

THREATS TO SUCCESS IN MATHEMATICS:
EXAMINING THE COMBINED EFFECTS OF CHOKING UNDER PRESSURE AND
STEREOTYPE THREAT

BY

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DISSERTATION

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ABSTRACT

Girls and boys do not choose to go into mathematics dependent careers at the same rate. Understanding this gap is more complicated than simply looking at performance differences between boys and girls. This disparity in career choice could stem from differences in motivation that can be seen as early as middle school. In this dissertation, I investigate three possible motivational factors that may contribute to the gender gap in achievement in mathematics. The study from which the data for each of these investigations come, was an experimental study looking at how stereotype threat and high pressure would impact the performance and motivation of high-achieving seventh- and eighth- grade students. I found that stereotype threat may not have an impact on the performance of middle school girls, that an ego-approach goal may be beneficial for gaining recognition as one of the top students in mathematics, and that students' view of their own femininity and masculinity in conjunction with their gender may be important factors to measure when looking at performance differences in mathematics. Taken together, these findings indicate that achievement motivation likely plays an important role in the performance of students in mathematics and may help to explain the gender gap. Understanding how these factors work to curb or support students' interest and performance in mathematics is necessary to create effective interventions to reduce the gender gap.

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TABLE OF CONTENTS

CHAPTER 1 OVERVIEW	1
CHAPTER 2 STEREOTYPE THREAT	6
CHAPTER 3 PEER ACADEMIC REPUTATION	37
CHAPTER 4 FEMININITY	64
CHAPTER 5 CONCLUSIONS	88
REFERENCES	91
APPENDIX.....	113

CHAPTER 1

OVERVIEW

Gender Gap in Mathematics: An Overview

Science, technology, engineering, and mathematics (STEM) fields are notorious for lacking diversity, especially in the upper echelons. One group that is consistently under-represented in these fields is women. We find that women do not participate and do not succeed at the same rate as men (e.g., Stewart, Malley, & LaVaque-Manty, 2007). For instance, in 2006, women made up less than 20% of full professors in STEM fields. In fact, in mathematics and physics, women made up less than 10% of full professors (NSF, 2006). Furthermore, the Congressional Committee on the Advancement of Women and Minorities in Science, Engineering, and Technological Developments (2000) found that even the select few women who did make it into the professoriate as tenure-track assistant professors in STEM fields were on average, half as likely as tenure-track men to obtain tenure. This trend exists even before women enter the workplace: women receive only about a fourth of the doctorates awarded in STEM fields, compared to approximately half of the doctorates in the social sciences (NSF, 2006). Taken together these findings indicate a dearth of women in STEM fields and a reduced likelihood of success for those who do enter these fields, as compared to their male counterparts.

During school, the pattern of gender differences is complex: The evidence for a difference in performance between boys and girls on mathematics tests is mixed, but it is clear that girls are doing just as well as boys in the classroom. Some have suggested that the gender difference in math test performance is shrinking or eliminated (Hyde, 2005; see also Halpern et al., 2007; Spelke, 2005; Hyde & Linn, 2006; Hyde et al., 2008). Others report that there are still persistent, albeit small, gender differences in test performance during school (College Board,

2009, 2010; Gibbs, 2010; Gonzales et al., 2008; McGraw, Lubienski, & Strutchens, 2006; Robinson & Lubienski, 2011). In fact, in a recent meta-analysis, Lindberg et al. (2010) found only a very small effect size of $d = 0.07$ for the difference between boys' and girls' performance on mathematics tests.

Although it still appears that high-achieving boys are outperforming high-achieving girls on mathematics tests, recent evidence has indicated that girls are doing just as well as and in some cases, outperforming, boys in the mathematics classroom (AAUW, 2008; Catsambis, 1994; Ding, Song, & Richardson, 2006; Pomerantz et al., 2002). From 1998 to 2005 girls and boys enrolled in advanced placement mathematics classes at equal rates (AAUW, 2008). Similarly, researchers have found that girls earned better classroom grades than boys in mathematics (Ding, Song, & Richardson, 2006; Pomerantz et al., 2002). Although this dichotomy between classroom performance and test performance in mathematics is curious, it may be explained by the fact that classroom grades and test scores do not measure the same facets of mathematics performance. Classroom grades tend to measure only material that is explicitly taught in the classroom and behaviors that are not related to mastery of the material such as effort, classroom behavior, and attendance (Friedman & Frisbie 2000; Ornstein 1994), whereas test scores tend to measure both mathematics that is taught in the classroom and mathematics that requires a new application of knowledge. .

Variability and Distribution Differences. Although there are only small or perhaps even negligible mean differences in performance between boys and girls on mathematics tests, many researchers have found that at the top end of the distribution, boys do significantly better than girls (Fiengold, 1992; Halpern et al., 2007; Hedges & Friedman, 1993; Hedges & Nowell, 1995; Hyde, Fennema, & Lamon, 1990; Lindberg et al., 2010). That is, the best-performing

boys are outperforming the best-performing girls. Strand, Deary, and Smith (2006) found that boys showed more variability in scores than girls on the mathematics section of the Scholastic Aptitude Test (SAT). In fact, Strand et al. (2006) found that in the top of the 4% of scorers, 60% were male. Similarly, McGraw et al. (2006) found the largest gender differences in achievement on the NAEP exam at the top end of the distribution. A recent meta-analysis (Lindberg et al., 2010) found that the effect size of the difference between high scoring boys and girls was a moderate $d = 0.40$. Taken together, these findings indicate that although mean differences in performance between boys and girls may be small, this difference increases as the achievement of the sample gets higher.

Why Motivation?

My motivation for seeking a Ph.D. in Educational Psychology was to understand why so many mathematically talented students decide not to pursue mathematics. In my application essay, I described three anecdotal trends that I had noticed while working with mathematics students: (a) students, even those who are talented, often identify themselves as “not good at mathematics” at an early age; (b) when students identify themselves as “not good at mathematics”, they tend to give up easier when attempting a hard problem than students who consider themselves good at mathematics; (c) The goal of students, particularly high-achieving students, who identify themselves as “not good at mathematics” often focus on getting good grades, but do not worry about understanding the material. At the time, I was not aware that the anecdotal observations I had made were actually fairly well established phenomena in the achievement motivation literature; I only knew that I wanted to understand how students begin to identify themselves as “not good in mathematics.” I reasoned that this early identification as

“not good at mathematics” took a career in mathematics off the list of possibilities for these students.

Understanding how and why mathematically talented students (particularly girls) come to the decision to opt out of mathematics has been the focus of my research career thus far and is the focus of this dissertation. Just like when I started graduate school, to me, the most interesting piece of this puzzle is how students begin to disidentify themselves with mathematics and what aspects of their personality enable or protect from this decision. For this reason, all three of the manuscripts included in this dissertation look at a different aspect of achievement motivation (stereotype threat in girls, peer academic reputation, and gender socialization) and how it may or may not impact the performance and/or identification with mathematics of high-achieving middle school students.

Present Investigations

This dissertation contains three manuscripts all using the same primary data set. This data set was collected from 21 advanced seventh- and eighth-grade mathematics classrooms in five different schools. The first investigation is a look at the effects of stereotype threat on middle school students. In this investigation, the findings from three stereotype threat experiments with middle school students are reported along with a review of all the extant literature on stereotype threat in childhood and adolescence. This investigation suggests the possibility that stereotype threat may not be as pervasive in childhood and adolescence as previously thought and that publication bias may be to blame.

The second paper in this portfolio investigates several potential correlates of peer academic reputation. In this investigation, gender, performance, achievement goals, and domain identification are tested as possible correlates of peer academic reputation. The findings suggest

that students use more than simply performance when deciding which of their peers have mathematical prowess.

The third investigation investigates the idea that gender identification may impact mathematics performance. In this investigation, gender, masculinity, and femininity are tests as potential correlates of academic performance. The findings indicate that on easy tasks, gender is a successful predictor of performance, but as tasks get more difficult, students' femininity becomes more salient, regardless of their gender.

Although seemingly quite different, each of the three studies included in this portfolio investigates a different facet of achievement motivation: stereotype threat, peer academic reputation, and gender socialization. They also have, at their base, a desire to understand the differences in motivation between boys and girls in mathematics and how these ultimately impact success in mathematics.

CHAPTER 2

STEREOTYPE THREAT

There is currently a debate in the literature with regard to whether or not the gender gap in mathematics achievement has closed (Corbett, Hill, & St. Rose, 2008; Entwisle, Alexander, & Olson, 2007; Hyde, 2005; Lindberg, Hyde, Peterson & Linn, 2011; Robinson & Lubienski, 2011). With regard to research on mathematics test performance, some studies have found no gender differences (Hyde, 2005; Spelke, 2005; Hyde & Linn, 2006; Hyde, Lindberg, Linn, Ellis, & Williams, 2008), while others have found small gender differences (College Board, 2009, 2010; Gibbs, 2010; Gonzales et al., 2008; McGraw, Lubienski, & Strutchens, 2006; Robinson & Lubienski, 2011). Importantly, recent research indicates a larger gap still exists at the top end of the distribution. That is, within the top part of the distribution, the highest performing boys significantly outperform the highest performing girls (Hedges & Friedman, 1993; Lindberg et al., 2010; Strand, Deary, & Smith, 2006).

In a recent meta-analysis, Lindberg and colleagues (2010) concluded that there are no overall gender differences in mathematics performance. However, their data suggest that small to medium-sized differences still exist in high school ($d = 0.23$) and with high ability students ($d = 0.40$). In a number of other studies, using a nationally representative dataset, researchers have shown that although there are no gender differences at kindergarten, gender differences develop by the third grade ($d = 0.24$; Fryer & Levitt, 2010; Penner & Paret, 2008; Robinson & Lubienski, 2011). In addition, these researchers found that the gender difference emerges earlier, and is often larger, in the upper tail of the distribution.

In contrast to the research on mathematics test performance, research on mathematics classroom grades shows that girls perform similarly or better than boys in the classroom across

all years of schooling (Corbett et al., 2008; Ding, Song, & Richardson, 2006; Pomerantz et al., 2002). Classroom grades provide a somewhat different measure of mathematics performance when compared to test scores. Grades measure mastery of material explicitly taught in school and are likely to reflect other non-academic skills that girls tend to possess at higher levels than boys (e.g., classroom behavior, conscientiousness; Friedman & Frisbie 2000; Ornstein 1994).

Taken together, this body of research reveals complex and sometimes conflicting results concerning gender differences in mathematics. Yet, despite the diversity of findings across ages and types of measures, we feel confident in saying that there is likely a small gender difference in mathematics test performance that may increase as students get older, and that this difference is larger in higher performing students. Because gender differences do not exist early on and tend to develop, it is important to understand the factors related to the progression of this gender gap in mathematics. If high achieving girls and boys begin on an even playing field in mathematics test performance, why do high achieving girls fall behind?

Researchers have posited a number of potential explanations for gender differences in mathematics performance and for the underrepresentation of women in mathematics- and science-related careers, including biological factors (e.g., Benbow & Stanley, 1980; Geary, 1996; Scarr & Satzman, 1982), social factors (e.g., Eccles, 1987; Eccles & Jacobs, 1986; Heller & Ziegler, 1996), and the interaction between biological and social factors (e.g., Halpern & Tan, 2001; Nuttall, Casey, & Pezaris, 2005). One of the key social factors that has been suggested as contributing to high achieving women's underperformance on mathematics tests is stereotype threat (Steele, 1997; Steele & Aronson, 1995). Yet, as reviewed below, empirical evidence concerning the effects of stereotype threat is inconsistent for adults (Nguyen & Ryan, 2008; Stoet & Geary, 2012) and for children and adolescents (e.g., Ambady, Shih, Kim, & Pittinsky,

2001; Dinella, 2004; Huguet & Regner, 2007, 2009; Stricker & Ward, 2004).

Stereotype Threat Theory and Gender Differences in Mathematics Performance

Stereotype threat is a phenomenon whereby certain groups of people are affected by an unconscious fear of confirming a negative stereotype concerning their performance in a particular domain (e.g., that men are better than women in mathematics). The idea is that women, when the stereotype is primed prior to taking a mathematics test, perform worse on the test than women in a situation without the priming of the stereotype, whereas men perform equally in both conditions (Schmader & Johns, 2003; Spencer, Steele, & Quinn, 1999; Steele, 1997). Consistent with the notion of stereotype threat, women in a stereotype nullification condition, in which they are presented with information that is inconsistent with the stereotype (e.g., about girls doing as well as boys in mathematics), could be expected to perform better than women in normal or stereotype-threat conditions (e.g., Smith & White, 2002).

Conditions under which stereotype threat effects occur. In discussing stereotype threat effects, it is important to address for whom and under what conditions these effects occur. Past research with college students has suggested that to be impacted by stereotype threat, women must be *identified with mathematics* and take a *difficult mathematics test* in an *evaluative* situation in which their *gender is made salient*.

Identification with mathematics. Steele (1997) proposed that stereotype threat affects people who identify with the domain in question (in this case, women who are identified with mathematics; Forbes, Schmader, & Allen, 2008; Jamieson & Harkins, 2007; Smith & White, 2001). Research with high school and college students shows that women who are at least moderately identified with mathematics are more susceptible to stereotype threat effects than those who are not mathematics-identified (Keller, 2007; Nguyen & Ryan, 2008; Smith & White,

2001). Domain identification in mathematics involves two components: feeling that you are good at mathematics, and feeling that it is important to you to be good at mathematics (Smith & White, 2001). The reason that domain identification is necessary for someone to be affected by stereotype threat is because if a person is not identified with the domain, the idea that a group they belong to might underperform on a task in that domain is not threatening to them.

Testing conditions. Researchers suggest that three testing conditions must be met for stereotype threat to impact women's mathematics performance: (1) the situation in which the test is taken must be evaluative in nature, (2) gender must be made salient, and (3) the mathematics assessment administered must be difficult. Tests that are introduced as evaluative, or indicative of one's ability, lead to the feeling that poor performance on the test indicates low ability (Aronson & Steele, 2005; Good & Aronson, 2008; Steele, 1997). This, combined with one's gender being made salient, leads women to believe that if they perform poorly on the test, they are at risk of confirming the negative stereotype about women and mathematics (Good & Aronson, 2008; Steele, 1997). Note that gender can be made salient in a number of ways—mentioning gender differences, marking one's gender, or taking the test in a mixed-gender group. The effects of these feelings are more salient when women are taking difficult tests for two reasons. First, women are more likely to perform poorly on these assessments, making their fear of confirming the stereotype more plausible (Neuville & Croizet, 2007; O'Brien & Crandall, 2003; Spencer et al., 1999; Steele, 1997). Second, more difficult tests contain items that require more processing in working memory, and since working memory appears to be compromised when students are under stereotype threat (Cadinu, Maass, Rosabianca, & Kiesner, 2005; Schmader & Johns, 2003; Schmader, Johns & Forbes, 2008), performance on items that require more working memory resources would suffer more than performance on those items requiring

fewer working memory resources (Quinn & Spencer, 2001; Schmader & Johns, 2003). These characteristics of the participants and testing situation are critical when examining stereotype threat.

