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Student Attitude Toward Mathematics At the Middle and High School Level

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HONORS THESIS

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Table of Contents

Introduction to Problem

The question of attitude toward mathematics is one of great importance and one that is associated with large implications for students. Studies on student attitude focus on determining the relationship of attitude to the perceived relevance of mathematics to future academic and career choices. Student attitude toward math in middle and high school can affect student enthusiasm for taking advanced math courses in high school and college and can largely determine future career choices. For these reasons generating positive attitudes toward mathematics among middle and high school students is an important goal of mathematics education.

To this end, many studies focus on measuring attitudes toward mathematics and the relationship between these attitudes and student achievement. Researchers have identified many aspects affecting attitude and have classified these factors into three main groups; factors associated with students themselves, factors associated with the school, teacher, and teaching of mathematics, and factors from the home environment and society (Brown, 2003; Hembree, 1990; Llyod, 2005; Tocci, 1991; Wigfield & Meece, 1988). Factors associated with students include mathematical achievement, math anxiety, self-efficacy and self-concept, motivation, and experiences with mathematics in the school setting. In the second classification, those factors associated with school, teaching materials, classroom management, teacher knowledge, teacher attitude towards mathematics, and teacher guidance may play a role in student attitude toward mathematics. Finally, factors from the home environment and societal factors include parental educational background and expectations, the gender bias, and cultural norms and beliefs.

From this extensive list, it becomes clear that many factors influence student attitude. Isolating the direct effect of each factor is an extensive and often difficult process as many of the factors are interrelated and have some effect on each other. For the purposes of this study, focus was placed on seven specific factors affecting attitude toward mathematics, with each of the three classifications represented. The gender stereotype (often referred to as gender bias) associated with mathematics, math anxiety, peer influence and social factors, intrinsic interest in the subject, the enjoyment of mathematics, student's perceived competence of their math skills, and student perceived importance of mathematics were measured and evaluated.

Perhaps the most widely studied of these chosen factors is the gender stereotype and the implications this factor has on student attitude and achievement in mathematics. Traditionally, gender stereotype was believed to have a tremendous effect on student perception of mathematics and student attitude toward mathematics. In the more recent research however (from 1980 to present), results suggest that this gender gap is closing, as more females are taking higher-level math courses in high school and college and are better represented in careers in the science, technology, engineering, and math fields (STEM fields).

Research at the elementary and secondary level examined from 1970 to present suggests that the mathematics gender stereotype is perhaps the most influential of these factors as it affects many other factors determining student attitude toward mathematics (Cavanaugh, 2008; Ellison & Swanson, 2010; Gallagher & Kaufman, 2005; Leahey & Guang, 2001). To test the claim that the gender stereotype is an important and influential aspect of student attitudes toward math, this study compared student gender to each of the seven chosen factors. The findings of this study describe the relationship between student gender and student belief in each of the seven categories and attempt to offer insight into the evolution of gender role and expectation as it relates to the realm of mathematics education.

At this point, some personal remarks are perhaps warranted. I chose to do research on student attitude toward mathematics because as a math major I often have interactions with people who do not see math as a desirable or even favorable field of study. In my experience working with college students in my job as a tutor, I have seen attitudes towards math range from hate to love, with a large majority of those attitudes closer to the hate end of the spectrum. I am interested in understanding where these attitudes come from, and at what level of schooling they are acquired, whether it be at the elementary, secondary, or post-secondary level.

As a future middle school or high school teacher, I think it is important to understand the development of such negative attitudes toward math and to understand the different factors affecting these attitudes. In my experience, math is generally perceived as "too hard," or as something that students feel they are not "smart enough" to understand. I want to know *why* these beliefs exist, and what steps can be taken to facilitate more positive attitudes toward math in order to leave my students with attitudes toward math on the "love" end of the spectrum.

Summary of Research

Gender Stereotype

The gender stereotype in mathematics implies that males are better at understanding and performing mathematical concepts than are females. Unfortunately, students have bought into this idea. By middle school, "females believe more strongly than do males that studying math is as appropriate for them as it is for their male peers" (Tocci & Englehard, 1991).

Gender as a sociocultural construct is the outcome of a "social, historical, and cultural processes, which develop through practices, symbols, representations, social standards, and values" (Santos et al. 2006). The gender gap in mathematics achievement has been a field of study for many years, and the evolution of research and conclusions about the gender gap is both interesting and hopeful. The gender stereotype in mathematics does not stay in the classroom; it is a relevant and pervasive part of social conditioning and affects students through societal, parental, cultural, and peer influence.

Traditionally, explanation of the gender gap was largely biologically based. Early research found evidence that males perform better in numerical and spatial tests while women perform better in verbal recall test; making mathematics a male-dominated domain (Guiso, Monte, et al. 2008). Further, studies found that in junior high school, the sex difference becomes obvious, with female students exceling in computation while boys excel on tasks requiring "math reasoning ability" (Benbow & Stanley, 1980). The early research credited male students with higher math aptitude than their female counterparts when considering "essentially identical formal educational experiences" (Benbow & Stanley, 1980).

Beginning around 1990, the traditional patterns in the gender gap began to change as female students began to catch up to their male counterparts in measures of mathematical achievement. As this gap closes, new research is aimed at understanding why this change is occurring. At the academic level, speculations include changing college admission requirements forcing female students to take higher level math and science classes, and the opening up of Title IX in 1972 of STEM intensive specialty high schools, colleges, and grad schools, leading to opportunities in STEM career fields (Hyde et al. 2009).

Much of the recent research agrees that gender differences in taking math courses had an important role in explaining what had tended to be interpreted as gender differences in inherent mathematical ability (Gallagher & Kaufman, 2005; Llyod et al. 2005; Tocci & Englehard, 1991; Downey & Vogt Yuan, 2005). After 1990, studies including measures of spatial ability did not provide any strong evidence for gender difference in spatial ability; contrary to previous findings that this was a reliable cognitive difference (Gallagher and Kaufman, 2005). As part of a national initiative to understand why gender differences in mathematics exist, researchers focused on two possible affective variables in determining course enrollments and math achievement; liking for mathematics, and math anxiety or confidence.

Results showed that there is no gender difference in liking for mathematics; males and females had equal interests and intrinsic motivation. However, there did exist a consistent sex difference in math anxiety or confidence, which has been suggested to be a result of social influence. Because of the gender-biased environments students are subjected to, it might be that female students are either implicitly or explicitly affected by social pressures causing them to be less willing to express high confidence in themselves as math students, even if they do possess confidence, giving what they perceive to be a socially correct answer (Gallagher & Kaufman, 2005).

The data suggests that males do not outperform females in mathematics, and that gender differences are nonexistent prior to high school. While the gender gap is closing at the secondary and post-secondary academic levels, the STEM workforce remains female deficient. Studies suggest this may be due to the fact that for females, the primary utility of math study in high school may be to meet college admission requirements, rather than as an inherent requirement of their future occupation (Santos et al. 2006).

Beginning in high school the gender gap becomes significant, however attitudes toward math begin to change as early as late elementary to early middle school. A study measuring initial mathematics status, middle school, and high school growth, found consistent negative change in student attitudes toward belief about the societal importance of math in both males and females. Interestingly, male students initially had a significantly more positive attitude toward math and a more "progressive view of the nature of math" than did their female peers (Wilkins & Ma, 2003). In middle school, results show that females developed negative beliefs about the social importance of math at a faster rate than did males, while in high school the trend was reversed.

Biological differences are cited as affecting the timing of the emergence of the gender gap in high school, as males tend to go through puberty later than females, and experience this biological transition around the time they enter high school. Environmental factors may include differential coursework, which does not arise until high school, or the tendency of males to enroll in higher-level science classes in which similar logical and mathematical skills are taught (Leahey & Guo, 2001). Though these are plausible explanations for the emergence of the gender gap, it seems that the role of confidence or self-esteem and attitude are likely more influential as they are influenced by the gender stereotype. The internalized belief system of a student at the high school level becomes more important as they prepare for their future; choices of college and career may highlight perceived gender discrimination (Scafidi & Bui, 2008).

While the gender gap does exist, it is minimal and decreasing. The stereotype that females lack math ability, while not as strong as previously believed, still exists and is accepted by teachers, parents, and students. The results of many studies suggest that the gap exists not because of differences in ability, but because of the affect of the gender stereotype, indicating a discrepancy between popular belief and reality (Scafidi & Bui, 2008).

Math Anxiety

Anxiety is a state of emotion "underpinned by qualities of fear and dread," one which is directed toward the future, and is out of proportion to the presented threat (Hembree, 1990). Anxious people experience feelings of uncertainty and helplessness in the face of danger; in an academic setting, danger can be perceived as failure or under performance, or public embarrassment in a classroom setting. In academics, the two most prominent forms of anxiety are test anxiety, and math anxiety. While both inhibit maximum student understanding and benefit, math anxiety, the feeling of tension, apprehension, or fear that interferes with math performance (Ahscraft, 2002), has lasting implications for student mathematic competence, achievement, and attitude.

