determine the expectancy of success in mathematics. SAT scores were used to represent the participants' mathematics achievement. Stepwise multiple regression analysis revealed that math achievement and the self-schema for masculinity predicted expectance of success (β=.306. $p<.0001$). Expectancy of success predicted the attribution of failure to lack of ability, and expectancy of success and the self-schema for androgyny predicted the attribution of failure to task difficulty (β= .434, $p<.0001$).

A strength of this study included that participants were assured anonymity because their student identification numbers were used to collect data instead of their names. A weakness included that the sample was self-selecting, as all participants were enrolled in English classes. Findings can only be extrapolated to females who choose to take English classes for this reason.

Kloosterman and Cougan (1994) found that students who enjoyed math were also confident of their math abilities, students with moderate achievement were just as confident as high performing students, and most students believed in was important learn math and that anyone who tried could learn math. Participants (N=62) were in grades one through six from one school where teachers were participating in a project to improve math teaching. In interviews with students, they were asked: whether they liked school and math, whether their parents helped them with schoolwork, whether they confident in their math abilities, whether they felt mathematics were useful and whether all children had the ability to learn mathematics. Academic achievement was measured by scores of the California Achievement Test. Students were categorized into high, medium or low achiever. Kloosterman et al found that when students responded about how well they do in math, almost all of their answers had to do with teacher feedback and marks.

Strengths of this study include approximately equal numbers of boys and girls were interviewed from each grade. Weaknesses of this study include that the students were not randomly selected. Teachers were asked to identify students with a range of math abilities. With only 62 students in the sample, and numbers from each grade under 30, statistical significance is questionable. When such a small group of students are involved, the findings cannot be extrapolated to all or even mist students.

Summary

Attributions are the things or people that people credit for their success or failure. The attribution research overviewed in this section mostly found that males and females attribute math success and failure differently and that attributions affected achievement.

Some of the research did not find significant relationships between attributions and gender. Rogers (1991) found that gender had no effect on attribution patterns. However, the small size of the sample ($N=157$) needs to be taken into account.

Other articles presented the opposite findings, strongly suggesting that attributions are influenced by gender and visa versa. Lloyd, Walsh and Yailagh’s (2005) results suggested that the significant main effect of student’s grade level on the composite variable was related to three variables; attributions of effort for success, attributions of teacher’s help for success and total self-efficacy. The results revealed that males and females differed significantly in only two measures; attributing failure to lack of teacher help ($p<.01$) and relative self-efficacy ($p<.05$). Krauser and Ballif(1988) found that math achievement and the self-schema for masculinity predicted expectance of success ($\beta=.306$. $p<.0001$).

This section also presented a finding about how early attributions can affect gender differences in math. Gilbert's (1996) finding that gender differences in math and science don't emerge until after age 12 directly conflicts with articles like Neuville and Croizet (2007). Their study suggests that gender identities are in place and negatively affecting female math achievement by age seven.

Eccles et al's (1993) confirmatory factor analyses found that boys had more positive competence beliefs and values than did girls for sport activities and more positive competence beliefs for mathematics. Girls had more positive competence beliefs and values than did boys for reading and music activities (p.001). According to these results, children do hold differentiated self and task perceptions in the skill linked activity domains studied herein, even at the first grade.

The Kloosterman and Cougan (1994) study adds to the pattern in the research that students who enjoy math are the ones who are most confident in it, despite not having the highest achievement. If students can develop confidence and self-efficacy in mathematics, their enjoyment might increase and encourage them to continue into higher levels of math.

These articles emphasize the important thread of efficacy research that examines attributions of success and failure. Some of the findings suggested that boys and girls tend to attribute triumphs and struggles in mathematics in different ways. Others found no significant relationship between gender and attribution patterns or achievement. (Rogers, 199) Students may learn their attribution patterns from their parents, which is examined in the next section.

Parent and Teacher Influence

Introduction

Teachers, parents and guardians are very important players in a child's education. It is only through a healthy working relationship between all three actors, teacher, parent and student that a student can thrive in school. Teacher and parents not only provide the adult supervision and materials the student needs but also set an example of how to relate to math and they communicate expectations of the students' performance in math.

Friedel, Cortina, Turner and Midgley (2007) found in a longitudinal study that students' perceptions of teacher and parent goals predicted personal goals, that boys perceived a slightly greater emphasis from parents than did girls on performance goals and that boys endorsed personal performance goals more strongly than girls. The participants were 1021 seventh graders, 52% of which were girls and 48% boys. Each child completed a survey that consisted of 145 items about reasons they do their math work and how they feel about their math class. Friedel et al conducted an exploratory factor analysis with half the sample to see if students could distinguish between their own goal orientations and the expectations of parents and teachers. Confirmatory analysis was completed on the other half of the sample to create six constructs (personal mastery and performance goal orientations, perceived teacher and parent mastery and performance goal emphases). Friedel et al found a significant correlation (p.001) between student's personal goal orientations and their perception of parent's goal emphases. Correlations suggested that children's performance-approach orientation was strongly predicted by perceived parental performance emphasis (.70), but not significantly predicted by perceived teacher performance emphasis.

The many variables and scales measured by the researchers was a strength of this study. Perceived parent goals, perceived teacher goals, personal goal orientations and more were taken into account when analyzing the data. Additionally, the analysis techniques used were varied and well-matched to the data measured. A weakness of this study included that the surveys asking questions about how the students felt about their math classroom and the expectations from their teacher were administered during math class. The setting for the survey could have affected the responses students felt comfortable writing down, even if the survey was anonymous. Also, the survey took approximately 45 minutes and had 145 items. This seems very lengthy for middle school students, who may lose attention over this period of time. This may have resulted in some answers, especially those near the end of the survey, to be less accurate than if the survey had been administered in installments and in a different environment.

