“Math Class is Tough”: The Role of Mindset in Middle School Girls’ and Boys’ Math Achievement

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by

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Abstract

Academic mindset, the importance of how students think about their intelligence, can affect their achievement in mathematics. Over many years, researchers have tried to understand a perceived gender gap in math achievement in favor of boys, but research has been inconsistent. Whether or not a gender gap exists in math achievement, sex differences remain in the STEM professions. Understanding the biological, psychological, and social factors that influence math achievement and beliefs about intelligence might help to shed light on the issues. The current study assesses middle school students’ implicit theories of intelligence (i.e., mindsets), achievement goals, study behavior, and math anxiety in order to understand math achievement. Results show that regardless of sex, students’ math achievement is equivalent. However, girls are more likely to have higher math anxiety than boys, while boys report greater enjoyment in math than do girls.
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In 1992, one of the most revered toys for young girls, Barbie, stimulated widespread controversy for Mattel (Reckard, 7-A). Teen Talk Barbie was programmed with over two hundred different phrases, each doll including four, and one of them being, “math class is tough.” Mattel was severely criticized by the American Association of University Women for reinforcing gender stereotypes, specifically with respect to mathematics, and “undermin[ing] girls’ confidence” (Reckard, 7-A). Subsequently, the phrase was removed from Barbie’s bank of phrases. Despite long-standing stereotypes, the research on sex differences in math achievement are rather inconsistent (Fennema, Peterson, Carpenter, & Lubinski, 1990; Fennema & Sherman, 1977).

Besides the “math class is tough” gender stereotype, other stereotypes have emerged over time. One stereotype is that boys have a more “natural talent” and do not have to put as much effort into their math performance (Gunderson, Ramirez, Levine, & Beilock, 2012). When boys do well in math, the stereotype assumes it is due to their math ability; however, when girls do well in math, it is assumed to be because they put an extensive amount of effort into doing well (Gunderson et al., 2012; Fennema et al., 1990).

Over time, research on the math gender gap has included assessment of sex differences, ability, and biology (Halpern et al., 2007). More recent research has begun to address students’ achievement goals, students’ beliefs about their intelligence, math anxiety, and their interactions with parents and teachers (Gunderson et al., 2012; Fennema et al., 1990; Li, 1999; Beilock, Gunderson, Ramirez, & Levine, 2010). Currently, research uses a more holistic approach to understanding possible gender gaps, which includes these psychological and social factors.
In order to promote math achievement for boys and girls, researchers have recognized that academic mindsets must be utilized (Rattan, Savani, Chugh, & Dweck, 2015). When students are provided with information and skills that support positive beliefs about their intelligence, their motivation and school achievement increases (Blackwell, Trzseniewski, & Dweck, 2007). Specifically, students who are at a disadvantage and underperform in school (e.g., girls and the math gender gap) are more likely to benefit from emphasizing academic mindsets. The current project addresses the role of middle school students’ beliefs about their intelligence in relation to math achievement.

The Current State of the Gender Gap

Over the years, research has identified how this math achievement gender gap may have changed (Halpern, et al., 2007; Robinson & Lubienski, 2011). Some studies have found a small, significant gender math achievement gap in favor of males (Reilly, Neumann, & Andrews, 2015; Robinson & Lubienski, 2011); however, grade level matters. A relatively larger gap can be found after kindergarten, which remains consistent until middle school (Robinson & Lubienski, 2011).

In some respects though, the gender gap is nonexistent given that men and women are equal in math achievement (Halpern et al., 2007; Lindberg, Hyde, Petersen, & Linn, 2010). In a meta-analysis of data for elementary to college students, no significant gender differences could be found in mathematics achievement (Lindberg et al., 2010). Currently, researchers are trying to understand why some studies have pointed to an existing gap, while others do not. Perhaps “different sorts of data give different answers…because mathematics is not a unitary domain and neither are the competencies assessed across studies” (Halpern et al., 2007, p. 10). Therefore,
the method used to operationally define mathematics achievement varies across research, which may lead to inconsistent results and conclusions.

Another explanation for inconsistent findings and a minimal math achievement gender gap addresses the variability in math achievement within gender groups (Halpern et al., 2007; Strand, Deary, & Smith, 2006). While looking at distributions in achievement on quantitative reasoning and other math tasks, male students are more likely to score on both ends of a bell-curve distribution; therefore, their math achievement scores are more variable and overrepresented in relation to girls (Halpern et al., 2007; Strand et al., 2006). Male and female students’ achievement distributions overlap more when looking at medians, and this acknowledges that their achievement is more equal.

Currently, more girls are taking higher-level math classes than ever before (Niederle & Vesterlund, 2010). Despite findings of equal achievement (Lindberg et al., 2010), as well as boys outperforming girls (Reilly et al., 2015), other researchers have emphasized a reversal as females may now be doing better than males (Niederle & Vesterlund, 2010). Ultimately, the significance of math achievement is being translated to career paths, where there are fewer girls in math, science, and engineering-related professions (Wang, Eccles, & Kenny, 2013). This is cause for consideration particularly if no sex differences are found in ability.

Whether or not a sex difference in math is found may be in part a function of sex differences in spatial ability (Casey, Nuttall, Pezaris, & Benbow, 1995). For example, sex differences in the math section of the SAT are reduced when statistically controlling for mental rotation skill (Casey et al., 1995). However, when mental rotation skills are necessary and important to complete some mathematics problems, boys tend to receive higher math scores. Depending on what questions are asked on standardized tests and how they are framed may yield
different advantages for one sex over the other, or may reduce or eliminate achievement between sexes. Visuospatial ability is important in many mathematics-related professions such as engineering and computer science (Halpern et al., 2007), which may provide a partial reasoning for why there are fewer females in STEM professions (Wang et al, 2013).

**Middle School: A Sensitive Period for the Math Gender Gap**

Adolescence is a critical time of development for boys and girls. Although it has been stereotyped as a difficult and stressful time, not all adolescents find it to be a time of “storm and stress” (Eccles et al., 1993; Blackwell et al., 2007). When stress does arise it may be attributed to “a mismatch between the needs of developing adolescents and the opportunities afforded them by their social environments” (Eccles et al., 1993). Social environments include schools, students, teachers, parents, peers, and extra-curricular programming. An example of a mismatch between the needs and environment is adolescents’ pubertal experience and possible body image apprehension (Santrock, 2012). Adolescents move from a close, caring elementary school environment, to a more distant, middle school environment at a time when they may be more apprehensive about the changes in their bodies. Additionally, adolescents may have decreased self-esteem and motivation to do well in school (Eccles et al., 1993; Blackwell et al., 2007; Santrock, 2012).

Another significant change for the adolescent is moving physical locations from elementary school to middle or junior high school. Students go from being in the oldest grade in elementary school, to the youngest grades in middle and junior high, known as the top-dog phenomenon (Santrock, 2012). Additionally, students shift from having one teacher for all subjects in elementary school, to having usually one teacher per subject in middle school.
Middle school comes with new responsibilities for the adolescent student and these physical changes can leave students feeling more vulnerable.

Adolescence is a critical time in understanding changes in adolescents’ beliefs about intelligence and ability with respect to mathematics. Adolescents may develop certain beliefs about their ability, and interest in mathematics, and this in turn may have an effect on their math achievement. How do boys and girls respond differently to their beliefs? Do math-related gender stereotypes play a role in what adolescents believe about themselves and others? Can math-gender stereotypes affect math achievement? Math achievement as discussed next, is affected by biological, psychological, and social factors.

Girls and boys may experience the transition to middle school differently. Both girls and boys are more likely to have decreased math interest and ability-based beliefs over the course of their grade school education (Fredricks & Eccles, 2002). However, as they transition from elementary to middle or junior high school, boys are more likely to think they are better at mathematics than girls, while girls’ competency beliefs decline (Watt, 2004). This decline in ability perceptions during middle school may be related to the many developmental changes adolescents experience at that time and the mismatch between their needs and school environments. This gap decreases as students progress to higher-grade levels (Fredricks & Eccles, 2002).