Math anxiety has both behavioral and cognitive elements. Emotionality as a dimension of math anxiety can affect not only mental capabilities, but is a factor in physiological responses as well. Feelings of nervousness, tension, and dread are part of this affective dimension of math anxiety, and can produce unpleasant physical responses such as increased heart rate, nervous fidgeting, or sweating (Ho, et. al., 2000). Conscious worry or concern is the cognitive component of math anxiety, and it is this component which theorists believe interferes most with achievement performance (Ho et. al., 2000). The cognitive dimension of anxiety consists of self-deprecatory thoughts about ability and performance and the preoccupation with negative expectations; these are also referred to as task irrelevant behaviors as they reduce a student's ability to succeed on a given task.

Studies by Hembree (1990), and Wigfield and Meece (1988) done at the secondary level show that math anxious people divide their attention between task relevant efforts such as the completion of a test or assignment, and a preoccupation with worry, self-criticism, and physiological concerns. With less attention available for a math directed activity, student performance and achievement is depressed. This cycle of poor performance connected with math anxiety perpetuates, and highly math anxious students end up with lower perceived competence and lower mathematics achievement (Ashcraft, 2002).

While math anxiety and performance are connected, it is difficult to determine the causal direction of the connection, and whether math anxiety depends more on the behavioral or cognitive dimension. In a 1990 study of high school math students, researchers concluded that math anxiety depresses mathematical performance, and that it appears to be a learned condition. Findings show that anxiety depressed grades in math classes and test scores proportionally, and that high math anxiety was consistently related to lower math performance. The study reports an increase, and even in some cases a restoration of performance, of formerly highly math anxious individuals to low math anxious individuals through specifically designed treatments. These treatments were implemented as part of the study and consisted of changes in curriculum or physical interventions (Hembree, 1990).

Because math anxiety disrupts cognitive processing by compromising the working memory, it has large implications for future student achievement and performance, and arguably, more importantly, for future student interest and enjoyment of mathematics. Hembree also reports avoidance behaviors characteristic of highly math anxious students. These students took fewer high school math classes and were less interested in taking more math later in high school and into college.

Gender is an important factor in math anxiety as well. Males and females at the high school and middle school level report similar levels of math worry, that is they are both equally concerned with succeeding in math; however, females reported experiencing more negative affective reactions than did males. This result may be due to the fact that females are more willing to admit to affective reactions of anxiety, or that they are more capable of coping with such reactions while maintaining a level of performance achievement (Hembree 1990, Wigfield and Meece 1988, Ashcraft 2002). Females may also feel more math anxiety as a result of cultural expectations; math is thought to be inherently difficult and aptitude is considered more important than effort. In a culture where a Barbie doll says, "math is hard," it is difficult for females to completely escape gender bias and avoid the development of math anxiety.

In their insightful 1988 study, Wigfield and Meece measured two types of math anxiety; math test anxiety, and numerical anxiety, or the anxiety experienced when dealing with math in everyday situations. This is an important distinction when considering the implications of math anxiety, as an individual with high numerical anxiety may avoid math classes, and may be more likely to have negative attitudes toward math related jobs and activities. The results of this study show that these components of math anxiety are distinguishable, and that they are similar across grade level and gender. The results of this study show that math test anxiety primarily stems from the worry component of anxiety, while numerical anxiety primarily stems from the emotional component; however, it seems that the two dimensions overlap, as correlations between the cognitive and emotional factors do exist.

The results of the Hembree and Wigfield and Meece studies suggest that math anxiety should be conceptually distinguished from perceptions of math ability. The anxiety that students report represents more than a lack of confidence in individual ability; it also depends heavily on negative emotional reactions to mathematics (Wigfield, Meece, 1988). Both studies propose treatment of anxious students in the form of training directed at the reduction of fear of math, and include focus on intervention efforts in both the cognitive and emotional domains. While such treatment has been shown to be preliminarily beneficial, the long-term success of such treatment remains to be seen.

Social Factors and Peer Influence

Societal influence can manifest itself in many different forms: family, community, religion, mass media, cultural ideals, and implicit or explicit messages from societal roles. All have a part in the overall social pressures a student is subjected to and affect student attitude toward math either. These hidden cultural pressures color socialization processes and shape each student differently. Depending on the environment in which a student is raised and the significant people in his or her life, attitudes toward math are affected positively or negatively.

Again, gender difference plays a large role in the social impact of attitudes toward math. One study of secondary students describes society as "'gendered' and producing a generally hostile environment for girls' success in math" (Downey & Vogt Yuan, 2005). In a recent study of countries around the world, researchers looked at different measures of women's education, political involvement, welfare, and income in each country and found that there was "some variability among countries when it came to gender differences in math and how it related to the status and welfare of women" (Science Daily, 2010). If certain countries had more women in research-related positions, or positions of greater academic merit, the female students in that country were more likely not only to do better in math, but to be more confident in their math skills (Science Daily, 2010).

This study provides a striking example of the impact of social influences on attitudes toward math. The results show that female students are capable of, and do in fact, perform at the same level as male students when they are given the appropriate female role models and the proper gender-directed encouragement.

Research suggests that societal expectation also affects the absence of females in math, especially in the upper percentiles of achievement. In a 2010 study of elementary and secondary students, researchers discovered support for the idea that girls suffer in becoming high achievers in math because they are more "compliant with authority figures, and/or are more sensitive to the social environment" (Ellison & Swanson, 2010). If social factors make female students less likely to join math teams, or take advanced courses, then they will likely be underrepresented when higher achievement levels are measured.

Some researchers have explained this gap in achievement not as a difference in gender capability, but as the pursuing of alternate paths. It may be that female students choose a less math focused path based on varying skills and interests, in order to develop the necessary kills which are of value to them (Ellison & Swanson, 2010). The value judgment of the utility of math is unique to each student and is determined throughout each student's academic career. Societal influence plays a significant role in determining the present and future value of mathematics for a student, and gender roles and expectations are an integral part of social influence.

Differential classroom treatment based on socially acceptable behavior affects student attitude towards math as it determines the amount of teacher-student interaction and reinforcement. A 2005 study concludes that a major deciding factor of student attitude and achievement in mathematics is gender-specific classroom behavior. This study found that while the traditional result of higher male test scores still holds, when considering the gender gap in math grades, females come out on top. The researchers attribute this to female classroom behavior; "girls do well in school because they are socialized to be good" (Downey & Vogt Yuan, 2005).

Being a "good girl" in school, according to the researchers' definition, means "dutifully following orders and instructions from teachers, being decorous, and compliant, and accepting rules with little protest" (Downey & Vogt Yuan, 2005). Traditionally, this behavior is more compatible with female sex roles, rather than male sex roles. While this behavior may raise grades, it appears that the more aggressively behaved students receive more attention and reinforcement from teachers.

Shapka and Keating performed a study at the secondary level testing the effect of girls-only curriculum in which they concluded that in a co-ed classroom, males and females receive unequal amounts of help, support, and attention. The researchers observed that males are called on more often, allowed to speak out more, and are given more praise and useful criticism. This study also provided evidence that relative to males, females reported more anxiety about attending math classes and asking questions in math classes (Shapka & Keating, 2003).

Social influence is pervasive in a student's acquisition of beliefs about and feelings toward math as it shapes the motivations, expectations, and values that are critical in the development of attitude. Perhaps the most prominent aspect of social influence, from a student's perspective, is peer influence. In order to understand the tremendous influence of peers, one must acknowledge the role of peers in adolescence.

Adolescence is the time in a student's life when he or she is faced with the task of establishing autonomy from parents; a time when the socializing power of peers increases dramatically (Berndt & Murphy, 2002; Crosnoe, 200). Peer norms and characteristics influence academic behavior directly and indirectly. Social approval of behavior, self-enhancement through perceived social competence, modeling and social learning, expectations of accomplishment, group regulation, and overt peer pressure are all ways in which peers influence academic performance (Crosnoe et al. 2008)

In an insightful 2008 study of secondary students, researchers tested peer influence in two categories: the close circle of friends, and the larger division of course mates, in which the circle of friends can be included (Crosnoe et al. 2008). Researchers define the circle of friends, or a clique, as characterized by sustained interaction and emotional ties, while course mates are characterized by a group of peers who are similar in "number and kinds of courses shared," and as peers who share a similar "academic/social space in school" (Brown & Klute, 2003).

This study found that male and female students were more alike than they were different in the connection between peer contexts and math course taking. This was slightly surprising, as adolescent females usually have smaller groups of friends to which they are dedicated, while adolescent males usually have a more spread out friend group with minimal emotional connection (Ryan, 2001). Further, this study found that in general, both friends' and course mates' achievement were associated with adolescents' course taking in math, and this pattern was slightly more consistent among females than among males. Consistently, both friends' and course mates' achievement had stronger association with math course taking in the later part of high school than in the earlier grades (Crosnoe et al. 2008).