Malinsky, McJunkin, Panells and Ross (2006) measured the math anxiety of pre-service teachers. University students (N=481) in areas the researchers believed would have high levels of math anxiety, including elementary education students were selected for the study. MARS was used to determine the participants' level of anxiety. After the scale was administered, participants responded to 12 true or false math myths. An ANOVA of mean scores for the MARS and gender indicated a significant difference (p=.024) between males and females, with females having higher anxiety levels.

Strengths of this study included the use of the MARS to determine anxiety levels. This tool is very commonly used as a measure of anxiety surrounding math, and therefore, the MARS scores in this study can easily be compared to other studies whose findings can be compared to Malinsky et al's work. A weakness of this study included that the participants were chosen by the researchers as being likely demographics for having math anxiety. This makes the results less reliable and universally applicable because those who participated in the study were not randomly selected.

Ai (2002) used a 3-level longitudinal and multi-level analysis comparing seventh grade mathematics achievement and social-psychological factors between four groups of students (N=3,116). The groups were high-achieving boys, high-achieving girls, low-achieving boys and low-achieving girls. Subjects were followed from grade seven to ten, and data was taken only from the grade seven and grade ten year. Using the Item Response Theory technique scale ranging from 0 to 100, Ai found that for those who started low, girls started higher than boys ($p<.01$) but their growth rate was slightly lower than boys' ($p<.01$). For those who started high, there were no gender differences in initial status and growth rate. Additionally, aggregated school resources had a significant effect on growth.

A strength of the study includes its' design; a multi-level research analysis allows for simultaneous research of many factors. This provides a fuller look at the many influences affecting math achievement including community, school, individual and home. Additionally, the participants were randomly selected. A weakness of Ai's study was that the boys and girls were grouped into 'high' and 'low' groups according to initial performance. Wherever they were placed in seventh grade is where they stayed over the entire study. Placement in the 'high' or 'low' group could affect the students' self-efficacy and result in skewing their subsequent math performance. Additionally, the groups were determined solely on a math assessment and not on other important aspects of student relationships with math like self-efficacy or task perception.

Jayaratne (1987) investigated the impact of parental math experiences and attitudes on their daughters' math attitudes. Questionnaires were used to measure students' and parent's (N=1090) math attitudes**.** Scales measured students' self-perceptions of ability and effort/difficulty in math and current and future expectations in math classes. Students from fifth-12th grade, 563 mothers 527 fathers. When parent's own attitudes about math were correlated with their children's attitudes about math significant effects ($p<.01$) were only present in one sub-group, higher educated mothers and their daughters. All three measures of the mother's past attitudes were significantly correlated ($p<.05$) with all six of the daughters' attitudes. Children were found to be no more accurate in predicting their mothers' math attitudes than their fathers'.

A strength of this study included that the researchers asked the children their opinion of their parent's attitudes about math. This could be compared to the parents' report of their feelings about math and the reader can see a more complete picture of what parents report feeling and how those feelings are communicated to the children. A weakness in this study is that depending upon the parent's involvement in the child's life, their report of the child's difficulty and effort in math may not be accurate. For example, if a child does their homework alone, if the parent has a language barrier or if the child is in shared custody, it's possible that the parent is unaware of how much the child might struggle with math or how hard they might try.

In 1983, Jayaratne examined how parents' math achievement, feelings about math and sex-typing attitudes affect their child's math achievement. Parents of students were asked to complete questionnaires about their own math achievement, their students' achievement in math and sex-type roles. The questionnaire was given twice, one year apart. The findings suggested that parents were strongly sex-typed regarding their self-assessment of the subjective experience with math and their daughters or son's math achievement. Mothers' attitudes toward their daughters' math achievement were strongly related to their view of their own math achievement. Parents of daughters were more likely to say that boys and girls had equal mathematical ability than parents of only sons ($t=2.33$, $df= 513$, $p<.05$).

A strength of this study included the longitudinal structure of the research. Administering the questionnaire twice produces more data, increasing reliability and it also allows the reader to observe any changes of attitudes over time. A weakness of the study included that the number of participants was not reported in the research. Only percentages of the sample were presented in the findings but not the total number of parents participating.

Gresham (2008) studied the relationship between math anxiety and math teacher efficacy in pre-service teachers, elementary pre-service teacher perceptions towards their math skills and their abilities to teach elementary math effectively. Participants (N=156) were elementary pre-service teachers. The sample included eight males and 148 females. The mathematics anxiety rating scale (MARS), mathematics teaching efficacy beliefs instrument (MTEBI) and interviews with the pre-service teachers were the data collection devices in this study. Two pen and paper questionnaires were conducted for all the participants and one oral interview for some of the participants. The 10 participants with the highest levels of math anxiety as well as the 10 participants with the lowest levels of math anxiety were administered these oral interviews. A significant, negative relationship between math anxiety and math teacher's efficacy was found (r=-.475, p=<.05)

A strength of this study was that it include that oral interviews were included to help interpret the quantitative data. A weakness of this study was that because the two groups selected to give oral interviews were the two extreme ends of the achievement scale, the voice of students in the middle was lost. It could be that the students who fall in the middle of the group in achievement have something very valuable to tell researchers about what will help them move to the higher end of achievement or result in them dropping to the bottom. Another weakness is the very low number of male participants. This means the findings cannot be extrapolated to male pre-service elementary teachers.

Tiedemann (2000) found in a quantitative study that teachers believed that their average achieving girl students were less logical than equally achieving boy students and that girls profited less than boys did from additional effort. Participants for this study were third and fourth grade teachers (N=52). Questionnaire data collected from teachers was analyzed using MANOVA tools. Teachers provided responses about the following areas; estimation of the child's competence, attribution of current performance in mathematics, attribution of improvement, attribution of deterioration, prognosis of performance and presumed self-concept of the child. Six multivariate analyses were run to assess gender differences on the items of the six categories. Boys were considered to be more capable of logical thinking than girls (F(1,49) = 11.37; p = 0.001). Mathematics as a subject was considered to be more difficult for girls than for boys (F(1,46) = 9.36; p =0.004).

