Female Teachers' Math Anxiety Impacts Girls' Math Achievement

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Abstract

People's fear and anxiety about doing math – over and above actual math ability – can be an impediment to their math achievement. We show that when the math anxious individuals are female elementary school teachers, their math anxiety carries negative consequences for the math achievement of their female students. Early elementary school teachers in the U.S. are almost exclusively female (> 90%) and we provide the first evidence that these female teachers' anxieties relate to girls' math achievement via girls' beliefs about who is good at math. 1st and 2nd grade female teachers completed measures of math anxiety. The math achievement of the students in these teachers' classrooms was also assessed. There was no relation between a teacher's math anxiety and her students' math achievement at the beginning of the school year. By school year's end, however, the more anxious teachers were about math, the more likely girls (but not boys) were to endorse the commonly held stereotype or belief that "boys are good at math and girls are good at reading" *and* the lower these girls' math achievement. Indeed, by the end of the school year, girls who endorsed this stereotype had significantly worse math achievement than girls who did not and than boys overall. In early elementary school where the teachers are almost all female, teachers' math anxiety carries consequences for girls' math achievement by influencing girls' beliefs about who is good at math.
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At most U.S. colleges and universities, the mathematics requirements for students majoring in elementary education are minimal.[1] As a result, students can successfully pursue a career as an elementary school teacher even if they have a propensity to avoid math. Interestingly, elementary education majors are largely female and have the highest levels of *math anxiety* of any college major.[2] Math anxiety manifests itself as an unpleasant emotional response to math or the prospect of doing math and is more common in women than in men.[2] Because of these negative reactions, people high in math anxiety tend to stay away from math courses and math-related career paths.[3-6]

Not only do math anxious people avoid math, they also perform more poorly than their abilities would suggest when they are exposed to math. This is because math anxiety is not simply a proxy for poor math ability. Rather, the fears that math anxious individuals experience when they are called upon to do math – whether it is working through a problem at the chalk board as an entire class looks on, taking a math test, or even calculating a restaurant bill – prevent them from using the math knowledge they possess to show what they know.[3] When worries and self-doubt occur, thinking and reasoning can be compromised.[7]

Math anxiety has been recognized as an impediment to math achievement.[8] Yet, fears and anxiety about math may have more widespread consequences than merely impacting the achievement of math anxious individuals themselves. If people who are anxious about math are charged with teaching others mathematics – as is often the case for elementary school teachers – teachers' anxieties could have consequences for their students' math achievement.

Even more striking is that any relation that may exist between teacher anxiety and student achievement might not be uniform across all students and their teachers. Children are more likely

to emulate the behavior and attitudes of same-gender versus opposite gender adults.[9,10] Because

early elementary school teachers in the U.S. are almost exclusively female (> 90%),[11] and gender

is a highly salient feature to children at the early elementary school age,[12] girls may be more

likely than boys to notice their teacher's negativities and fears about math. This, in turn, may

negatively impact girls' math achievement.

The research reported here assessed the math anxiety of seventeen 1st and 2nd grade

female teachers from a large Midwestern urban school district. The math achievement of the

students (52 boys; 65 girls) in these teachers' classrooms, along with students' beliefs about

gender and academic success in domains like math, was also assessed.

Our first hypothesis was that the more math anxiety a female teacher had, the lower her

students' math achievement. Our second hypothesis was that this relation would only hold for

girls. Finally, our third hypothesis was that any relation between female teachers' math anxiety

and girls' math achievement that did exist could be accounted for by whether girls in these

teachers' classrooms believed in traditional academic gender stereotypes (i.e., boys are good at

math while girls are good at reading).

To test these hypotheses, we assessed students' math achievement in the first three

months of the school year and again in the last two months of the year. We predicted that if

female teachers are influencing their students, a relation between teacher anxiety and student

achievement should be evident at the end of the school year, but not at the beginning of the year

when children's classroom exposure to their teachers is minimal. To test our third hypothesis

regarding how female teachers' anxieties might affect girls math achievement, we asked students

to perform a task that gauged the extent to which they adhered to traditional gender stereotypes

that boys are good at math and girls are good at reading. At both the beginning and end of the

school year, students were told two gender-neutral stories, one about a student who was good at

math and one about a student who was good at reading, and were asked to draw these students.[16]

We were interested in the genders of the drawings that children produced for each story. From

these drawings, we formed a measure of students' *gender ability beliefs* by assigning drawings of

boys a 1 and drawings of girls a 0 and subtracting the reading from the math drawing score [math

drawing – reading drawing]. The higher the score, the more children ascribed to traditional (or

stereotypic) gender roles in school.