Historically, there has been a large gender gap in secondary mathematics, but in recent years girls have begun to catch up with boys in terms of math courses taken in high school. An argument for the closing of this gap is centered on peer influence, especially for female students. Social factors mean more for females than for males when considering decisions about math coursework, especially when enrollment in math classes is optional, such as at the high school level (Science Daily, 2008). Friendships mean a great deal to adolescents and serve as a context for learning about the world and about self. Thus, adolescents look to their close friends and peers when faced with important decisions, such as deciding whether math is important, or deciding to take an extra math class.

Interest and Enjoyment (Intrinsic Motivation)

Math is often perceived as a difficult subject "in which motivational factors are particularly important for the enhancement of learning," and compared to other academic subjects, studies show that there is a relatively strong relationship between interest and achievement in math (Koller et. al., 2001). It is not surprising that an interested student is also a more motivated and higher achieving student. Academic interests are assumed to be important intrinsic motivational determinants of academic achievement, and based on numerous studies (Koller et. al. 2001, Downey et. al. 2005, Hilton & Berglund 1974, VanLeuvan 2004) this is an important factor in math achievement as well. For the purposes of measuring interest, it is generally considered to be a "person-object relation characterized by value commitment and a positive emotional relationship" (Koller et. al., 2001). Interest determined activities are those involving personally valued objects and are accompanied by self intentionally positive emotions. The value component of interest is determined by the interested individual and is defined by their emotional experience and the personal importance or utility gained from that experience.

In a study of German secondary schools, Koller, Baumert, and Schnabel provide evidence for the link between intrinsic motivation, or interest, and achievement. The study found that intrinsic values connected with learning activities in academic domains, and particularly in mathematics, become more important when students are given more freedom to choose the course of their education. In the American school system, this would occur at the high school level; math courses become optional for students, and those who are intrinsically motivated by their interest for the subject may pursue higher math courses, and in turn develop a more positive attitude toward mathematics. These choices result in a deeper understanding of math concepts and higher learning rates (Koller et. al., 2001).

The authors of this study argue that academic choices are "mainly determined by subjective measures like self perceived competencies or valuing the domain," and that these academic choices are strongly influenced by achievement levels. An academic setting forces students to cope with developmental tasks which allows students to select and reinforce specific fields of interest while forgoing others which they find less interesting or less intrinsically motivating. Motivational factors, whether intrinsic or extrinsic, are of huge importance for successful learning and achievement, especially in mathematics.

Studies show that gender may also influence individual interest in mathematics. This influence has been explained with the idea that "members of each sex are encouraged in, and become interested and proficient at, the kinds of tasks that are most relevant to the roles they fill currently or are expected to fill in the future" (Hilton, Berglund, 1974). This thinking explains the more antiquated belief of the math gender stereotype; males are encouraged to pursue math because they may become engineers or scientists, while females are given less encouragement as their future careers or occupations do not require math. As much as we would like to trust that this belief system is no longer applicable, there are still underlying cultural and social messages supporting this gender stereotype and influencing student (especially female) interest in mathematics.

The research suggests "interest becomes a more important antecedent of math achievement...when learning activities are not primarily driven by extrinsic values and the associated positive and negative consequences" (Koller et. al., 2001). Intrinsic motivation can be fostered outside of the classroom with the educational use of computers (i.e. math games, logic puzzles, etc.) and student involvement in math and science fairs and clubs. A recent study suggests that students with home computers used as educational tools have higher levels of math skill than those who do not have home computers (Downey, Vogt Yuan, 2005). Higher skill levels influence self-efficacy, which in turn influences performance and achievement, and attitude toward mathematics.

In their 1974 longitudinal study, Hilton and Berglund found that achievement and attitudes toward mathematics have a reciprocal influence. Attitude towards math affects mathematical achievement and achievement in turn, affects attitude. Greater achievement results from an increase in interest and greater interest results from greater achievement. Interest in mathematics is closely linked to achievement level, and is an important and integral aspect of student attitude toward mathematics. Giving students the opportunity to explore mathematical concepts free from extrinsic factors such as tests or grades (as found in the classroom) may be beneficial to the development of intrinsic motivation and interest in mathematics.

Perceived Competence

Attribution theory, first proposed by Bernard Weiner in 1980, has important implications for academic motivation and success. This theory emphasizes the idea that students are strongly motivated by the outcome of positive self image and self-worth, and that a student's current self-perception will strongly influence the ways in which that student interprets personal success or failure. Perceived competence due to current effort leads to future effort and the tendency to perform the same behaviors that helped a student to arrive at a feeling of competence. According to attribution theory, the explanations people use to describe personal success or failure are analyzed based on causes which are internal or external, stable or unstable, and controllable or uncontrollable (Weiner, 1980).

Understanding the distinction between these causes can help determine a student's future success and future motivation. Internal or external causes that affect success are those which a student believes originate within him or herself (internal) or originate in his or her environment (external). Stability as a cause of success or failure has large implication on future performance; if a student believes the cause of success is stable, then the outcome is likely to be the same if the same behavior is performed on another occasion. If the cause is believed to be unstable, the outcome is likely to be different on a different occasion, as the student does not feel in control of an unstable cause.

Both internal and external causes and the stability of a cause can be classified as controllable or uncontrollable. A controllable factor is one that a student believes he or she can alter if they so choose, while an uncontrollable factor is one that cannot be easily changed (a student might perceive their teacher as an uncontrollable factor). An internal factor can be controllable; a student is able to control the amount of effort they give by trying harder. Similarly, an external factor can be controllable or uncontrollable; if a student fails a math class, they may be able to succeed by taking an easier math course; however, if they are failing that particular math class because the concept is too abstract, that abstraction is an uncontrollable factor (Bempechat, 2013).

A basic principle of attribution theory is that a student's own perceptions of attribution of success or failure determine the amount of effort he or she will expend on that activity in the future. Students tend to attribute success or failure based on four key elements: ability, task difficulty, effort, and luck.

Attribution Theory	Internal	External
Stable	ABILITY: student does not have much direct control	TASK DIFFICULTY: beyond learner's control
Unstable	EFFORT: learner has a great deal of control	LUCK: very little control

Fig. 1. Adapted from Bempechat, 2013.

Research shows that students are more likely to succeed academically if they attribute academic successes to either internal, unstable factors over which they have control (effort) or internal, stable factors over which they have little control but which can be disrupted by other factors; ability can be disrupted by infrequent bad luck (Bempechat, 2013; Weiner, 1980). When failure is attributed to internal, unstable factors over which they have control, such as effort, students are more likely to succeed academically.

Traditionally, research suggests that the gender gap in mathematics was partly due to performance attribution differences between male and female students (Harris et al., 1986; Shaughnessy et al., 1983; Hart, 1989). It was believed that male students' attribution patterns and levels of self-efficacy were higher and more self-enhancing that those of their female peers. A recent study contradicts these findings, instead suggesting that female students are "more apt to display under-confidence relative to their actual mathematics achievement and to attribute math failure to lack of teachers' help than were boys" (Llyod et al., 2005). The goal of this recent study is to determine whether the close in the gender gap of mathematics achievement has been matched by higher self-efficacy for female students and with more self-enhancing performance attributions.

Researchers are encouraged, as their results show that female students are making gains in attribution of math success. The study focused on three main attributions: effort, ability, and help from teachers. In the case of both males and females, students were equally likely to attribute their success to effort, and ability was the attribution that both sexes rated as most important in explaining their success (Llyod et al., 2005). The study finds that "girls tend to be under confident relative to their actual academic achievement, whereas boys tended to be relatively over confident" (Llyod et al., 2005). This is an interesting distinction, and one that may be perpetuated (whether implicitly or explicitly) by the gender stereotype and cultural beliefs about the role of females in mathematics.

Students with self-enhancing attribution develop increased confidence in their skills, and this perceived competence is an important tool in continuing self-enhancing behaviors. In mathematics, this is increasingly important, as research has shown improved feelings of intrinsic motivation in areas where they perceive themselves to be competent (Koller et al. 2001; Harter, 1982).

Brophy (1983) suggests that the self-fulfilling prophecy is a result of performance attribution. Students with high self-perception create more opportunity for academic interaction and teacher response than do those with low self-efficacy. Higher levels of perceived competence allow students to experience praise or teacher reinforcement, further reinforcing their positive self-belief. This "self-fulfilling prophecy" becomes a cycle; those students with higher self-concepts feel more confident and more willing to participate in class or ask for teacher direction, strengthening their skill and further increasing their perceived competence. Those students with less confidence refrain from teacher interaction or class participation in order to avoid failure or embarrassment, and therefore do not have as many opportunities for reinforcement (Brophy, 1983).

