MIND, BRAIN, AND EDUCATION

Teacher and Students' Mathematics Anxiety and Achievement in a Low-Income National Context

Lindsey Engle Richland[1], Emma Naslund-Hadley[2], Haydee Alonzo[3], Emily Lyons[4], and Elayne Vollman[5]

ABSTRACT— Negative relationships between mathematics anxiety and achievement appear in many countries globally (Lee, 2009; OECD, 2013), suggesting that mathematics anxiety could be an underconsidered factor in regions with persistently low mathematics achievement. We draw on a national sample of students and their teachers in Belize to examine relations between mathematics anxiety and achievement. The data replicated the negative relationships between students' math anxiety and achievement observed in many higher achieving, higher resourced regions, and importantly also revealed that teachers' mathematics anxiety predicted their students' mathematics attitudes and sometimes achievement. The effects were small overall so the robustness of this relationship is not clear, but they provide novel data toward building a comprehensive theory of mathematics anxiety's relationship to achievement across cultural, gender and age contexts, and offer insight into how addressing mathematics anxiety might improve mathematics teaching and achievement in low resourced countries.

Mathematical proficiency is a global area of concern, and improving the efficacy of mathematics education is viewed by many as a key to increasing nations' successful participation in the global economy. In light of the growing demand for science, technology, engineering, and mathematics (STEM) skills seen worldwide (BBC, 2013; Lacey & Wright, 2009; NEC, 2015), improving mathematics education could particularly serve as a powerful lever for boosting the economic outcomes of citizens of low wealth nations (Hanushek & Woessmann, 2012a, 2012b). Yet, even as many countries seek to enhance STEM education in their schools (Lacey & Wright, 2009), some are making more progress than others (Shimizu & Kaur, 2013). While there are many contributors to the widespread challenges faced by educators and policy makers in this regard, we draw attention to a factor that is often underconsidered in the global discourse on mathematics education: mathematics anxiety in both teachers and students, and the potential for relations between these two.

Mathematics anxiety has been described as a feeling of tension and anxiety regarding mathematics that interferes with the activities of numerical calculation, manipulation, or solving of mathematics problems in everyday, as well as academic, contexts (Ashcraft & Kirk, 2001; Richardson & Suinn, 1972). In most countries where it has been assessed, mathematics anxiety has been linked to reduced mathematics achievement, with the strongest relationships observed in the highest-performing youth, though there are exceptions at the national level (OECD, 2013).

Women and girls generally report higher levels of trait mathematics anxiety than their male counterparts (Bieg, Goetz, Wolter, & Hall, 2015; Devine, Fawcett, Szűcs, & Dowker, 2012; Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013; Hembree, 1990; Hyde, Fennema, Ryan, Frost, & Hopp, 1990). However, the magnitude of these gaps vary geographically, suggesting that gender differences in mathematics anxiety appear to depend in part on cultural context (Else-Quest, Hyde, & Linn, 2010; Stoet, Bailey, Moore, & Geary, 2016). When the gaps are evidenced, they generally

[1]University of California Irvine, Irvine, CA
[2]Inter-American Development Bank, USA
[3]Independent Consultant, USA
[4]TERC, USA
[5]University of Chicago, USA

Address correspondence to Lindsey Engle Richland, University of California Irvine, 3200 Education Building, Irvine, CA 92697; e-mail: l.richland@uci.edu

reveal girls as more anxious than boys. Thus, mathematics anxiety may be one explanation for the persistence of gender gaps in STEM careers worldwide despite overall advances in gender equality, and math achievement, internationally (NSF, 2014a, 2014b).

Links between mathematics anxiety and performance have been described as a "global phenomenon" (Foley et al., 2017). Indeed, the largest set of international data on mathematics anxiety to date, developed by the Organization for Economic Co-operation and Development (OECD, 2013), shows links between 15-year olds' mathematics anxiety and achievement both within and between countries. In the 64 countries that participated in the most recent Program for International Assessment (PISA), students tended to have lower than average math anxiety in those countries with higher than average math performance (OECD, 2013; see Foley et al., 2017). Though the PISA data could not link individual student data between anxiety and performance, at the national level in all but one of the 64 countries sampled, mathematics anxiety was negatively related to 15-year olds' test performance (OECD, 2013; see Foley et al., 2017).