The Biopsychosocial Model

The mathematics gender gap whether real or apparent, may be best understood from the perspective of the biopsychosocial model highlighting the many factors that influence behavior. Research on the mathematics gender gap provides links between biological factors and mathematics achievement such as sex differences in ability (Halpern et al., 2007). Additionally,
psychological factors have been studied which include academic mindsets, achievement goal orientations, and math anxiety. Finally, social factors focus on students’ relationships with their parents, teachers, and their school environment. Interactions among these factors may create a more holistic picture of the gender gap and math achievement.

**Biological factors.** Does one sex have more of an “innate ability” than the other in mathematics as the stereotype suggests? Some research has identified biological differences that might account for differences in girls and boys’ math ability (Halpern et al., 2007). Biological research has focused on differences in spatial ability between males and females, how it might have emerged, and how the difference affects math performance. For example, as will be show below, differences may be attributed to brain lateralization in ability. Finally, research has considered the role of hormones such as testosterone in mathematics ability.

**Evolutionary explanations.** The significant gender gap in visuospatial ability can be detected at a young age, when children are in preschool (Levine, Huttenlocher, Taylor, & Langrock, 1999). According to evolutionary psychologists, men had been naturally selected for this ability because they traditionally did more of the hunting, fighting, and traveling long distances (Halpern et al., 2007). Although evolutionary psychology can provide important insights into sex differences, it only tells a portion of the story and has many criticisms. Although men were hunters and required good visuospatial ability, women also needed to have good visuospatial ability as they gathered food for their families from the surrounding environment. Today, males have taken on more traditional female roles such as full-time childcare. Therefore, the argument that men needed to have a better visuospatial ability for their roles is not necessarily the most reliable (Halpern et al., 2007). Women are working in more
areas now that require visuospatial skill. Evolutionary explanations can only address some biological differences in males and females.

**Hormones and brain lateralization.** Past research has emphasized the role of hormones in hemispheric lateralization (Van Goozen, Cohen-Kettenis, Gooren, Frijda, & Van De Poll, 1994). In the late twentieth century, research had been conducted on ability differences between sexes, and how levels of hormones affected verbal and spatial ability. It was assumed from past research that men were better at spatial ability tasks compared to women who were more efficient at verbal tasks and that such differences are attributed to differences in hemispheric lateralization (Van Goozen et al., 1994).

One of the main theories in the line of research is the Geschwind-Galaburda theory, which acknowledges the inhibitory effect that testosterone may have on development (Kolb & Wishaw, 2009). The theory explains that, “testosterone’s inhibitory action takes place largely in the left hemisphere, thus allowing the right hemisphere to grow more rapidly which leads to altered cerebral organization” (Kolb & Wishaw, 2009, p. 315). The right hemisphere is more associated with spatial ability skills, which allows males to perform better on these tasks. While the theory has had criticisms, it does acknowledge that skills can be somewhat localized in the brain, creating hemispheric lateralization (Kolb & Wishaw, 2009).

In one study, in order to understand hemispheric lateralization and testosterone exposure, transsexuals’ verbal and spatial abilities were assessed during their transition to the desired sex (Van Goozen et al., 1994). Female-to-male transsexuals, who were exposed to more testosterone, were more likely to do better on spatial ability tasks, but their performance on verbal tasks was not affected. Therefore, this shows that female-to-male transsexuals did not willingly assume the stereotypical male role by doing worse on the verbal tasks. Rather, it was
more likely due to the increased exposure to androgens and not due to being stereotyped towards a different sex (Van Goozen et al., 1994). The amount of testosterone exposure is also important.

To test the effects of varying levels of testosterone, men and women were invited to partake in a study requiring them to undergo fMRIs while performing spatial ability tasks (Kalmady et al., 2013). Although controversial, the ratio between the length of one’s index finger (second finger) and their ring finger (fourth finger) has been shown to be a sign of testosterone exposure in prenatal development (Manning, Scutt, Wilson, & Lewis-Jones, 1998). Men are more likely to have longer ring fingers. The study found that males with a higher prenatal testosterone exposure were more likely to do well on right hemispheric tasks related to spatial ability (Kalmady et al., 2013). On the other hand, women did not do as well on spatial ability tasks due to less prenatal exposure to testosterone. Therefore, there is a relationship between testosterone exposure and spatial ability. Biology can explain some of the reasons for a possible gender mathematics gap, since spatial ability is a significant aspect of mathematics.

**Conclusions to the impact of biological factors.** In the end, however, most sex differences in ability are relatively small and girls and boys are more similar than different (Halpern et al., 2007). Research has acknowledged that there is more variability in boys’ math abilities compared to girls. Biology only accounts for part of the reasons for why there might be a math gender gap. It does not account for children’s mindsets, their beliefs about their own ability, intelligence, and what goals they create for themselves based on those beliefs. It is the interaction between biology and the environment, where psychological and social factors emerge.
Psychological factors. While biological factors are important in examining math achievement and gender research, the role of students’ mindsets related to their intelligence is also essential to study. Mindsets refer to how people think of their intelligence and whether that has an effect on their achievement and ability (Dweck, 2006). The way middle school students think of their intelligence is important as well as how they approach an assignment or task in school. Students’ study and self-handicapping behaviors also affects their math achievement. Incorporating these factors can provide a richer picture on the effects on math achievement.

Implicit theories of intelligence. One important psychological influence is girls’ and boys’ implicit theory of intelligence- the way they think about their own intellectual capabilities. According to Dweck and Leggett (1988), individuals who adopt an incremental theory of intelligence believe that knowledge is malleable. For example, it involves believing that math skill is changeable and that it can be developed over time. Alternatively, those who hold an entity theory believe that intelligence is fixed, exists in a certain amount, and is not easily changeable. For example, it involves believing that the amount of math intelligence they have is fixed and there is not much that can be done to change it. This view may be problematic because it may directly affect students’ motivation and achievement in mathematics, particularly in the face of challenge (Blackwell et al., 2007). For example, if a student thought she could not improve her math intelligence, she might not try as hard and subsequently, not do as well in math.

Implicit theories of intelligence are important and are rooted in how students think of academics. However, they may not impact how students actually feel about themselves (De Castella & Byrne, 2015). For example, if a female student believes that knowledge in general is changeable (incremental), she may not consider that to be true for herself. She may believe that
her knowledge is fixed and she is unable to change it. Current research has examined self-efficacy, whether someone believes they are capable or fit a certain label (De Castella & Byrne, 2015).

Past research has found gender differences in implicit theories of intelligence (Diseth, Meland, & Briedablik, 2014). Specifically, even though female middle school students were more likely to have higher math achievement than boys in one study, they were more likely to have lower self-esteem and hold more entity theories of intelligence (Diseth et al., 2014). They were more likely to think that intelligence was fixed compared to boys. This is still a significant finding, even if they did better in mathematics because the findings can have long-term effects, which were not addressed in the study. More research is required to understand gender differences in implicit theories of intelligence. In order to modify long-term effects, implicit theories of intelligence must also be modified.

Some research has focused on reframing math gender stereotypes to reflect a more incremental theory of intelligence, focused on effort (Thoman, White, Yamawaki, & Koishi, 2008). For example, in one study, female undergraduate students were either exposed to the gender stereotype that boys are better at girls than math because of their ability, due to effort, or not exposed to the stereotype at all (Thoman et al., 2008). They were then asked to take a standardized mathematics test. Results indicated that students exposed to the effort stereotype condition were more likely to spend more time on each individual problem and get more correct (although not statistically significant) compared to students given the ability stereotype or none at all. This explains that female students exposed to more effort-based, incremental theories of intelligence, are more likely going to spend more time on mathematics and have higher achievement (Thoman et al., 2008). For students who are exposed to more entity-based beliefs
about math intelligence, it may affect how they think about math, and subsequently disrupt their math achievement.