Perceived Importance

When measuring student perception of the importance of math, it is helpful to consider possible interpretations. Having a working knowledge of mathematics and useful concepts is a necessary skill beyond the academic or career setting. In their 2003 longitudinal study of middle to high school students, Wilkins and Ma describe this practical importance as "quantitative literacy," or the possession of a functional knowledge of mathematical content. A quantitatively literate person possesses an ability to "reason mathematically, a recognition of the societal impact and utility of math, an understanding of the nature and historical development of math, and a positive disposition towards math" (Wilkins & Ma, 2003). Quantitative literacy as a multidimensional concept is one that many students probably do not fully understand and certainly do not fully possess. However, this concept is helpful is addressing the definition and interpretations of the "importance" of mathematics in a student's academic and non- academic life.

Student perception of importance is largely based on the level of success in future careers attributed to mathematics. A 2004 study of students ages seventh grade through high school suggests that males and females have "nearly equivalent" math and science course completion rates and achievement, but those females are only a small percentage of the STEM workforce (VanLeuvan, 2004). (STEM, an acronym for Science, Technology, Engineering, and Math, is referred to both in academic settings and in career fields as an area in which females are underrepresented.)

Explanations for the lack of female presence in STEM career fields and classes at the high school and post-secondary level focus on interest in math and science as a determining factor. Research suggests that this interest is largely determined by gender.

VanLeuvan concludes that STEM career preferences were related mostly to "girls' interest in and enjoyment of" science and math experiences, and these interested girls pursued STEM careers as a result of preparation in high school and other non-academic experiences (VanLeuvan, 2004). For both males and females, these extra curricular activities influence attitude toward math by increasing intrinsic value and utility value, or practical importance, of mathematics.

Gender roles play a large part in student attribution of importance of mathematics. Individual attribution depends on perceived gender roles, and societal expectations. Further findings from the VanLeuvan study suggest that females experience conflict between their interest in math and science and their own personal life and popularity. This finding has huge implications for middle and high school students, as so much of their individual perception is based on how they are viewed by their peers. The study also proposes that females are less likely to choose post-secondary classes and majors in the STEM field when family responsibility and personal life are high priorities; the traditional role of women as caretakers still seems to be relevant, affecting the perception of importance of mathematics.

Another study found that females avoid STEM fields not because they lack academic skill or preparation at the secondary level, but because they see those professions as male-dominated (Cavanagh, 2008). The designation of mathematics as "important" depends on perceived utility and practicality, and females may label these fields as less important simply because they are incompatible with their interests. Cavanaugh speculates, "women are not engineers because they don't want to take math; they're not taking math because they don't want to be engineers" (Cavanaugh, 2008). Making mathematics classes more accessible and important to both males and females, not just as a vehicle for a future STEM career, but as a useful and necessary tool of a successful student and career person may be highly beneficial. By illustrating the importance of math as a skill unrelated to career choice, more students may feel that math and science are valuable, viewing higher-level math courses as useful and relevant.

Creating the student perception that math is valuable and significant begins with parent influence and increases with both student and parent enthusiasm. Studies have shown that both subtle and direct encouragement from parents affect student interest in math for males and especially for females. This encouragement affects student perception of the importance of math and affects performance level (Cavanaugh, 2008; Tocci & Englehard, 1991). Student attitude toward math, and more importantly, perceived importance, have been linked with parental "conception of student educational goals...and with the extent of math education desired for the child by the parents" (Hilton & Berglund, 1974), and with education level of the parent. Students with more highly educated parents report a higher perceived importance of mathematics, both in the personal and social realms (Wilkins & Ma, 2003).

Not surprisingly, research has shown that gender plays a part in parental influence as well. In a 1991 study of secondary students, researchers concluded that parental support had a significant main effect on perceived importance of mathematics (Tocci & Englehard, 1991). Fathers in particular have a major influence on whether their daughters develop an interest in math; if the gender stereotype is found at home, it is further perpetuated by the student in an academic setting (Cavanaugh, 2008). If that student is female, the results of this perpetuation are disappointing. Acceptance of the gender stereotype can influence personal importance by decreasing it in female students and increasing in it in male students. If a father with traditional gender beliefs influence a male student, they are more likely to enroll in math classes and deem mathematics of high personal and social importance (Tocci & Englehard, 1991).

Positive encouragement from teachers, peers, and parents is associated with the initial existence of positive beliefs about the social importance of math and the diminished development of negative beliefs and attitudes. Parental influence is related to status and change in beliefs about importance of math and to perception of gender-related importance (Wilkins & Ma, 2003).

Methods of Study

Instrument

The instrument (found in Appendix A) used to measure student attitude toward mathematics was a twenty-four-item survey, with the response to each item measured with a Likert Scale. The items in the instrument for this study were adapted from various instruments used in previous research (Fennema & Sherman, 1976; Cupillari et al., 1992; Aiken, 1972)

The survey method is frequently used in studies which focus on measuring attitude directly, and has been accepted as a valid and useful research technique as it allows attitude measures to be interpreted as scaled measurements. However, it is important to note the possible down falls of such measurement techniques. Likert scales may be subject to bias as the respondents may avoid using extreme response categories (central tendency bias), agree with statements presented (acquiescence bias), or try to portray themselves in a more favorably (social desirability bias) (Allen & Seaman, 2007). Such bias is somewhat unavoidable; in creating this instrument, careful attention was given to minimize any possible bias.

Research Subjects

This survey was given to two middle school math classes; a class with mostly below standard students (a class called Extended Learning), and a class with all at standard or above students, and two high school math classes; Geometry and Algebra II. The total number of students (subjects) in each class varied; combined, the middle school classes had a total of 51 students, and the high school classes had a total of 48 students participating in the survey. The middle school students were in sixth grade, and the high school students ranged from freshman to seniors.

Procedure

Before administering the survey, I spent several weeks in each class working with the students and getting to know them on a more personal level. While doing this, I was able to talk informally with some students about their attitudes towards mathematics, and gain a deeper understanding of their thoughts and feelings on the subject. I spent six weeks in the middle school classes before administering the survey, and four weeks in the high school classes (the complete journal documenting these experiences can be found in Appendix C).

During my time in the classroom, I was interested to learn about many different perspectives on math at both the middle and high school level. When working with students, I asked, "Do you like math?" and received a variety of responses. The feelings toward math ranged from, "I really like math! It's fun because you get to play with numbers and I can move them around to make them mean different things. It's like a game," to "I don't really like math. It's kind of boring and hard sometimes too." With each expression of like or dislike, I tried to follow-up by asking the student *why* he or she felt that, and *how* he or she came to that feeling. These informal conversations provided me with insight into which aspects of attitude toward math may have a bigger effect on student attitude, and how these aspects differ based on grade level.

Scoring

When responding to each item, students specified their level of agreement or disagreement on a symmetric agree-disagree scale. The instrument is based on a five-point scale, with five possible answers for each item: strongly disagree, disagree, neutral, agree, and strongly agree. The items were written in this way in order to measure the intensity of student feeling on any given item. For two items in the instrument, the scale was reversed in order to measure the data consistently. The following is an example of two items measuring perceived importance, using reversed scales:

2. I think learning math is important and necessary to be successful

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5	4	3	2	1

16. Math is not important for my life or my future

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	2	3	4	5

Item 2 was scaled with a value of five assigned to Strongly Agree, a value of one *assigned to Strongly Disagree, and decreasing integer values for each of the other choices. In order to be consistent, item 16 was scaled with a value of one assigned to Strongly Agree, and so on.*

The individual Likert items were then summed in order to be made into Likert scales. The scales were created based on seven criteria: gender stereotype, math anxiety, peer influence and other social factors, intrinsic interest, enjoyment of mathematics, perceived competence, and perceived importance. The responses for each category were summed to create a Likert scale for each category, this scale was then used to measure attitude.

The Likert scale items were analyzed using the Mann-Whitney U test. This is a non-parametric statistical hypothesis test for determining whether one of two samples of independent observations tends to have larger values than the other. Through the Mann-Whitney U test, data can be considered ordinal, with no consistent difference between any two values necessary. In order to use this test, conditions must be met: the independent variable must be dichotomous (i.e. gender: male/ female), and the dependent variable must be continuous or ordinal. In this case, the dependent variable (Likert scale responses) is ordinal data. Along with these criteria, two assumptions must also be met in order for the Mann-Whitney U test results to be valid:

1. The data should have independence of observations. This means that there is no relationship between the observations in each group, or between the groups themselves. This can be satisfied when there are different participants in each group (male and female) with no participant in both groups.
2. The two variables don't need to be normally distributed; however both distributions need to be the same shape. This is something that is tested for using SPSS software before the test is carried out.