At the same time, there was also evidence that the nature of the relationships between mathematics anxiety and performance may be culturally specific. The Latin American and Caribbean (LAC) countries included in the OECD data collection were among the highest internationally in mathematics anxiety, and the lowest in overall achievement, suggesting that mathematics anxiety may be an important consideration in addressing achievement in this region. Further, not all nations demonstrated the negative relationship between anxiety and performance, and the strength of the relationship between mathematics anxiety and performance varied betweelen countries (OECD, 2013). In China, both mathematics anxiety and achievement were high, suggesting that, like gender gaps in mathematics anxiety, relationships between mathematics anxiety and performance may depend in part upon cultural context.

Similar relationships were observed in data from 43 nations participating in the 2003 PISA administration (Lee, 2009). In this dataset as well, students in several Asian countries had high mathematics achievement despite also having high mathematics anxiety, translating into low within-country correlations between achievement and anxiety in mathematics in Indonesia (−0.12), Thailand (−0.15), and Japan (−0.16) (Lee, 2009). These differences were supported in a more individual level analysis comparing cognitive (the worry component) and affective anxiety (the emotional component) with mathematics achievement in United States, Chinese, and Taiwanese samples (Ho et al., 2000). The authors find that while there is a positive and significant relation between cognitive anxiety and mathematics achievement (parameter estimate is 0.25) in Taiwan, affective anxiety is more strongly negatively correlated with achievement in all three countries, resulting in parameter estimates of −0.68, −0.54, and −0.57 for China, Taiwan, and the United States, respectively.

While most of the research on mathematics anxiety conducted to date has been in Western, educated, industrialized, rich, and democratic, or "WEIRD," societies (Henrich, Heine, & Norenzayan, 2010), PISA findings make clear that the link between mathematics anxiety and performance is not exclusive to WEIRD countries, nor do these always function the same way across cultural contexts.

Little work has focused on the role of math anxiety in low wealth and low performing countries. It is possible that this is a context where anxiety plays an even larger role due to persistently low achievement. Mathematics anxiety is often highest in low-*achieving* countries, and math achievement tends to correlate with national wealth (OECD, 2013).

One of the few studies to examine relations between mathematics anxiety and achievement in a relatively low-income/low performing nation, Turkey, found that mathematics anxiety more powerfully predicted mathematics achievement among males—a pattern indicating that the relations between gender and math anxiety may vary across cultural contexts (Erden & Akgül, 2010).

Thus, understanding the role of mathematics anxiety globally requires a more systematic approach which extends beyond "WEIRD" or other high-achieving nations. We review key considerations in deconstructing the mechanisms underlying mathematics anxiety and achievement.

TEACHERS' KNOWLEDGE AND ATTITUDES TOWARD MATHEMATICS

Few studies examining mathematics anxiety and performance also examine the role of individual teacher factors related to knowledge and confidence about teaching mathematics, which may function differently from confidence about doing mathematics. Teachers' mathematics skill and their knowledge of students' mathematical thinking required for teaching, such as knowing their common misconceptions and errors, described as knowledge of mathematics for teaching (Hill, Schilling, & Ball, 2004), are known to relate to instructional practices as well as student learning (for review, see Hill, Charalambous, & Chin, 2018). However, the relationships between teachers' affective relationships to mathematics teaching and learning are much less well understood, particularly at a global level. We are particularly concerned with the possibility that teachers' affective relationships toward mathematics may play an underacknowledged role in shaping youth's mathematics knowledge and affect. U.S. data have revealed that teachers' mathematics anxiety can lead to lower mathematics achievement in their students

(Beilock, Gunderson, Ramirez, & Levine, 2010), with similar results in a related STEM domain revealing that teachers' spatial anxiety could negatively impact students' spatial learning (Gunderson, Ramirez, Beilock, & Levine, 2013).