A strength of the study included that participation in the study was voluntary and anonymous. This increases the validity of the answers given on the questionnaires because the participants do not risk professional or personal judgment for their responses. A weakness included the limited number of males in the study, only five of 52 participants. Because there were so few male participants, results cannot be extrapolated to male teachers' views of their students' math performance or attitudes.

Helwig, Anderson and Tindal (2001) examined the mathematical skill level, classroom behavior, and effort of 512 students. Participants were rated by 15 third-grade teachers and 14 fifth-grade teachers. Of those students, 464 completed mathematics and reading achievement tests. Teachers responded on a five-point, Likert-type scale ranging from very low proficiency to very high proficiency. To measure effort teachers were asked to rate on a five-point scale the amount of effort the student puts into their mathematics work. Classroom behavior was measured by asking teachers to rate the students' behavior in terms of compliance with classroom rules and expectations. Correlation and regression analyses were performed to measure the relationship between student gender and teacher perceptions of their mathematics proficiency. In both third and fifth grades, regression results showed that mathematics and reading achievement test scores, together with student effort, were significant predictors of teacher rating of student mathematics achievement. Gender was not a significant contributor in either grade. Similar results were found when students were split by general or special education. The findings suggested that the teachers did not consider student gender when rating the mathematics skill level of their students.

This study's sample was fairly large, making it more reliable to extrapolate to similar populations. Weaknesses of this study include that the researchers did not collect information about socioeconomic status or parental involvement. Jayaratne (1987) and others provide research results that indicate parental involvement as critical to understanding students' mathematics attitudes and achievement. Socioeconomic status may also have contributed to teacher perception of students, but this information is unavailable because socio-economic status was not a collected variable.

Summary

Parents more so than teachers proved to be very influential figures in this section of research. Friedel, Cortina, Turner and Midgley (2007) found a significant correlation ($p<.001$) between student's personal goal orientations and their perception of parent's goal emphases. Correlations suggested that children's performance-approach orientation was strongly predicted by perceived parental performance emphasis (.70), but not significantly predicted by perceived teacher performance emphasis.

Jayaratne (1987) found that when parent's own attitudes about math were correlated with their children's attitudes about math significant effects ($p<.01$) were only present in one sub-group, higher educated mothers and their daughters. All three measures of the mother's past attitudes were significantly correlated ($p<.05$) with all six of the daughters' attitudes. Children were found to be no more accurate in predicting their mothers' math attitudes than their fathers'.

Jayaratne's (1983) findings suggested that parents were strongly sex-typed regarding their self-assessment of the subjective experience with math and their daughters or son's math achievement. Mothers' attitudes toward their daughters' math achievement were strongly related to their view of their own math achievement. Parents of daughters were more likely to say that boys and girls had equal mathematical ability than parents of only sons ($t=2.33$, $df= 513$, $p<.05$).

Some of the research looked at teacher expectations and teacher anxiety in relation to math and gender. Malinsky, McJunkin, Panells and Ross (2006) found an ANOVA of mean scores for the MARS and gender indicated a significant difference ($p=.024$) between males and female teachers, with females having higher anxiety levels.

Gresham (2008) found a significant, negative relationship between math anxiety and math teacher's efficacy ($r=-.475$, $p=<.05$). Tiedemann (2000) found that boys were considered by teachers to be more capable of logical thinking than girls ($F(1,49) = 11.37$; $p = 0.001$). Mathematics as a subject was considered to be more difficult for girls than for boys ($F(1,46) = 9.36$; $p =0.004$). Helwig, Anderson and Tindal (2001) found that in both third and fifth grades, regression results showed that mathematics and reading achievement test scores, together with student effort, were significant predictors of teacher rating of student mathematics achievement. Gender was not a significant contributor in either grade. Similar results were found when students were split by general or special education. The findings suggested that the teachers did not consider student gender when rating the mathematics skill level of their students.

The findings in this section that parents have more of an impact on students' attitudes and achievement about math is not surprising. The teacher spends less time with the child and has a much less significant role in most children's lives. The importance of collaboration between home and school will be discussed in chapter four.

Classroom Environments

Introduction

This section examines two aspects of classroom environment, the structure of the classroom (specifically whether it is co-ed or single-sex) and the curriculum. In light of the observed gender gaps in mathematics achievement, some educators and educational institutions have chosen to separate females and males in hopes of improving female math attitudes and performance. This solution implies that there is something inherently damaging to females about being in a co-educational classroom; that somehow boys' presence causes females' lower success rates in mathematics. The studies available on this subject were varied in their results.

Zohar and Gershikov (2007) investigated how context of mathematical tasks affects student performance. Five hundred twenty three children aged five to 11 were divided into three treatments; a stereotypical boys' context, a stereotypical girl's context and a gender neutral context. Boys' and girls' mean scores on an individual written activity were compared for each group. MANOVA analysis of variance was used to test the interaction between age and gender. In the boys' context, analysis of variance showed a significant main effect for gender (f=32.8, df=1, p=.0001). In the girls' context, girls outperformed boys in the higher grades (five and six) but not in kindergarten through fourth grade. The analysis of variance in the gender neutral context showed no significant differences for age or gender.

One strength of this article is its size; the number of participants is large enough to see some significant trends and correlations. It also provided the reader with a control context (neutral) against which to compare the results from the gender-specific contexts. A weakness of this study is its location. The research was performed in Israel, presenting the complicating factor of culture. Gender roles and expectations, as well as the educational system in Israel differ from those in the United States and therefore results of this study should be applied to contexts in the U.S. with caution.