If the conditions and assumptions have been met, the null hypothesis for this test states that "the distribution of 'dependent variable category' is the same across categories of gender." (Laerd, 2013). The following are the null hypotheses for each Likert scale item:

1. H_{01}: The distribution of gender stereotype is the same across categories of gender.

2. H_{02}: The distribution of perceived competence is the same across categories of gender.
3. H_{03}: The distribution of perceived importance is the same across categories of gender.
4. H_{04}: The distribution of math anxiety is the same across categories of gender.
5. H_{05}: The distribution of peer influence is the same across categories of gender.
6. H_{06}: The distribution of intrinsic interest is the same across categories of gender.
7. H_{07}: The distribution of enjoyment of mathematics is the same across categories of gender.

For the purposes of determining gender influence on attitudes toward mathematics, each Likert scale category was tested against gender using SPSS software. The middle school data and the high school data were tested separately.

Results

First, SPSS was used to determine if the distributions for each variable were in fact the same shape (these results can be found in Appendix B) for both the middle school and the high school data. After confirming the conditions and assumptions had been met for each Likert scale item, SPSS was used to run a Mann-Whitney U test at the standard significance level of $p = 0.05$, again for both sets of data.

Middle School Results

In total, 51 students participated in the survey, 23 male and 28 female.

Test Statistics

	GENDER STEREOTYPE	PERCIEVED COMPETENCE	PERCEIVED IMPORTANCE	MATH ANXIETY	PEER INFLUENCE	INTRINSIC INTEREST	ENJOYMENT
Mann-Whitney U	288.000	277.500	321.500	281.500	275.000	264.500	239.500
Standardized Test Statistic	.649	.851	-.010	.772	.903	-1.10	1.594
Significance (2-tailed)	.516	.395	.992	.440	.366	.271	.111

Figure 1. Grouping Variable: GENDER, significance level 0.05.

Median Values

GENDER	GENDER STEREOTYPE	PERCIEVED COMPETENCE	PERCEIVED IMPORTANCE	MATH ANXIETY	PEER INFLUENCE	INTRINSIC INTEREST	ENJOYMENT
Males	12.00	10.00	13.00	10.00	10.00	14.00	6.00
Females	12.00	11.00	14.00	10.50	10.00	13.00	7.00
Total	12.00	11.00	14.00	10.00	10.00	13.00	6.00

Figure 2

Figures 1 and 2 provide the descriptive statistics given by the Mann-Whitney U test. In each case, at a significance level of 0.05, we fail to reject the null hypothesis and conclude:

1. Fail to reject H_{01}. Conclude that the distribution of gender stereotype is the same across categories of gender.

2. Fail to reject H_{02}. Conclude that the distribution of perceived competence is the same across categories of gender.
3. Fail to reject H_{03}. Conclude that the distribution of perceived importance is the same across categories of gender.
4. Fail to reject H_{04}. Conclude that the distribution of math anxiety is the same across categories of gender.
5. Fail to reject H_{05}. Conclude that the distribution of peer influence is the same across categories of gender.
6. Fail to reject H_{06}. Conclude that the distribution of intrinsic interest is the same across categories of gender.
7. Fail to reject H_{07}. Conclude that the distribution of enjoyment of mathematics is the same across categories of gender.

High School Results

In total, 48 students participated in the survey, 25 males and 23 females.

Test Statistics

	GENDER STEREOTYPE	PERCEIVED COMPETENCE	PERCEIVED IMPORTANCE	MATH ANXIETY	PEER INFLUENCE	INTRINSIC INTEREST	ENJOYMENT
Mann-Whitney U	276.000	224.000	257.000	194.000	261.500	274.500	202.000
Standardized Test Statistic	-.242	-1.321	-.634	-1.939	-.543	-.270	-1.795
Significance (2-tailed)	.809	.186	.526	.053	.587	.787	.073

Figure 3. Grouping Variable: GENDER, significance level 0.05

Median Values

GENDER	GENDER STEREOTYPE	PERCEIVED COMPETENCE	PERCEIVED IMPORTANCE	MATH ANXIETY	PEER INFLUENCE	INTRINSIC INTEREST	ENJOYMENT
Males	12.00	12.00	14.00	13.00	10.00	11.00	7.00
Females	12.00	10.00	16.00	15.00	10.00	11.00	8.00
Total	12.00	11.00	14.00	13.00	10.00	11.00	7.00

Figure 4

Figures 3 and 4 provide the descriptive statistics given by the Mann-Whitney U test.

In each case, at a significance level of 0.05, we fail to reject the null hypothesis and conclude:

1. Fail to reject H_{01}. Conclude that the distribution of gender stereotype is the same across categories of gender.
2. Fail to reject H_{02}. Conclude that the distribution of perceived competence is the same across categories of gender.
3. Fail to reject H_{03}. Conclude that the distribution of perceived importance is the same across categories of gender.
4. Fail to reject H_{04}. Conclude that the distribution of math anxiety is the same across categories of gender.
5. Fail to reject H_{05}. Conclude that the distribution of peer influence is the same across categories of gender.
6. Fail to reject H_{06}. Conclude that the distribution of intrinsic interest is the same across categories of gender.
7. Fail to reject H_{07}. Conclude that the distribution of enjoyment of mathematics is the same across categories of gender.

(Note: the critical values presented in Figures 1 and 3 were found using SPSS software, but the interested reader can find a table of critical values for the Mann-Whitney U test in Appendix D)

Conclusions and Implications

When comparing the distribution of gender to the distributions of gender stereotype, perceived competence, perceived importance, math anxiety, peer influence, intrinsic interest, and enjoyment, the results show that for each category the distributions are the same. While the sample size of the data is not very large, these results are still valid and worth interpreting in the context of student attitude toward math as they represent a larger population of middle school and high school students. While unable to reject any null hypotheses, looking more closely at the data reveals an interesting difference between the middle and high school data.

With the middle school data, the test statistics for each test was much greater than the critical number ($U = 218$, $p = 0.05$), while in the high school data, the test statistics for math anxiety ($U = 194$) and enjoyment of mathematics ($U = 202$) were close to the critical value and close to the level of significance ($U = 182$, $p = 0.05$). In the context of this study, these results suggest that at the middle school level, gender has no effect on any of the measured aspects of student attitude toward math, while at the high school level gender may have a more well defined effect on certain aspects of attitude toward mathematics. This agrees with previous studies which found that the gender gap becomes apparent in high school and increases as students move up to more advanced math courses, especially when the student is able to decide which courses he or she takes (Ellison & Swanson, 2010; Gallagher & Kauffman, 2005; Leahey & Guang, 2001).

These results are encouraging; at both the middle school and high school level, gender does not have a significant effect on attitudes toward mathematics, and in both data sets the gender stereotype does not seem to exist as the distribution of gender across gender stereotypes is the same. Even when scrutinizing the data further to identify those aspects of attitude with the closest test statistics to the critical value (math anxiety and the enjoyment of math at the high school level), these differences only occur in two of the seven identified factors.

The early research on student attitude toward math, especially research focused on gender and attitude (beginning around 1970), suggests that males and females possess fundamentally different characteristics which allowed males to achieve superior levels of mathematics understanding and acquisition (Benbow & Persson, 1980; Scharf, 1971; Hilton, Thomas & Berglund, 1974). Later research (beginning around 1980) refutes these findings and instead asserts that males and females are equally capable of mathematics achievement but that social factors, particularly the mathematics gender stereotype, are responsible for the perceived gender gap in high school and post secondary mathematics performance (Llyod et al., 2012; Santos et al., 2011; Tocci & Englehardt, 1991). The results of this study agree with the later research, implying progress is truly being made in the advancement of females in mathematics.

With mathematics being a traditionally male-dominated realm, results like these are important as they show the incredible progress of mathematics education; teachers need to help students see that males and females are equally capable and valuable in the field of mathematics in both the academic and career setting. Cross-national research has shown that in societies with strong female role models in high academic positions, especially in the STEM fields, the gender gap diminishes and in some cases disappears (Guiso et al., 2008; Cavanaugh, 2008). It is interesting to note that the teachers of both the middle and high school classrooms used in this study were female; perhaps providing more evidence for the idea of role models as part of the reduction of gender stereotype.

While great progress has been made in understanding the effects of gender on various factors affecting student attitude toward mathematics, and ultimately the effects of gender on attitude toward math as a whole, the belief that males are superior at math is still present (however, this belief is not present in the results of this study). Future research may focus on the acquisition of these belief systems in order to determine effective strategies for minimizing and possibly even eliminating such negative beliefs. Further, it may be interesting to investigate which attributes of attitude toward math are correlated highest with gender; giving a more clear picture of which areas of student experience positively and negatively affect attitude. Alternatively, because the gender gap continues to be minimized, it may also be prudent to put more focus on other domains affecting attitude to develop a more clear and comprehensive picture of the true nature of attitude.