Teachers with more negative mathematics attitudes, as well as with lower mathematical knowledge, may also bring lower confidence about teaching to their teaching practices, together leading to less engagement of students in active mathematics learning activities (Hill et al., 2008; Lee, 2009; Stipek, Givvin, Salmon, & MacGyvers, 2001; Wilkins, 2008). Normative teaching is well known to be culturally variable (Hiebert et al., 2005; Sims et al., 2008), and instruction in low-income LAC countries tends to be teacher centered, with large classrooms and few opportunities for student participation, and engagement in deep/ analytical thinking (Näslund-Hadley, Loera Varela, & Hepworth, 2014). This may make the role of teacher knowledge and affect particularly impactful in this context, since it could exacerbate students' already low engagement in activities beyond drill, practice, and memorization. Alternatively, teachers' mathematics anxiety could play a smaller role in such contexts, since even low anxiety teachers with adequate knowledge may not rely upon these skills.

The teachers' level of mathematics anxiety might also directly affect their students' math anxiety, which can then have its own consequences for students' math engagement and achievement. Teachers may not only teach mathematics content differently when they are anxious, but they may also directly model an attitude. While this has not yet been directly documented, we anticipate that in the context of low mathematics achievement at a national level, anxiety could be passed from teacher to students, which would create an even more challenging problem for instructional reform than simply improving mathematics understanding. One would also need to address worries and anxiety at a systems level.

ATTITUDES AFFECTING THE RELATIONS BETWEEN MATHEMATICS ANXIETY AND ACHIEVEMENT

Affective attitudes toward mathematics include both negative and positive assessments of one's ability to engage with mathematical content and calculations, and may play a crucial role in mathematics teaching and learning in low-income nations (Ho et al., 2000). Mathematics anxiety has been shown to be related to students' self-confidence, enjoyment, and motivation, which could compound the direct effects of mathematics anxiety on achievement (Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014; Skaalvik, Federici, & Klassen, 2015; Tapia & Marsh, 2004).

When measured at two points beginning at school entry, Gunderson and colleagues were able to show that math anxiety, math achievement and motivational attitudes (beliefs that ability is innate or can change with effort) seemed to operate in reciprocal relations. Early high achievement predicted lower math anxiety, while higher math anxiety and lower math achievement tended to predict each other, suggesting that these attitudes and achievement build on one another in positive or negative cycles (Gunderson, Park, Maloney, Beilock, & Levine, 2018a).

Self-efficacy, an individual's belief that his or her actions can lead to desired outcomes and that he or she has the ability to succeed in a given domain (Bandura, 1986; Dweck, 2014; White, 1959), may be a particularly strong candidate for an underlying mechanism whereby mathematics anxiety results in reduced achievement (Ganley & Lubienski, 2016; Hoffman, 2010; Pajares, 1996). Self-efficacy is hypothesized to influence choice of behavioral activities, effort expenditure, persistence in the face of obstacles, and task performance (Honicke & Broadbent, 2016; Multon, Brown, & Lent, 1991), influencing a child's acquisition, transfer, and use of knowledge and skills (Schunk & Hanson, 1987; Skaalvik et al., 2015). Indeed, self-efficacy in mathematics has been shown to be a strong predictor of mathematics performance (Fast et al., 2010; Pajares & Miller, 1994). For example, Collins (1982) found that even when previous mathematics performance was controlled for, children with high self-efficacy performed better on novel math problems, persisted longer, and showed greater effort.

Self-efficacy may have both direct and indirect relationships to achievement and anxiety. Siegel, Galassi, and Ware (1985) showed that self-efficacy accounted for a large proportion of variance in mathematics performance, beyond that of mathematics anxiety, and a path analysis similarly revealed strong direct relationships between self-efficacy and both mathematics anxiety and choice of math-related careers (Lee, 2009). Other research posited that self-efficacy may moderate the relationship between mathematics anxiety and achievement (Hoffman, 2010).

Together, this research underscores that affective responses, including both mathematics anxiety and self-efficacy, are strong influencers on achievement as well as enrollment and persistence in STEM-related fields and long-term career trajectories (Bandura & Barbaranelli, 2001, Skaalvik et al., 2015). However, questions remain regarding the directionality of these complex relationships over time and the relative contributions of self-efficacy versus mathematics anxiety. The relationships among anxiety, self-efficacy, and achievement are especially uncertain in low-income countries, which have lower levels of STEM involvement and achievement overall.