Results

As expected, at the beginning of the school year, there was no significant relation

between teachers' math anxiety and students' math achievement [girls: r=-.13, p=.31; boys:

r=.12, p=.40]. However, by the end of the school year, the higher a teacher's math anxiety, the

lower the girls' [r=-.28, p=.022] but not boys' [r=-.04, p=.81] math achievement.[13]

Why might female teachers' math anxiety relate to girls' math achievement? Gender is an

individuating feature that early elementary school children notice.[12,14] Moreover, children at this

age are aware of commonly held beliefs about gender and ability[15,16] and are most likely to

embrace behaviors and attitudes that they feel are gender-appropriate.[10] One possibility is that

female teachers' math anxiety helps to confirm stereotypes about which gender is good at math

and this, in turn, impacts girls' math achievement. If so, then teachers' math anxiety should

relate to the beliefs that girls hold about which gender is good at math.

As with math achievement, there was no significant relation between teachers' math

anxiety and the gender ability beliefs of boys' [r=-.04, p=.80] or girls' [r=.20, p=.10][17] at the

beginning of the school year, before teachers had spent a significant amount of time with their students. This was true for boys at the end of the school year as well [r=.09, p=.52]. In contrast, for girls, by the end of the school year, the higher a teacher's math anxiety, the more likely girls' ability beliefs were to fall along traditional gender lines [r=.28, p=.022].[18] In addition, the more girls at the end of the year endorsed the notion that boys are good at math and girls are good at reading, the lower their math achievement [r=-.28, p=.025].

Female teachers' math anxiety negatively relates to girls' math achievement and also to girls' gender ability beliefs at the end of the school year. If this link between teacher anxiety and student math achievement occurs because teachers influence girls' gender ability beliefs and this in turn impacts girls' math performance, then the relation between teacher and student should be mediated (or accounted for) by girls' gender ability beliefs.

As seen in Figure 1, the relation between teacher math anxiety and girls' math achievement at the end of the school year became non-significant when girls' gender ability beliefs at the end of the year were also used to predict student math achievement. Only a strong negative relation between girls' gender ability beliefs and their math achievement remained. This relation did not hold for boys.

By school year's end, female teachers' math anxiety negatively relates to girls' math achievement and this relation is mediated by girls' gender ability beliefs. We speculate that having a highly math anxious female teacher pushes girls to confirm the stereotype that they are not as good as boys at math which, in turn, affects girls' math achievement. If so, then it follows that girls who confirm traditional gender ability beliefs at the end of the school year (i.e., draw boys as good at math and girls as good at reading) should have lower math achievement than

girls who do not *and* than boys more generally. This is exactly what we found. As seen in Figure 2, students' math achievement at the end of the year depended on their gender *and* whether they confirmed common gender ability beliefs [a student gender x gender ability belief interaction, $F(1,113)=3.79$, $p=.05$].

Girls who confirmed traditional gender ability beliefs had significantly lower end of the year math achievement (M=102.5, SE=2.41) than girls who did not [M=107.84, SE=1.61; 95% CIs: 104.66-111.03; d=.66]. Moreover, girls who confirmed traditional gender ability beliefs had significantly lower math achievement than boys overall at the end of the year as well [M=107.69, SE=1.62; 95% CIs: 104.49-110.90; d=.37]. Boys' end of the year math achievement did not differ as a function of gender ability beliefs [Don't Confirm: M=106.14, SE=1.80; Confirm: M=109.25, SE=2.69; 95% CIs: 103.92-114.58].

Importantly, these differences were not seen at the beginning of the school year, at which time teachers presumably had not had ample time to influence gender ability beliefs or relations between gender ability beliefs and math achievement. Indeed, in terms of the four groups displayed in Figure 2, there were no significant differences in math achievement at the beginning of the school year [no gender x gender ability belief interaction, $F(1,113)=2.11$, $p=.15$; Girls: Don't Confirm: M=101.44, SE=1.86; Confirm: M=99.0, SE=2.74; Boys: Don't Confirm: M=98.83, SE=2.04; Confirm: M=103.56, SE=3.06]. In concert with the mediation analysis above, these data suggest that girls' math achievement is, at least in part, related to their confirmation of traditional academic gender beliefs – beliefs that are affected by the math anxiety levels of their female teachers.

Discussion

Using a mediation analysis which depicts a model of a causal chain of events, we showed that female students' math achievement at the end of the school year is negatively impacted by the way in which their teachers' math anxieties alter these girls' gender ability beliefs.

Similar to previous work,[19] we did not find gender differences in math achievement at either the beginning [t(115)=.18, p=.86] or end [t(115)=.44, p=.66] of the school year. However, as Figure 2 clearly shows, by school year's end, girls who confirmed traditional gender ability roles performed worse than girls who did not, and worse than boys more generally. We show that these differences are related to the anxiety these girls' teachers have about math.