Modifying students’ implicit theories of intelligence, regardless of gender, has been shown to help increase math achievement scores (Blackwell et al., 2007). Interventions have been used to increase incremental theories of intelligence. In one study, junior high school students were either placed into one of two classes that took place weekly for eight weeks. One class emphasized the importance of holding incremental theories of intelligence, that the brain is flexible, the possibility for neurogenesis (new neural pathways), and that persistent learning pays off. The control group received a memory workshop, with no reference to implicit theories of intelligence, but was similar in talking about brain physiology (Blackwell et al., 2007). Researchers assessed students’ academic achievement and motivations, including implicit theories of intelligence before and after the intervention (Blackwell et al., 2007). They also assessed how well students learned the material discussed in the interventions.

Results suggest that students exposed to positive, incremental theories of intelligence, were more likely to have better long-term academic achievement (Blackwell et al., 2007). Therefore, students who believe they have the power to work on their intelligence may subsequently do better in their academics. They feel that due to the flexibility of the brain, working to master rather than perform on a task is more important. Despite emphasizing incremental theories of intelligence in class, it may be even more essential to focus specifically on the student and how they can improve their own intelligence.

Some students may hold different beliefs about their own intelligence compared to others’ (De Castella & Byrne, 2015). For example, a female student may believe that in general, people can change their intelligence through effort. However, she may personally believe she
cannot improve her own intelligence. Therefore, there may be a discrepancy between implicit theories of intelligence and one’s own intelligence self-theory. In order to test this hypothesis, one study compared Carol Dweck’s implicit theories of intelligence scale with a modified version to represent statements about the self (De Castella & Byrne, 2015). Results showed the self-theory scale to be more predictive of student achievement. Specifically, when students were assessing intelligence in general, they believed it to be more fixed for society compared to their self-beliefs about intelligence, where they could modify and adjust it. This aligns with the self-serving bias and helps to raise their self-esteem and confidence in mathematics (De Castella & Byrne, 2015). Beliefs students hold about themselves and others affect the

**Achievement goal orientations.** Implicit theories of intelligence have a direct effect on achievement and goal orientation. Goal orientation refers to the reasons for how and why a person might work on a task (Dweck & Legget, 1988; Elliott & Dweck, 1988). Two types of performance goal orientations have been identified in the research, avoidance and approach (Midgley et al., 2000). Those who adopt performance goals are more likely to choose tasks that display their perceived ability level (Elliott & Dweck, 1988; Midgley et al., 2000). Therefore, they are more likely to work on tasks they feel confident working on and can show their best results, aligning with a performance-approach goal orientation. Furthermore, people may avoid tasks on which they might struggle because the struggle would indicate lack of ability (i.e., performance-avoidance goal orientation). In general, those who hold performance achievement goal orientations are more likely to have an entity theory of intelligence. They believe their intelligence is contingent upon their ability rather than the effort focused towards a task (Elliott & Dweck, 1988, Midgley et al., 2000).
In contrast, individuals who hold an incremental theory of intelligence are more likely to adopt mastery goals, which are considered to be more developmental because people want to improve their skills by using effort (Elliott & Dweck, 1988). They view challenge as an opportunity to help them improve their skills and are less likely to use avoiding strategies when they may not have as high of achievement on a specific task (Elliott & Dweck, 1988).

Past research has explored gender differences in achievement goal orientations (Leondari & Gonida, 2007; Steinmayr & Spinath, 2008). In one particular study, elementary, middle and high school students were asked about their achievement goal orientations and math achievement and found there to be no gender differences in the types of achievement goals held (Leonardi & Gonida, 2007). This finding was replicated in another study assessing older adolescents’ achievement goal orientations and the relationship to mathematics grades and gender (Steinmayr & Spinath, 2008).

Although prior research identified no gender differences in achievement goal orientation (Steinmayr & Spinath, 2008), other research has tried to reinforce the math-gender stereotype to directly manipulate achievement goals (Smith, 2006). For example, female undergraduate students were given an article related to the findings of math-gender stereotypes, that men do better in math than women. In the experimental condition, students were told that the math test they were about to take had results that aligned with the stereotype, while the other condition was told that the test goes against the stereotype, that both genders perform equally (Smith, 2006). While the students never actually took a math test, they participated in a questionnaire asking about achievement goal orientations: whether students were fearful of looking bad if they did not do well (performance-avoidance goal orientation), if they were motivated to do well so they wouldn’t look dumb, or if they strived to do well in order to perform better than others.
Results showed that students who were told that the upcoming math test showed math-gender stereotypes in its results were more likely to hold performance-avoidance goal orientations. Therefore, female students were more likely to want to avoid situations that would be consistent with the stereotype, and ultimately under the pressure of stereotype threat. In the end, achievement goal orientations can be manipulated and people can adjust their goals to align with the stereotype threat they perceive for themselves (Smith, 2006).

Although the study did not test male students, a small group of male and female undergraduate students were tested in a second study (Smith, 2006). The study used the same article from the previous study explaining the math-gender stereotype, but this time, researchers explained that gender differences (males performed better) had been found in the math test they were about to take. They were then given the same achievement goal orientation questionnaire and asked to predict how well they think they will do on the upcoming math test. Female students were more likely to accept the math-gender stereotype and hold a performance-avoid goal orientation. Male students were more likely to think they would perform better on the math test. They were less likely to hold a performance-avoid goal orientation due to them believing they would be successful (Smith, 2006). Considering the effects of stereotypes people are exposed to, as described later in the paper, parents, teachers, and researchers can influence how students think of themselves and what they can and cannot do.

The focus of achievement goal orientations and implicit theories of intelligence is usually domain-general (Steinmayr & Spinath, 2008). An achievement goal orientation is seen as a more overarching view of all subjects a student might take in school. In reality though, goal orientations may not be so static or stable, and may be adjusted based on the domain in focus.
For example, a female student might hold a mastery goal orientation and believe she is a good student generally. However, in math class, she finds it to be overwhelming, so she may hold a performance goal orientation in math. She may avoid situations where her perceived “lack of ability” would be apparent to others. Therefore, her achievement goal orientation depends on the discipline, subject she is studying, and situation. Also, as described previously, depending on information like math-gender stereotypes a student is exposed to, achievement goals may shift (Smith, 2006).

**Study behaviors.** It is important to consider what types of studying is most effective for students. Study behavior can come in two different forms, shallow and deep (Biggs, Kember, & Leung, 2001). When a student uses shallow study habits, he or she may be trying to learn material for short-term gains (i.e., studying for a test). Fear of failure may be a significant motivator for the student, so he or she may try to learn for extrinsic sake. While using deep study habits, a student may try to retain the material for long-term learning and development and has a more intrinsic interest in the topic. By using reflection, time, and energy, a student is able to more effectively learn material for the long-term (Biggs, Kember, & Leung, 2001).

Students may develop different study habits based on their beliefs about their own intelligence and corresponding achievement goal orientations (Miele & Molden, 2010). Students who hold an entity theory of intelligence might not adopt effective study strategies. For example, if they experience difficulty understanding material, they might believe the content is beyond their ability level threshold and avoid studying, and hold a performance goal orientation. They may consider that “easy is better”, that learning about things one is competent in shows their ability, therefore reinforcing a performance goal orientation. In contrast, those who hold incremental theories of intelligence may feel that through effort, they were able to “master” the
material and more deeply understand and process it (mastery goal orientation) (Miele & Molden, 2010).