GENDER GAPS

Gender gaps must also be considered in an analysis of the relationships between mathematics anxiety and achievement, since gender gaps persist in almost all nations in mathematics anxiety (OECD, 2013) as well as STEM achievement and career representation more broadly (Leslie, Cimpian, Meyer, & Freeland, 2015; NRC, 2013; Stoet & Geary, 2018). The magnitude of gender differences in mathematics anxiety and achievement varies geographically (Else-Quest et al., 2010; Stoet et al., 2016), suggesting that these gaps may be sensitive to environmental factors and depend in part on cultural context. Unfortunately, however, overall improvements in gender equality are unlikely to attenuate gender gaps in STEM careers. Counterintuitively, gender gaps in both mathematics anxiety (Stoet et al., 2016) and relative achievement scores (here comparing science and reading achievement percentiles, Stoet & Geary, 2018) tend to be largest in nations with high levels of gender equality.

Sex differences in affective feelings about mathematics can already be observed in early elementary school (Beilock et al., 2010; Eccles, Wigfield, Harold, & Blumenfeld, 1993), and these have been linked to participation in STEM careers (Bian, Leslie, Murphy, & Cimpian, 2018; Chipman, Krantz, & Silver, 1992). Reasons for these gender gaps are not well understood, though cultural socialization mechanisms have been posed, such that socialized stereotypes and worries may load girls' working memory resources, leading to underperformance on tests (Beilock et al., 2010; Bian et al., 2018; Ganley & Vasilyeva, 2014). There is some suggestion from U.S. samples that mathematics anxiety in female teachers (Beilock et al., 2010) can have deleterious effects and may be especially harmful for girls' achievement, through increased negative stereotypes about girls' abilities in math. If regularly involved in students' work, anxious parents' attitudes can also impact mathematics achievement and attitudes in children (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Additionally, mathematics anxiety may have a larger detrimental impact on mathematics achievement among girls than among boys. For example, Erturan and Jansen (2015) found that mathematics anxiety negatively predicted the mathematics achievement of girls, but not of boys, though self-efficacy was the strongest predictor for all students. Thus in a region such as Belize, the gender differences in anxiety and the strengths of their relationships with achievement are unclear.

THE CURRENT STUDY

Context

The current study provides novel insights into mathematics anxiety through a national sample of paired student and teacher data in the highly diverse, low resourced nation of Belize. In Belize, there are seven primary languages across the country, as well as diversity by race and ethnicity. Common ethnic and cultural identifications include mestizo, Maya, Creole, Garifuna, and Mennonite, and there are growing populations of immigrants from various Middle Eastern and East Asian nations. English is the primary language used in schools for instruction and testing, although it is the first language of a minority of the population. A majority of the schools are operated by private providers, mainly churches from the Roman Catholic, Anglican, Methodist, and Seventh-day Adventist. The country's literacy rate reached 82.8% in 2015, representing an increase from 70.3 in 1991 (UNESCO Institute for Statistics). Primary education is free of charge and compulsory to the age 14.

Belize therefore offers a unique context to study the relationships between mathematics achievement, anxiety, and self-efficacy because it has such a diverse population of school enrolled children, and allows for examining patterns of relationships that persist above and beyond these sources of variability (Naslund-Hadley et al, 2013).

Study Overview

We report on a cross-sectional study examining mathematics anxiety, attitudes, and self-efficacy across grade levels to provide new insights into the relationships between them. The data for the study were collected from April–May 2016 and was part of a national data collection—meaning data were collected from all schools and students across the nation. This national data collection also paired teachers and their students, enabling analyses testing relationships between teachers' affective and mathematical knowledge levels with students' affective and achievement outcomes in mathematics. Three main research questions were addressed, all involving mathematics anxiety and skills among both teachers and students.

First, we report the overall characteristics of teachers' mathematics anxiety in Belize, examining the hypothesis that mathematics anxiety will be high in a nation with low mathematics achievement overall. We also describe correlations with gender and evaluate claims made in the literature that teachers' anxiety will be inversely correlated with their knowledge of mathematics content and pedagogy, and confidence in teaching mathematics, which we test while controlling for socioeconomic status.

Second, we report the overall characteristics of students' mathematics anxiety and achievement in Belize. We examine the hypotheses that mathematics anxiety will be high overall, higher in girls than in boys, inversely correlated with achievement, and will be related to other affective attitudes toward mathematics, including self-efficacy and enjoyment.