Stereotype Threat Effects in Childhood and Adolescence

Much research has been conducted investigating stereotype threat in samples of college women (see Nguyen & Ryan, 2008). Although researchers often consider stereotype threat to be a well-established phenomenon in college women a recent review and meta-analysis calls the strength of this phenomenon into question, suggesting that claims that stereotype threat is a robust phenomenon are exaggerated (Stoet & Geary, 2012). Taken together, it appears that stereotype-threat effects do affect some women in some specific situations, although the findings are less consistent than previously thought. We have even less of an understanding of the nature of stereotype threat effects in childhood and adolescence (Good & Aronson, 2008). Knowing when stereotype threat occurs can provide evidence to suggest the most appropriate ages at which to target interventions designed to alleviate the effects of stereotype threat.

Developmental requirements. It has been posited that for stereotype threat to exert an impact on girls' mathematics performance, several cognitive and social-cognitive abilities are needed to enable individuals to understand the implications of negative stereotypes. Specifically, Aronson & Good (2003) suggest four necessary developmental conditions for girls' mathematics performance to be impacted by stereotype threat. Girls must (1) be aware of gender stereotypes, (2) understand the societal and personal implications of these stereotypes, (3) have a sufficiently developed gender identity, and (4) have a well-formed conception of academic ability. These authors argued that these developmental requirements emerge around the time students begin middle school (age 11-12). However, some evidence suggests that many of these factors emerge

earlier in development (e.g., Cvencek, Meltzoff, & Greenwald, 2011; Levy & Carter, 1989; Nicholls, 1978). A number of researchers have sought to examine stereotype threat effects across childhood and adolescence, but this work has not come to a clear conclusion with regard to particular ages at which stereotype threat effects occur.

Empirical findings. The evidence for stereotype threat effects for girls in mathematics across elementary, middle, and high school is inconsistent. Some studies report evidence of stereotype-threat effects with girls as young as kindergarten (Ambady et al., 2001; Tomasetto, Alparone & Cadinu, 2011), whereas others have not found these effects even in high school girls (e.g., Cruz-Duran, 2009; Stricker & Ward, 2004). We have summarized the findings from the extant research on the effects of stereotype threat on girls' mathematics performance, including the studies reported in the present paper and unpublished dissertations in Table 1. Stereotype threat activation methods for each study can be found in Table 2.

Before discussing the findings summarized in Table 1, we would like to make several points concerning our approach to interpreting the analyses reported in prior studies. First, some studies have reported marginal findings ($.08 < p's < .12$) as indicative of stereotype threat effects; however, we consistently used a significance level of .05 across studies in our interpretations of their findings. Second, we included in Table 1 a separate column indicating whether the study involved both girls and boys because we view this as an important issue in understanding stereotype threat effects. Several of the reviewed studies included only girls. This leaves open the possibility that boys would show the same difference in performance between the two conditions, preventing us from concluding that the observed difference in performance as a function of stereotype threat is unique to girls (Stoet & Geary, 2012). Thus, we obtain stronger

evidence from studies with both genders because we can deduce both that there is a stereotype threat effect for girls and that there is not one for boys.

From a statistical perspective, we interpret findings as showing stereotype-threat effects only if certain conditions are met. For studies involving both boys and girls, we require there to be a significant interaction between gender and stereotype threat condition. Further, for all studies, we require there to be a significant difference between girls in the stereotype-threat condition and girls in the no-threat condition. If a study involving both gender groups finds a significant interaction but not a difference between the girls in the two conditions, it may mean that the interaction is pulled by an opposite performance pattern in boys, preventing one from making strong conclusions about stereotype-threat effects on girls.

Lower elementary school. Among studies investigating stereotype-threat effects in lower elementary school students, one study found stereotype-threat effects (Ambady et al., 2001), two studies report mixed results (Neuville & Croizet, 2007; Tomasetto et al., 2011), and one study did not find effects (Muzzatti & Agnoli, 2007). Neuville & Croizet (2007) found that stereotype threat only had a negative effect on performance on difficult test items, and that it actually led to increased performance on easy items. Tomasetto and colleagues (2011) found that girls whose mothers neither accepted nor rejected the gender stereotype about mathematics were susceptible to stereotype threat effects but girls whose mothers rejected the stereotype were not affected.

Upper elementary school. Two published studies and one unpublished dissertation have examined stereotype threat effects in upper elementary school students (Ambady et al., 2001; Good, 2001; Muzzatti & Agnoli, 2007). Stereotype threat effects were not found in any of these studies. In fact, Ambady and colleagues (2001) found that girls of this age in the stereotype threat condition performed better than girls in the no-threat condition.

Middle school. Three published studies have shown evidence of stereotype threat effects during middle school (Ambady et al., 2001; Huguet & Regner, 2009; Muzzatti & Agnoli, 2007 Experiment 2), one published study shows mixed results (Huguet & Regner, 2007 Study 2), and one published study (Huguet & Regner, 2007 Study 1) and one unpublished dissertation (Good, 2001) showed no evidence of a stereotype threat effect. Huguet and Regner (2007; Study 2) found that girls who completed the task in a mixed-gender setting were impacted by stereotype threat but those taking it in a same-gender setting were not.

High school. For high school students, two published studies found mixed results (Keller, 2007; Picho & Stephens, 2012), one published study found unclear results (Stricker & Ward, 2004), and one published and two unpublished dissertations found no effect (Cruz-Duran, 2009; Dinella, 2004; Keller & Dauenheimer, 2003). Keller (2007) found that stereotype threat led to poorer mathematics performance for girls who were highly mathematics-identified on difficult items. Picho and Stephens (2012) found stereotype-threat effects among girls attending co-educational schools in Uganda but not among girls attending single-sex schools.

The results are unclear for a study that examined stereotype threat with high school students taking actual Advanced Placement (AP) Calculus tests (Stricker & Ward, 2004). The researchers did not find stereotype threat effects. However, Danaher and Crandall (2008) later argued that although the findings were statistically non-significant, they may still have practical significance. These researchers reanalyzed Stricker and Ward's (2004) data and found that inducing stereotype threat by inquiring about gender before the test resulted in 6% fewer girls receiving a score of 3 or higher, meaning that 3,000 fewer girls receiving college credit for AP scores. Therefore, it can be argued that stereotype-threat effects, although not statistically

significant, might be practically important for high school students in real-world high-stakes testing environments.

Purpose of the Present Research

Given the inconsistent evidence in extant research, our aim was to further investigate stereotype threat effects on mathematics performance in children and adolescents in the United States. We conducted three studies, two with young adolescents and a third with children, younger, and older adolescents.

We used evidence from stereotype-threat theory to inform our choices with regard to sampling, activation methods, and mathematics assessments. First, we chose higher performing participants because they were more likely to be identified with mathematics and were thus more likely to be susceptible to stereotype threat effects (Forbes et al., 2008; Smith & White, 2001; Steele & Aronson, 1995). Second, the testing situations were designed to both make gender salient and be evaluative (Aronson & Steele, 2005; Good & Aronson, 2008; Steele, 1997). Third, in each study we used fairly difficult mathematics assessments (Neuville & Croizet, 2007; Nguyen & Ryan, 2008; O'Brien & Crandall, 2003; Spencer et al., 1999; Steele, 1997).

Study 1

Study 1 was conducted with middle- and high-performing eighth-grade students. In this study, boys and girls were assigned to either a stereotype threat condition or a stereotype nullification condition using a randomized block design. Students in the stereotype-threat condition were shown a video that presented fictitious scientific evidence showing that mathematics intelligence is fixed and that girls have lower levels of this type of intelligence. Students in the stereotype nullification condition were shown a video that presented evidence that the brain is malleable and that boys and girls have equal levels of mathematics ability.

Method

Participants. Participants were 212 (102 boys, 110 girls) middle- and high-performing eighth-grade students (13-14 years old) from three small urban schools with about 15-45% of the student body eligible for free or reduced price lunch. These middle and high performing students were identified based on course enrollment, standardized test scores, and classroom grades. The ethnic make-up of the sample was 85.4% Caucasian, 6.1% African American, 1.4% Hispanic, 0.9% Asian American, and 3.8% other.

Stereotype-threat manipulation. Before taking the test, students were shown one of two videos, which activated stereotype threat or nullified it. These videos adopted imagery similar to that used by Dweck and her colleagues in their Brainology® program (Dweck, 2008). The video shown to the stereotype threat group depicted a scientist telling students that recent research “shows that math intelligence levels among students do not change as students get older. Students are born with a certain amount of natural math ability which does not change.” Students were then shown brain imagery and were given a detailed explanation regarding how some students are born with better mathematics skills (as indicated by more brain activity). In this condition, the students were also told that “females have lower levels of this kind of brain activity than males. This makes sense because girls often get lower scores on standardized tests compared to boys.” These students were also told that the “test that you will take today is a *very* good measure of your natural math ability.”

Conversely, the video shown to the stereotype nullification group depicted a scientist telling students that recent research “shows that among students, such as yourselves, math ability levels can and do change as students get older. We are finding that math ability is not just something you are born with. Math ability grows with practice, just like exercise strengthens

your muscles. Students are capable of learning and mastering new math concepts at any time in their lives”. Students were then shown brain imagery and were given a detailed explanation regarding how learning mathematics can change the brain and increase brain activity over time. In this condition, students were also told that “males and females have equal levels of this kind of brain activity. This makes sense because young men and women, like yourselves, score the same on standardized math tests.”

Mathematics test. Each participant was given a mathematics test consisting of 30 retired items (mean percent correct = 65%) from the eighth-grade mathematics section of a state NCLB accountability assessment, the Large Midwestern Achievement Test (LMAT). Each of the items on the LMAT assessed one or more of the mathematics state learning standards. The reliability estimate for the test was high ($\alpha = .90$; Cronbach, 1951).

Procedure. Prior to the test day, participants were randomly assigned to either the stereotype threat or stereotype nullification condition using a blocking design based on their gender, seventh-grade standardized test scores, and grades. Students in the two groups were tested in separate classrooms. The students watched the video that either activated stereotype threat or nullified the stereotype and then completed the mathematics test. The testing session took approximately 40 minutes.

Results and Discussion

To investigate the effects of stereotype threat, we ran a factorial analysis of variance (ANOVA) with two between-subject variables: stereotype threat condition (stereotype threat, stereotype nullification) and gender (girls, boys). The dependent variable was the percent of items answered correctly on the mathematics test.

The interaction between gender and stereotype threat was not significant, indicating that there was no stereotype threat effect, $F(1, 208) = 0.40, p = .53$ (Table 3). The effect sizes for the differences between performance in the two condition are $d = 0.14$ for girls and $d = 0.00$ for boys. Note that a positive effect size indicates that the stereotype-threat group performed better and a negative effect size indicates that the stereotype-threat group performed worse. The main effect of stereotype threat was also not significant, $F(1, 208) = 0.21, p = .65$. There was, however, a significant main effect of gender with boys outperforming girls, $F(1, 208) = 6.23, p = .01$. The effect size for this gender difference was $d = 0.34$.

A follow-up analysis focusing only on more difficult items (items with less than 50% correct; 6 items; 16.4% of participants incorrectly answered all 6 problems) revealed the same pattern of findings: in particular we found no significant interaction between gender and stereotype threat (the effect size for the comparison between girls in the two groups was $d = .01$). We attempted another follow-up analysis, with only students who are mathematics identified. We selected students whose mathematics identification was above the midpoint of a mathematics identification scale; however, only 3 participants (1.4%) had mathematics identification below the midpoint, so this analysis was unnecessary as the sample was almost exclusively identified with mathematics.

In summary, in Study 1, we found no evidence of a stereotype threat effect (even on the most difficult items and for math-identified students) when a stereotype threat condition was compared to a stereotype threat nullification condition. However, there was a main effect of gender, indicating that the girls in this study underperformed compared to boys regardless of the condition under which they took the test.

Study 2

The second study was conducted with high-achieving seventh- and eighth-grade students. In this study, participants were randomly assigned to stereotype-threat and no-threat conditions and given a very difficult mathematics test (to increase the likelihood that effects of stereotype threat on performance would be found). As in Study 1, the stereotype threat activation method was explicit, but it was more similar to methods used in past research than the activation method used in Study 1 (e.g., Keller, 2007; Keller & Dauenheimer, 2003).

Method

Participants. Participants were 224 (105 boys, 119 girls) seventh-grade students (12-13 years old) and 177 (82 boys, 95 girls) eighth-grade students (13-14 years old) in advanced mathematics classes. Participants were recruited from five schools in a small urban community and the surrounding areas: four regular-education public middle schools and 1 selective-admission public laboratory high school. In these schools 17.7% to 73.4% of the students were eligible for free or reduced price lunch. The ethnic make-up of the sample was 65.0% white, 12.4% Asian, 13.6% African American, 4.4% Latino, and 1.7% other.

Stereotype-threat manipulation. In the stereotype-threat condition, participants read instructions just before they took the exam that stated “please be sure to put an “X” on the line next to your gender on the cover of the test booklet. This is very important, as boys have done much better than girls on this test in the past.” In the no-threat condition, the students were given only instructions pertaining to the test.

A manipulation check was included to ensure that students in the stereotype threat condition were aware of the statement about gender differences. Eighty-seven percent of students

indicated that the instructions said that boys have performed better on this test in the past, indicating that the manipulation was successful.

Mathematics test. Students were given a mathematics test containing 13 open-ended questions taken from a larger set of SAT problems. The problems represented three different difficulty levels (based on pilot testing): 4 were medium, 4 were difficult, and 5 were challenge problems. The questions of each difficulty level were interspersed within the test, not in a particular order. Students were instructed to show their work and not to use calculators. The problems covered subject areas such as basic algebra, geometry, and arithmetic. The reliability estimate for the test was .87.

Procedure. Participants in each classroom were randomly assigned to one of two testing conditions: stereotype threat and no-threat. Once condition was assigned, students were told that the test measured their problem-solving ability and asked to read the instructions on the front cover of the testing packet. Once the instructions were read, the students were given 25 minutes to complete the mathematics test.

Results and Discussion

To investigate the effects of stereotype threat, we ran a factorial ANOVA. There were three between-subject variables: stereotype threat condition (stereotype threat, no-threat), gender (girls, boys) and grade (seventh, eighth). The dependent variable was the percent of mathematics test items answered correctly. Both grades were included in the same analysis because the students took the same mathematics test, although the test was much more difficult for the seventh-grade students ($M = 24\%$) than the eighth-grade students ($M = 34\%$).

The two-way interaction between gender and stereotype threat, $F(1, 393) = 2.93, p = .09$, $d_{girls} = 0.03$, $d_{boys} = -0.04$ and the three-way interaction between gender, stereotype threat, and

grade, $F(1, 393) = 1.45, p = .23, d_{seventhgirls} = 0.28, d_{eighthgirls} = -0.16, d_{seventhboys} = -0.30, d_{eighthboys} = -0.21$, were not significant (see Table 4), indicating that there was no stereotype-threat effect overall and that it did not differ by grade. Although the interaction between gender and stereotype threat was marginally significant, the pattern was not in the expected direction. We found a significant main effect of grade, $F(1, 393) = 30.04, p < .001$, such that the eighth graders performed better than the seventh graders, as would be expected. The main effects of gender, $F(1, 393) = 0.32, p = .57$, and stereotype threat, $F(1, 393) = 0.70, p = .40$ were not significant. The two-way interactions between stereotype threat and grade, $F(1, 393) = 0.92, p = .34$, and gender and grade, $F(1, 393) = 0.17, p = .68$, were also not significant, showing that gender and stereotype threat effects did not differ by grade.