Research has tried to answer the question of whether those who adopt performance goal orientations, and hold more entity theories of intelligence, react differently to challenge than those who adopt mastery goal orientations and hold implicit theories of intelligence (Hong, Chiu, Dweck, Lin, & Wan, 1999). For people who hold more ability-based beliefs and performance goals, doing well on a task leads them to want to demonstrate their skill further. They do not need effort to do well because they hold innate ability. However, when they do not do well, they are less likely to take remedial action to learn more and improve. If they do not have the ability, then effort will not matter as much, according to entity theorists. Alternatively, those who hold more incremental theories of intelligence are more likely to use remedial efforts to do better, even in the face of setbacks as well as success (Hong et al., 1999).

While adopting a performance goal orientation is more closely aligned with a lower probability of working further on a task (Hong et al., 1999), current research has not considered different types of studying behavior and their relationship to implicit theories of intelligence and achievement goal orientations. It also has not touched on the effects of math gender stereotypes on studying behavior. Although Blackwell and colleagues did foster implicit theories of intelligence, ideas that the brain can change and develop, for positive math achievement, they did not assess students’ studying behaviors (Blackwell et al., 2007). How might their implicit theories of intelligence affect the way they study? Specifically, behaviors that undermine studying may relate to a student’s implicit theory of intelligence (Leonardi & Gonida, 2007).

**Self-handicapping behaviors.** Many students who consider their performance on a task as most important may be more likely to engage in self-handicapping behaviors (Leonardi &
Gonida, 2007). Self-handicapping is the use of maladaptive behaviors to undermine their performance, while shifting blame of failures from one’s own dispositions and ability to outside circumstance. For example, a student may purposely go to sleep late the night before a test because they feel they will not do well. They believe they will not be successful, so they are able to blame their failure on not getting enough sleep (Leonardi & Gonida, 2007).

In one study, self-handicapping behaviors were assessed in relation to math achievement and achievement goal orientations for elementary through high school students in Greece (Leonardi & Gonida, 2007). Results showed that students who held performance goal orientations were more likely to engage in self-handicapping behaviors. Because this study also assessed students’ social goals (trying to gain approval from others), research was able to show how they believe others perceive them influences their study, performance, behaviors. Therefore, “…students’ attempts to demonstrate ability or avoid the demonstration of lack of ability are intertwined with wanting to please others” (Leonardi & Gonida, 2007, p. 603). The main conclusion from the research is that those who hold more performance-approach and performance-avoidance achievement goal orientations are more likely to engage in self-handicapping behaviors and end up having poorer math achievement. Math anxiety is another factor that can emerge from math gender stereotypes.

Math anxiety. Mathematics can cause a lot of stress and anxiety for students. Math anxiety is described as an uneasiness and distress when working on math-related tasks (Devine, Fawcett, Szücs, & Dowker, 2012). Those who have higher math anxiety are less likely to want to work on mathematics tasks and further their studies in math (Meece, Wigfield, & Eccles, 1990). Students who have higher math anxiety are more likely to have lower perceptions of their math ability. Additionally, women are more likely to have higher math anxiety than males...
(Meece et al., 1990, which may be another reason for why fewer women pursue math-related fields and professions (Wang et al., 2013).

Why is math anxiety so important for math achievement? Students with higher levels of math anxiety are more likely to do worse in math compared to their similar achieving peers with less math anxiety (Ashcraft, 2002). These students may then pursue fewer math courses in school and in the long-term, fewer math-related careers. As described later, math teachers’ own math anxieties can have an effect on their students’ anxieties and achievement (Beilock et al., 2010).

**Social factors.** While individual level factors like students’ academic mindset are important in math achievement, their relationships with others must also be addressed. Students’ beliefs are influenced by feedback from others. For example, adults’ praise of children affects children’s beliefs about intelligence and undermines their mastery goals. In an observational study of parents and children, children with lower self-esteem were less likely to seek out challenge after their parents gave them inflated praise (e.g., “You are terrific! Perfect!”) (Brummelman, Thomaes, de Castro, Overbeek, & Bushman, 2014).

Another big social influence on children is their teachers. Teachers’ own implicit theories of intelligence and goal orientation might impact the feedback they give to students, thus reinforcing students’ developing theories (Rattan, Good, & Dweck, 2012). For instance, teachers might give different advice or comments to their students based on students’ successes and struggles. They might comfort a struggling student by saying, “it is okay because not every can be good at the task.” Alternatively, they might reinforce students’ talent rather than effort, sending the message that intelligence is fixed (e.g., “You are so smart!”). This feedback emphasizes the performance goal orientation where the student only does tasks she believes she
can look competent in doing (Rattan et al., 2012). Furthermore, she would avoid tasks that would display her difficulty on those skills.

**Teachers’ implicit theories of intelligence.** Depending on how a teacher thinks knowledge can be obtained and the ability of a student based on gender, can perpetuate gender-math stereotypes in the classroom. If teachers hold gender-math stereotypes, they might be more likely to think that a girl cannot change her ability in math and hold an entity theory of intelligence (Espinoza, Arêas da Luz Fontes, & Arms-Chavez, 2014). This can be conveyed through praise teachers give to their students based on their gender and if they think that intelligence is fixed or can be changed.

Similar to math achievement gender gap research, research related to teachers’ beliefs about male and female math students is also inconsistent. Some research has identified teachers’ ratings as more positive for male students’ ability (Fennema et al., 1990; Tiedemann, 2000). In one study, first grade female teachers were asked about their beliefs related to students’ successes and failures in math class (Fennema et al., 1990). They were also asked who their best and worst student was in class relative to if the student was a boy or a girl. Results showed that teachers were more likely to attribute and convey that female students’ successes in math were due to effort, while male students’ successes were to ability. They were more likely to believe their best and worst students were male (Fennema et al., 1990). Although the study did not assess teacher interaction with students or teachers’ implicit theories of intelligence, it did acknowledge that these factors are important in shaping students’ views and achievement. Teachers in the study would more likely have held an entity theory of intelligence due to their beliefs about math intelligence being fixed and based on ability.
However, other research has found female students to be rated higher than males in math by teachers (Robinson & Lubienski, 2011). While research is inconsistent, it still is important to consider teachers’ ratings of their students and their effects on students’ math achievement. As noted in Blackwell and colleagues study, interventions can be used to support growth mindsets and incremental theories of intelligence (2007). The type of instruction teachers give does matter. Teachers who emphasize a performance-goal oriented classroom are more likely to have students who place lesser value on mathematics (Anderman, Eccles, Yoon, Roeser, Wigfield, & Blumenfield, 2001). Therefore, the performance-oriented teaching strategy influences the way students value and think about mathematics.

*Teachers’ math anxiety.* Past research has pointed to possible effects of teachers’ math anxieties relayed to their students, which could cause achievement problems as well as the endorsement of math-gender stereotypes (Beilock et al., 2010; Gunderson et al., 2012; Hadley & Dorward, 2011). In order to test this, in one study, female elementary school teachers and their students were assessed at the start of the school year and at the end (Beilock et al., 2010). There was no significant difference in math achievement or math anxiety at the start of school. However, as the school year went on, female students with higher math anxiety were more likely to adhere to math-gender stereotypes. They were more likely to convey these stereotypes to their students. Female students were more likely to model after their teacher and endorse math gender stereotypes, while doing less successful in math class. It is not as clear in how this process emerges and unfolds (Beilock et al., 2010). What exactly does the teacher do to show their anxieties about math? In some way, the teachers do transmit these beliefs to their female students (Gunderson et al., 2012).
Some research has found that teachers who emphasize problem solving instead of just teaching concepts, are more likely to provide a more beneficial learning environment for their students (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996). Students are able to apply the concepts they learn in class to real-life situations. They are more likely to hold a greater interest in mathematics and are more likely to think that mathematics is important. This allows the teacher to be active in the teaching process, but also let the students be able to develop skills and interest in an important subject like math (Fennema et al., 1996).