If it is simply the case that highly math anxious teachers are worse math teachers, then one would expect to see a relation between teacher anxiety and the math achievement of both boys and girls. Instead, teachers with high math anxiety seem to be specifically affecting girls' math achievement – and doing so by impacting girls' gender-related beliefs about who is good at math.

This is the first study to explore the relation between teachers' math anxieties and their students' math achievement. Thus, it is an open question as to whether there would be a relation between teacher math anxiety and student math achievement if we had focused on male instead of female teachers. In one sense, the lack of male elementary school teachers in the U.S. makes this a hard question to answer. Yet, it is an important question given research suggesting that girls are more socially sensitive than boys in early elementary school.[20] Thus, it is possible that even with male teachers, a relation between teacher anxiety and female student achievement might occur. Nevertheless, the literature on math anxiety, gender modeling, and the impact of

negative stereotypes on achievement lead us to speculate that any relation between male teacher

anxiety and girls' math achievement would be obtained through a different route than the one

proposed here. Moreover, in the current work, the relation between female teachers' math

anxieties and girls' math achievement was mediated (or accounted for) by girls beliefs that boys

are better at math. Hence, it seems unlikely that a male teacher's math anxiety would affect girls'

math achievement by pushing girls to confirm that boys are good at math.

In addition, children do not blindly imitate adults of the same gender. Instead, they model

behaviors they believe to be gender-typical and appropriate.[10] Thus, it may be that 1st and 2nd

grade girls are more likely to be influenced by their teachers' anxieties than their male

classmates because most early elementary school teachers are female and the high levels of math

anxiety in this teacher population confirm a societal stereotype about girls' math ability.[2] This

match between teacher math anxiety and societal norms would not hold for male teachers

exhibiting math anxiety. However, if such a correspondence is important in influencing student

achievement, we would expect that for school subjects where females are stereotyped to excel

(e.g., language arts), male teachers' anxieties would impact male more than female students'

achievement.

It is important to note that the effects reported in the current work, although significant,

are small. There are likely many influences on girls' math achievement and gender ability beliefs

over and above their current teachers' anxieties. For instance, previous teachers, parents, peers,

and siblings who either do or do not model traditional academic gender roles may play an

important part in shaping girls' gender ability beliefs and their math achievement more generally.

Exploring these relationships – in addition to the influence of both male and female teachers –

will help to elucidate the full range of social influences on student achievement.

In conclusion, we show for the first time that female teachers' math anxiety has

consequences for the math achievement of girls in early elementary school grades. Given that

this relation is mediated by girls' gender ability beliefs, we speculate that female teachers model

commonly held gender stereotypes to their female students through their math anxieties. These

findings open a new window into gender differences in math achievement and attitudes that

emerge over the course of schooling.

Interestingly, math anxiety can be reduced through math training and education.[21-23] This

suggests that the minimal mathematics requirements for obtaining an elementary education

degree at most U.S. universities needs to be rethought. If the next generation of teachers –

especially elementary school teachers – are going to effectively teach their students, more care

needs to be taken to develop both strong math skills *and* positive math attitudes in these

educators.

Methods

Teachers

Seventeen female first and second grade teachers (12 first grade, 5 second grade) from five public elementary schools in a large Midwestern school district participated in this study. The teachers had an average of 13 years of teaching experience (SD=9.20).

Teachers' math anxiety and math knowledge were assessed during the last two months of the school year. Math anxiety was assessed using the sMARS (short Mathematics Anxiety Rating Scale),[24] which is a 25-item version of the widely used, 98-item MARS.[25] Teachers responded to questions about how anxious different situations would make them feel (e.g., "reading a cash register receipt after you buy something" or "studying for a math test"). Responses were recorded on a Likert scale from 1 (low anxiety) to 5 (high anxiety). All analyses were performed on the average of the 25 items.

Teachers' math knowledge was assessed using the Elementary Number Concepts and Operations subtest of the Content Knowledge for Teaching Mathematics measure (CKTM).[26] This task measures teachers' facility in using mathematics knowledge for classroom teaching, including the ability to explain mathematical rules, assess the validity of unusual algorithms produced by students, and illustrate mathematical equations using diagrams or word problems. The content areas included addition, subtraction, multiplication, and division with whole numbers and fractions. The task consisted of 26 multiple-choice questions. Items that were left blank were considered incorrect. All analyses were performed on raw scores, the number of items correct out of 26.

Students

A total of 117 students (65 girls and 52 boys) participated. The number of girls and boys was fairly evenly distributed across the two grades [girls: 40 first graders, 25 second graders; boys: 38 first graders, 14 second graders] and including grade as a factor did not alter the significance of the mediation analyses reported above in any way.