To address the possibility that these very difficult test items did not reveal stereotype threat effects due to a floor effect, we ran the analysis with only the easiest items (50% or more correct; 3 items; 3.2% of participants incorrectly answered all 3 problems). This analysis revealed the same pattern, there was no stereotype threat effect ($d_{girls} = 0.04$). We attempted another follow-up analysis, with only students who are mathematics identified. We selected students whose mathematics identification was above the midpoint of a mathematics identification scale; however only 3 participants (0.75%) had mathematics identification below the midpoint, suggesting that the original sample of students was almost exclusively identified with mathematics and therefore this additional analysis was unnecessary.

Overall these results are similar to those of Study 1: there was also no evidence of a stereotype threat effect in Study 2. However, unlike Study 1, there was no main effect of gender on mathematics performance.

Study 3

In the third study, a larger sample of ages was investigated (fourth-, eighth- and twelfth-grade students). This larger age span can help us understand how stereotype threat effects might vary across ages when students are presented with the same stereotype threat activation. In this study, boys and girls were randomly assigned to stereotype-threat and no-threat conditions, and given a mathematics test. An implicit stereotype threat activation method was used (modeled after Muzzatti & Agnoli, 2007).

Method

Participants. Participants were 68 (39 boys, 29 girls) fourth-grade students (9-10 years old), 105 (40 boys, 65 girls) eighth-grade students (13-14 years old), and 145 (69 boys, 76 girls) twelfth-grade students (17-18 years old). Participants were recruited from five high performing (based on state standardized test scores) suburban schools in New England. In these schools 3.5% to 18.6% of the students were eligible for free or reduced-price lunch.

Stereotype-threat manipulation. The stereotype threat manipulation was done as part of the introduction to the testing session in the form of a sample mathematics problem. In the stereotype threat condition, the sample problem portrayed a situation in which a much larger proportion of boys than girls received a mathematics award or were chosen for the mathematics team based on their performance on a mathematics test. For example, eighth graders read the sample word problem stating: “At the Miller Middle School, the boys were much better at math than the girls. The math teachers chose the 20 students with the highest math test scores for the math team to represent the school at the statewide math competition. Eighteen of the students were boys and two were girls. What proportion of the students on the math team were boys?”

In the no-threat condition, students were presented with a sample problem about a topic unrelated to gender or mathematics (i.e., groups of students attending a field trip). For example, eighth graders read: “At the Miller Middle School, students were invited to participate in a special field trip, but there were only 20 spots available. The teachers chose 18 students from Ms. Fletcher’s homeroom and two other students from Ms. Johnson’s homeroom. What proportion of the students going on the field trip were from Ms. Fletcher’s homeroom?”

Students then chose the correct answer to the mathematics problem from among five choices. In the no-threat condition, the students were told that they were going to do some *mathematics problems*, whereas in the stereotype threat condition students were told they would be taking a *mathematics test*. This was done to make the mathematics assessment seem more evaluative in the stereotype threat condition, which has been shown to increase stereotype threat effects (Aronson & Steele, 2005; Good & Aronson, 2008; Steele, 1997). The mathematical knowledge required for the sample problem was different for each grade level, so as to make it age-appropriate. At each grade level, the computational task required to solve the sample problem was identical in the two conditions (Muzzatti & Agnoli, 2007).

Mathematics test. The mathematics test was made up of 12 multiple-choice items sampled from NAEP, TIMSS, and Massachusetts Comprehensive Assessment System (MCAS) mathematics assessments for fourth, eighth, and twelfth grades. Students completed a block of six algebra problems and a block of six geometry/measurement problems. The order of the blocks was counterbalanced across students within each experimental condition. Fourth and eighth graders were given five minutes to complete each section and twelfth graders were given six minutes for each section. Students’ mathematics scores were calculated as the proportion of items answered correctly (fourth grade $M = 66\%$, eighth grade $M = 61\%$, twelfth grade $M =$

51%). The reliabilities for the mathematics test were moderate at each grade level (fourth grade: $\alpha = .80$, eighth grade $\alpha = .67$, twelfth grade $\alpha = .64$).

Procedure. Students were randomly assigned to either the stereotype threat or no-threat condition. They were separated into two groups based on condition, and each group was tested in a separate room. Instructions, including the sample mathematics problems, were read aloud by the researcher as the students followed along. First, students read the sample word problem that either activated stereotype threat or did not. Then they answered the mathematics question embedded in the word problem. Then the students completed the mathematics test for their grade level. The testing session took approximately 15-20 minutes.

Results and Discussion

To examine the effects of stereotype threat, three factorial ANOVAs were run, one at each grade level. The analyses were run separately for each age group because students completed different mathematics tests at each grade. Stereotype threat condition (stereotype threat, no-threat) and gender (girls, boys) were between-subject variables. The dependent variable was the percent of mathematics items answered correctly.

At all three grade levels, the interaction between gender and stereotype threat was not significant (see Table 5), indicating that there were no stereotype-threat effects at any grade level, fourth grade $F(1, 64) = 0.00, p = .99, d_{girls} = 0.17, d_{boys} = 0.28$; eighth grade $F(1, 101) = 0.27, p = .61, d_{girls} = 0.14, d_{boys} = -0.05$; twelfth grade $F(1, 141) = 0.87, p = .35, d_{girls} = -0.27, d_{boys} = 0.00$. The main effect of stereotype threat was also not significant at any grade level, fourth grade $F(1, 64) = 0.69, p = .41$; eighth grade $F(1, 101) = 0.06, p = .80$; twelfth grade $F(1, 141) = 0.55, p = .46$. There were, however, significant main effects of gender at each grade with boys outperforming girls in fourth grade $F(1, 64) = 4.57, p = .04$; eighth grade $F(1, 101) = 6.13, p =$

.02; and twelfth grade $F(1, 141) = 10.63, p = .001$. An examination of effect sizes at each grade level shows that gender differences were similar in magnitude at all three grades (fourth $d = 0.59$; eighth $d = 0.51$; twelfth $d = 0.54$).

Follow-up analysis focusing only on the most difficult items (with less than 50% correct; 2 items at fourth grade, 5 items at eighth grade, 6 items at twelfth grade; 37% of fourth graders, 10% of eighth graders, and 7% of twelfth graders incorrectly answering all difficult problems) revealed the same pattern of findings. In particular, there was no significant interaction between gender and stereotype threat (the effect size for the comparison between girls in the two conditions was $d = 0.31$ at fourth grade, $d = 0.11$ at eighth grade, $d = -0.41$ at twelfth grade). We conducted another follow-up analysis only with students (fourth grade $N = 60$, eighth grade $N = 78$, twelfth grade $N = 120$) with high levels of mathematics identification (greater than the midpoint on a mathematics identification scale) and we found no evidence of a stereotype threat effect (the effect size for the comparison between girls in the two conditions was $d = 0.08$ at fourth grade, $d = 0.22$ at eighth grade, $d = -0.43$ at twelfth grade).

Consistent with Studies 1 and 2, Study 3 found no evidence of a stereotype-threat effect. Similar to Study 1, girls underperformed compared to boys in both conditions. One aspect of this study that is different from Studies 1 and 2 is the fact that the stereotype was implicitly activated. The word problem activates the stereotype in a much subtler way than explicitly stating that girls are not as good as boys in mathematics. Although this may make stereotype threat more difficult to induce, some studies with children have found stereotype threat with subtle activation methods (e.g., Ambady et al., 2001; Muzzatti & Agnoli, 2007).

General Discussion

The present work adds to our understanding of stereotype-threat effects in children and adolescents. The three studies put girls in a situation where, if stereotype-threat effects occur at their age, they would be likely to experience it; however, stereotype-threat effects were not found in any of the three studies. Below we discuss our findings in the context of the existing literature.

Summary of Findings: Past Research and the Current Studies

An examination of Table 1, which summarizes results from published studies, unpublished dissertations, and the current three studies, shows how much inconsistency there is in the findings on stereotype threat in children and young adolescents. Note that we could not perform a meta-analysis because of the small number of available empirical investigations – there were 14 papers (including the present one) with 36 individual tests of stereotype threat across four age groups, making meta-analyses with age as a factor inappropriate. In addition, many studies did not report enough information with which to calculate effect sizes. We encourage researchers to include means, standard deviations and sample sizes for each cell so that studies can be better utilized in future meta-analyses as the research base grows larger.

Instead of a formal meta-analysis, we have summarized the results across the literature by examining the percentage of findings (within and across age groups) that revealed stereotype threat effects. We did this in two ways. First, we calculated the percentage of significant results for the *individual tests* (a total of 36) reported in the literature. In this analysis, if the results showed that stereotype threat effects interacted with another variable, we considered results separately for different levels of that variable. For example, when a study found that mathematics identification was an interaction variable, we examined the results for math-identified and not-identified individuals as 2 separate tests. This analysis showed that for early elementary school, 3

out of 6 tests showed a stereotype threat effect (50%), for upper elementary school, none of the 9 tests (0%) showed an effect, in middle school, 4 of the 10 tests (40%) revealed an effect, and at the high school level, 2 out of 11 (18%) tests found stereotype threat effects. Across age groups, 25% of the 36 tests conducted found stereotype threat effects.

Another way to summarize the existing findings is by looking at them at the level of the paper rather than looking at the individual tests included. As indicated earlier, we identified 14 published and unpublished papers that examined the issue of stereotype threat effects in children and adolescents. It should be noted that some of these studies investigated more than one age group and in this analysis we examined the findings for each age group separately (thus papers in which stereotype threat effects were tested across multiple age groups are included more than once—once for each age group). Looking at the studies examining stereotype threat in early elementary school, 3 out of 4 studies (75%) revealed a stereotype threat at least for some students or under certain manipulations. None of the 4 studies (0%) in upper elementary school, 4 out of 6 studies (67%) in middle school and 2 out of 7 studies (29%) in high school found stereotype threat effects. Overall, 43% of studies found stereotype threat effects (when counting each age group in a study as a separate study).

When comparing published and unpublished papers (excluding the current studies) we find that 8 out of 10 (80%) published articles found at least one instance of a stereotype-threat effect. Among the published articles, the non-significant findings were almost always reported in an article along with some significant stereotype threat effects found either at another age (Ambady et al., 2001; Muzzatti & Agnoli, 2007), only with certain students (Keller, 2007), on certain items (Neuville & Croizet, 2007), or in certain contexts (Huguet & Regner, 2007 Study 2; Picho & Stephens, 2012; Tomasetto et al., 2011). Interestingly, none of the three unpublished

dissertations showed a stereotype threat effect. This observation suggests the possibility that publication bias is occurring. Publication bias refers to the fact that studies with null results are often not written up for publication or accepted for publication (Begg, 1994). This bias is a serious concern, especially if these results are being used to make recommendations for interventions.

Potential Explanations for Not Finding Stereotype Threat Effects and Future Directions

We offer two potential explanations for why stereotype threat effects are not consistently found in the literature. First, it is possible that stereotype threat has a limited effect on children and adolescents and that it takes some specific conditions to elicit this effect. Second, stereotype threat may be always present for school age girls unless mitigated, and thus may affect performance in both conditions, regardless of the experimental manipulation. In discussing these potential reasons, we will also discuss directions for future research in each area.

Potential that stereotype threat has a limited effect. It is possible that stereotype threat has a limited effect on girls' mathematics performance and manifests itself only under specific conditions. However, it is unclear what exactly those conditions are, because in many cases researchers have taken into account the factors currently known to induce stereotype threat and have not found an effect. In future research, it is critical to determine whether there are particular factors that could reliably produce stereotype-threat effects in children and adolescents. Once these factors are identified, we can focus on them when thinking about intervention approaches.

Activation methods. An important issue is the particular experimental manipulation employed. At present, studies with children and adolescents have reported a variety of methods ranging from subtle, implicit manipulations aimed at activating students' gender awareness (e.g., by having them mark their gender or asking them gender-related questions before taking the test)

to more explicit, almost blatant, ways of activating the stereotype (e.g., by telling students prior to taking the test that boys do better than girls on this test). The studies reported here used three different stereotype activation methods, all of which were designed based on the findings of past research, and none of these produced stereotype-threat effects.

To understand better the stereotype-threat manipulations that may provoke stereotype-threat effects in children and adolescents, future research could benefit from systematically testing different activations methods in the same sample. Large-scale studies that use multiple stereotype manipulations (and a no-threat condition), keeping all other experimental conditions equal, would help to tease apart which activation methods are most likely to lead to stereotype-threat effects during childhood and adolescence.

Study populations. In addition to the particular stereotype-threat-activation method, it is important to consider the characteristics of the population being studied. Although past research with adult women has found that mathematics identification is an important factor, some studies with math-identified children and adolescents, including the present studies, still do not find effects (e.g., Dinella, 2004). Perhaps other factors are also important. For example, Tomasetto and colleagues (2011) found that stereotype threat impacted the mathematics performance of girls whose mothers held neutral gender stereotypes about mathematics but not girls whose mothers reject the gender stereotype about mathematics. It may be useful to follow up this finding to determine whether mothers' characteristics predict their daughters' behavior under stereotype threat (i.e., if we take a sample of children and collect information about their mothers' stereotyping, we should be able to predict how the children will respond to stereotype threat).

Potential that stereotype-threat effects are always occurring. In two of the three studies reported here, gender differences were found on the mathematics tests across conditions. Thus, although we did not observe a difference in girls' performance between the two conditions, there is still a possibility, pointed out by some researchers, that stereotype threat impairs girls' mathematics performance in any mathematics testing situation (Smith & White, 2002; Steele, 1997). Perhaps the testing situation in general activates stereotype threat that occurs in everyday testing environments, regardless of the added manipulation or the nullification of the stereotype.

If stereotype threat effects occur all the time, it should be the case that girls who are in a stereotype nullification condition do better than both girls in a stereotype threat and a no-threat conditions (see Smith & White, 2002). To date, only three studies, including Study 1 of the present manuscript, have used a stereotype threat nullification condition with children or adolescents (Keller, 2007; Keller & Dauenheimer, 2003). In the present Study 1, girls in the stereotype nullification condition did not perform better than girls in the stereotype threat condition, which potentially raises questions about the idea of whether stereotype threat occurs all the time. One of the prior studies with adolescents found a positive effect of the stereotype threat nullification condition compared to a stereotype threat condition (Keller, 2007) but one did not (Keller & Dauenheimer, 2003). Due to these inconsistent findings, future research should include a stereotype nullification condition in addition to the stereotype threat and no-threat conditions in order to better understand the nature of this phenomenon.

This explanation is also somewhat at odds with the fact that girls earn similar or better mathematics classroom grades, which are made up at least in part by test scores (Corbett et al., 2008). If girls are earning similar or better grades, could they be suffering from stereotype threat in *every* testing situation? There are two possible ways that these ideas could coexist. First,

because stereotype threat only effects performance on difficult items, and classroom tests may not contain a large portion of difficult items, stereotype threat effects may not occur on these particular tests. Second, it is possible that girls perform more poorly on class mathematics tests class than boys, however other factors taken into account when assigning grades (e.g., homework completion, effort) could lead to girls obtaining better grades despite poorer test performance.

Conclusion

Taken together, the findings from published research, unpublished manuscripts, and the present studies reveal inconsistency in the effects of stereotype threat on girls' mathematics performance. The discrepancy in results from published and unpublished studies suggests publication bias, which may create an inaccurate picture of the phenomenon. A recent review suggests that this publication bias may also be an issue in the literature on stereotype threat in adult women (Stoet & Geary, 2012). Overall, these results raise the possibility that stereotype threat may not be the cause of gender differences in mathematics performance prior to college. Although we feel that more nuanced research needs to be done to truly understand whether or not stereotype threat impacts girls' mathematics performance, we also believe that too much focus on this one explanation may deter researchers from investigating other key factors that may be involved in gender differences in mathematics performance. For example, there are a number of factors (e.g., mathematics anxiety, mathematics interest, spatial skills; see Ceci & Williams, 2010) that have been shown to be more consistently related to mathematics performance and STEM career choices and may warrant more research attention than does stereotype threat.