Third, we test the hypothesis that mathematics anxiety has a social basis and that students' mathematics anxiety can be predicted by their teachers' mathematics anxiety and knowledge of mathematics. While previous studies identified relationships between teachers' math anxiety and children's achievement, which we test for replication, we also examined whether children's math anxiety itself was predicted by their teacher's anxiety.

METHODOLOGY

Participants

A total of all enrolled 8,798 children from 252 publicly financed primary schools participated in the study conducted in Belize, which was directed by the Belize ministry of Education.[1] All children in two grades—standard 2 and standard 5—at these schools participated as part of a national data collection. However, data from 25 schools (1,007 observations) were not considered in the sample due to their participation in a government in-service teacher professional development program, which included training in mathematics teaching practices. Additionally, students without information on gender were also eliminated from the current analyses (288 observations).

Our final sample comprised 7,443 children attending 226 publicly financed primary schools, 3,741 of them in standard 2, and 3,702 in standard 5. Though, each analysis has different sample sizes included due to missing data points. See Supplemental Materials for a full listing of missing data per data point. These are the approximate equivalents of grades 4 and 7 in the United States, though the grades are not quite comparable since children in Belize enter school 1 year younger than children in the United States. So—the ages of children are comparable to U.S. grades 3 and 6, though the number of years in school is comparable to grades 4 and 7. We use the latter numbers throughout for clarity since that is the most recognized equivalent. Official attendance ages for these grade levels were 8/9 and 11/12 years, though consistent with many low-income nations, the proportion of overaged students (that is, older than they should be for their grade level) was high (50.7% in standard 2 and 56.6% in standard 5). The gender breakdown of the sample was even and matched the gender distribution of children in Belize: 50% female and 50% male. Most of the students (81%) attended schools operated by private providers, mainly churches from the Roman Catholic, Anglican, Methodist, Seventh-day Adventist, and Mennonite denominations. Almost 45% of the study participants attended schools in the country's two largest districts, Belize and Cayo. Most of the schools (74.5%) are located in rural, not urban, areas. See Table 1 for full demographic data.

Students were informed that their participation was voluntary and that it would not influence their grades.

The teachers of the participating students were also included in the sample (Table 2). These included 213 standard 2 teachers and 208 standard 5 teachers. As is typically the case at the primary level of education in Belize, the teachers were generalist teachers who study and teach all core subjects, including mathematics. Although not specialized mathematics instructors, approximately 80% have completed mathematics methods courses as part of their preservice teacher training. Almost 60% of the teachers were female and approximately half (50.8%) were younger than 36 years. About three quarters (74.1%) of the group of teachers taught in rural areas, and slightly more than 40% were located in the central districts of Belize and Cayo.

MEASURES

The measures administered and test properties are described in more detail below.

Teacher Assessments

Teachers' Mathematical Content Knowledge

This was assessed using the final examination that all primary school students take in the equivalent of eighth grade in Belize. The test was comprised of 30 multiple-choice items that reflected curricular aims addressed in the mathematics curriculum. The majority of teachers (84%) who took the exam obtained scores that reflected a nationally designated "satisfactory" (Grade C) or higher. More than a third (41%) scored "excellent" (Grade A), and close to a fifth (16%) scored a Grade D and below. The average score of teachers on the test was 22.5/30 ($SD = 4.79$), with teachers obtaining scores as low as 1 and as high as 29. The reliability of the test was high ($\alpha = 0.88$, KR20 = 0.80). While teachers of younger grades may not be required to teach all of the mathematics assessed on this measure, the nature of mathematics as cumulative systems suggests that high quality introductions to key arithmetic principles would require complete understanding of mathematics from basic number, arithmetic and geometry to early algebra, as was assessed on this measure.

Teachers' Pedagogical Content Knowledge

Teachers' knowledge of mathematics for teaching was assessed in a core domain of elementary school mathematics—the teaching of number concepts and operation (NCTM, 2000). Teachers were administered Form A of the Elementary Number Concepts and Operations Content Knowledge, which consists of 26 multiple-choice items (Hill et al., 2004). While this instrument was developed with U.S. teachers, thus an educational landscape different from that