Students' math achievement and gender ability beliefs were assessed during the first three months and the last two months of the school year. Math achievement was measured using the Applied Problems subtest of the Woodcock-Johnson III Tests of Achievement.[27] The Applied Problems subtest consists of orally presented word problems involving arithmetic calculations of increasing difficulty. Students were assessed at school during a one-on-one session with an experimenter. A different version of the Woodcock-Johnson was used for each assessment. Testing continued until a basal (6 items correct in a row) and a ceiling (6 items incorrect in a row) were established. All analyses within gender were performed on students' W scores, a transformation of the students' raw score into a Rasch-scaled score with equal intervals (a score of 500 is the approximate average performance of a 10-year-old). [28-29] Due to its properties as an interval scale with a constant metric, the W score is recommended for use in studies of individual growth. [30-31] All between gender analyses were performed on students' raw scores standardized as a function of their age (a score of 100 means that a student is at the average achievement level for his or her age). This was done to account for a marginally significant difference in age as a function of gender [$F(1,115)=3.47$, $p=.065$].

Students' gender ability beliefs were assessed after the math achievement task. Children were read two gender-neutral stories, one about a student who is really good at math, and another

about a student who is really good at reading. After each story, children were asked to draw a

picture of the student in the story, and were then asked whether the student they drew was a boy

or a girl. The order of the math and reading stories was counterbalanced across students within

classrooms.

The combined measure of *gender ability beliefs* was formed by assigning a 1 to drawings

of a boy and a 0 to drawings of a girl, and then subtracting the reading drawing score from the

math drawing score [math drawing – reading drawing]. Thus, a score of 1 indicates that a child

drew a boy as being good at math and a girl as being good at reading; a score of 0 indicates that a

child drew the same gender for each story; and a score of -1 indicates that a child drew a girl as

being good at math and a boy as being good at reading. In other words, the higher the gender

ability belief score, the more children ascribed to the traditional gender belief that boys are good

at math and girls are good at reading.

See supplementary methods for more details

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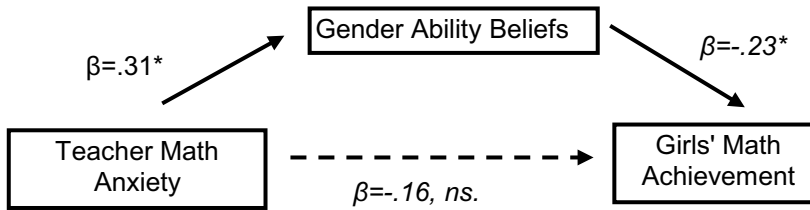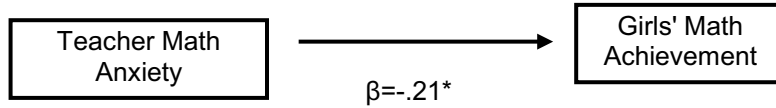[32]When teachers' math anxiety was in the equation, their math knowledge was controlled and when girls' end-of-year math achievement was in the equation, their beginning of the year math achievement was controlled.

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Figure Captions

Figure 1. A regression analysis established that **(A)** teachers' math anxiety had a significant

negative effect on girls' math achievement at the end of the school year [β=-.21, t=-2.17,

p=.034].[32] **(B)** Teachers' math anxiety also had a significant effect on girls' endorsement of

common gender ability beliefs (i.e., drawing a boy as good at math and a girl as good at reading)

at the end of the year [β=.31, t=2.22, p=.030]. Finally, girls' gender ability beliefs [β=-.23, t=-

2.81, p=.007] were a significant predictor of their end-of-year math achievement. When teacher

math anxiety and girls' gender ability beliefs were simultaneously entered as predictors of end-

of-year math achievement, teacher anxiety no longer significantly predicted girls' math

achievement [β=-.16, t=-1.59, ns.], whereas girls' ability beliefs [β=-.19, t=-2.24, p=.029]

remained significant in the equation. The reduction in the direct relation between teacher anxiety

and girls' math achievement was significant (95% CI:-2.4143 to -.0045, p<.05, as tested by a

bias-corrected bootstrapping procedure).[33] This provides support for our conclusion that

teachers' math anxiety hinders girls' math achievement through girls' relatively increased

acceptance of traditional gender norms in school. See supplementary methods for more details.

Figure 2. Math achievement scores (standardized based on students' age) at the end of the

school year for boys and girls as a function of whether they confirmed common gender ability

beliefs (drew a boy to depict a student good at math and a girl to depict a student good at

reading; **Confirm**) or did not (**Don't Confirm**) [Girls: Confirm: n=20; Don't Confirm: n=45;

Boys: Confirm: n=16; Don't Confirm: n=36].

Teacher Math Anxiety → Girls' Math Achievement

β=-.21*

Gender Ability Beliefs

β=.31*

β=-.23*

Teacher Math Anxiety

β=-.16, ns.

Girls' Math Achievement

*p<.05