The Current Study

The current study is part of a larger study addressing the effects of educational practices on middle school students’ implicit theories of intelligence, achievement goals, study behaviors, feelings about math, and math achievement. Within this context, the goals of the current study are:

1. To examine sex difference in middle school students’ implicit theory of intelligence (i.e., mindset)
2. To examine whether sex differences in theories of intelligence contribute to the adoption of different achievement goals
3. To examine whether mindset and achievement goals impact math performance

In order to address these questions, boys and girls were given scales to measure mindset and achievement goals. For half of the participants, the scales address academics in general, but for the remaining half, the scales address math in particular. Thus, this study uses a 2 x 2 (sex x scale type) between-subjects design. We predict that sex differences will be greater when questions address math than when questions address academics in general. Specifically, in the
domain of math, girls may be more likely than boys to endorse entity theory and performance goals.

**Methods**

**Participants**

The study surveyed 1,331 middle school students from four different schools in a Midwestern school district. Participants at the time of data collection were in 7th or 8th grade. Of the 1,329 students, 175 students were missing Measures of Academic Progress (MAP) math test scores for Fall 2014, Fall 2015, or both. These students were excluded from data analysis, and 1,154 students remained, 48% females and 52% males. Table 1 shows the breakdown by grading approach, grade, and sex in terms of numbers of students.

Table 1

*Number of Students by Grade Level and Sex*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Girls</th>
<th>Boys</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>7th</td>
<td>284</td>
<td>299</td>
<td>515</td>
</tr>
<tr>
<td>8th</td>
<td>270</td>
<td>301</td>
<td>502</td>
</tr>
</tbody>
</table>

**Materials**

The following measures were included in the study to address students’ beliefs about math/intelligence, study processes, and achievement goal orientation (see Appendix A).

*Implicit theories of intelligence.* Adapted from the Implicit Theories of Intelligence Scale (Dweck, 1999), this measure includes eight items assessing students’ beliefs about their own intelligence, whether students think their intelligence is fixed or adjustable (De Castella & Byrne, 2015). Four items are related to an entity theory of intelligence and four items to an incremental theory of intelligence. Incremental theory of intelligence questions were reverse
scored. Items were ranked on a six-point Likert scale, where 1 equaled “Strongly Agree” and 6 equaled “Strongly Disagree”. Students given the domain-general survey had identical questions to De Castella and Byrne’s study, while students who were given the math-specific survey were asked similar questions, but within the context of math (i.e., “I don’t think I personally can do much to change my intelligence” vs. “I don’t think I personally can do much to change my math intelligence”).

**Achievement goal orientation.** Three subscales were used from the Patterns of Adaptive Learning Scales (PALS) to assess students’ mastery and performance achievement goal orientation (Midgley et al., 2000). The subscales were Mastery Goal Orientation (included 5 items), Performance-Approach Goal Orientation (5 items), and Performance-Avoid Goal Orientation (4 items). Items were scored on a five-point Likert scale, where 1 equaled “Not at all True” and 5 equaled “Very True”. Students taking the domain-general survey were given identical items to the original PALS measurement, while students taking the math-specific were given similar items, but related to math (i.e., “It’s important to me that I don’t look stupid in class” vs. “It’s important to me that I don’t look stupid in math class”).

**Self-handicapping behavior.** One subscale from the PALS measurement, Academic Self-Handicapping Strategies, was used to assess students’ behavior that may impede their academic achievement (Midgley et al., 2000). The subscale includes six items rated on a five-point scale, where 1 equaled “Not at all True” and 5 equaled “Very True”. The domain-general survey questions related to self-handicapping behavior were identical to the original PALS measurement, while the math-specific items were similar but in mathematics context (i.e., “Some students fool around the night before a test. Then if they don’t do well, they can say that is the...
reason. How true is this of you?” vs. “Some students fool around the night before a math test. Then if they don’t do well, they can say that is the reason. How true is this of you?”

**Study behavior.** The revised two-factor Study Process Questionnaire (R-SPQ-2F) was used to look at students’ study habits and behavior in school, whether it is a more deep or surface approach (Biggs, Kember, & Leung, 2001). The original measurement was given to college students, so terminology was adjusted to fit the developmental level of middle school students (i.e., “I find that at times studying gives me a feeling of deep personal satisfaction” was changed to “At times, studying for class makes me feel good.”) The items were rated on a 5-point Likert scale, where 1 equaled “Never or only Rarely True” and 5 equaled “Always or Almost Always True”. The original R-SPQ-2F contains twenty items, but three were removed for the current study to remain developmentally appropriate, leaving seventeen items. After editing items for developmental appropriateness, the math-specific survey questions were almost identical to the domain-general questions, but in math context (i.e., “At times, studying for class makes me feel good.” was changed to “At times, studying for math class makes me feel good.”)

**Math anxiety.** The Child Math Anxiety Questionnaire (CMAQ) (Ramirez, Gunderson, Levine, & Beilock, 2013), which had been adapted from Mathematics Anxiety Rating Scale for Elementary children (Suinn, Taylor, & Edwards, 1988) was used to test anxiety in math class. The CMAQ had been used with early elementary school students, so in the current study, items were adjusted to fit middle school students developmentally (i.e., “How do you feel when you have to solve 27 + 15?” was changed to “How would you feel when solving for x in 2(x + 9) + 8x = 24?”). The questionnaire contained eight items, which were scored on a four-point Likert scale (1 equaled “Very Anxious” and 4 equaled “Not Anxious at All”). The domain-general
survey had the same, identical questions as the math-specific survey, where all surveys asked about math anxiety specifically.

**Math enjoyment.** In order to assess a middle school student’s enjoyment in mathematics, one item was included in the questionnaire. The item, “Overall, how much do you enjoy math?” was scored on a 5-point scale, where 1 equaled “Not at All” and 5 equaled “A Great Deal”. All students answered this question, regardless of survey type.

**Self-reported math performance.** Using a more subjective measure, students were asked to answer one question about their math performance. The item “Overall, how would you judge your performance in math?” was rated on a 5-point scale, where 1 equaled “Not at All” and 5 equaled “A Great Deal”. All students answered this question, regardless of survey type.

**Math achievement.** The objective measure used to assess middle school students’ math achievement was the Measures of Academic Progress (MAP) math test for both Fall 2014 and Fall 2015. The MAP test is scored in terms of Raush units (RIT scores), which take into account item difficulty and which particular items a student misses. RIT scores reflect students’ level of achievement and reflect the highest level of question they can answer about half of the time. MAP RIT scores are independent of grade level and each point is consistently one point (i.e., interval scale). In the 2015 norming sample, the average 7th grade score is 222.6 ($SD= 16.59$) and the average 8th grade score is 226.3 ($SD= 17.85$).

**Procedure**

The study was approved by the university’s Institutional Review Board (IRB). Parents were sent home letters and were asked to return them if they did not wish their child to participate. Students were given surveys via Google Forms during the same week in their third quarter of the school year during their regularly scheduled math class. Prior to beginning the
surveys, students were given instructions on the Google Forms explaining the study and their assent rights. Those students who did not wish to proceed were given an alternative activity to work on during survey time. Students answered the questions in the order displayed in the materials section above. Even though all students were given the same set of surveys, for half of the students in each grade, the context for each item was with respect to mathematics in particular (e.g., “At times, studying for math class makes me feel good.”), and for the remaining students, the context was for intelligence in general (e.g., “At times, studying for class makes me feel good.”)(see Table 2 for an overview).

Table 2

Overview of Research Design

<table>
<thead>
<tr>
<th>Grade</th>
<th>Thoughts about...</th>
<th>Math feelings</th>
<th>Math achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Math intelligence (mindset)</td>
<td>“Do you enjoy math?”</td>
<td>2014 &amp; 2015 Measures of Academic Progress (Math RIT score)</td>
</tr>
<tr>
<td></td>
<td>Math achievement orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Math study behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General intelligence (mindset)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General achievement orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General study behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Math intelligence (mindset)</td>
<td>Math anxiety scale</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Math achievement orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Math study behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General intelligence (mindset)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General achievement orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General study behavior</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Results**

Scores for each of the research instruments were calculated. For mindset, we first calculated an average score for the entity items and an average score for the incremental items in order to assess the relationship between them. We then reverse scored the items reflecting an
incremental theory of intelligence and then summed all 8. This score was divided by 6 to reflect an average rating on the 6-point Likert scale.