Table 1
Demographic Data on Students by Grade

	Grade 4		*Grade 7*		*Total*	
Characteristics	*Frequency*	*%*	*Frequency*	*%*	*Frequency*	*%*
Gender						
Boys	1,877	*50.2*	1,837	*49.6*	3,714	*49.9*
Girls	1,864	*49.8*	1,865	*50.4*	3,729	*50.1*
Age						
6 to 7 years	42	*1.1*	0	*0.0*	42	*0.6*
8	1,443	*38.6*	0	*0.0*	1,443	*19.4*
9	1,303	*34.8*	7	*0.2*	1,310	*17.6*
10	414	*11.1*	30	*0.8*	444	*6.0*
11	133	*3.6*	1,249	*33.7*	1,382	*18.6*
12	37	*1.0*	1,229	*33.2*	1,266	*17.0*
13	8	*0.2*	648	*17.5*	656	*8.8*
14	0	*0.0*	174	*4.7*	174	*2.3*
15	0	*0.0*	46	*1.2*	46	*0.6*
Did not report	361	*9.6*	319	*8.6*	680	*9.1*
Funding						
Government aided	2,991	*80.0*	3,038	*82.1*	6,029	*81.0*
Government	750	*20.0*	664	*17.9*	1,414	*19.0*
Geographic zone						
Urban	1,202	*32.1*	1,191	*32.2*	2,393	*32.2*
Rural	2,539	*67.9*	2,511	*67.8*	5,050	*67.8*
District						
Corozal	631	*16.9*	590	*15.9*	1,221	*16.4*
Orange Walk	487	*13.0*	459	*12.4*	946	*12.7*
Belize	800	*21.4*	730	*19.7*	1,530	*20.6*
Cayo	867	*23.2*	911	*24.6*	1,778	*23.9*
Stann Creek	397	*10.6*	459	*12.4*	856	*11.5*
Toledo	559	*14.9*	553	*14.9*	1,112	*14.9*
Total observations	3,741		3,702		7,443	

of Belize, it is a measure that has been well validated for use with a range of teachers and offers an additional perspective on the ways that teachers in Belize are conceptualizing mathematical knowledge. The measure is unique as it does not capture ability to execute procedures in these domains, nor cultural norms for teaching, which are known to vary across nation and region (Hiebert et al., 2005). Rather, this measure assesses teachers' ability to be flexible and fully understand the mathematical implications of the content for teaching, such as recognizing nonstandard correct solutions or common misconceptions. At the same time, it is a very difficult test and is often designed to examine growth following an intervention.

We specifically used the version of the assessment measuring knowledge of mathematics for teaching: number concepts and operations (Hill et al., 2004), since that is a core part of these teachers' content focus in early to middle elementary school. The test measure was originally designed to meet a normative score of 50%. A majority of teachers in Belize (90.1%) who took the exam scored in the % to 50% range, which was below the normative score. A minority of teachers (4.8%) scored in the 61–100% range, which was above the normative score and thus was interpreted as "satisfactory." Teachers scored 6.99/26 ($SD = 4.83$) on average and obtained scores as low as 0 and as high as 25. The reliability of the test was high when measured 1 year later ($\alpha = 0.83$, KR20 = 0.83).

Teachers' Mathematics Anxiety

Teachers completed the Mathematics Anxiety Rating Scale-A (MARS-A), developed by Suinn and Winston (2003). This measure asked adults to rate their math anxiety on 30 questions, from not at all to very much on a 5-point scale. The questions asked about common situations such as calculating the cost of items or dividing multidigit numbers with paper, or academic situations such as studying for a math test. The latter items may have been less sensitive for teachers. A majority of teachers who completed the test obtained scores that imply a low (49.6%) or medium (47.8%) level of mathematics anxiety. 2.6% of teachers scored high. The test–retest reliability was 0.91 ($p < .001$), with retest data being conducted 1 year later.