Examining the role of gender stereotype as it affects student attitude toward mathematics reveals interesting and important results. When comparing gender with each of the seven identified factors affecting attitude (gender stereotype, perceived competence, peer influence, perceived importance of mathematics, intrinsic interest, and enjoyment), this study provides further evidence of positively changing perception of gender roles. The relationship between student gender and student belief for each category suggests that the gender bias is not as much of an issue in mathematics education as it has been in the past. This research supports the belief that we are moving away from a society in which Barbie dolls say, "math is hard" and one in which females are thought to be at a fundamentally lower achievement level than their male counterparts. Progress has been made towards a society in which females are represented in STEM fields at an increasing rate, and one in which it is not uncommon for a student to have a female mathematics teacher.

Appendix A

Instrument

Please circle one: I am **female** I am **male**
I am a **Freshman** **Sophomore** **Junior** **Senior**

For each of the following statements, circle the level to which you agree. There are no "right" answers, only those that are true for you, so please be as honest as possible. Be sure to answer every question, and use your experiences to help you decide your agreement for each.

1. I am good at math

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

2. I think learning math is important and necessary to be successful

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

3. If I had to choose a partner to work with in math class, I would choose a girl to work with

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

4. Boys and girls are equally good at math

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

5. I get nervous when I have to take a math test

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

6. I think math will be something I use frequently in my life outside of school

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

7. I think math will help me find a good job when I grow up

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

8. My friends think I am good at math

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

9. When my friends show interest in math, it makes me want try harder in math class

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

10. People who like to do math are the smartest students in math class

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

11. Math is interesting

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

12. Math is hard

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

13. Math is my favorite subject

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

14. I am good at doing math problems and understanding math concepts

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

15. I think about unanswered questions after math class is over

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

16. Math is not important for my life or my future

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

17. Math makes me feel uneasy and confused

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

18. I would trust the answer for a math problem if it were solved by a boy

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

19. Math is fun and exciting

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

20. Girls who enjoy math are a little weird

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

21. I am confident in my ability to learn math

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

22. When doing math, my mind goes blank and I am unable to think clearly

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

23. If math were easier to understand, I would like it more

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

24. I get nervous when I have to take a test

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

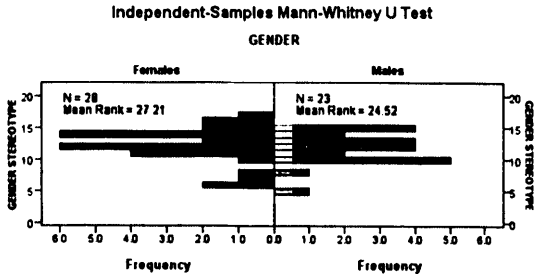
Note: for the middle school survey, the choices for grade level at the beginning were omitted; otherwise the same instrument was used for both the middle school and high school

Appendix B

Verifying assumption two for each category

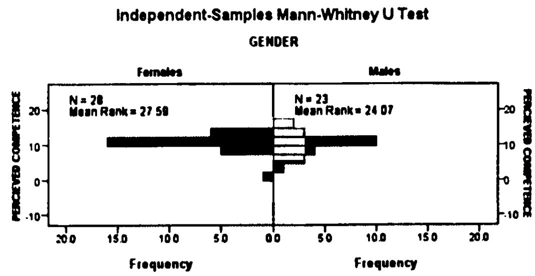
Middle School data

Gender Stereotype:



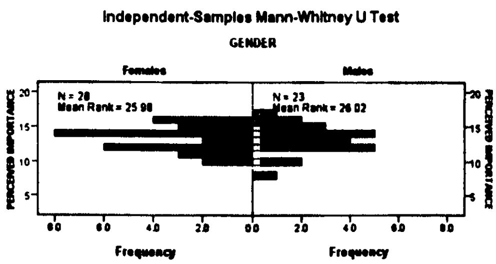
Total N	51
Mann-Whitney U	356.000
Wilcoxon W	762.000
Test Statistic	356.000
Standard Error	52.366
Standardized Test Statistic	.649
Asymptotic Sig. (2-sided test)	.516

Percieved Competence:



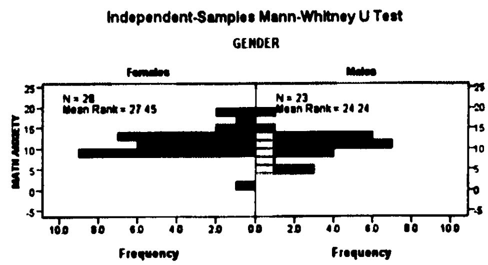
Total N	51
Mann-Whitney U	366.500
Wilcoxon W	772.500
Test Statistic	366.500
Standard Error	52.274
Standardized Test Statistic	.851
Asymptotic Sig. (2-sided test)	.395

Percieved Importance:



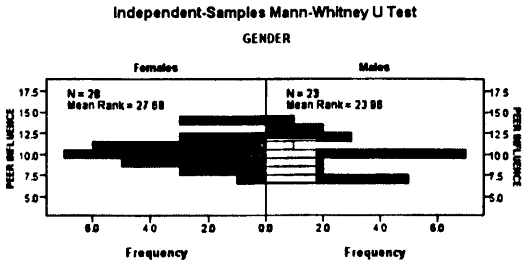
Total N	51
Mann-Whitney U	321.500
Wilcoxon W	727.500
Test Statistic	321.500
Standard Error	51.980
Standardized Test Statistic	-.010
Asymptotic Sig. (2-sided test)	.992

Math Anxiety:



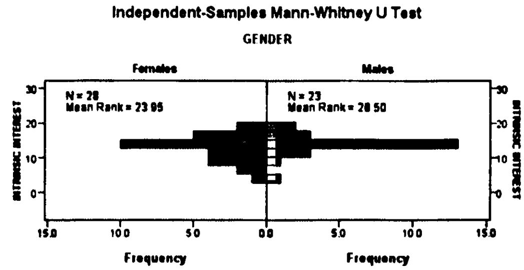
Total N	51
Mann-Whitney U	362.500
Wilcoxon W	768.500
Test Statistic	362.500
Standard Error	52.430
Standardized Test Statistic	.772
Asymptotic Sig. (2-sided test)	.440

Peer Influence:



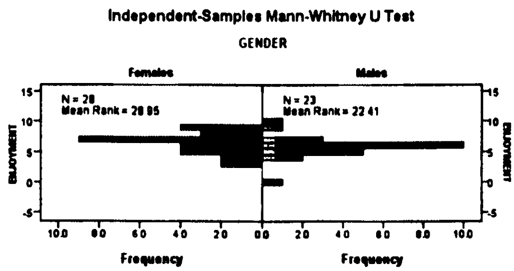
Total N	51
Mann-Whitney U	369 000
Wilcoxon W	775 000
Test Statistic	369 000
Standard Error	52 034
Standardized Test Statistic	903
Asymptotic Sig. (2-sided test)	366

Intrinsic Interest:



Total N	51
Mann-Whitney U	264 500
Wilcoxon W	670 500
Test Statistic	264 500
Standard Error	52 264
Standardized Test Statistic	-1 100
Asymptotic Sig. (2-sided test)	271

Enjoyment of Mathematics:

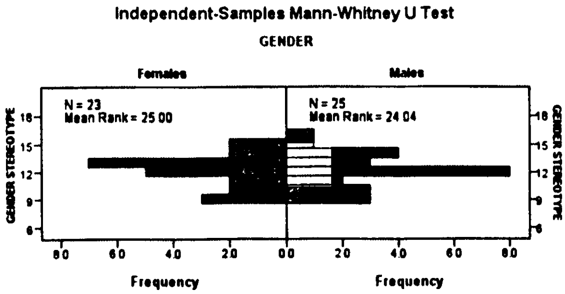


Total N	51
Mann-Whitney U	404 500
Wilcoxon W	810 500
Test Statistic	404 500
Standard Error	61.746
Standardized Test Statistic	1 594
Asymptotic Sig. (2-sided test)	111

In each case, the distributions of the independent and dependent variables are relatively the same shape with some exceptional outliers. Thus, the assumptions of the Mann-Whitney U test have been satisfied, and the results from this test are valid.