For achievement goal orientation, there were three different subscales, mastery-goal, performance-approach, and performance-avoid. An average rating was calculated for each subscale. With respect to self-handicapping behavior, an average rating was also calculated.

The Study Process Questionnaire’s 17 items were split into two different categories, deep approaches to studying and surface approaches to studying. An average score reflecting the 8 items for deep was calculated and an average score reflecting the 9 items for surface approach were calculated.

Implicit Theory of Intelligence

A 2 Item (Entity vs. Incremental) x 2 Survey (Domain Specific vs. Domain General) x 2 Grade (7th vs. 8th) x 2 Sex mixed AONVA was run on average entity-theory score. Recall that half of the students were asked questions about their beliefs about math intelligence (e.g., “I don’t think I can personally do much to change my math intelligence.”) while others were asked about intelligence in general (e.g., “I don’t think I can personally do much to change my intelligence.”). There was a significant Item effect, $F(1, 1146) = 2385.62, p < .001$. Overall, students gave higher ratings to items addressing incremental theory of intelligence than items addressing entity theory of intelligence (see Figure 1). With respect to the type of implicit theory of intelligence being held, no significant differences were found by grade, sex, or survey type.
Figure 1. Average ratings of implicit theory of intelligence items (fixed/entity) vs. (growth/incremental) by grade level (7th and 8th), survey type (general vs. math), and sex.

The Effect of Implicit Theories of Intelligence on Achievement Goal Orientation

A single score for Dweck’s measure was calculated. Students with the top 25% highest scores were considered to be entity theorists, while students with the lowest 25% were considered to be incremental theorists. Then, in order to assess the effect of mindset on achievement goal orientation, a 2 Mindset Group x 2 Grade x 2 Achievement Goal mixed ANOVA on average achievement goal orientation was run. There was a significant main effect of achievement goal $F(1, 909) = 921.83, p < .001$. Overall, students were more likely to give higher ratings to mastery goal orientation items than performance goal orientation items. This
main effect may be explained in terms of the significant interaction between achievement goal orientation and the mindset group (see Figure 2), $F(1, 909)= 91.60, p < .001$. Students with an incremental mindset gave higher ratings on mastery goal orientation items than did students with an entity mindset. These groups, however, did not differ with respect to their endorsement of items related to performance goals.

Figure 2. Average rating on items addressing performance and mastery achievement goals as a function of whether students hold an entity theory of intelligence or an incremental theory of intelligence. Both groups endorse performance goals similarly, but the incremental group endorses mastery goals more strongly than the entity group.

Sex Differences
As discussed previously, there were no significant differences between males and females in the types of implicit theory of intelligence or achievement goal orientations they held. To evaluate sex differences in feelings about math and performance on standardized assessment of math, average z-scores were calculated for enjoyment ratings, average math anxiety, self-rated performance, and MAP math scores for Fall 2014 and Fall 2015. Average z-scores on these measures as a function of sex are shown in Figure 3. The 2 (sex) multivariate ANOVA on these measures revealed no significant difference between males’ and females’ performance on the MAP test for Fall 2014 $F(1, 1152) = .93, p = .33$, or Fall 2015 $F(1, 1152) = .57, p = .45$. However, a sex difference in math anxiety was found $F(1, 1152) = 29.14, p < .001$. Females’ math anxiety score was significantly higher compared to males’ math anxiety. Also, sex difference in math enjoyment was also significant $F(1, 1152) = 9.01, p < .003$. Males were more likely to rate their enjoyment in math as higher than females.
MINDSET IN MATH ACHIEVEMENT

Figure 3. Average standardized z-score on math anxiety, math enjoyment, self-reported math performance rating, Fall 2014 MAP math score, and Fall 2015 MAP math score with respect to sex.

Overview of Relations Between Factors

A set of Pearson correlations was run on mindset (an average entity score), mastery goal orientation, performance goal orientation, surface studying approach, deep studying approach, and math anxiety (see Figure 4). Higher ratings on the entity mindset measure were negatively related to mastery goal orientation. The higher a student rated themselves on entity items, the less likely they were to adopt a mastery goal orientation. Mastery goal orientation was negatively correlated with how strongly students endorsed surface studying approaches and was
positively correlated with how strongly they endorsed deep studying approaches. A student adopting a more mastery goal orientation is less likely to use surface studying approaches and inversely, more likely to use deep studying approaches. A higher rating of performance goal orientation items is both positively correlated with more strongly adopting surface studying and deep studying approaches, a very interesting and surprising finding. Having higher ratings on mastery goal orientation items is negatively correlated with math anxiety. Therefore, when there was stronger endorsement of mastery goals, it was related to lower ratings on math anxiety. When performance goal items were rated more strongly, it was positively correlated with math anxiety. Showing stronger ratings on surface studying approaches is positively related to scoring higher on math anxiety items, while deep studying strategies is negatively correlated with lower scores on math anxiety items.

*Figure 4.* A framework for how implicit theory of intelligence (mindset), mastery goal orientation, performance goal orientation, surface studying approach, deep studying approach, and math anxiety are related. *p*<.01, **p**<.001

**Math Achievement**

A stepwise multiple linear regression was run using mindset (entity theory of intelligence), mastery goal orientation, performance goal orientation, surface studying approach, deep studying approach, and math anxiety to predict Fall 2015 math achievement. The model
including math anxiety, deep studying approach, entity theory of intelligence, and surface studying approach explained 14% of the variation in MAP scores, $F(4, 1149) = 48.85, p < .001$ (see Figure 5).

![Figure 5](image)

**Figure 5.** Results of a stepwise multiple linear regression assessing Fall 2015 MAP math scores using math anxiety, deep studying, approach, implicit theory of intelligence (entity), surface studying approach, performance goal orientation, and mastery goal orientation as predicting variables. Standardized beta weights are shown on the lines (NS= not significant).

A stepwise multiple linear regression was run using mindset (entity theory of intelligence), mastery goal orientation, performance goal orientation, surface studying approach, deep studying approach, and math anxiety as predictors of change in MAP math achievement scores from Fall 2014 to Fall 2015. The model including math anxiety, mastery goal orientation, and deep studying approach explains 5% of variability in MAP score changes, $F(3, 1150) = 18.99, p < .001$ (see Figure 6). The most significant predictor, math anxiety, when there were
higher ratings, it was predictive of more positive change in math achievement between Fall 2014 and Fall 2015. Also, higher scores on mastery achievement goals were predictive of positive change in math achievement scores from one year to the next. Surprisingly, deep studying was predictive of a drop in MAP performance scores from Fall 2014 to Fall 2015.

Figure 6. A stepwise multiple linear regression explaining the change in math achievement from Fall 2014 to Fall 2015 using math anxiety, mastery goal orientation, deep studying approach, implicit theory of intelligence (entity), performance goal orientation, and surface studying approach as predicting variables. Standardized beta weights shown on the lines (NS= not significant).

Because math anxiety is the highest predictor in math MAP performance in Fall 2015 and the change in performance from Fall 2014 and Fall 2015, two stepwise multiple linear regressions were run, one for boys and one for girls to examine predictors of anxiety. Each analysis included these factors: entity theory of intelligence, incremental theory of intelligence,
mastery goal orientation, performance goal orientation, surface studying approach, and deep studying approach as predictors and math anxiety as the criterion/dependent variable (see Figure 7).