Leonard and Derry (2001) investigated whether adapting instruction to gender-type preferences can improve the attitudes of students in mathematics. The gender-type activities were determined for young adult college students (N=69) in a remedial mathematics program. Students were randomly assigned to gender-adapted or gender-maladapted treatment conditions. In the gender-adapted condition, females received the feminine version of instruction, and males received the masculine version. In the maladapted condition, students received instruction designed for the other gender. No performance difference was found between the groups (F=.45, sig=.51).

One strength of this study included that participants were placed into one of two gender-types based upon a survey of their attitudes and interests, not solely on their biological sex. This approach acknowledges the difference between gender and sex and its impact on how people interact with mathematical tasks and instruction. A weakness of this study included that masculinity and femininity can mean very different things to different individuals because of cultural norms. Therefore, administering 'masculine' versus 'feminine' versions of instruction may not be perceived that way by the students. Depending upon the individual's concept of masculine and feminine instruction, and upon their gender-identity, the affects of the same treatment will vary widely and cannot be extrapolated based on gender alone.

Topping, Campbell, Douglas and Smith (2003) conducted a case study investigating the impact on attitudes toward math, mathematics skill and knowledge of a structured cross-age peer-tutoring program using mathematical games. Participants in the project were all primary pupils in a composite class (n = 14; six girls, eight boys). Thirty four games were used throughout the project from a variety of sources and were selected as likely to be easily understood and enjoyable. The overall mean MALS score for the n = 14 primary seven participants increased from 3.625 (s.d. = 0.672) to 3.971 (s.d. = 0.675) from pre- to post-intervention (W = –3.114, p = 0.002). There were statistically significant differences in two of the ten component scales of the MALS: Confidence about school work: Academic self-efficacy (W = –2.836, p = 0.005) and Confidence about learning ability: Learning self-efficacy (W = –2.232, p = 0.009).

Strengths of this study include that MALS scores were measured prior to and after treatment in the same manner so the two statistics can be compared easily. Weaknesses of this study included that some games were discarded during the project as they were not observed to promote discussion in practice and/or were described by some participants as ‘boring’. The results, therefore, are skewed in a favorable direction and do not entirely accurately represent the students’ reactions to the project.

Orhun (2007) aimed to investigate whether there was a relationship between gender and learning style, mathematical achievement and attitude toward mathematics. The participants were fifth-semester students (42 females, 31 males) from the mathematics department a university. The study collected data from three sources: the Learning Style Inventory (LSI), Grades of Achievements Acquired in Mathematics (MA), and Attitude Toward Mathematics (ATM) Scale. Two-sample t-tests were conducted and results found that there were differences among learning modes preferred by female and male students, their mathematical achievements, and their attitudes towards mathematics.

A strength of this study included that there were multiple kinds of learning styles available for participants to fit into in addition to gender groups. This study accounts for multiple layers of diversity within learners that might affect their math attitudes and achievement. The findings of this study are weak because the researchers do not provide the reader with concrete data to evaluate themselves. This diminishes the credibility of the study, even if the narrative is fascinating.

Summary

Educating males and females separately in mathematics is one way educators have attempted to close the gender gap. The research in this section explores cases where students are educated in gender-specific environments and the affect on their math achievement is measured. It also looks at the affect of teaching gender-specific curriculum.

Zohar and Gershikov's (2007) compared the affects of boy-context curriculum, girl-context curriculum and gender-neutral curriculum. In the boys' context, analysis of variance showed a significant main effect for gender (f=32.8, df=1, p=.0001). In the girls' context, girls outperformed boys in the higher grades (five and six) but not in kindergarten through fourth grade. The analysis of variance in the gender neutral context showed no significant differences for age or gender.

Leonard and Derry (2001) randomly assigned students to gender-adapted or gender-maladapted treatment conditions. In the gender-adapted condition, females received the feminine version of instruction, and males received the masculine version. In the maladapted condition, students received instruction designed for the other gender. No performance difference was found between the groups (F=.45, sig=.51).

Chapter Summary

The question that the research aimed to answer was; how does gender affect math attitudes and achievement? Studies were broken down into five sections; self-efficacy, gender roles, attributions, parents and teachers and classroom environments. Each section had mixed findings with the methods of the research presenting both strengths and weaknesses.

One of the major findings in the self-efficacy section included that the gender gap may be more perception or anxiety-based than achievement-based. Pajares' (2005) analysis found that the direct effect of self-efficacy on performance was as strong (r=.348) as was the effect of ability(r=.321). Marsh and Tapia's (2002) findings showed that the more anxiety a student had towards math, the less motivated they were and the less they enjoyed math although there was not enough information to determine a two-way multivariate interaction.

Also in the self-efficacy research, Herbert and Stipek (2005) found that beginning in third grade; girls rated their math competencies lower than boys even though the teacher's competency rating and the actual math achievement remained the same. Parents also rated boys' math competencies higher than girls in the third and fifth grades actual achievement and teacher's ratings. These findings suggest that gender stereotype not only affects students' self-efficacy but the perception their teachers have of them. This is explored further in the section concentrating on parents and teachers.

Several of the studies did not find significant gender differences in math attitudes and achievement despite hypotheses that they would. Caporrimo (1990) found in a Pearson correlation analysis that a significant correlation between problem-solving strategies score and standardized test score existed ($r=-.19$, $p<.04$), but no gender differences were found in these variables. Chouinard (2007) found no significant relationship was found between gender and utility value, but girls reported higher mastery goals and effort while reporting lower competence beliefs in the subject of math.