Table 1

Summary of Research on Stereotype Threat in Childhood and Adolescence

Study	Population	Grade	Age (years)	Stereotype Threat Effect Found	N (girls)	d^{ab}	Male comparison
<i>Lower Elementary School</i>							
Ambady et al. (2001)	US (Asian-American)	K-2	5-7	Yes	20 ^c		No
Muzzatti & Agnoli (2007) Exp 1	Italy	2	7-8	No	34	0.05	Yes
Neuville & Croizet (2007)	France	2	7-8	Yes, difficult items No, easy items	45	-0.62 0.62	Yes
Tomasetto et al. (2011)	Italy	K-2	5-8	Yes, when mom has no stereotype No, when mom rejects stereotype	Total: 124		No
<i>Upper Elementary School</i>							
Ambady et al. (2001)	US (Asian-American)	3-5	8-10	No (opposite effect)	29 ^c		No
Study 3	US	4	9-10	No	29	0.17	Yes
*Good (2001)	US	4, 5	9-11	No	4 th : 22 5 th : ≈17		Yes
Muzzatti & Agnoli (2007) Exp 1	Italy	3, 4, 5	8-11	No	3 rd : 68 4 th : 64 5 th : 42	0.23 0.13 -0.43	Yes
Muzzatti & Agnoli (2007) Exp 2	Italy	3, 5	8-9, 10-11	No	3 rd : 44 5 th : 48		Yes
<i>Middle School</i>							
Ambady et al. (2001)	US (Asian-American)	6-8	11-13	Yes	28 ^c		No
Study 1	US	8	13-14	No	110	0.14	Yes
Study 2	US	7, 8	12-14	No	7 th : 119 8 th : 95	0.28 -0.16	Yes
Study 3	US	8	13-14	No	65	0.14	Yes
*Good (2001)	US	6	11-12	No	26		Yes
Huguet & Regner (2007) Study 1	France	6, 7	11-13	No	20		Yes
Huguet & Regner (2007) Study 2	France	6, 7	11-13	Yes, in a mixed-gender setting No, in a same-gender setting	223		Yes

Table 1 (cont.)

Huguet & Regner (2009)	France	6, 7	11-13	Yes	92		Yes
Muzzatti & Agnoli (2007) Exp 2	Italy	8	13-14	Yes	33		Yes
<i>High School</i>							
*Cruz-Duran (2009)	US	10-12	14-18	No	415	-0.18	No
*Dinella (2004)	US	9-12	13-18	No	133	0.36	Yes
Study 3	US	12	17-18	No	76	-0.27	Yes
Keller (2007) ^d	Germany	10	15-16	Yes, high math ID, difficult items	Hi ID: 23	-.0.82	Yes
				No (opposite effect), low math ID, difficult items	Lo ID: 32	0.80	
				No, high math ID, easy items			
				No, low math ID, easy items			
Keller & Dauenheimer (2003) ^d	Germany	10	15-16	No	35	-0.47	Yes
Picho & Stephens (2012)	Uganda	10	15-16	Yes, co-ed school	Co-ed: 38	-0.76	No
				No, single sex school	SS: 51	-0.14	
Stricker & Ward (2004) Study 1	US	11, 12	16-18	No	694	-0.16	Yes

Notes. * denotes an unpublished dissertation. ID = identification ^a A negative effect size indicates that girls in the stereotype threat condition performed worse than girls in the no-threat condition (i.e. a stereotype threat effect for girls). ^b A number of studies did not include enough information with which to compute effect sizes. ^c The sample size reflects the number of girls in 3 different conditions, one of which is an Asian identity condition not discussed in the current study – sample sizes were not disaggregated by condition. ^d This study compared a stereotype threat condition with a stereotype nullification condition.

Table 2

Stereotype Threat Activation Methods

Study Authors	Stereotype Threat Condition	Comparison Condition
Ambady et al. (2001) grades K-2; Neuville & Croizet (2007); Tomasetto et al. (2011)	Drew a picture of girl holding doll	Drew a picture of a landscape
Ambady et al. (2001) grades 3-8 Muzzati & Agnoli (2007)	Answered gender-related question Saw a picture of 9 male & 1 female mathematician	Answered neutral questions Saw a picture of 9 flowers & 1 fruit
Huguet & Regner (2007) Study 1	Told that the task was a “geometry test”	Told that the task was a “memory game”
Huguet & Regner (2007) Study 2; Huguet & Regner (2009)	Told that the task measured ability in geometry	Told that the task measured ability in drawing
Stricker & Ward (2004) Keller & Dauenheimer (2003); Keller (2007)	Checked gender before test Read that the test showed gender differences	Checked gender after test Read that the test showed no gender differences ^a
Cruz-Duran (2009)	Shown research evidence that men do better than women on math tasks	Shown research evidence that there are no gender differences on math tasks
Dinella (2004)	Indicated gender at beginning of tests and told that it is important to do because gender differences are sometimes present on tests	Indicated gender at beginning of test
Good (2001)	Told that the test will show how smart they are in math	Told that the problems are to see how students think about math and reading
Picho & Stephens (2012)	Told that the test assesses students’ ability in math and that there are gender differences on the test.	Given only basic test instructions

^a This is a stereotype nullification condition.

Table 3

Study 1: Mathematics Scores (Means and Standard Deviations) by Gender and Stereotype

Threat Condition

	Girls		Boys	
	Stereotype Threat	Stereotype	Stereotype Threat	Stereotype
	Nullification		Nullification	
Eighth Grade	64% (15%)	62% (14%)	68% (16%)	68% (18%)
	N = 58	N = 52	N = 53	N = 49

Table 4

Study 2: Mathematics Scores (Means and Standard Deviations) by Grade, Gender, and Stereotype Threat Condition

	Girls		Boys	
	Stereotype Threat	No-Threat	Stereotype Threat	No-Threat
Seventh Grade	28% (19%) N = 55	23% (17%) N = 60	21% (15%) N = 56	26% (18%) N = 52
Eighth Grade	33% (15%) N = 50	36% (22%) N = 49	32% (17%) N = 39	36% (21%) N = 40

Table 5

Study 3: Mathematics Scores (Means and Standard Deviations) by Grade, Gender, and Stereotype Threat Condition

	Girls		Boys	
	Stereotype Threat	No-Threat	Stereotype Threat	No-Threat
Fourth Grade	61% (30%) N = 14	56% (29%) N = 15	75% (18%) N = 18	69% (25%) N = 21
Eighth Grade	58% (22%) N = 32	55% (20%) N = 33	67% (24%) N = 18	68% (20%) N = 22
Twelfth Grade	42% (20%) N = 36	48% (24%) N = 40	57% (19%) N = 40	57% (22%) N = 29

CHAPTER 3

PEER ACADEMIC REPUTATION

The issue of gender differences in performance in mathematics has long been of interest to researchers and policy makers. In recent years, the concern regarding gender difference in mathematics has shifted away from concern about the underperformance of girls to a concern about the differential performance of both boys and girls. That is, recent evidence has suggested that girls are doing at least as well as boys in the classroom (AAUW, 2008; Catsambis, 1994; Ding, Song, & Richardson, 2006; Pomerantz, Altermatt, & Saxon, 2002), but still underperforming boys on mathematics sections of standardized tests (College Board, 2009, 2010; Gibbs, 2010; Gonzales, Williams, Jocelyn, Roey, Kastberg, & Brenwald, 2008; McGraw, Lubienski, & Strutchens, 2006; Robinson & Lubienski, 2011).

From 1998 to 2005, girls and boys enrolled in advanced placement mathematics classes at equal rates (AAUW, 2008). Furthermore, researchers have found that girls earned better classroom grades than boys in mathematics (Ding, Song, & Richardson, 2006; Pomerantz et al., 2002); however, on standardized tests, the opposite pattern emerges. Although some have suggested that the gender difference in math test performance is shrinking or eliminated (Hyde, 2005; see also Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2007; Hyde & Linn, 2006; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Spelke, 2005), there are still persistent gender differences in performance at the top end of the distribution on mathematics sections of standardized tests (Fiengold, 1992; Halpern et al., 2007; Hedges & Friedman, 1993; Hedges & Nowell, 1995; Hyde, Fennema, & Lamon, 1990; Lindberg, Hyde, Petersen, & Linn, 2010). That is, the best-performing boys are outperforming the best-performing girls. A recent meta-analysis

(Lindberg et al., 2010) found that the effect size of the difference between high scoring boys and girls was a moderate $d = 0.40$.

Researchers have posited a number of potential explanations for gender differences in mathematics performance and for the underrepresentation of women in mathematics- and science-related careers, including biological factors (e.g., Benbow & Stanley, 1980; Geary, 1996; Scarr & Satzman, 1982), social factors (e.g., Eccles, 1987; Eccles & Jacobs, 1986; Heller & Ziegler, 1996), and the interaction between biological and social factors (e.g., Halpern & Tan, 2001; Nuttall, Casey, & Pezaris, 2005). However, very few researchers have considered the role that peers and peer academic reputations may play in the performance and recognition of students in mathematics.

Peers' Effects on Achievement

Peers play an important role in the lives of children and adolescents. Peers have been cited as contributing to personality development (Harris, 1995); drug use (Dishion & Loeber, 1985; Maxwell, 2002); scholastic achievement, motivation and engagement (Altermatt, 2010; Chen, Hughes, Liew, & Kwok, 2010; Ryan, 2000; 2001); and classroom participation (Ladd, Herald-Brown, & Reiser, 2008; Ryan, 2000). Peers' influence on the academic achievement and behaviors of children and adolescents is substantial. In fact, Ryan (2000; 2001) found that peers are the most important predictor of academic achievement and motivation. Peers also provide feedback that can impact students' self-concept. (Altermatt, Pomerantz, Ruble, Frey, & Greulich, 2002), and peer support has been cited as important when students are facing academic difficulties (Causey & Dubow, 1992; Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Compas, Malcarne, & Fondacaro, 1988).

Because peers play such a large role in the lives of children and adolescents, it makes sense that a student's academic reputation with his or her peers would be an important factor in achievement. As early as elementary school, students begin to develop social reputations (Asher & Coie, 1990; Masten, Morison, & Pellegrini, 1985), and as students transition into early adolescence, they tend to develop more concern for peer acceptance (Rubin, Bukowski, Parker, & Bowker, 2008). For example, Hymel, Wagner, and Butler (1990) found that feedback from peers is influenced by students' reputation, and Harter (1998) found that peer reputations have an impact on students' self-concept.

Academic reputations among peers are important to development. Cole (1991) found that, even when controlling for teacher evaluations of ability, peer evaluations of ability were a contributing factor in students' academic self-concept. Jones, Audley-Piotrowski, and Keifer (2012) found that peer perceptions of academic behaviors are directly related to academic performance, but only if those perceptions align with self-perceptions of ability.

These peer evaluations of academic ability are termed *peer academic reputations*. "Peer academic reputation refers to a student's relative status in a peer group in terms of peer evaluations of academic competence" (Chen, Hughes, Liew, & Kwok, 2010, p. 449). Typically, this is assessed by having students nominate classmates who have characteristics usually associated with students who are academically successful (Gest, Domitrovich, & Welsh, 2005; Gest, Rulison, Davidson, & Welsh, 2008; Hughes et al., 2009). Peer academic reputations are associated with academic self-concept, teacher-rated effort, and performance in upper elementary school (Gest et al., 2005; Gest et al., 2008).

Gest et al. (2008) conducted a study with 427 third- to fifth-graders and found that peer academic reputation correlated with teacher's perceptions of skill, academic self-concept,

teacher-rated academic effort, and grade point average. Gest et al.'s (2008) results “suggest that peers may possess unique information about classmates’ academic functioning, that children’s [peer academic reputations] are psychologically meaningful, and that these reputations may serve as a useful marker of processes that forecast future academic engagement and performance” (p. 625). If peer academic reputation has the potential to support or curb students’ interest in a subject, it is important to understand what factors may impact their peers’ perception of their ability, especially what peers are noticing when they designate which students are talented.

In the present investigation, we examine several potential correlates of peer academic reputation in order to better understand what factors may be linked to their development. We consider the possibility that gender, achievement goals, academic achievement (as measured by classroom grades and standardized test scores) and domain identification, as well as interactions between these factors, may correlate with peer academic reputation.

Gender

Because peer academic reputations are so influential in students’ self-concept and academic performance, it is of note that students nominate boys (more often than girls) as one of the best students in mathematics classrooms (Theule-Lubienski, 1996). Relatedly, as early as second grade, both boys and girls endorse the stereotype that math is for boys (Cvencek, Meltzoff, & Greenwald, 2011). This is particularly interesting in light of the recent findings that girls are doing just as well as boys in terms of mathematics grades and participation in mathematics AP courses (AAUW, 2008; Ding, Song, & Richardson, 2006; Pomerantz et al., 2002). This inconsistency (between mathematical performance and peer nominations) suggests that gender itself may be influencing peer perceptions of ability. For this reason, the present study investigates that idea that gender may correlate with peer nominations and explores the

idea that gender may interact with other factors to explain some of the variability in the number of peer nominations.

Achievement Goal Orientations

Another factor that we expect to correlate with the number of peer nominations a student receives is students' endorsement of achievement goals. To date, no studies have investigated the relationship between achievement goal endorsement and peer recognition; however, several have linked achievement goals with classroom and general academic performance (for a review see Hulleman, Schrager, Bodmann, & Harackiewicz, 2010). Although there are several types of achievement goals that could possibly be examined, for the purposes of this investigation, we will consider two main types of achievement goals: mastery-approach and performance-approach goals. Traditionally there are two subtypes of each goal (approach and avoidant; Dweck & Leggett, 1988; Elliot & Harackiewicz, 1996; Elliot & McGregor, 2001; Heyman & Dweck, 1992; Nicholls, Patashnick, Cheung, Thorkildsen, & Lauer, 1989; Pintrich, 2000), but as a first step, in this investigation we focus only on mastery-approach and performance-approach goals.

Performance-approach goals. A performance-approach goal is when the student's focus is on appearing good in a specific domain (e.g., getting good grades or praise from the teacher). This type of goal orients the student to "the self and [their desire] to demonstrate competence relative to others" (Dupeyrat et al., 2011, p. 242). Particularly with younger students, performance goals tend to be associated with negative learning and engagement outcomes. For instance, Midgley and Urdan (1995) found that children holding performance goals exhibited more handicapping behaviors such as procrastination and spending time with friends rather than studying than did children holding mastery goals. Others have also cited holding performance goals as indicative of avoiding asking the teacher and others for help for fear of appearing

incompetent (Ryan & Pintrich, 1997), more often engaging in shallow processing and exhibiting fewer self-regulating behaviors than students endorsing mastery goals (Ames & Archer, 1988; Bouffard, Boisvert, Vezeau, & Larouche, 1995; Dupeyrat, Escribe, & Marine, 2006; Harackiewicz, Barron, Tauer, & Elliot, 2002), avoiding challenges and experiencing more negative affect following a failure than students with mastery goals (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Midgley, Kaplan, & Middleton, 2001; Urdan, 1997), and more anxiety and lower self-efficacy (Skaalvik, 1997).