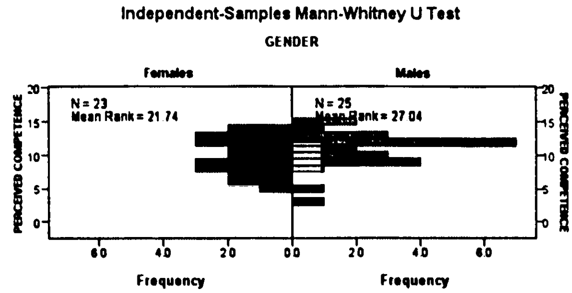
High School Data

Gender Stereotype:



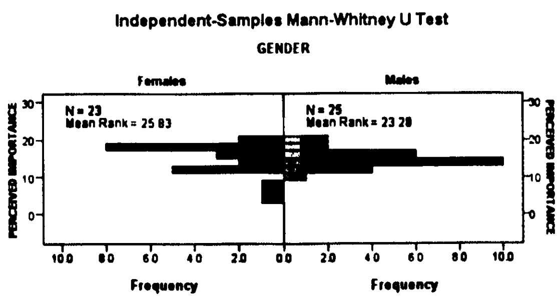
Total N	48
Mann-Whitney U	299.000
Wilcoxon W	575.000
Test Statistic	299.000
Standard Error	47.616
Standardized Test Statistic	.242
Asymptotic Sig. (2-sided test)	.809

Perceived Competence:



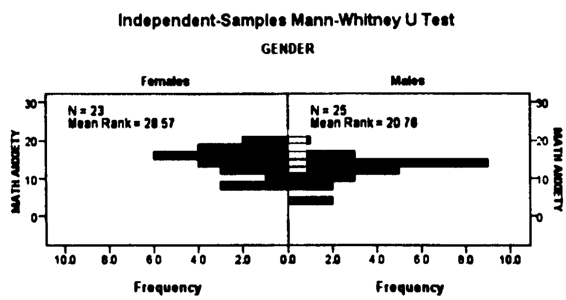
Total N	48
Mann-Whitney U	224.000
Wilcoxon W	500.000
Test Statistic	224.000
Standard Error	48.054
Standardized Test Statistic	-1.321
Asymptotic Sig. (2-sided test)	.186

Perceived Importance:



Total N	48
Mann-Whitney U	318.000
Wilcoxon W	694.000
Test Statistic	318.000
Standard Error	48.092
Standardized Test Statistic	.634
Asymptotic Sig. (2-sided test)	.526

Math Anxiety:

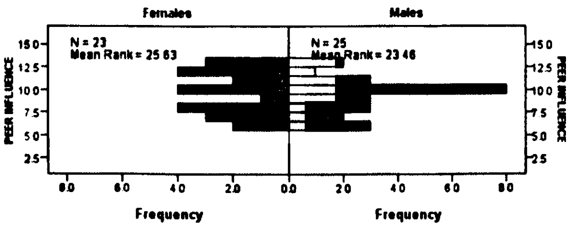


Total N	48
Mann-Whitney U	381.000
Wilcoxon W	657.000
Test Statistic	381.000
Standard Error	48.230
Standardized Test Statistic	1.939
Asymptotic Sig. (2-sided test)	.053

Peer Influence:

Independent-Samples Mann-Whitney U Test

GENDER

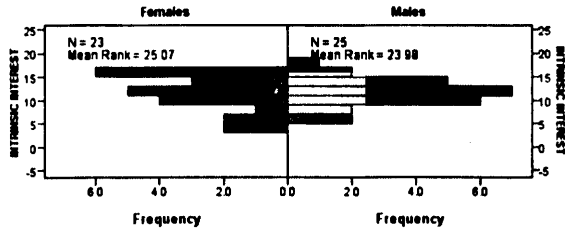


Total N	48
Mann-Whitney U	313 500
Wilcoxon W	589 500
Test Statistic	313 500
Standard Error	47 857
Standardized Test Statistic	543
Asymptotic Sig. (2-sided test)	.587

Intrinsic Interest:

Independent-Samples Mann-Whitney U Test

GENDER

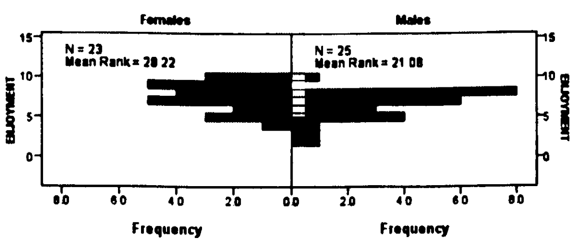


Total N	48
Mann-Whitney U	300.500
Wilcoxon W	576 500
Test Statistic	300 500
Standard Error	48.164
Standardized Test Statistic	270
Asymptotic Sig. (2-sided test)	.787

Enjoyment of Mathematics:

Independent-Samples Mann-Whitney U Test

GENDER



Total N	48
Mann-Whitney U	373 000
Wilcoxon W	649.000
Test Statistic	373 000
Standard Error	47 642
Standardized Test Statistic	1 795
Asymptotic Sig. (2-sided test)	.073

Again, in each case, the distributions of the independent and the dependent variable are relatively the same shape, with the exception of some outliers. All of the assumptions have been met, and the results of the Mann-Whitney U test are valid.

Appendix C

Journal

Shuksan Middle School
Ms. J's Sixth Grade
Extended Learning and Regular Sixth Grade Math

Wednesday, October 10, 2012
9: 15-11:15
Worked with first period on logging onto computers and taking ALEKS assessment. Independent assessments, so I walked around helping kids log on and answered any questions they might have. Second period worked on section 2.1 and ACE questions, having to do with equal fractions and dividing a given length of licorice into equal parts for 4,6 and 8 people. Students worked in table groups of 3-6 The two classes are the kids who are below standard (first period) and a group of kids who are pretty diverse in the second period, with some kids below standard as well.

Observations:
1. Students lacked confidence in answers, and when explaining to other group members
2. Hard for the group dynamic to work: students were wary of working together and sharing ideas
3. Those who understood really got it, and were excited about the problems
4. One student seemed less sure of himself and his answers, but when helped one-on-one, he could work through the problems and arrive at the right answer. When he would ask me if he was right, I told him to convince me (and himself), which he could do after some thought. (loved working with this student)

Wednesday October 17, 2012
9:15-11:15
Early release day, so the usual schedule was shortened and shifted. Instead of math today, we did two classes of science: watched Bill Nye and took notes. Ms. J showed me the goals they are working on converting between mixed, improper and regular fractions and comparing fractions to each other. Interestingly, these are standard for fifth grade, but she said she will take up to the first semester working on this stuff to get everyone up to the same level. I went to technology elective-so cool! The kids were assigned a college and their task was to create a talking mascot that told about the college. The teacher does a lot of STEM stuff with the kids, which is interesting because from the research that is supposed to increase interest and achievement level in math classes.

Wednesday October 24, 2012
9:15-11:15
I got to work with small groups of student outside of the classroom. Ms. J sent out groups of three who she felt needed more one-on-one attention. In each group I worked with, I asked the kids, "Do you like math?" Simple question with many answers! (Note that in both groups I worked with, all the students were female...interesting?)

1. "No. Math is hard and I don't like it because it's hard and boring. "
2. "If math were easier, I would like it better. "
3. "I really like math! It's fun because you get to play with numbers and I can move them around to make them mean different things. It's like a game."
4. "I don't get it."

With each of these responses, I asked follow-up questions to gain a better understanding of WHY they answered the way they did.

- After working with the student with response (1), it became clear rather quickly that she was extremely capable of the work being asked of her; she just had an extremely fatalistic attitude. When she actually did the work, she got it all correct and even showed meaningful understanding of the problems she was doing. When this happened, her face would light up and she later told her teacher about the discoveries she made. This leads me to believe that when she actually tries and commits herself to possible failure, she will be very successful!!
- Student with response (2) seemed to just want to get her work done and move on. No intrinsic motivation to understand the material and little value placed on the importance of mathematics. I asked her what she wanted to be when she grew up, and she told me she wants to be an elementary school teacher...I told her that would mean she has to take math in high school and college, and then she told me she wanted to be a baker to escape math. I reminded her that bakers need to use fractions and know how to do bills, etc. She looked at me and said, "I can't escape it! Math is everywhere! Ugh." I had a good laugh at this (secretly)
- Response (3) made me happy to hear. The student was genuinely excited that she had found ways to play with the numbers and manipulate problems. This is so cool!! Lots of intrinsic motivation. I don't remember being like that in middle school!
- Response (4) seems to be the result of low self-esteem, which may have come from the fact that the student is below standard in math. Working with her, I could tell that she really didn't firmly grasp the concepts we were working with, and that she didn't even grasp some of the most basic concepts of dividing a smaller number into a bigger one....so, I think the material is a struggle for her to learn which lowers her self-esteem and makes her not want to try hard so that she might avoid further failure

Wednesday October 31, 2012

9:15-11:15

Worked with small groups again today. Working on changing mixed numbers into impartial fractions, and decimals into percents into fractions. I worked with a group of five, and all but two really understood the material and the process of changing between different proportions. They were given two worksheets and moved through both fairly quickly...I challenged them all to do the last problem (ordering fractions from least to greatest) using decimals to check their answers, and they all seemed pretty hesitant to do the extra step. But they did it anyway ☺

Again, I asked the question "Do you like math?" and again, I got varied responses.

1. "I don't like it cause it's hard."
2. "I used to like math, but now I don't."