Anxiety produced by breaking gender expectations was an important focus of set of studies. Buckley and Ribordy (1982) found that subjects who were given high-stakes instructions prior to taking a math assessment experienced higher levels of anxiety and that those heightened levels of anxiety negatively affected their performance.

Osborne's (2007) results showed significant physiological reactance (skin conductance, skin temperature, blood pressure) as a function of a stereotype threat condition. Performance on the achievement test was significantly related to sex and condition ($p<.02$), meaning there was a large gap in achievement between the sexes in the high stress condition that did not appear in the low stress condition.

Neuville and Croizet(2007) offer the possibility of behavioral priming as a cause for gender achievement gaps in math. Behavioral priming occurs when a person becomes aware of stereotypes of a group they belong to and then let their behavior emulate memories of stereotypes they have heard. This research suggests that *femininity*, as opposed to the female sex, seems to be mentally linked to low math achievement and a predisposition for areas like language arts.

Kaczala (1981) found that boys felt it more important for either a girl or a boy to engage in same-sex types activities than did girls. Boys perceived math as less difficult than girls ($t=3.93$, $p<.001$) requiring less effort ($t=3.78$, $p<001$). Males also held higher expectancies of their success in math ($t=3.86$, $p<.001$). Girls' attitudes about English were significantly more positive than boys. Girls perceived English as less difficult ($t=4.49$, $p<.001$) and requiring less effort ($t=3.59$, $p<.001$) than did boys.

Bandura, Barbaranelli, Capara and Pastorelli (2001) found that boys had a higher sense of efficacy for mathematics ($F = 6.29$, $p < .02$) and geographic science ($F = 4.13$, $p < .05$) whereas girls judged themselves more efficacious for language coursework ($F = 9.05$, p s< .01). Girls also judged them-selves more efficacious to regulate different aspects of their own learning activities. Girls surpassed boys in their scholastic activities and to abstract instructional material, ($F = 11.13$, $p < .001$).

Bandura et al (2001) presented findings that supported their theory that gender role expectations will affect student's curricular and career choices. Two of the articles did not support these findings. Brewer and Blum (1979) found that of the 124 female respondents, 55% had taken a math/physical science course during their last year in high school, but only 41 (33%) enrolled in a math/physical course their first quarter in college. Controlling for enrollment, however, there were no significant differences between male and female respondents in degree of liking for M/PS ($M = 2.24$, and 2.44, respectively). Wulff and Steitz (1997) hypothesized that the choice of curricular track would correspond to traditional sex-role stereotypes and that there would be a significant difference between the two groups in terms of feminine orientation. Neither was supported by the findings. The cosmetology group demonstrated higher levels of androgynous identification than the math course students.

The attribution research mostly found that males and females attribute math success and failure differently and that attributions affected achievement. Attributions are the things or people that people credit for their success or failure. The attribution research overviewed in this section mostly found that males and females attribute math success and failure differently and that attributions affected achievement.

Some of the research did not find significant relationships between attributions and gender. Rogers (1991) found that gender had no effect on attribution patterns. However, the small size of the sample (N=157) needs to be taken into account. Other articles presented the opposite findings, strongly suggested that attributions are influenced by gender and visa versa. Lloyd, Walsh and Yailagh's (2005) results suggested that the significant main effect of student's grade level on the composite variable was related to three variables; attributions of effort for success, attributions of teacher's help for success and total self-efficacy. The results revealed that males and females differed significantly in only two measures; attributing failure to lack of teacher help ($p<.01$) and relative self-efficacy ($p<.05$). Krauser and Ballif(1988) found that math achievement and the self-schema for masculinity predicted expectance of success ($\beta=.306$. $p<.0001$). Gilbert's (1996) finding that gender differences in math and science don't emerge until after age 12 directly conflicts with articles like Neuville and Croizet (2007). Their study suggests that gender identities are in place and negatively affecting female math achievement by age seven.

Eccles et al's (1993) confirmatory factor analyses found that boys had more positive competence beliefs and values than did girls for sport activities and more positive competence beliefs for mathematics. Girls had more positive competence beliefs and values than did boys for reading and music activities (p.001). According to these results, children do hold differentiated self and task perceptions in the skill linked activity domains studied herein, even at the first grade.

The Kloosterman and Cougan (1994) study adds to the pattern in the research that students who enjoy math are the ones who are most confident in it, despite not having the highest achievement. If students can develop confidence and self-efficacy in mathematics, their enjoyment might increase and encourage them to continue into higher levels of math.

Parents proved to be very influential figures in the research. Friedel, Cortina, Turner and Midgley (2007) found a significant correlation ($p<.001$) between student's personal goal orientations and their perception of parent's goal emphases. Correlations suggested that children's performance-approach orientation was strongly predicted by perceived parental performance emphasis (.70), but not significantly predicted by perceived teacher performance emphasis.

Jayaratne (1987) found that when parent's own attitudes about math were correlated with their children's attitudes about math significant effects ($p<.01$) were only present in one sub-group, higher educated mothers and their daughters. All three measures of the mother's past attitudes were significantly correlated ($p<.05$) with all six of the daughters' attitudes. Children were found to be no more accurate in predicting their mothers' math attitudes than their fathers'.

Jayaratne's (1983) findings suggested that parents were strongly sex-typed regarding their self-assessment of the subjective experience with math and their daughters or son's math achievement. Mothers' attitudes toward their daughters' math achievement were strongly related to their view of their own math achievement. Parents of daughters were more likely to say that boys and girls had equal mathematical ability than parents of only sons ($t=2.33$, $df= 513$, $p<.05$).

Some of the research investigated teacher expectations and teacher anxiety in relation to math and gender. Malinsky, McJunkin, Panells and Ross (2006) found an ANOVA of mean scores for the MARS and gender indicated a significant difference ($p=.024$) between males and female teachers, with females having higher anxiety levels.