Researchers have also found some positive outcomes associated with performance-approach goals. For example, researchers have found that performance-approach goals are associated with positive self-concept, affect, attitudes, the valuing of academic work (Midgley, Arunkumar, & Urdan, 1996; Nicholls, Patashnick, & Nolen, 1985; Pajares, Britner, & Valiante, 2000; Pintrich & Garcia, 1991; Roeser, Midgley, & Urdan, 1996; Skaalvik, 1997; Wolters, Yu, & Pintrich, 1996), as well as the production of effort (Bouffard, Boisvert, Vezeau, & Larouche, 1995; Elliot & McGregor, 1999; Elliot, McGregor, & Gable, 1999). Several researchers have even found positive relationship between performance-approach goals and achievement (Bouffard et al., 1995; Church, Elliot, & Gable, 2000; Elliot & Church, 1997; Elliot & McGregor, 1999; Elliot et al., 1999; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Harackiewicz et al., 2000; Kaplan & Maehr, 1999; Midgley, Anderman, & Hicks, 1995; Midgley & Urdan, 1995; Pintrich & Garcia, 1991; Roeser et al., 1996; Skaalvik, 1997; Wolters et al., 1996).

To clarify these apparently contradicting claims regarding the impact of performance goals on achievement and positive learning outcomes, Hulleman et al. (2010) conducted a meta-analysis of the achievement goal literature and found that the positive or negative outcomes of

performance goals depend on how you measure a students' endorsement of those goals. That is, if the researcher defines performance goals as the desire to appear talented relative to peers, they tend to find positive outcomes associated with these goals. On the other hand, if a researcher defines performance goals as a general focus on appearing smart, they tend to find negative outcomes.

For the purpose of this investigation, we define performance-oriented goals as the desire to appear good in a subject relative to others. That is, we defined performance-approach goals as normative goals or those that “suggest an objective standard whereby the individual can judge whether he or she has performed better than others” (p. 424, Hulleman et al., 2010). We chose this definition of performance approach goals because we had an interest in how this social comparison piece may influence peer perceptions of ability. That is, if a student is interested in performing better than his or her peers, do those peers notice this desire for good relative performance?

Mastery-approach goals. If a student endorses a mastery goal, the student's focus is on truly mastering the material. This type of goal orients the student to “the task and on progress by aiming to develop competence and mastery” (Dupeyrat, Escribe, Huet, & Regner, 2011, p. 242). In general, the behaviors associated with mastery goals are considered positive for learning. Studies have shown that students holding mastery goals use deep processing strategies, are better at self-regulating (Bouffard, Boisvert, Vezeau, & Larouche, 1995; Dupeyrat, Escribe, & Marine, 2006; Greenwood, Horton, & Utley, 2002; Harackiewicz, Barron, Tauer, & Elliot, 2002), tend to be more engaged in the classroom (Dweck & Leggett, 1988; Meece, Blumenfeld, & Hoyle, 1988; Wolters, 2004), tend to have higher self-efficacy (Middleton, Kaplan, & Midgley, 2004; Roeser, Midgley, & Urdan, 1996), engage in more adaptive reactions to challenging situations

(Ames & Archer, 1988; Elliott & Dweck, 1988; Turner, Thorpe, & Meyer, 1998), have less disruptive behavior (Bennett et al., 1993; Kaplan & Maehr, 1999; Kurdek & Sinclair, 1988; Middleton & Midgley, 1997; Midgley & Urdan, 1995; Pintrich, 2000; Roeser et al., 1996), and higher achievement (Keys, Conley, Duncan, Domina, 2012; Linnenbrink, 2005). The consensus overall is that mastery goals are beneficial both to learning and for student achievement.

We define mastery approach goals as the desire to achieve a personal best and fulfill potential in a subject. That is, we defined our mastery goals as a combination of “mastery-potential”, “mastery challenge”, and “mastery general” (p. 431, Hulleman et al., 2010). We chose to define mastery-approach goals in this way because we were interested in the aspect of mastery goals that focuses on internal (rather than external comparison). That is, if a student is only interested in comparing their performance with themselves rather than others, do their peers recognize their talent?

Gender Differences in Achievement-Goal Endorsement. In general, boys have a tendency to endorse performance- more than mastery-oriented goals in mathematics, whereas girls have a tendency to endorse mastery-oriented goals more than performance-oriented goals (Anderman & Midgley, 1997; Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006; Roeser, Midgley, & Urdan, 1996; Ryan, Hicks, & Midgley, 1997; Stipek & Gralinski, 1996). These differences in achievement goals likely also lead to different behaviors in mathematics classrooms, such as differences in participation and academic risk-taking (Dweck & Leggett, 1988; Elliott & Dweck, 1988; Grant & Dweck, 2003; Mueller & Dweck, 1998; Pintrich & De Groot, 1990; Wolters, Yu, & Pintrich, 1996). Similarly, the research on gender differences in behavior in mathematics and science classrooms has found behavioral differences that are consistent with the achievement goal differences we see between males and females. For

instance, the Association of American University Women (AAUW, 1995), among others (e.g., Altermatt, Jovanovic, & Perry, 1998; Becker, 1981; Cherry, 1975; Duffy, Warren, & Walsh, 2001; Irvine, 1986; Jones & Dindia, 2004), suggest that boys volunteer more than girls in mathematics and science classes, an indication that boys are more competitive and more anxious to demonstrate their ability. If boys are competent at mathematics, their relative endorsement of performance-oriented goals compared to girls may actually serve to reinforce their accurate belief in their own competency and remind their peers of their mathematical prowess.

These findings led us to wonder how interactions between gender and achievement goals may correlate with peer nominations of ability. Do boys who endorse performance-approach goals receive more nominations than girls who endorse performance-approach goals? Similarly, is it valued by peers for girls to endorse mastery-approach goals?

We would also expect to see a correlation between peer nominations and an interaction between achievement goals and performance (as measured by classroom grades or state standardized test scores). It seems plausible that students who show both high performance and endorse performance-approach goals would gain the most recognition as one of the best students in the classroom because these students are both talented and willing to demonstrate that talent. Conversely, we would expect that students who endorse mastery-approach goals and have high performance would not similarly be recognized for their talent because, although it is present, these students are not focused on demonstrating their talent.

Domain Identification

In addition to gender and achievement goals, we would expect that domain identification may be related students' perceptions of ability. That is, it is possible that students who identify themselves as "math people" would garner more recognition from their peers for their

performance because these students may be likely to participate in class and perhaps even talk about mathematics outside of the classroom.

Domain identification in mathematics involves two components: feeling that you are good at mathematics, and feeling that it is important to you to be good at mathematics (Smith & White, 2001; Steele, 1997). That is, it is a combination of mathematics self-concept and value of mathematics. Domain identification indicates that students who are identified with mathematics see math as important to how they view themselves (Hess, Olejnik, & Huberty, 2001) and, more particularly, think they are both good at mathematics and that mathematics is important. This combination of factors is important as domain identification often leads to higher motivation and higher rates of success in that subject (Finn, 1989). In mathematics, boys tend to be more identified than girls (Hess, Olejnik, & Huberty, 2001); however, even when controlling for gender, mathematics domain identification was a significant predictor of mathematics performance (Hess, Olejnik, & Huberty, 2001).

Although the definition of domain identification we use here is internal to the student, we expect domain identification to predict peer nominations because the students who are the most identified with mathematics (both value mathematics and think they are good at it) may also be likely to pursue extracurricular mathematics activities and discuss mathematics outside of the classroom. These students are likely noticed as students who like mathematics.

We are also curious to see if there is an interaction between gender and domain identification. That is, do students value a congruence of the stereotypes about gender and mathematics? Would they hold boys who have a high domain identification in mathematics in higher regard than girls who have similarly high domain identification?

The Present Study

In the present investigation, we identify several correlates of peer academic reputation and account for a portion of the variability in peer nominations. We test gender, achievement goals (mastery and performance), domain identification, performance (classroom grades and state standardized test scores), as well as interactions among these terms to predict peer nominations as one of the top students in mathematics. We examine correlates of peers' perceptions of mathematical talent as a way to provide new insights into the development of students' success in mathematics.

Method

Participants

Participants attended one of five schools in a small-urban community and its surrounding areas: four regular-education-public middle schools and one selective-admission-public laboratory high school (which accepts seventh- and eighth-grade students for a pre-high-school year). 78% of the students solicited returned permission forms and participated in the study.

Participants included students from seventh- and eighth-grade classes. Participants were 224 seventh-grade students (105 boys, 119 girls) and 177 eighth-grade students (82 boys, 95 girls) in advanced math classes. The ethnic make-up of the sample was 65.0% white, 12.4% Asian, 13.6% African American, 4.4% Latino, and 1.7% other. The percent of low-income students at each school is reported in Table 6.

We only chose students from advanced mathematics classes. That is, mathematics classes identified by the school district as advanced, pre-AP, or honors to ensure that we would locate students identified by their peers as mathematically talented.

Measures

In the Fall of 2011, each student completed a survey designed to assess: (a) students' endorsement of a performance-approach and mastery-approach achievement goals in mathematics, (b) mathematics domain identification, (c) demographic information (i.e., age, grade, gender, ethnicity, and expected grade in math), and (d) whom they thought were the top three students in their math class. The survey took students approximately 15 minutes to complete.

The performance-approach achievement goal in mathematics was assessed with 5 items (Ryan & Ryan, 2005): "It is important for me to do better than most students on math tests," "My goal on math tests is to do better than other students," "On math tests, I like to show my teachers that I'm smarter than other students," "My goal on math tests is to get a better score than most of the other students," and "Doing better than other students on math tests is important to me." The reliability of these items was good, $\alpha = .91$. Descriptive statistics are reported in Table 7.

The mastery-approach achievement goal in mathematics was assessed with 5 items (Ryan & Ryan, 2005): "I kind of like math tests because they challenge me to do my best thinking", "When I take math tests the most important thing to me is to do my personal best", "An important reason why I try on math tests is because I want to see what skills I need to develop", "When I take a math test, I focus on doing my best not just my score", "An important reason why I try on math tests is because I want to see what skills I have". The reliability of these items was good, $\alpha = .72$. Descriptive statistics are reported in Table 7.

Mathematics self-concept was assessed with 5 items (Ryan & Ryan, 2005): "How good at math are you?" "How have you been doing in math this year?" "Compared to most other subjects, how good are you at math?" "If you were to rank all the students in your math class

from best to worst, where would you put yourself?” and “I have always done well in math.” The reliability of these items was good, $\alpha = .88$. Descriptive statistics are reported in Table 7.

Value of mathematics was assessed with 5 items (Ryan & Ryan, 2005): “How important is it to you to get good grades in math?” “For me, learning the information in math class is important” “For me, doing well in math is important,” “For me, being good at solving problems in math is important,” and “Compared to other subjects, math is important to me.” The reliability of these items was good, $\alpha = .89$. Descriptive statistics are reported in Table 7.

Students were asked to list whom they thought the top three students in their math class were. They were told to choose only students from their classroom and that they were able to nominate themselves if they thought they were one of the best students. Students were also told that there was not an order to their nominations (i.e., *not* first best, second best, third best). Descriptive statistics are reported in Table 7.

In addition to the survey data collected directly from the students, we obtained the students’ fall semester mathematics grades and their previous year’s state standardized test scores directly from school personnel. Descriptive statistics are reported in Table 7. A correlation matrix for all measures can be found in Table 8.

Procedure

Participants were given a packet with the survey and asked to respond to all the questions as a proctor read them aloud. After the proctor finished reading the questions, the students were asked to list the three students in the classroom that they thought were the best at mathematics. Students were instructed that spelling and order did not matter. When all the students finished this list, the packets were picked up and the students were thanked for their participation.

Scoring

A scale score was created for each scale of the survey by averaging the student's responses to each scale item. For all the scales, if data were missing, we averaged the remaining item responses. If more than half of the scale items were missing, a scale score was not calculated.

Results

To examine the correlates of peer nominations, we ran a series of regressions with gender, standardized test scores, classroom grades, performance and mastery goal endorsement, and domain identification as predictor variables. We also tested several interactions of these variables. We found that in every model, gender, standardized test scores, classroom grades, and domain identification were significant correlates of peer nominations (Tables 8 and 9). Endorsement of performance goals only approached significance ($p=.081$) when entered into the regression model (Table 11). Endorsement of mastery goals was not a significant correlate of peer nominations (Table 11).

In terms of interactions, we tested gender by standardized test score and gender by grades interactions. We found that there was a significant interaction between gender and standardized test score, but not gender and grades. Because it was not significant (and to save space), the model testing the gender by grades interaction was removed from Table 11. We also tested gender by domain identification and grades by domain identification. Only the grades-by-domain identification interaction was significant (Table 11). Although endorsement of performance goals was not significant at the $p = .05$ level, we tested an interaction between performance goals and classroom grades. This interaction was not significant (Table 11),

In the final regression model, we included gender, state standardized test scores, grades, domain identification, the interaction between gender and state standardized test scores, and the interaction between grades and domain identification. The adjusted R^2 for this model was .250, indicating 25% of the variability in peer nominations as one of the top students in the classroom could be accounted for by the variables in our model.

To get a better sense of the interactions in the model, we graphed them (Figure 1 and Figure 2). The graph of the interaction between gender and state standardized test score (Figure 1) illustrates that the boys in our sample who had the highest state standardized test scores also tended to have the highest number of peer nominations. For girls in our sample, the reverse was true. The girls with the highest number of peer nominations tended to have lower state standardized test scores.

The graph of the interaction between classroom grades and domain identification was much less clear. There were only enough data points to get a best-fit line for students making an A-, A, or A+ on their report cards. We were unable to discern any reliable patterns from this information.

Discussion

The strongest correlates we found with peer nominations as one of the top students in the classroom were gender, standardized test score performance, and domain identification. This indicates that as students are deciding who is the most mathematically talented in the classroom, they are paying attention not only to the students' performance, but also whether the student is a boy or girl and how the nominated students feel about themselves in mathematics.

In many ways this is not surprising, as we have evidence that students are aware of gender stereotypes about mathematics from a very young age (Cvencek, Meltzoff, & Greenwald,

2011), so it stands to reason that they would use this information to inform their decision regarding the distribution of mathematical talent. We would expect that students who are aware of this stereotype would nominate boys more often than girls and that is exactly what we and others (Theule-Lubienski, 1996) have found.

The strong relationship we uncovered between domain identification and peer nominations may be less obvious. On the one hand, it makes sense that students who see themselves as “math people” would garner notice as being good in mathematics because they are likely to be the most engaged in the classroom and pursue mathematics activities and conversation outside of the classroom, thereby linking how they view themselves (and likely how others view them) with mathematics and their performance in it. On the other hand, it is unclear that domain identification is obvious to peers. The definition of domain identification that is currently being used is a very individual one. That is, it is about how the students feel about themselves in mathematics rather than how they think others feel about them in mathematics. It is also unclear if high domain identification is related to any particular behaviors that would allow others to pick up on the students’ personal relationship with mathematics.

We found two interactions that were significant correlates of peer nominations. The first, a gender-by-state standardized test score interaction, showed a clear pattern: as boys’ test scores increased, so did the number of nominations they received. For girls, the opposite pattern emerged: as girls’ test scores increased, the number of nominations they received decreased. This is an odd and surprising pattern. We suspect this pattern has to do with the state standardized test. Peers are not aware of state standardized test scores in the way that they are aware of classroom grades, so these test scores likely do not inform their perceptions of talent directly.