Table 2
Demographic Data on Teachers by Grade

	Grade 4		*Grade 7*		*Total*	
Characteristics	*Frequency*	*%*	*Frequency*	*%*	*Frequency*	*%*
Gender						
Male	74	*34.7*	91	*43.8*	165	*39.2*
Female	132	*62.0*	109	*52.4*	241	*57.2*
Did not report	7	*3.3*	8	*3.8*	15	*3.6*
Age						
Younger than 24 years	20	*9.4*	12	*5.8*	32	*7.6*
Between 24 and 35 years	101	*47.4*	81	*38.9*	182	*43.2*
Between 36 and 45 years	58	*27.2*	76	*36.5*	134	*31.8*
Between 46 and 55 years	23	*10.8*	28	*13.5*	51	*12.1*
Older than 55 years	5	*2.4*	5	*2.4*	10	*2.4*
Did not report	6	*2.8*	6	*2.9*	12	*2.9*
Funding						
Government aided	164	*77.0*	160	*76.9*	324	*77.0*
Government	49	*23.0*	48	*23.1*	97	*23.0*
Geographic zone						
Urban	54	*25.4*	55	*26.4*	109	*25.9*
Rural	159	*74.6*	153	*73.6*	312	*74.1*
District						
Corozal	33	*15.5*	34	*16.4*	67	*15.9*
Orange Walk	29	*13.6*	28	*13.5*	57	*13.6*
Belize	40	*18.8*	41	*19.7*	81	*19.2*
Cayo	49	*23.0*	44	*21.2*	92	*22.1*
Stann Creek	22	*10.3*	23	*11.1*	45	*10.7*
Toledo	40	*18.8*	38	*18.3*	78	*18.5*
Total observations	213		208		421	

Teachers' Self-Efficacy (or Self-Concept)

Due to time constraints, teachers were asked to rate their confidence in teaching mathematics using a single question: "How confident are you to teach math?" Using a Likert-type scale, respondents could specify if they were: not at all confident, somewhat confident, confident, or very confident (Lee, 2009; OECD, 2013; Lemke, Williams, Roey, Smith, Kastberg, Jocelyn, & Ferraro, 2003). This assessed self-efficacy about *teaching* mathematics, rather than *doing* mathematics, which was assessed in the MARS-A as described above.

Student Assessments

Students' Mathematics Achievement

The administered mathematics measures were developed as part of this study to ensure alignment with curricular content and Belize's national learning plans for standards 2 and 5, and to ensure contextually appropriate questions. The measure underwent a rigorous process of development, review by local and international experts, refinement, and piloting. The tests were administered in the final quarter of the school year.

Each measure included 20 multiple-choice questions, with a range of items ranging from simple to more complex in difficulty. Each test took 30 minutes to complete, and all questions were scored 1 for correct and 0 for incorrect; missing responses were also captured. In standard 2, the mathematics test covered five areas: operations and algebraic thinking; place value understanding and properties; fractions; measurement and data; and geometry. On average, standard 2 students scored 6.50/20 ($SD = 2.84$) on the test, with the minimum and maximum scores being 0 and 19, respectively. At the school level, the average score was 6.51/20 ($SD = 1.55$), while the median score was 6.35. In standard 5, the test also covered five areas: ratios and proportional relationships; multiplications and rational numbers; expressions and equations; statistics; and geometry. The average score of standard 5 students on the test was 6.70/20 ($SD = 2.87$), with students obtaining scores as low as 0 and as high as 18. The average score of schools was 6.66 ($SD = 1.72$), and the median score was 6.29. The reliability of the test was moderate in both standard 2 ($\alpha = 0.54$, KR20 = 0.54) and standard 5 ($\alpha = 0.55$, KR20 = 0.55), though lower than would be ideal. In part, this variability was unavoidable due to the Belize context, with a combination of low mathematical skill and the complexity of assessing a multilingual community in which English is the mandated language of instruction and assessment, but not the primary language for the majority of students.

Students' Mathematics Anxiety

This was measured using the Mathematics Anxiety Rating Scale-Elementary (MARS-E) Form (Suinn, Taylor, & Edwards, 1988). The validity and reliability of MARS-E has been extensively studied, and MARS-E is one of the most widely used methods of measuring mathematics anxiety among elementary students. The scale was developed to be appropriate in content difficulty and reading level for upper elementary school children (Suinn et al., 1988), and modified versions of the scale have been used successfully with children as young as four (Gunderson et al., 2018a; Ramirez, Gunderson, Levine, & Beilock, 2013). Its scale consists of 26 5-point Likert-type items that assess the degree of anxiety that students experience in specific life situations. Several center on the school context; for example, "When getting your mathematics book and seeing all the numbers in it, how nervous do you feel?" (item 1), or "when you have to add 976 + 777+ 458 on paper" (item 4). Others measure anxiety in everyday life situations, such as: "When figuring out if you have enough money to buy a candy bar and a soft drink, how nervous do you feel?" (item 26). Importantly, because children are not required to actually solve problems, the scale can be used with children of a wide range of achievement levels (Suinn et al., 1988; Suinn, Taylor, & Edwards, 1989).