Gresham (2008) found a significant, negative relationship between math anxiety and math teacher's efficacy ($r=-.475$, $p=<.05$). Tiedemann (2000) found that boys were considered by teachers to be more capable of logical thinking than girls ($F(1,49) = 11.37$; $p = 0.001$). Mathematics as a subject was considered to be more difficult for girls than for boys ($F(1,46) = 9.36$; $p =0.004$). Helwig, Anderson and Tindal (2001) found that in both third and fifth grades, regression results showed that mathematics and reading achievement test scores, together with student effort, were significant predictors of teacher rating of student mathematics achievement. Gender was not a significant contributor in either grade. Similar results were found when students were split by general or special education. The findings suggested that the teachers did not consider student gender when rating the mathematics skill level of their students.

Zohar and Gershikov's (2007) compared the affects of boy-context curriculum, girl-context curriculum and gender-neutral curriculum. In the boys' context, analysis of variance showed a significant main effect for gender (f=32.8, df=1, p=.0001). In the girls' context, girls outperformed boys in the higher grades (five and six) but not in kindergarten through fourth grade. The analysis of variance in the gender neutral context showed no significant differences for age or gender.

Leonard and Derry (2001) randomly assigned students to gender-adapted or gender-maladapted treatment conditions. In the gender-adapted condition, females received the feminine version of instruction, and males received the masculine version. In the maladapted condition, students received instruction designed for the other gender. No performance difference was found between the groups (F=.45, sig=.51).

One of the major findings of the classroom environment section included the gender gap may be more perception or anxiety-based than achievement-based. Pajares' (2005) analysis found that the direct effect of self-efficacy on performance was as strong (r=.348) as was the effect of ability(r=.321).

Marsh and Tapia's (2002) findings showed that the more anxiety a student has towards math, the less motivated they were and the less they enjoyed math although there was not enough information to determine a two-way multivariate interaction.

Chapter four will shift the reader's attention to practical application by offering a summary of findings, classroom implications, areas for further research and a final conclusion.

CHAPTER FOUR: CONCLUSION

Introduction

Chapter one of this paper outlined the relevance, rationale and limits of the guiding question for this paper, how does gender affect math attitudes and achievement. Chapter one also presented the reader with controversies within the research. It discussed the importance of mathematics achievement and noted what positive results could come from closing the gender gap in math. Chapter one also discussed the controversies within gender gap research, and presented the reader with limitations for the literature review offered in chapter three.

Chapter two explored the history of differing gender roles and expectations in education for men and women. It also followed the development of women's roles in education throughout United States history. In reviewing the history, it was noted that although great strides towards gender equity have been made, a gap between American men and women in math attitudes and achievement still persists. The gap in mathematic attitudes and achievement may appear to be a dichotomous separation of male/female. The research often frames the gap as such, 'boys' outperforming 'girls' or men over representing women in mathematical fields. Rarely is gender identity discussed as anything more than biological sex. This oversimplifies the dynamic between gender and mathematics attitudes and achievement. One reason the research persists to look at the issue in this male/female comparison lies in a different history of educational opportunities along the sex line. Historically, education in the United States has been divided into biological sex groups and assigned roles accordingly. However, recent research suggests a much more complex combination of variables that constitute an individual's attitudes and achievement in mathematics.

Chapter three reviewed a sampling of the relevant research on the subject of math attitudes and achievement in relation to gender. The research examined how gender affects the math attitudes and achievement of three critical players in a students' math education; the parent, the teacher and the student. The research was divided into five areas: student self-perceptions, gender roles, attributions, parents and teachers, and the classroom environment.

Summary of Findings

The question that the research aimed to answer was; how does gender affect math attitudes and achievement? Studies were broken down into five sections; self-efficacy, gender roles, attributions, parents and teachers and classroom environments. Each section had mixed findings with the methods of the research presenting both strengths and weaknesses. The following are the major findings and trends found in the research overviewed in chapter three.

Self-Efficacy

One of the major findings in the self-efficacy section includes that the gender gap may be more perception or anxiety-based than achievement-based. Pajares' (2005) analysis found that the direct effect of self-efficacy on performance was as strong ($r=.348$) as was the effect of ability($r=.321$). Meelisen and Luyten (2008) suggested a similar conclusion in their study of Dutch students. If actual performance of students is equitable across the board, then the viewpoint that the math achievement gap has closed and there is still a disparity between men and women in mathematics attitudes can be reconciled. If females have the ability to perform at the same level as males in math but do so with anxiety, it's unlikely they will enjoy math and will not pursue it. Marsh and Tapia's (2002) findings showed that the more anxiety a student has towards math, the less motivated they were and the less they enjoyed math although there was not enough information to determine a two-way multivariate interaction.

Herbert found that beginning in third grade; girls rated their math competencies lower than boys even though the teacher's competency rating and the actual math achievement remained the same. Parents also rated boys' math competencies higher than girls in the third and fifth grades actual achievement and teacher's ratings. These findings suggest that gender stereotype not only affects students' self-efficacy but the perception their teachers have of them. This is explored further in the section concentrating on parents and teachers.

Several of the studies did not find significant gender differences in math attitudes and achievement despite hypotheses that they would. Caporrimo (1990) found in a Pearson correlation analysis that a significant correlation between problem-solving strategies score and standardized test score existed ($r=-.19$, $p<.04$), but no gender differences were found in these variables. Chouinard (2007) found no significant relationship was found between gender and utility value, but girls reported higher mastery goals and effort while reporting lower competence beliefs in the subject of math.

Gender Roles

Anxiety produced by breaking gender expectations was an important focus of set of studies. Buckley and Ribordy (1982) found that subjects who were given high-stakes instructions prior to taking a math assessment experienced higher levels of anxiety and that those heightened levels of anxiety negatively affected their performance.