The second interaction, a classroom grades by domain identification interaction, is much less clear in part because of the restricted range of grades in the math classrooms recruited for this study. Also, because students with low grades were rarely nominated, we do not have a clear pattern to investigate for students with grades below an A-. For students at the highest end of the grade spectrum, those with As or A+s, the amount of domain identification necessary to be noticed increased as talented decreased. For example, if a student was an A+ student, it did not matter if they are identified with mathematics or not, they are recognized as being talented. Conversely, if a student is an A- student, they would need to have a higher domain identification for their peers to recognize them as talented. This makes sense as someone you think of as a “math person” who maybe has less than perfect grades would still likely get noticed because of their connection to the subject.

Although we suspected that there would be a correlation between achievement goals and peer nominations as one of the best students in the classroom, we found only evidence of a very slight relationship between performance approach goals and peer nominations. This indicates that achievement goals and the behaviors associated with them do not have a strong influence on which students their peers perceive as mathematically talented in the classroom.

The implications from this study are potentially large. Peers play a large role in the academic success (see Ryan, 2001) and the choices students make. Receiving feedback from your peers that you are talented in a particular subject likely leads to a stronger emphasis on a particular subject, so it is important to understand the factors that may contribute to the formation of peer academic reputations.

Limitations and Future Research

Because we were particularly interested in understanding how recognition of talent was implicated in students' perceptions of themselves, we chose to focus on high-achieving students. But because our sample was only high-achieving students, we cannot generalize to more typical seventh- and eighth-graders. Future research should investigate the relationships between achievement, peer recognition, gender, and mathematics domain identification with a more representative sample of students. Similarly, these relationships should be investigated in students at both younger and older ages to determine how the relationships may change over the course of development.

Another limitation is that our measure of achievement goals focuses on testing situations, but peer nominations are classroom-based. Because of this, we might expect that our findings regarding the relationships between these factors are underestimates. Future research should create a measure of achievement goals that is classroom performance-based and investigate the relationship these measures have to peer nominations.

Future studies should also more closely investigate the patterns that emerged in our significant interactions. It is important to understand if these patterns are consistent across populations and how they develop. Researchers should also focus on how boys and girls may differentially demonstrate their ability in the classroom and how these differences may influence not only peer's perceptions of ability, but also the future career choices and achievement of students. Similarly, it is important to take a closer look at the relationship between grades, domain identification, and peer perceptions of ability. Researchers should investigate the idea that domain identification can make up for less than perfect grades when being evaluated by

peers and what behaviors associated with high domain identification indicate to others that students are talented.

In conclusion, it is important to understand the factors that may contribute to the formation of peer academic reputations because our findings indicate that recognition of talented individuals may feedback powerful messages about mathematics. We would expect that the students' classmates will recognize this among some of their peers, but we found that this is more likely to happen for boys than for girls, so interventions may be needed to support the recognition of mathematical success among all students. This will allow others to identify and potentially foster that success, giving students a higher belief in their own abilities and recognition from peers for their efforts. Ideally, educators should be able to do this for all students during successful mathematical moments, but especially in cases when students who are mathematically talented are at risk of not valuing their own talent.

Table 6

The Percent of Low Income Students at Each School

School	Percent Low Income Students
Middle School 1	55.1
Middle School 2	60.2
Middle School 3	56.8
Junior High 1	19.6
Junior High 2	88.0
Selective Public High School	Unreported
State Average	49.0

Table 7

Descriptive Statistics for Measures

Measure	Mean (Standard Deviation)	Minimum	Maximum
Performance Approach	2.95 (1.06)	1.00	5.00
Mastery Approach	3.93 (0.67)	1.00	5.00
Domain Identification	8.42 (1.01)	4.40	10.00
Peer Nominations	2.48 (3.69)	0.00	21.00
Classroom Grade	B+ – A- (2 letter grades)	D	A+
Standardized Test Score	281.16 (29.31)	196.00	360.00

Table 8

Correlation Matrix

		Performance	Mastery	Domain	Classroom	Standardized
	Gender	Goals	Goals	Identification	Grades	Test Scores
Gender	1.00	.034	-.028	.052	-.141*	.082
Performance Goals	.034	1.00	.067	.203**	.032	.057
Mastery Goals	-.028	.067	1.00	.541**	.037	-.024
Domain Identification	.052	.203**	.541**	1.00	.379**	.253**
Classroom Grades	-.141*	.032	.037	.379**	1.00	.434**
Standardized Test Scores	.082	.057	-.024	.253**	.434**	1.00

* $p < .05$ ** $p < .01$

Table 9

Initial Regression Models

Predictors	Model 1			Model 2			Model 3			Model 4		
	β	t (df)	p	β	t (df)	p	β	t (df)	p	β	t (df)	p
Gender	.145	2.87 (383)	.004	.169	2.89 (250)	.004	.169	2.87 (242)	.004	.149	2.57 (242)	.011
State Standardized Test				.148	2.30 (250)	.023	.148	2.28 (242)	.023	.127	1.98 (242)	.049
Grades				.299	4.64 (250)	.000	.300	4.62 (242)	.000	.247	3.68 (242)	.000
Performance Goals							.102	1.76 (242)	.081	.079	1.35 (242)	.177
Mastery Goals							.065	1.11 (242)	.267			
Domain Identification										.178	2.83 (242)	.005
Adjusted R^2		.019			.162			.178			.201	

Table 10

Interaction Regression Models

Predictors	Model 5			Model 6			Model 7			Model 8		
	β	t (df)	p	β	t (df)	p	β	t (df)	p	β	t (df)	p
Gender	-1.45	-2.71 (241)	.007	-.393	-0.81 (241)	.420	.148	2.59 (241)	.010	.149	2.57 (241)	.011
State Standardized Test	-.051	-0.60 (241)	.552	.117	1.81 (241)	.072	.111	1.75 (241)	.081	.124	1.93 (241)	.055
Grades	.246	3.73 (241)	.000	.247	3.68 (241)	.000	-.97	-2.36 (241)	.019	.102	0.55 (241)	.582
Performance Goals	.085	1.48 (241)	.140	.075	1.29 (241)	.198	.076	1.33 (241)	.186	-.110	-0.47 (241)	.636
Domain Identification	.165	2.66 (241)	.008	.130	1.71 (241)	.088	-.320	-1.80 (241)	.073	.185	2.91 (241)	.004
Gender * State Standardized Test	1.63	3.00 (241)	.003									
Gender * Domain Identification				.553	1.12 (241)	.263						
Grades * Domain Identification							1.49	2.99 (241)	.003			
Performance Goals * Grades										.245	0.84 (241)	.401
Adjusted R^2		.226			.202			.226			.198	

Table 11

Final Regression Model

Predictors	<i>B</i>	<i>t</i> (df)	<i>p</i>
Gender	-1.46	-2.77 (241)	.006
State Standardized Test	-0.07	-0.81 (241)	.417
Grades	-1.01	-2.50 (241)	.013
Domain Identification	-0.33	-1.90 (241)	.058
Gender * State Standardized Test	1.65	3.08 (241)	.002
Grades * Domain Identification	1.54	3.14 (241)	.002
Adjusted R^2		.250	

Figure 1. Graph of Gender by State Standardized Test Score Interaction with Best-Fit Lines

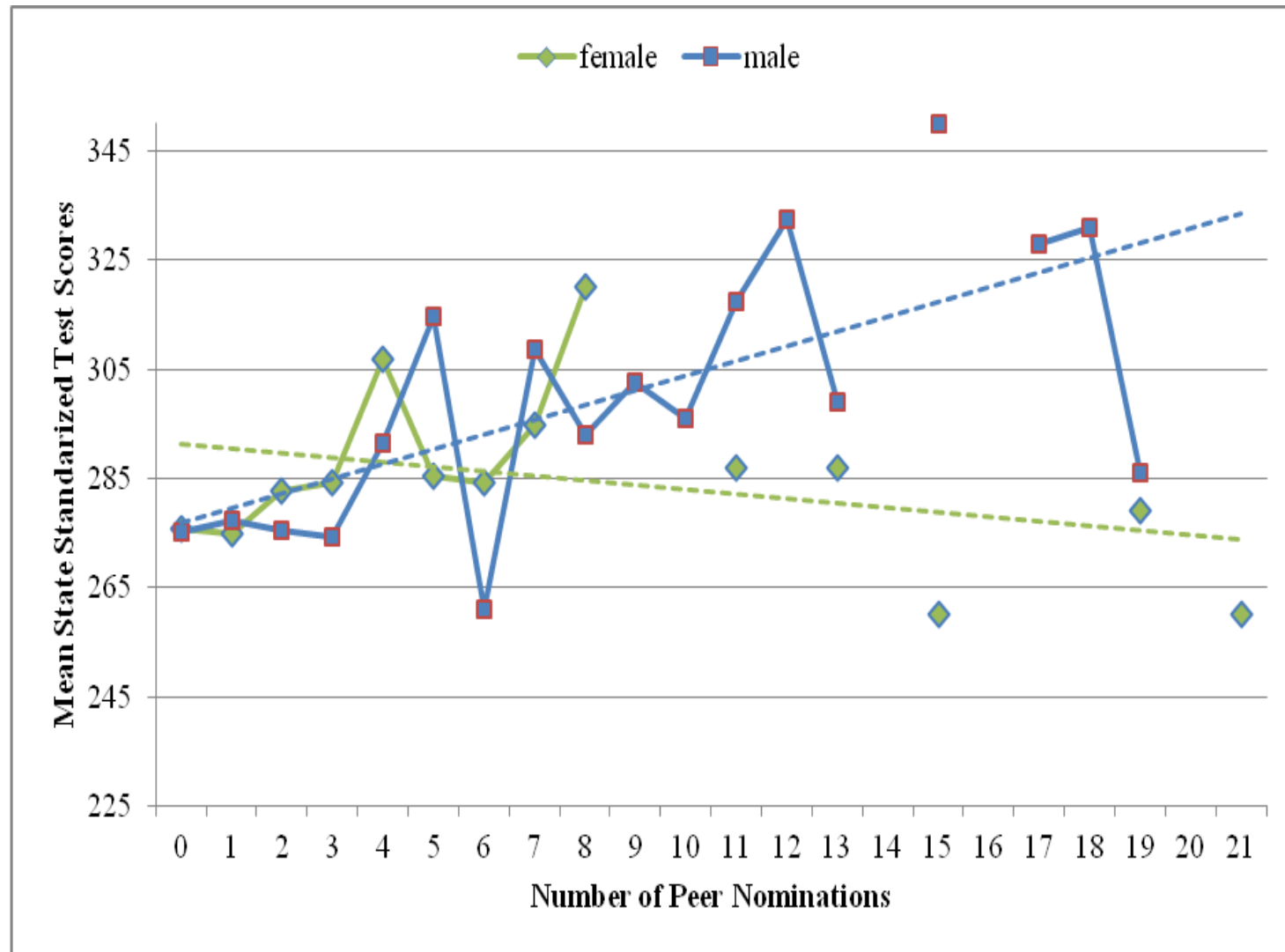
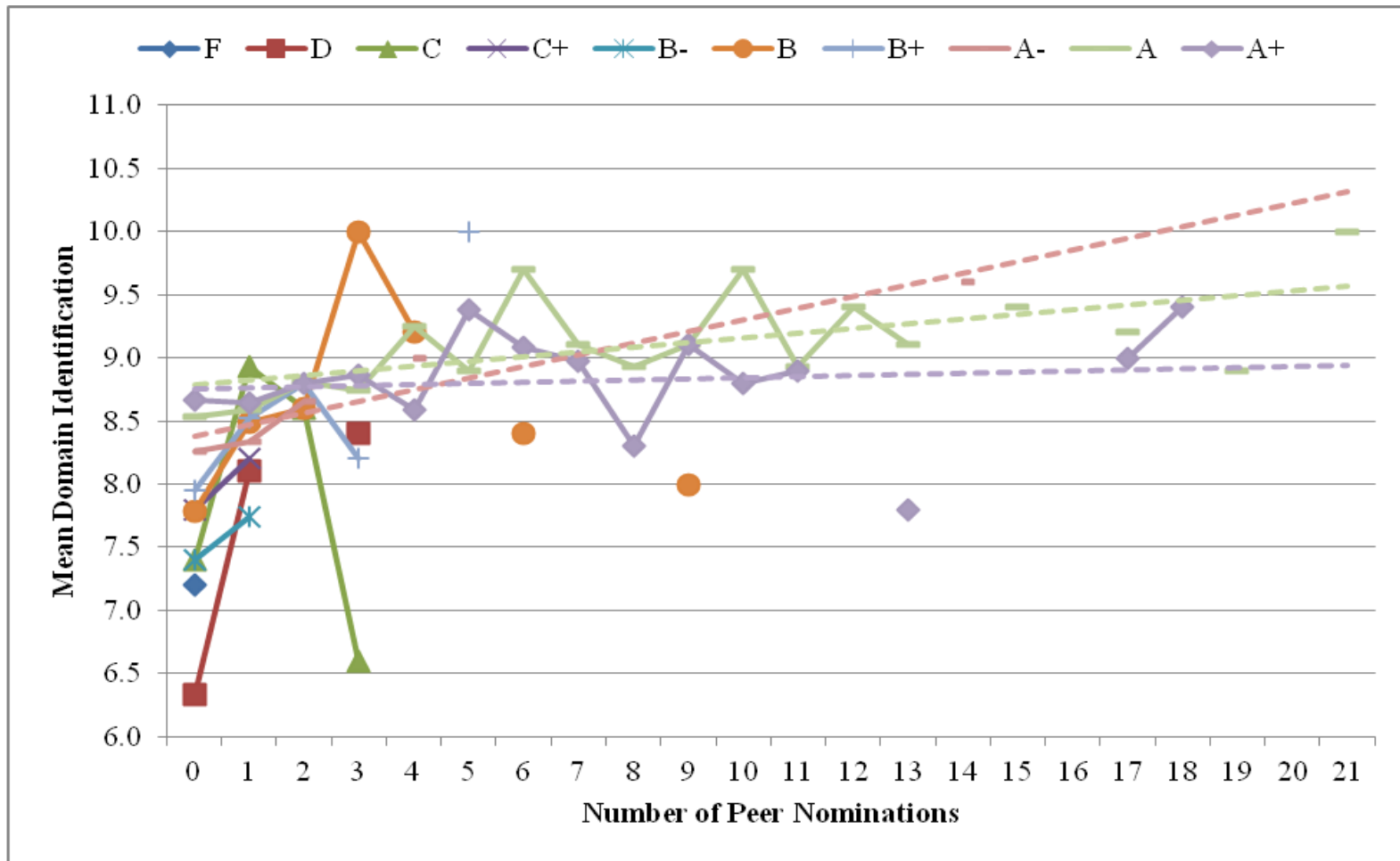


Figure 2. Graph of Grades by Domain Identification Interaction with Best-Fit Lines



CHAPTER 4

FEMININITY

For high-achieving students, there is an interesting pattern of performance between genders in mathematics: high-achieving boys outperform high-achieving girls on standardized tests (Fiengold, 1992; Hedges & Friedman, 1993; Lindberg, Hyde, Petersen, & Linn, 2010; McGraw, Lubinski, & Strutchens, 2006; Strand, Dreary, & Smith, 2006; Robinson & Lubinski, 2011), but girls perform as well as or outperform boys in the classroom (AAUW, 2008; Catsambis, 1994; Ding, Song, & Richardson, 2006; Kimball, 1989; Pomerantz et al., 2002; Willingham & Cole, 1997). Very few studies have addressed this discrepancy, although many have proffered possible explanations for the gender differences we see in mathematical performance on tests. These explanations rely on different sources for the differences, including biological, social, and a combination of both (Benbow & Stanley, 1980; Carr, Steiner, Kyser, and Biddlecomb, 2008; Fox, 1982; Geary, 1996; Halpern & Tan, 2001; McGraw et al., 2006; Steele, 1997; Steele & Aronson, 1995). Understanding how and why girls do at least as well as boys in mathematics classrooms, but then, during the same time period, do worse than boys on standardized tests is likely to be important to understanding the nature of gender differences in mathematics.