For girls, a surface studying approach, entity theory of intelligence, and performance goal orientation explained 9% of the variability in math anxiety, $F(2, 550) = 18.32, p < .001$. Higher ratings of surface study strategies were predictive of an increase in math anxiety for girls. Higher ratings for entity mindset/theory of intelligence were also predictive of an increase in math anxiety. Lastly, higher ratings on adopting performance goal orientations was predictive of an increase in math anxiety.

For boys, a surface studying approach and incremental theory of intelligence explains 10% of the variance in math anxiety, $F(2, 597) = 33.00, p < .001$. Having higher surface study strategy ratings was predictive of having more math anxiety in boys. Also, higher ratings on incremental mindset/theory of intelligence were predictive of a decrease in math anxiety.

*Figure 7. Two stepwise multiple linear regressions explaining math anxiety in middle school students’. For girls (on the left), significant predictors included surface study strategy, entity theory of intelligence, and performance goals, whereas for boys (on the right), significant predictors included surface study strategy and incremental theory of intelligence. Standardized beta weights are shown.*
In order to assess how math anxiety may affect boys’ and girls’ performance in math, unstandardized beta weights were calculated. The predicted variables included were: self-rated math performance, Fall 2015 MAP math performance, and the change in MAP math performance from Fall 2014 to Fall 2015 (see Figure 8). Boys and girls are affected by math anxiety in similar ways. An increase of one point on math anxiety is predictive of decreasing 8.82 points on the MAP math test for girls and 8.69 points for boys. Also, an increase of one point on math anxiety average is predictive of negative change between math scores on the MAP test from Fall 2014 to Fall 2015 for both boys and girls.

![Unstandardized β weights](image)

**Figure 8.** A stepwise multiple linear regression predicting math anxiety’s effect on self-rated math performance, Fall 2015 MAP math scores, and the change in MAP math scores from Fall 2014 to Fall 2015. Unstandardized beta weights are included.

**Discussion**

The goal of the current study was to examine sex differences in middle school students’ math achievement as a function of beliefs about intelligence, math, anxiety, and study processes.
Within the study, another goal was to examine possible sex differences in implicit theories of intelligence and if that contributes to adoption of different achievement goals. Does implicit theory of intelligence and achievement goal orientation affect math achievement? Finally, are there sex differences in math anxiety and studying strategies, and how do these factors influence math achievement in middle school?

During a sensitive developmental period, middle school students are influenced by many factors in relation to their math achievement. The current study assessed these factors in order to more fully understand the relationship. Consistent with previous literature and research (Halpern et al., 2007, Lindberg et al., 2010), no sex differences in math achievement were found. Girls and boys performed similarly in mathematics in middle school, therefore showing no gender gap.

The manner in which middle school students think about their intelligence, whether it is fixed or adaptable, is important, as shown in the current study. Despite previous research finding sex differences in implicit theories of intelligence (Diseth et al., 2014), the current study did not find sex differences in relation to adopting either entity or incremental theories of intelligence. Using a more modified implicit theory of intelligence scale specifically related to self-theory (De Castella & Byrne, 2015) also did not yield significance in predicting math achievement. However, holding more entity mindset beliefs is related to the type of achievement goal orientations adopted, studying approaches used, and math anxiety.

Past research had identified a sex difference in beliefs about ability in mathematics, where boys are more likely to think they are better at math than girls (Watt, 2004). However, in the current study, this was not replicated as boys and girls rated themselves similarly on their beliefs about their ability in math. Boys were no more likely than girls to think of themselves as better in mathematics. However, interestingly, boys were more likely to show more enjoyment
in mathematics compared to girls. This shows that enjoyment in math may not necessarily reflect how a student does in math, but it is important in how students think of math as a subject in school and the math anxiety they may have, which is discussed later. The lower enjoyment in math may be a result of girls accepting the math gender stereotype that boys are better at math than girls, even when their achievement disconfirms the stereotype.

Similar to past research (Elliott & Dweck, 1988), the current study found that holding an entity theory of intelligence was related to performance goals and incremental theory of intelligence was related to mastery goals. The beliefs students have about their achievement influences what they do in school and how they might engage in a task. Relating back to studying approaches, those who hold more mastery goals are likely to use deep studying approaches in order to further understand the material in school for the sake of learning and progressing through material.

Surprisingly, in the current study, performance goal orientations were both positively related to using deep and surface studying approaches. Therefore, this shows that depending on the situation, students may use “deeper” approaches to studying if they feel competent, want to learn more, or are passionate about the subject. On the contrary, similar to what was predicted, students holding more performance goal orientations may use surface study strategies with the goal to “look good” on a test or assignment. Achievement goal orientations are not as binary and divided as they seem and can adjust depending on the situation or subject being studied.

In the current study, math anxiety was found to be a key predictor in math performance. As found in previous literature (Meece et al., 1990), this study replicated the finding that girls are more likely to have higher math anxiety than boys. Despite their higher math anxiety, boys and girls have similar achievement in mathematics. It is important to note that math anxiety affects
boys and girls similarly on math performance. When students have higher math anxiety, they are less likely to do well in math, regardless of sex. Math anxiety is therefore a critical factor and must be addressed to harness all students’ potentials. However, the current study shows that there are many other factors not accounted for that could mediate this relationship between math anxiety and math performance.

In the current sample, overall, students are more likely to hold an incremental theory of intelligence (a growth mindset). They are also more likely to adopt mastery goal orientations. This is very encouraging in light of the research on leveraging growth mindsets in schools today (Rattan et al., 2015; Blackwell et al., 2007). Emphasizing incremental theories of intelligence and mastery goal orientations is beneficial in motivating students and increasing math achievement.

Limitations and Future Research

While the current study sheds light on the importance of harnessing growth mindsets in schools, it does have its limitations. One of the biggest limitations is that students were not randomly selected into the study. All students came from the same school district, so it is unclear if there is a selection bias in the type of student present in the district. In the study, students were more likely to hold growth mindsets and mastery goal orientations, but this could be due to the nature of the district. As noted by Rattan and colleagues, “[a]cademic mindsets are powerful when implemented correctly: They can lift grades and motivation, particularly among struggling students…” (2015). The schools in the study are aware of Carol Dweck’s mindset research district-wide and they continually use explicit attempts to promote growth mindsets to their students (N. Gupta, personal communication). The district is highly performing
compared to many others in the Midwest. Therefore, emphasizing growth mindsets may not provide as much improvement in already high-performing students.

Another limitation of the study was the inability to assess teachers’ implicit theories of intelligence, adoption of achievement goals, and their own math anxieties. Unfortunately, in predicting math achievement, only 14% of the variation was explained in MAP math scores in the stepwise multiple linear regression. Not assessing teachers limited the “social” factors that may influence students’ math performance, leaving much of the variance unexplained.

Unfortunately, there was no explicit manipulation of the impact of growth mindsets on students. Because students were not randomly selected for the study and it is unknown of the nature in which students had learned about the importance of growth mindsets, it is impossible to know cause and effect. Therefore, only relationships between factors in association with math achievement can be assessed.

One of the biggest avenues for future research is assessing the role of teachers and parents and how they affect the adoption of growth mindsets and adaptive achievement goals. While plenty of research has considered the effect of praise parents and teachers give to their children and students (Rattan et al., 2012; Brummelman et al., 2014), it is important to consider the relationship their own beliefs about intelligence, math, and achievement affect others in which they interact.