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Bandura et al (2001) presented findings that supported their theory that gender role expectations will affect student's curricular and career choices. Two of the articles did not support these findings. Brewer and Blum (1979) found that of the 124 female respondents, 55% had taken a math/physical science course during their last year in high school, but only 41 (33%) enrolled in a math/physical course their first quarter in college. Controlling for enrollment, however, there were no significant differences between male and female respondents in degree of liking for M/PS ($M = 2.24$, and 2.44, respectively). Wulff and Steitz (1997) hypothesized that the choice of curricular track would correspond to traditional sex-role stereotypes and that there would be a significant difference between the two groups in terms of feminine orientation. Neither was supported by the findings. The cosmetology group demonstrated higher levels of androgynous identification than the math course students.

Attributions

Attributions are the things/people that people credit for their success or failure. Attributions can become very closely tied to self-identity and expected gender roles, which is why they are important to pay attention to. If failure in mathematics is attributed to an inherent characteristic like gender, this can negatively impact motivation. Similarly, if success is credited to chance or circumstance, the student still does not claim responsibility for the performance and will not learn the cause and effect of effort and success.

The attribution research overviewed in this section mostly found that males and females attribute math success and failure differently and that attributions affected achievement. Attributions are the things or people that people credit for their success or failure. The attribution research overviewed in this section mostly found that males and females attribute math success and failure differently and that attributions affected achievement.

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This section also presented a finding about how early attributions can affect gender differences in math. Gilbert's (1996) finding that gender differences in math and science don't emerge until after age 12 directly conflicts with articles like Neuville and Croizet (2007). Their study suggests that gender identities are in place and negatively affecting female math achievement by age seven.

Eccles et al's (1993) confirmatory factor analyses found that boys had more positive competence beliefs and values than did girls for sport activities and more positive competence beliefs for mathematics. Girls had more positive competence beliefs and values than did boys for reading and music activities (p.001). According to these results, children do hold differentiated self and task perceptions in the skill linked activity domains studied herein, even at the first grade.

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The findings in this section that parents have more of an impact on students' attitudes and achievement about math is not surprising. The teacher spends less time with the child and has a much less significant role in most children's lives. The importance of collaboration between home and school will be discussed in chapter four.

Classroom Environments

Classroom environments are something that teachers can manipulate to either help or hurt their students' learning process. Understanding how gender affects math attitudes and achievement in classroom environments will help teachers engineer a place with their math students can feel competent and be successful. The research in this section looked at two aspects of classroom environments, the peers in the classroom (uni-sex or mixed) and the curriculum taught (feminine or masculine).

Zohar and Gershikov's (2007) compared the affects of boy-context curriculum, girl-context curriculum and gender-neutral curriculum. In the boys' context, analysis of variance showed a significant main effect for gender (f=32.8, df=1, p=.0001). In the girls' context, girls outperformed boys in the higher grades (five and six) but not in kindergarten through fourth grade. The analysis of variance in the gender neutral context showed no significant differences for age or gender.

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Classroom Implications

Achievement is what is measured in most classrooms exclusively. SAT scores, standardized tests, etc. do not measure the students' attitudes about the subject, themselves as students of it or their likelihood to continue to be involved with and successful in the area. This section shows that teachers should think deeply about monitoring how students are feeling about their competence in math and be better able to provide self-efficacy building math activities for students.

Bandura et al (2001) support the theory that stereotypes affect career choices for girls. These stereotypes need to be challenged by real examples, or role models, to refute the myth that women cannot do mathematical jobs. To meet this need, teachers should provide their class with examples of women and men who are successful in other usually female-typed arenas like art, English and music and also in mathematical fields. By broadening the presented role model figures in the classroom, students are more likely to be able to see themselves in the picture as a mathematician, engineer or physicist.

As a teacher, I am responsible for students' achievement in mathematics and therefore am concerned with the self-efficacy. Creating class norms that allow and expect students to need help from their learning community to solve problems might help with this. I like the idea of having a student try something on their own first, and then if they with opening up the option for a class mate to give them a hint or the next step in the problem. Asking for just a little guidance doesn't pull the thinking from the students' hands but could encourage them to focus their learning in a more productive direction.

Stereotype threat can hinder girls and boys from entering into fields where their gender is *supposed* to fail. Studies like Neuville and Croizet (2007) found that especially when the *feminine* identity is strong in the individual, incompetence or uselessness in mathematics is the comfortable stereotype. These identities often begin to form before the child enters school, and it is therefore important to understand the familial dynamics of stereotype threat.

Jayaratne's findings in 1987 and 1983 suggested that elementary teachers need to strategize ways to access parents' previous experiences with math and support mothers who have had negative math experiences so they do not pass those anxieties onto their daughters, negatively impacting their math attitudes and achievement. Gathering information about parents' educational history will have to be done in a tactful and respectful way. But it could provide valuable information about how much scaffolding a student will have at home for math. Inviting parents to complete a questionnaire similar to the one used in Jayaratne (1987) could provide this information. A conversation with the parents during a conference might be an alternative way of tapping parental attitudes and expectations about mathematics and their student.

Areas for Further Research

In order to become more relevant teachers, we must broaden our ideas of gender and its' impact on the students, the curriculum and yourself. Gender has been narrowly defined in the past and research on ambiguous or androgynous gender identities is just beginning to emerge. Although these kinds of studies were fascinating and add important insight into the dynamics of gender and mathematics, there was simply not enough of this research at the time of my paper to explore the topic in depth.