Although all of these studies have looked at gender differences through the lens of *gender identification*, we will argue for a slightly different lens through which to examine these differences: identification with feminine or masculine traits. The distinction between gender and femininity and masculinity may be subtle, but likely has a large impact on how students view themselves and their behaviors.

Gender is defined as how a student identifies him- or herself as male or female; femininity and masculinity are not dependent on gender. Instead, these constructs get at how the student identifies with feminine and masculine traits and behaviors. That is, it is possible that a boy would identify himself as male, but be more closely aligned with feminine than masculine traits. Similarly, a girl could identify herself as female, but identify more with masculine than with feminine traits. In this investigation, we explore the idea that identification with masculinity or femininity may provide a more nuanced understanding of performance differences in mathematics than that provided by identification as male or female.

Theoretical Context

Kohlberg and Maccoby (1966) suggested that people value things that fit within their view of themselves, and people will seek out activities and behaviors that are consistent with their view of who they are. Conversely, people will avoid activities and behaviors that are not consistent with their self-view. Following from this, one potential reason that we see the distinction between standardized test performance and classroom performance (typically indexed by grades) is that students value tasks that are consistent with their views of themselves. That is, because mathematics is considered to be a masculine field, both boys and girls who endorse feminine characteristics may not see it as a field worth pursuing; likewise boys and girls who endorse masculine characteristics may be more likely to pursue and excel in mathematics.

Later researchers (Bem, 1981; Martin & Halverson, 1981; Signorella & Jamison, 1986) suggested that a person's view of him- or herself can influence what information they process and how they process it. Signorella and Jamison (1986) argued "material inconsistent with the self will be processed more slowly and forgotten more easily." Nash, Wittig, and Peterson (1979) suggested that the consistency or inconsistency between the self and the material to be

processed may go so far as to explain gender differences in performance on spatial and reading tasks. They also suggested that this consistency between the self and the task would predict the performance of students of both genders. That is, Nash et al. (1979) expected that individuals (boys or girls) who identify themselves as masculine will perform better on tasks that are viewed as masculine and that individuals (boys or girls) who identify themselves as feminine will perform better on tasks that are identified as feminine. Following these ideas, we posit that investigating gender differences not through the lens of gender, but through the lens of personal identification with femininity and masculinity, may capture more of the impact of gender stereotypes and perhaps explain why gender differences in success in mathematics classroom performance—which does not necessarily favor males over females—and on standardized tests—which is something we expect out of males—are not congruent. More particularly, students who identify as feminine may be more likely to perform well in school, but less likely to perform well on difficult tests of mathematics.

Femininity, Masculinity, and Mathematics Performance

Very little research has investigated how identification with masculine and feminine traits may impact performance in mathematics in elementary or middle school. In their meta-analysis, Signorella and Jamison (1986) found that girls who had a high feminine self-concept performed worse on spatial tasks than girls with low feminine self-concepts. Overall, Signorella and Jamison (1986; see also, Nash, 1975) reported that “higher masculine and lower feminine self-concept scores were associated with better performance” on spatial tasks (p. 207). Nash (1975) found that the more masculine boys or girls viewed themselves, the better they performed on a spatial task. More recently, Kessels (2005) found that middle-school students rated girls who were successful in physics as less popular and less feminine than girls who were successful in

more traditionally feminine areas such as music. Furthermore, women who are seen by middle-school students as breaking the social norm and pursuing a masculine career are viewed more negatively than women who follow gender stereotypes (Yoder & Schleicher, 1996). Taken together, these findings indicate that at least as early as middle school, femininity impairs success in mathematics, and girls who are successful in these fields are viewed by their peers as less feminine, less popular, and even less likable.

Research with adults has indicated that women who identify with mathematics may try to distance themselves from their femininity (Pronin, Steele, & Ross, 2004; for a theoretical argument, see Steele, 1997). For instance, Pronin et al. (2004) found that women who took a large number of mathematics classes disavowed the feminine traits that were perceived to be related to their performance in mathematics (e.g., wanting to have children because it would require taking time off work), but not those that were *not* perceived to be related to their mathematics performance (e.g., empathy). Women who took fewer math classes did not demonstrate this pattern of disavowal. Furthermore, women in mathematics (and other masculine fields) are perceived as less attractive (Badgett & Folbre, 2003) and less feminine (Heilman & Okimoto, 2007; Yoder & Schleicher, 1996) than their counterparts in traditionally feminine fields.

These findings indicate a clear disassociation between mathematics and femininity. That is, in current U.S. culture, mathematics is viewed as a masculine field, sending the message to women that if they want to pursue mathematics, they should shirk their femininity. This line of research has indicated that the view of mathematics is not linked to being a boy, but rather being masculine. Because the relationship with mathematics is with masculinity and femininity rather than with gender, the behavioral and performance outcomes could extend to children and

adolescents who have a view of their femininity or masculinity that does not match their gender. That is, boys who relate to feminine characteristics may also be less inclined to pursue mathematics-dependent fields because they do not see themselves as masculine enough for them, as well as the converse: girls who relate to masculine characteristics may be more inclined to pursue mathematics-dependent fields because they do not see themselves as feminine.

Present Investigation

The present study tests the idea that femininity and masculinity may be predictive of gender differences in performance on a variety of indicators of success in mathematics: a difficult mathematics test, state standardized mathematics test scores, and mathematics classroom grades. Specifically, we expect that both male and female students who identify with feminine traits will perform better in the classroom because we associate “being a good student” with females, but worse on the two mathematics tests, which we associate with males. We also expect the converse; students who identify with more masculine traits will perform worse in the classroom, but better on the two mathematics tests. We believe that testing gender differences with respect to identification with feminine and masculine traits rather than with gender will provide a more nuanced and sensitive test of the impact of gender stereotypes.

Method

Participants

Participants include middle-school students from seventh- and eighth-grade classes. Because the largest gender differences are typically found with the highest achieving students (Hedges & Friedman, 1993; Fiengold, 1992; Strand, Deary, & Smith, 2006) only those students who were identified by their teachers or by the school district as high-achievers in mathematics were included (i.e., we recruited from classes identified as advanced).

Participants were 229 seventh-grade and 182 eighth-grade students, for a total of 411 participants. For the seventh-grade students, 46.9% were male and 53.1% were female. For the eighth-grade students, 46.3% were male and 53.7% were female. The ethnic make-up of the sample was 65.0% white, 12.4% Asian, 13.6% African American, 4.4% Latino, and 1.7% other. The mean age of the seventh-grade students was 12.08. The mean age of the eighth-grade students was 13.03.

Participants attended one of five schools in a small-urban community and the surrounding areas: four regular-education-public middle schools and one selective-admission-public laboratory high school (which accepts 7th and 8th grade students for a pre-high-school year).

Measures

Survey. The students were given a survey before the test. This survey assessed the student's association with feminine and masculine traits. Students' identification with masculine and feminine traits was assessed using the Bem Sex-Role Inventory (BSRI) measure of masculinity and femininity (Bem, 1974). Although this measure was created in 1974, studies have confirmed its continued validity (see Holt & Ellis, 1998). We used the shortened version of the BSRI that consists of 60 items: 20 to assess masculinity ($\alpha = .82$), 20 to assess femininity ($\alpha = .84$), and 20 neutral. Each item is a word or phrase that could describe a person (e.g., warm, conceited, loves children). Students were asked to rate how much each item described them on a scale of 0 to 7.

The BSRI consists of two sub-scales: masculine and feminine. Each scale is scored by averaging the student's responses to the masculine or feminine items. The mean masculinity and femininity scores across all students were, $M = 5.04$ ($SD = .78$), and $M = 4.68$ ($SD = .84$),

respectfully. For each scale, if data were missing, we averaged the remaining item responses. If more than half of the scale items were missing, a scale score was not calculated.

After the completion of the test, students were given a second survey containing demographic questions (i.e., age, grade, gender, ethnicity, and expected grade in math).

Mathematics test. Students were given a difficult mathematics test containing open-ended questions, $\alpha = .87$. The testing period was 25 minutes and the exams contained 13 problems, at three different difficulty levels: 4 easy, 4 medium, and 5 difficult problems. The questions were presented one problem per page, and the easy, medium, and difficult questions were interspersed within the test, not in a particular order. Students were instructed to show their work, and not to use calculators.

The problems were chosen from a set of 24 problems that were pilot tested in one seventh- (19 students) and one eighth- (14 students) grade classroom the semester prior to data collection. The 13 problems were chosen for use in the current study based on the number of students who were able to solve the problem during the pilot. Specifically, the easy problems were those that a majority of the seventh- and eighth-grade students in the pilot solved successfully. The medium problems were those that about half of the seventh-grade students and most of the eighth-grade students solved successfully. The difficult problems were those that about half of the eighth-grade students solved successfully and almost none of the seventh-grade students solved successfully. The problems covered subject areas such as basic algebra, geometry, and arithmetic (for a list of problems, see Appendix).

We scored the test by counting the number of items that each student got correct. This created a range of scores from 0-13. Any items that were unanswered were counted as incorrect.

The mean score on the test was 3.70 (s.d. = 2.42), and the mean score on only the difficult items was .62 (s.d. = 1.01). Descriptive statistics for all measures can be found in Table 12.

School-collected data. In addition to the test and survey, we asked teachers to report each participant's semester grade in mathematics for the semester data was collected as well as their previous years' state standardized test scores. Classroom grades were coded numerically on a scale from 1 to 10. A score of 1 indicated a failing grade, a score of 2 indicated a grade of D, a score of 3 indicated a grade of C, a score of 4 indicated a grade of C+, a score of 5 indicated a grade of B-, a score of 6 indicated a grade of B, a score of 7 indicated a grade of B+, a score of 8 indicated a grade of A-, a score of 9 indicated a grade of A, and a score of 10 indicated a grade of A+.

Procedure

Participants were initially given a packet with the Bem Sex-Role Inventory and asked to respond to all the questions while a proctor read them aloud. Once completed, a proctor picked up the first packet. Next, the students were given the test and told they would have 25 minutes to complete it. Students were given a few minutes to read the instructions and ask any questions before beginning. After the test was administered, the students were asked to respond to the items in the second survey. The entire procedure took approximately one hour.

Results

Overview

To begin, we found no gender differences in total score on the test or on the difficult items (see Table 13); however, there were gender differences in classroom grades (see Table 13).

Because this sample includes students from both seventh- and eighth-grade classes, we provide details about grade in school and performance on our mathematics performance

measure. Although we did not find any difference in classroom grades between the seventh- and eighth-grade students, not surprisingly, students in eighth grade performed significantly better than students in seventh grade on the state standardized test and the mathematics test we created (see Table 14).

Because we are interested in how masculinity and femininity may impact students' performance independent of gender, it is important first to know how these constructs may overlap with gender. We found no gender differences in mean reports of masculinity or femininity between boys and girls (see Table 15).

Do Gender, Femininity, or Masculinity Predict Test Performance?

To determine if gender, femininity, or masculinity predicted performance on the mathematics test, we ran two regressions with the overall score as the outcome. First, we ran a regression with femininity, masculinity, and gender as the predictors, and grade entered as a covariate (see Table 16). For overall test score, gender was approaching significance ($p=.076$), but none of the predictors reached significance at the $p=.05$ level. These findings indicate that, in terms of overall performance, neither masculinity nor femininity were significant predictors, and for the entire range of problems, gender may be more important than masculinity or femininity.

We ran a parallel regression with only the most difficult items (for a graph of the score distribution on these items see Figure 3) as the outcome variable. We did this because past literature has indicated that the greatest performance differences should be found on the most difficult problems (Geary, 1996; Halpern, et al., 2007; Hyde, Fennema, & Lamon, 1990). We isolated the five most difficult items on the test and ran the same regression, with the students' scores on the difficult items as the outcome. We again controlled for grade in these analyses (see

Table 17). Femininity negatively predicted performance on the most difficult items, indicating that identifying with feminine traits is associated with decreased performance on mathematics exams. Neither gender nor masculinity was a significant predictor of performance on the most difficult items.

Does Gender, Femininity, or Masculinity Predict Standardized Test Performance?

Similar to performance on the test we created, we expected a relationship between femininity, masculinity, and performance on the state standardized test. To test this, we ran a regression with femininity, masculinity, and gender as predictors of standardized test performance. We again controlled for grade in these analyses (see Table 18). We found that gender was a significant predictor of performance ($p=.043$) and femininity was approaching significance, but did not reach significance at the $p=.05$ level.

Does Gender, Femininity, or Masculinity Predict Classroom Performance?

Like test performance, we expected a relationship between femininity, masculinity, and performance in the classroom (as measured by classroom grades). To test this, we ran a regression with femininity and masculinity as predictors of classroom grades (see Table 19). In this regression we added gender as a covariate because there were significant gender differences in classroom grades. We also removed grade in school as a covariant, as we did not find significant differences in classroom grades between seventh- and eighth-grade students. We found that gender was the strongest predictor of classroom grades, but it did not reach significance.

Discussion

We chose to investigate the persistent finding that high-achieving females fail to engage with challenging math problems by taking a more nuanced approach in which we examined

students' identification with masculinity and femininity—as opposed to noting only a student's gender. We reckoned that this more nuanced approach could be an appropriate lens through which to conceptualize students' failure to engage successfully with challenging and difficult math problems.

In this investigation, we found a correlation between identification with feminine traits and relatively poor performance on the most difficult test problems, but we did not find this same relationship between gender and test performance or between masculinity and test performance. This suggests that a students' identification with feminine traits may be more important to—and work against—their performance on difficult mathematics problems than their gender. This is consistent with our hypothesis that femininity would negatively predict test performance, but, curiously, we did not find the opposite, that identification with masculine traits positively predicted test performance.

In some ways, it is not surprising that we did not find a correlation between masculinity and mathematics test performance. Although there have been some previous findings suggesting a negative relationship between femininity and math performance (Signorella & Jamison, 1986; Nash, 1975), very little if any previous research has documented a relationship between masculinity and performance. We reckon that this may be because there may be a baseline level of masculinity necessary to feel masculine enough to pursue mathematics. So, for instance, if a female student met this baseline level of masculinity and also does not strongly endorse feminine traits, she would see mathematics as not incongruent with her self-image and potentially eliminate the barrier of incongruence between her view of herself and mathematics, but not necessarily mean that she is interested in mathematics. That is, simply because there is a

congruence between the self and the task at hand, does not mean the task will be valued or pursued.

In terms of classroom grades and the state standardized test, we found a correlation with gender. Girls earned higher classroom grades than boys, on average. We did not find this same relationship between femininity or masculinity and classroom grades. We had expected femininity to be positively related to and masculinity to be negatively related to grades, but we did not find evidence for this.

A similar argument to the one about masculinity and mathematics test performance can be made about congruence between the self and the task at hand regarding classroom grades. Although there is evidence that girls receive better classroom grades than boys in mathematics (see present findings as well as, Ding, Song, & Richardson, 2006; Kimball, 1989; Willingham & Cole, 1997), there does not appear to be a strong association between classroom grades and femininity or masculinity. Therefore, it is possible that students view classroom work not as congruent, *per se*, but as not incongruent with their view of themselves.