- With response (1), I asked the follow-up question, "If math were easier, would you like it more?" The student responded that no, he wouldn't like it better because math is just "stupid" no matter what. Despite his attitude, he was one of the students who moved quickly through the worksheet and seemed to understand the learning targets.
- I tried to go more in depth with answer (2), but the bell rang, so of course the student ran to the classroom to get her stuff. It could be that math gets harder, and the student doesn't like it because of that, or because now that she is in middle school, it has a social factor…it's not "cool" to like math or to be good at math. The student with this response was the one who seemed most on top of the material, she was showing me how to do problems and explaining the tricks she used to the other students at the table. To me, she showed a deeper understanding than did the other kids.

Wednesday October 31, 2012

9:15-11:15

Early release Schedule, didn't work with the kids individually. Helped with the whole class.

Wednesday November 7, 2012

9:15-11:15

Early release schedule, didn't work with individual kids or small groups.

Wednesday November 14, 2012

9:15-11:15

Survey Day!

Ms. J gave the survey to the kids, and I collected the completed surveys the following day. It was fun to watch them take the survey…a bunch of them said that questions 5 and 25 are the same. Ms. J told them to look more closely! I thought that was funny, even though the questions were so far apart (to avoid the confusion), the kids still had a hard time reading it closely enough to see the difference.

Wednesday November 21,2012

Thanksgiving Break.

Wednesday November 28, 2012

9:15-11:15

Worked with kids in small groups on conversion from fractions to decimals, and decimal multiplication. When working with the small group, I didn't need to ask the question, "do you like math," the kids were telling me all about their feelings already! One of the girls told me she doesn't like math because her dyslexia makes it hard to work with all of the numbers (a valid excuse, I think). She also said that it's BORING and makes her want to fall asleep. She told me that people say math is "magic," but that she has never seen that magic happen....

The boy in the small group didn't like math because it was boring and because he likes language arts better. He likes the note-taking part of math because it involves writing (this is the student who is constantly being told to please put away his book in class). The other more "math-y" parts of math do not interest him.

Both students in the small group seem relatively proficient at the skills they were working on.

Sehome High School
Ms. D
Geometry and Algebra II

Monday January 6, 2013
10:05 - 12:22
Geometry
Worked with students on trig function and learning which functions to use in which situations. I think there was little instruction on this topic, as most kids didn't seem to know what was going on...there was a sub today, so Ms. D wasn't there to clarify/teach. I asked some kids if they like math:

- "No. I have never been good at math. I always get help from teachers, but it doesn't really help me. I just don't understand most of the time."
    - When working with this student, she did not seem receptive to questions and when prompted for an answer she would say "I don't know" instead of giving an answer (whether right or wrong)...needs more self-confidence!
- "I like math sometimes but I don't like it when it gets really hard. I like seeing how everything is connected though and seeing all of the ways math is related."

Algebra II
Worked with students on transformations in graphing toolkit functions. The students were told to turn in one sheet of homework that they all must agree on in table groups. The group idea is great, but the application of it was not so great....kids would split into pairs and the more prepared kids would finish the assignment for the whole group. Asked kids if they like math:

- "Yeah, I have always liked math because there is always one right answer. I just don't like this teacher because she confuses us with answers when she says they are right or wrong."
- "I don't really like math. It's kind of boring and hard sometimes too."
- "I like math a lot. I am good at it and it's pretty easy for me to do."

Monday January 7, 2013
10:05 - 12:22
Geometry
Lesson on special triangles, 30-60-90 and the useful properties. Didn't work with any kids, the class was note-taking and going over homework.
Algebra II
Kids worked on transformations of parent functions. Interesting to see different levels of understanding when working with the transformations...some really understood how each transformation affected the graph of the parent, and some just had no clue! I was able to work with students and ask some of them if they liked math:

- "I used to like math when it was easy. Now that it's hard, I hate it."
    - Common theme!
- "Sometimes I like math. When it's easy I like it, but when it gets hard I don't really like to do it at all."
    - This student was one with a good understanding of the transformations, and was helping people at his table. Interesting that he had achieved a level of understanding but still wasn't happy with the subject.

Monday January 14, 2013
10:05 - 12:22
Geometry
Kids worked on 'special triangles' and how to use these with trig identities to solve for unknown sides and angles. Ms. D introduced the law of sines and cosines. She really gets the class involved with deriving equations and recognizing relationships...there is a lot of good participation throughout the classroom. She has the kids do exploratory exercises before she introduces a new concept; a strategy I think is very cool! This allows them to develop intuition and makes the new concept or equation even more memorable and useful. When talking to the kids about how they feel about this method, they are not as enthusiastic....they want her to teach them the concepts so they know what to do right away. Probably the same attitude I would have had as a high school student, but from my point of view now I think this is a really important skill (especially in math) for these kids to learn. All instruction today, I didn't work with any students.
Algebra II
Again, an instruction day, so no working with students. Ms. D introduced an art project in which the kids had to incorporate functions and their equations...another option for the project assignment was to make a dance video where the kids were asked to dance out functions (so fun!!). Such a good idea! Lets the kids do something other than just work problems, and helps to remind them that math is an integral part of their life...in or out of the classroom.

Monday January 21, 2013
MLK day. No school.

Monday January 28, 2013
First semester finals for the kids. I didn't go today.

Monday February 4, 2013
10:05 - 12:22
Survey day!
Geometry
Students were put in groups of three and worked the whole class period on assigned "challenging" problems. These are problems that were more involved and required the kids to decide how to apply the concepts they have been learning-law of sines and cosines, and SOHCAHTOA. I worked with a couple of different groups; one was quick to find which concept applied and was pretty skilled at calculating and making sense of their answers. Another group I worked with was not as comfortable with the material and got really confused by the variable letters in the given diagrams and in the equations. When working with this group, I asked the question, "Do you like math?"

- "Some days I like to do math. But not on Mondays, because I am always really tired and math is always harder on Mondays. I like to do math when I have more energy and when it's fun. This math is hard too, so I don't like to do it so much."
  - Attitude is related to energy level...that is one I haven't heard before!
- "I like to do math sometimes, mostly when it's easy. This isn't easy because we don't know what's going on...the teacher doesn't really show us what we are supposed to do and she sometimes makes mistakes that mess me up."
  - Blames the teacher for attitude. Also alludes to the Ms. D's method of letting the kids explore ideas

Algebra II
Ms. D introduced a problem to the kids and then turned them loose to work with each other for the rest of the period. "Linear Programming" was the task...translating word problems into inequalities and constraint equations. The story problem was about half a page of writing, so there was a lot to read and keep track of, I heard a LOT of comments about how this wasn't English class, and who wants to read all of this stupid math stuff, anyway? Once people started to pay attention to the problem, for the most part students seemed to understand what was going on and how to proceed. One group of girls asked for my help and I sat with them and worked through the problems. I wasn't too familiar with the method of solving, so they were able to walk me through their thinking and steps, which I think helped them with their understanding. I have worked with these girls before, and they seem to be on top of their work and are not afraid to raise their hands when they have questions or need help.

Appendix D

Critical Values for the Mann-Whitney U-Test

Level of significance: 5% (P = 0.05)

Size of the largest sample (n_2)

Size of the smallest sample (n_1)

	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	13	13
4	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	17	18	19	20	21	22	23
5	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20	22	23	24	25	27	28	29	30	32	33
6		5	6	8	10	11	13	14	16	17	19	21	22	24	25	27	29	30	32	33	35	37	38	40	42	43
7			8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
8				13	15	17	19	22	24	26	29	31	34	36	38	41	43	45	48	50	53	55	57	60	62	65
9					17	20	23	26	28	31	34	37	39	42	45	48	50	53	56	59	62	64	67	70	73	76
10						23	26	29	33	36	39	42	45	48	52	55	58	61	64	67	71	74	77	80	83	87
11							30	33	37	40	44	47	51	55	58	62	65	69	73	76	80	83	87	90	94	98
12								37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97	101	105	109
13									45	50	54	59	63	67	72	76	80	85	89	94	98	102	107	111	116	120
14										55	59	64	67	74	78	83	88	93	98	102	107	112	118	122	127	131
15											64	70	75	80	85	90	96	101	106	111	117	122	125	132	138	143
16												75	81	86	92	98	103	109	115	120	126	132	138	143	149	154
17													87	93	99	105	111	117	123	129	135	141	147	154	160	166
18														99	106	112	119	125	132	138	145	151	158	164	171	177
19															113	119	126	133	140	147	154	161	168	175	182	189
20																127	134	141	149	156	163	171	178	186	193	200
21																	142	150	157	165	173	181	188	196	204	212
22																		158	166	174	182	191	199	207	215	223
23																			175	183	192	200	209	218	226	235
24																				192	201	210	219	228	238	247
25																					211	220	230	239	249	258
26																						230	240	250	260	270
27																							250	261	271	282
28																								272	282	293
29																									294	305
30																										317

The Open Door Web Site

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