From the vast research on gender that exists, the message of gender's *complexity* seems unanimous. It is unrealistic at this point to simplify everyone's gender identity into boy' equates to 'masculine' or that 'girl' equates to 'feminine'. In light of the vast number of possible combinations of sex, gender, behavior, culture and achievement, it seems overly simplistic to say one curriculum is 'masculine' and one 'feminine'. Instead, researchers and teachers should examine how different learning styles and individual preferences of students are served by their curriculum.

Some of the research explored in chapter three, i.e. Birenbaum and Nasser (2006), suggests that the dynamic between ethnicity and gender is critical to understanding mathematics gender achievement gaps. This is a natural area for further research considering that gender roles are often shaped by the cultural norms and expectations and should not be overlooked by teachers when making culturally and gender relevant choices in the classroom.

Long-term implications of gender on math attitudes and achievement need to be studied further to understand gender's true impact. More longitudinal studies like that of Ai (2002) need to be performed in order to understand gender's developing affects on math attitudes and achievement.

Conclusion

Chapter one outlined the relevance, rationale and limits of the guiding question for this paper, how does gender affect math attitudes and achievement. It discussed the importance of mathematics achievement and noted what positive results could come from closing the gender gap in math. Chapter one also discussed the controversies within gender gap research, and presented the reader with limitations for the literature review offered in chapter three.

Chapter two explored the history of differing gender roles and expectations in education for men and women. It also followed the development of women in education throughout United States history. In reviewing the history, it was noted that although great strides towards gender equity have been made, a gap between American men and women in math achievement still persists. This gap is relevant because it weakens our country's potential workforce and competitive edge in a global market. It is also important for elementary school teachers to be aware of gender-related mathematics gaps because they will impact the way they teach students and the way they will learn.

Chapter three reviewed a sampling of the relevant research on the subject of math attitudes and achievement in relation to gender. The research examined how gender affects the math attitudes and achievement of three critical players in a students' math education; the parent, the teacher and the student. The research was divided into five areas; student self-perceptions, task perceptions, attributions, parents& teachers and the classroom environment.

Major findings of the student self perceptions section of research included that the gender gap may be more perception or anxiety-based than achievement-based. Pajares' (2005) analysis found that the direct effect of self-efficacy on performance was as strong (r=.348) as was the effect of ability(r=.321). Meelisen and Luyten (2008) suggested a similar conclusion in their study of Dutch students. Marsh and Tapia's (2002) findings showed that the more anxiety a student has towards math, the less motivated they were and the less they enjoyed math although there was not enough information to determine a two-way multivariate interaction.

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Attribution research yielded a wide range of findings. Rogers (1991) found that gender had no effect on attribution patterns. However, the small size of the sample ($N=157$) needs to be taken into account. Lloyd, Walsh and Yailagh's (2005) results suggested that the significant main effect of student's grade level on the composite variable was related to three variables; attributions of effort for success, attributions of teacher's help for success and total self-efficacy. The results revealed that males and females differed significantly in only two measures; attributing failure to lack of teacher help ($p<.01$) and relative self-efficacy ($p<.05$). Krauser and Ballif(1988) found that math achievement and the self-schema for masculinity predicted expectance of success ($\beta=.306$. $p<.0001$). Eccles et al's (1993) confirmatory factor analyses found that boys had more positive competence beliefs and values than did girls for sport activities and more positive competence beliefs for mathematics. Girls had more positive competence beliefs and values than did boys for reading and music activities (p.001).

Research about parent and teacher influences showed that parents were the most influencial players in a child's math attitudes. Friedel, Cortina, Turner and Midgley (2007) found a significant correlation ($p<.001$) between student's personal goal orientations and their perception of parent's goal emphases. Jayaratne (1987) found that when parent's own attitudes about math were correlated with their children's attitudes about math significant effects ($p<.01$) were only present in one sub-group, higher educated mothers and their daughters. Jayaratne's (1983) findings suggested that parents were strongly sex-typed regarding their self-assessment of the subjective experience with math and their daughters or son's math achievement.

Some of the research investigated teacher expectations and teacher anxiety in relation to math and gender. Malinsky, McJunkin, Panells and Ross (2006) found an ANOVA of mean scores for the MARS and gender indicated a significant difference ($p=.024$) between males and female teachers, with females having higher anxiety levels. Gresham (2008) found a significant, negative relationship between math anxiety and math teacher's efficacy ($r=-.475$, $p=<.05$). Tiedemann (2000) found that boys were considered by teachers to be more capable of logical thinking than girls ($F(1,49) = 11.37$;

p = 0.001). Helwig, Anderson and Tindal (2001) found that in both third and fifth grades, regression results showed that mathematics and reading achievement test scores, together with student effort, were significant predictors of teacher rating of student mathematics achievement.

Finally, the classroom environment findings include; Zohar and Gershikov's (2007) analysis of variance showed a significant main effect for gender and classroom context (f=32.8, df=1, p=.0001). Leonard and Derry (2001) found that No performance difference was found between the groups (F=.45, sig=.51) when subjects were randomly assigned students to gender-adapted or gender-maladapted treatment conditions. Chapter four reviewed and extended into practice the research found in the previous three chapters. Additionally, areas for further research are identified and main findings are revisited. Areas for further research included; studies of the androgynous identity and math, how different learning styles and individual preferences of students are served by different math curriculum, the dynamic between ethnicity and gender in mathematics and increased longitudinal studies like that of Ai (2002).

A gender gap persists in the United States in the field of mathematics. The gap is demonstrable at an early elementary level and therefore must be addressed by elementary level teachers. Elementary school teachers are also overwhelmingly female, which makes their attention to the relationship between gender and math even more critical for student success. Creating classrooms where all students are able to learn and flourish in mathematics is critical for the United States' fiscal and social economy and necessary for it to meet its promise of equal opportunities for those who seek them. A deeper understanding of gender's affects on math attitudes and achievement will help teachers better meet the educational needs of their diverse students and move towards this vision.

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