Still, it is curious that we found that femininity is correlated with test performance, but not classroom grades and that gender is correlated with classroom grades, but not test performance. We expect that, at least in part, this result may have to do with the difficulty of our measure. The mathematics test given in this investigation was quite difficult, so perhaps an easier test would show a greater gender difference. That is, perhaps girls would outperform boys on less difficult problems, but when the problems increase in difficulty, like in the test we gave in this investigation, students' identification with femininity kicks in and leads to decreased performance. We have some support for this hypothesis in our findings with regard to the state standardized test: we found that gender was a significant predictor, but that femininity was only

approaching significance. Based on this hypothesis, we would expect that as the problems get harder, the students' femininity would become more salient. It is likely that the difficulty of the state standardized test falls somewhere in between the difficulty of the total researcher-created test and the difficulty of the most difficult items on the researcher-created test. Therefore, the fact that we see femininity approaching significance on this test suggests that it is possible that femininity becomes more salient as the difficulty increases. Further research is needed to confirm this.

Implications

Because we found that femininity was negatively correlated to performance on difficult mathematics problems, regardless of gender, and did not find a relationship between masculinity and test performance, we have some support for the idea that students do not necessarily view mathematics as masculine, but rather only as non-feminine. In other words, those who endorse and identify with femininity may not endorse or identify with mathematics because of its non-feminine nature. We suspect that, like adults, girls or boys who decide to pursue mathematics begin to shirk their feminine qualities in order to better fit with the image of a mathematician (Heilman & Okimoto, 2007; Kessels, 2005; Pronin, Steele, & Ross, 2004; Yoder & Schleicher, 1996). Further, we found this relationship only for performance on the most difficult items on our mathematics test. Thus, it could be that the negative influence of identification as feminine may only play out when the mathematics gets really difficult and where issues of femininity contradicting mathematics performance may be most heightened.

Interestingly, we also found mixed evidence that gender had a correlation with test performance, but we did find evidence that it had a significant correlation with classroom grades. This is somewhat inconsistent with previous research indicating that boys outperform girls on

mathematics standardized tests (Fiengold, 1992; Hedges & Friedman, 1993; Lindberg, Hyde, Petersen, & Linn, 2010; McGraw, Lubinski, & Strutchens, 2006; Strand, Dreary, & Smith, 2006; Robinson & Lubinski, 2011), but consistent with previous research indicating that girls outperform boys in the classroom (Ding, Song, & Richardson, 2006; Kimball, 1989; Willingham & Cole, 1997). These inconsistencies may be because this is a very recent sample of fairly young students. It could indicate that the stereotype about gender and mathematics is becoming less pervasive and we are starting to see the same patterns of girls outperforming boys in mathematics, just as we see in most other subjects. It could also be that the students are younger and, because gender gaps on standardized tests tend to increase with age (College Board, 2009, 2010), the differences in performance between these boys and girls has not yet emerged.

Limitations and Future Directions

As an initial investigation of identification with masculinity, femininity, gender, mathematics test performance, and mathematics classroom performance, we relied on a correlational design. We recognize that, with correlational designs, there is always the possibility of outside factors influencing the results. Future research should investigate and identify other factors that may influence the relationship between femininity and mathematics performance. A few candidate possibilities include teacher's gender and parents' and teacher's math attitudes (see e.g., Beilock, Gunderson, Ramirez, & Levine, 2010; Gunderson, Ramirez, Levine, & Beilock, 2012). It is also important for future research to pursue the idea that the negative impact of femininity that we uncovered may not come into play until the mathematics gets difficult.

We used a sample of only high-achieving students. Future research should investigate the relationship between gender, femininity, masculinity, and mathematics performance with a

larger, more representative sample. It is possible that a more diverse sample would provide more differentiated results.

Conclusions

In conclusion, there seems to be a connection between the way students view themselves and the way they approach difficult mathematics. Understanding how a student's identity may impact their performance both on mathematics tests and in the classroom is necessary to understanding why certain groups of students fall behind in mathematics. If an incongruence between the way students view themselves and the way they view mathematics is partially responsible for achievement gaps, it may be possible to take steps to change the image of mathematics. It is important to understand how and why students begin to distance themselves from mathematics to make it a field that is accessible to all.

Table 12

Descriptive Statistics for all Scales Used

	Mean (SD)	Min	Max
Femininity	4.68 (0.84)	2.00	6.60
Masculinity	5.04 (0.78)	2.30	7.00
Math Test – total score	3.70 (2.42)	0.00	13.00
Math Test – difficult items	0.62 (1.01)	0.00	5.00
State Standardized Test	281.16 (29.31)	196.00	360.00
Classroom Grades	B+ – A- (2 letter grades)	D	A+

Table 13

Means and Standard Deviations of Test Performance and Classroom Grades by Gender

	Mean Boys (SD)	Mean Girls (SD)	<i>T</i>	<i>p</i>
All Items	3.67 (2.39)	3.81 (2.46)	.58	.57
Difficult Items	.61 (1.03)	.66 (1.00)	.63	.63
Classroom Grades	7.40 (2.26)	8.00 (1.94)	-2.53	.01

Table 14

Means and Standard Deviations of Test Performance and Classroom Grades, by Grade

	Mean Seventh- Grade (SD)	Mean Eighth- Grade (SD)	<i>t</i>	<i>p</i>
All Items	3.12 (2.23)	4.43 (2.50)	-5.66	.00
Difficult Items	.46 (.91)	.82(1.08)	-3.72	.00
State Standardized Test	278.20 (30.84)	285.64 (26.34)	-2.03	.04
Classroom Grades	7.59 (2.05)	7.88 (2.16)	-1.23	.22

Table 15

Means and Standard Deviations of Masculinity and Femininity by Gender

	Mean Boys (SD)	Mean Girls (SD)	<i>t</i>	<i>p</i>
Masculinity	5.07 (.75)	5.01 (.81)	-.77	.44
Femininity	4.75 (.80)	4.64 (.86)	-1.24	.22

Table 16

Regression Model for Overall Test Performance

Predictors	<i>B</i>	<i>t</i> (df)	<i>p</i>
Femininity	-.035	-1.59 (368)	.557
Masculinity	-.048	-0.91 (368)	.364
Gender	.102	1.78 (368)	.076
Grade	.278	5.54 (368)	.000

Table 17

Regression Model for Performance on Difficult Problems

Predictors	β	t (df)	p
Femininity	-.152	-2.81 (365)	.005
Masculinity	.006	0.11 (365)	.911
Gender	.052	0.97 (365)	.334
Grade	.179	3.48 (365)	.001

Table 18

Regression Model for Standardized Test Scores

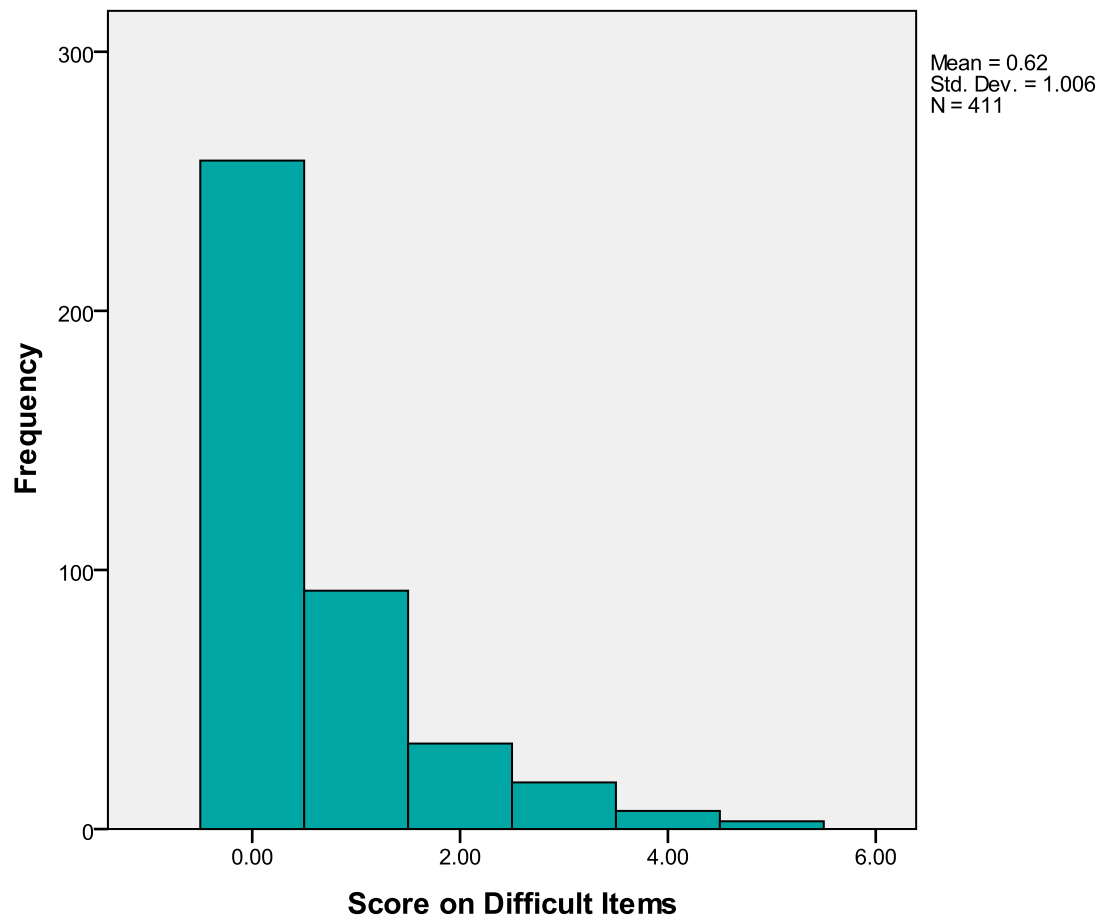
Predictors	β	t (df)	p
Femininity	.139	1.77 (236)	.078
Masculinity	-.050	-0.73 (236)	.467
Gender	.149	1.98 (236)	.049
Grade	.082	1.26 (236)	.208

Table 19

Regression Model for Classroom Grades

Predictors	β	t (df)	p
Femininity	-.03	-0.42 (293)	.678
Masculinity	-.07	-1.10 (293)	.271
Gender	-.12	-1.89 (293)	.060

Figure 3.



CHAPTER 5

CONCLUSIONS

Implications and Future Directions

In each of the three manuscripts included in this dissertation, the findings illustrate that motivation plays an important role in the development of the gender gap in mathematics. In middle school, the role that stereotype threat plays may be minimal, but the role of peer academic reputations and identification with feminine and masculine traits is likely influential in female students' decisions not to pursue mathematics.

The results of the first manuscript suggest that disidentification with mathematics is likely not a product of stereotype threat. Future research should consider other sources of motivation to investigate how and why girls begin to disidentify with mathematics at an early age.

The results of the second manuscript suggest that teachers and parents should try to foster the mathematical talent of their students by providing opportunities for those students who are quiet to demonstrate their abilities. This recognition has an impact on how students feel about themselves in mathematics and may lead to an increased identification with the subject. Future research should continue to investigate the link between achievement goals and recognition of talent by peers to determine if there is a causal relationship between gender, performance, recognition of talent, and identification with mathematics.

The results of the third manuscript suggest that gender socialization plays a big role in achievement in mathematics and that parents and teachers should be aware both of how their students identify themselves with regard to gender roles, but also how they are portraying mathematics. If the view of mathematics could be changed to a gender-neutral one, then perhaps

more mathematically talented girls would choose to pursue mathematics and mathematics-based careers. Future research in this area should continue to document differences in achievement as a function of gender identification rather than biological sex. In the future, researchers should also investigate how this gender identification may match or not match mathematics identification and how one may overrule the other in career selection.

My Future Directions

In my future as a researcher, I intend to continue to investigate this issue of early disassociation from mathematics by talented students. I am interested in when students begin to lose interest in mathematics as a possible career choice and how we may create interventions to prevent this from happening. In the future, I intend to pursue two intertwined, but separate lines of research.

The first centers around understanding how domain identification changes as students get older. For instance, in middle school, when students say they both like and value mathematics it means something very different than when college students say they both like and value mathematics. That is because in college, students are beginning to determine what fields they would like to pursue and rule out those they do not think will be important to their future. For younger students, saying mathematics is important to them implies a much weaker connection. I think that the way that the value of mathematics is measured is more reflective of how society tells students to feel about the value of mathematics and less a reflection of how the individual student feels about the value of mathematics in their lives. Figuring out how to measure that would provide a more clear view of how and when students begin to distance themselves from mathematics.

Another line of research that I am interested in pursuing is a series of follow-up studies to the study presented in Chapter 3: Achievement Goals. I am interested in further understanding the relationship between demonstrating ability and peer academic reputation; and peer academic reputation and performance and domain identification. That is, I would like to look at how peer academic reputations develop among high achieving students in mathematics. Is it something that happens as a result of positive performance and then that reputation fuels the need to demonstrate ability and maintain the reputation? Or is it something that is the result of demonstrating ability at an early age? Furthermore, is there a relationship between how peers view your mathematical prowess and how much or little you identify with mathematics? That is, if your peers identify you as a mathematically talented, do you then begin to identify more with mathematics?

In sum, my next research projects will continue to focus on how talented students begin to distance themselves from mathematics with an emphasis on how the pieces of this puzzle develop and interact.

Final Thoughts

In conclusion, the problem of the underrepresentation of women and minorities in mathematics fields does not seem to be ebbing. It is important to continue to look for ways to make mathematics a more open field where all students who are mathematically talented feel able to pursue and succeed within it.

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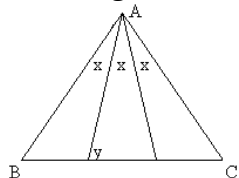
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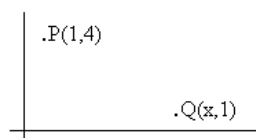
APPENDIX

1. In a class of 78 students 41 are taking French, 22 are taking German and 9 students are taking both French and German. How many students are not enrolled in either course?
2. If $4x + 10 = 34$, then $x - 4 =$
3. The average IQ of four people is 110. If three people each have an IQ of 105, what is the IQ of the fourth person?
4. If $pqr = 1$, $rst = 0$, and $spr = 0$, which variable must be zero, p , q , r , s , or t ?
5. A 50 foot tree casts a shadow 80 feet long at a certain time of day. A second tree near to the first casts a shadow 100 feet long at the same time. How many feet taller is the second tree than the first?
6. If $a^2 = 12$, then $a^4 =$

7. Triangle ABC is equilateral. What is the degree measure of angle y ?



8. The slope of the line passing through P and Q is $-3/5$. What is the value of x ?



9. In a certain game of 50 questions, the final score is calculated by subtracting twice the number of wrong answers from the total number of correct answers. If a player attempted all questions and received a final score of 35, how many wrong answers did he give?
10. A time-lapse camera takes pictures once every 40 seconds. How many pictures does it take in a 24-hour period? (Assume that it takes its first picture 40 seconds after the start of the time period.)
11. What is the slope of $3x + 4y = 24$?
12. $x + y = 15$, $y + z = 25$, and $x + z = 20$. What is the average (arithmetic mean) of x , y and z ?

CHALLENGE PROBLEM

What is the sum of the first 100 integers (i.e. 1, 2, 3, ... 99, 100)?