Future research may also more deeply consider the role of math anxiety and how it affects girls longitudinally with respect to pursuing specific majors, subjects, and career paths. As explained before, regardless of there being no sex difference in math achievement between middle school boys and girls, the fact that girls have higher math anxiety implies that there are some factors that influence how girls feel about mathematics. How girls feel about mathematics
ultimately affects what careers they eventually choose. Emphasizing mindsets is promising in
rethinking how society perceives girls achievement in mathematics, that regardless of sex, people
can harness positive and adaptive beliefs about their intelligence and achievement in school.
Author Note

I want to thank Dr. Neil Gupta, Director of Secondary Education, Worthington School District, for his partnership in this project. I also want to thank Worthington City middle school principals and teachers for their cooperation and participation in making this study possible. Finally, I want to acknowledge the middle school students’ participation in the study and parents of the students.
References


De Castella, K., & Byrne, D. (2015). My intelligence may be more malleable than yours: the revised implicit theories of intelligence (self-theory) scale is a better predictor of


Appendix
Google Form Survey Materials (Domain General Questions)

Achievement Goals in Middle School
You are being invited to participate in a study addressing achievement goals and thoughts about school and studying in middle school. This study is being conducted jointly by Ohio Dominican University and the Worthington School District.
While your parents and teachers have given their permission for you to respond to the questions below, the decision ultimately rests with you. While your parents and teachers have given their permission for you to respond to the questions below, the decision ultimately rests with you. Please direct your attention to your teacher before beginning as they have important information regarding your student ID and other instructions for the surveys below.
We would appreciate your honest and thoughtful responses to the items below. Please know that you may discontinue participation at any time without penalty -- your grades will not be impacted in any way. Also know that your responses will remain anonymous – although the Worthington Education Office will have a record of all responses, the researchers, your teachers and principal will never see your responses. The Education Office will remove your name and student ID before sending the entire set of student responses to us.
If you do not wish to participate, please let your teacher know so that you may be assigned another activity. Otherwise, thank you for taking the time to respond to the items below! Do not worry about projecting a good image. Your answers are CONFIDENTIAL.

Background
What is your first and last name?
I am...
- Male
- Female
What is your student ID number?
What school do you attend?
What is your grade level?
- 7th Grade
- 8th Grade
What Do You Think About Intelligence?
Read each sentence below and then choose the answer that shows how much you agree with it. There are no right or wrong answers.
I don't think I personally can do much to increase my intelligence.
- Strongly Agree
- Agree
- Mostly Agree
- Mostly Disagree
- Disagree
- Strongly Disagree
My intelligence is something about me that I personally can't change very much.
- Strongly Agree
- Agree
- Mostly Agree
To be honest, I don't think I can really change how intelligent I am.

I can learn new things, but I don't have the ability to change my basic intelligence.

With enough time and effort I think I could significantly improve my intelligence level.

I believe I can always substantially improve on my intelligence.

Regardless of my current intelligence level, I think I have the capacity to change it quite a bit.

I believe I have the ability to change my basic intelligence level considerably over time.
What Do You Think About Learning and Yourself as a Student?
Here are some questions about yourself as a student. Please choose the answer that best describes what you think.

It’s important to me that I don’t look stupid in class.
- 1 (Not at all True)
- 2
- 3 (Somewhat True)
- 4
- 5 (Very True)

It’s important to me that other students in my class think I am good at my class work.
- 1 (Not at all True)
- 2
- 3 (Somewhat True)
- 4
- 5 (Very True)

It’s important to me that I learn a lot of new concepts this year.
- 1 (Not at All True)
- 2
- 3 (Somewhat True)
- 4
- 5 (Very True)

Some students fool around the night before a test. Then if they don’t do well, they can say that is the reason. How true is this of you?
- 1 (Not at all True)
- 2
- 3 (Somewhat True)
- 4
- 5 (Very True)

Some students purposely get involved in lots of activities. Then if they don’t do well on their class work, they can say it is because they were involved with other things. How true is this of you?
- 1 (Not at all True)
- 2
- 3 (Somewhat True)
- 4
- 5 (Very True)

Some students look for reasons to keep them from studying (not feeling well, having to help their parents, taking care of a brother or sister, etc.). Then if they don’t do well on their class work, they can say this is the reason. How true is this of you?
- 1 (Not at all True)
- 2
- 3 (Somewhat True)
- 4
- 5 (Very True)

One of my goals in class is to learn as much as I can.
- 1 (Not at all True)
One of my goals is to show others that I’m good at my class work.

One of my goals is to master a lot of new skills this year.

One of my goals is to keep others from thinking I’m not smart in class.

It’s important to me that I thoroughly understand my class work.

One of my goals is to show others that class work is easy for me.

Some students let their friends keep them from paying attention in class or from doing their homework. Then if they don’t do well, they can say their friends kept them from working. How true is this of you?

Some students purposely don’t try hard in class. Then if they don’t do well, they can say it is because they didn’t try. How true is this of you?
One of my goals is to look smart in comparison to the other students in my class.

Some students put off doing their class work until the last minute. Then if they don’t do well on their work, they can say that is the reason. How true is this of you?

It’s important to me that I look smart compared to others in my class.

It’s important to me that I improve my skills this year.

It’s important to me that my teacher doesn’t think that I know less than others in class.*

One of my goals in class is to avoid looking like I have trouble doing the work.*

What Do You Think About Studying?

This questionnaire has a number of questions about your attitudes towards your studies and your usual way of studying. There is no right way of studying. It depends on what suits your own style and the course you are studying. It is important that you answer each question as honestly as you can. If you think your answer to a question would depend on the subject being studied, give the answer that would apply to the subject(s) most important to you.
I feel that any topic can be highly interesting once I get into it.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

At times, studying for class makes me feel good.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

My goal is to pass my classes while doing as little work as possible.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

I find most new topics interesting and I often spend extra time trying to understand them.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

I do as little work as possible when I do not find a class to be interesting.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

I learn some topics by repeating them over and over until I know them by heart even if I do not understand them.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

Sometimes studying can be as exciting as a good book or movie.
- Never or Only Rarely True
- Sometimes True
- True about Half the Time
- Frequently True
- Always or Almost Always True

I test myself on important topics until I understand them completely.
- Never or Only Rarely True
- Sometimes True
o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I can get by in most tests by memorizing important topics rather than trying to understand them.
  o Never or Only Rarely True  
  o Sometimes True  
  o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I usually study the most important information because it’s unnecessary to do anything extra.
  o Never or Only Rarely True  
  o Sometimes True  
  o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I spend a lot of free time finding out more about interesting topics that have been discussed in class.
  o Never or Only Rarely True  
  o Sometimes True  
  o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I work hard at my studies because I find the material interesting.
  o Never or Only Rarely True  
  o Sometimes True  
  o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I find it not helpful to study topics in depth. It confuses me and wastes time.
  o Never or Only Rarely True  
  o Sometimes True  
  o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I believe that teachers shouldn’t expect students to spend a lot of time outside of class studying material that won’t be turned in.
  o Never or Only Rarely True  
  o Sometimes True  
  o True about Half the Time  
  o Frequently True  
  o Always or Almost Always True  

I come to most classes with questions in mind that I want to be answered.
  o Never or Only Rarely True  
  o Sometimes True
I see no point in learning material that might not be on the test.

I find the best way to pass tests is to try to remember answers to questions that are likely to be asked.

How Do You Feel About Math?

Overall, how much do you enjoy math?

Overall, how would you judge your performance in math?

How do you feel when taking a big test in your math class?

How would you feel if you were given this problem? Aliyah had $24 to spend on seven pencils. After buying them she had $10. How much did each pencil cost?

How would you feel if you were given this problem? Mr. Jordan's 8th grade class has 12 girls and 15 boys. How many boys are in the class for every 4 girls?

How do you feel when getting your math book and seeing all the equations in it?
How would you feel when solving for \( n \) in \( 4n - 9 = -9 \)?

- Very Anxious
- Anxious
- Somewhat Anxious
- Not Anxious at All

How do you feel when figuring out if you have enough money to buy a candy bar and a soft drink?

- Very Anxious
- Anxious
- Somewhat Anxious
- Not Anxious at All

How would you feel when solving for \( x \) in \( 2(x + 9) + 8x = 24 \)?

- Very Anxious
- Anxious
- Somewhat Anxious
- Not Anxious at All

How do you feel when you get called on by the teacher to explain a math problem in class?

- Very Anxious
- Anxious
- Somewhat Anxious
- Not Anxious at All