Cronbach alpha reliability was high, indicating that MARS-E is a reliable measure of mathematics anxiety among Belizean primary school students ($\alpha = 0.88$). Results show that the scores ranged from 1 to 130 among standard 2 students, and that their average score was 63.55 ($SD = 22.74$), which is comparatively high, corresponding to the 75th percentile norms for children in this age group in the United States (Suinn et al., 1988). At the school level, similar results were observed: the average and median scores were 63.76 and 65.44, respectively. In standard 5, scores ranged from 1 to 123, with an average student score of 63.60 ($SD = 17.08$). The average and median school scores were 63.92 and 63.95, respectively. These scores were again relatively high, above the 75th percentile.

Student Self-Efficacy

Due to time constraints, students were asked to rate their confidence in mathematics using a single question: "How confident are you in your ability to do math?" Using a Likert-type scale, respondents could specify if they were not at all confident, somewhat confident, confident, or very confident.

Wealth Index

The wealth index measured socioeconomic status, calculated using a Principal Component Analysis of children's home environments. This was done following studies that find income or maternal education rates, typical measures in higher wealth regions, are not adequately meaningful measures alone in very low wealth regions. In particular, the estimation of wealth using this analysis was based on the first principal component. The wealth index for household i was defined as:

$$y_i = \alpha_1 \left(\frac{x_1 - \bar{x}_1}{s_1} \right) + \alpha_2 \left(\frac{x_2 - \bar{x}_2}{s_2} \right) + \ldots + \alpha_7 \left(\frac{x_7 - \bar{x}_7}{s_7} \right)$$

where $\bar{x}$ and s_i are the mean and standard deviation of asset x_i, and α_i corresponds to the weight for each asset x_i for the first principal component. The assets considered in the analysis were the following: cable TV, washing machine, computer, air conditioner, running water, sewerage, and car/vehicle. The measure was self-reported by children who were asked questions about their home context (e.g., "do you have cable television, a washing machine").

RESULTS

Data and identifiers were collected at three levels: students within classrooms within schools. So, we used hierarchical linear modeling (HLM) to account for the hierarchical structure of the data. We first report a set of regressions, using this methodology, that examine Belize teachers' overall mathematics knowledge and anxiety, examining whether negative relations between mathematics affect and achievement were observed in teachers in this context, controlling for teacher and school characteristics. We next report regressions that test the hypothesis that students would demonstrate this negative relationship between affect and knowledge, examining first contributors to students' mathematics anxiety, and secondly to students' mathematics achievement. We include teacher knowledge and attitudes as contributors in these models to determine whether one mechanism underpinning these growing negative relationships could be teacher influences on their own students.

Due to data collection of a national sample, and because the overall context of mathematics education in Belize was quite variable, (e.g., language minority and other cultural factors that led to some extreme measurements) we first eliminated outliers (atypical observations) in the math scores used in the regressions. The median absolute deviation (MAD) procedure developed by Leys and colleagues (2013) was applied to the samples since it is more robust to outliers. The MAD procedure is based on the median, which as a center measure is less sensitive to the presence of outliers than the mean, which is typically used in algorithms to find outliers. The MAD procedure is as follows: (1) calculate the deviation of each observation with respect to the median of the distributions; (2) compute the median of the absolute values of the deviations computed in 1; (3) compute the MAD as constant times the median computed in 2 (this constant is set as

Table 3
Zero-Order Correlations of Teacher Variables

Variables	*Male*	*Younger than 46 years*	*Years of experience*	*Math test score*	*Math anxiety score*	*Pedagogical Content test score*	*Confident teaching math*
Male	1.0000						
Younger than 46 years	−0.0139	1.0000					
Years of experience	0.0944	−0.6218*	1.0000				
Math test score	0.2967*	−0.0757	0.2706*	1.0000			
Math anxiety score	−0.1290*	0.0133	−0.0520	−0.2165*	1.0000		
Pedagogical Content test score	0.1759*	−0.0371	0.2117*	0.3851*	−0.1937*	1.0000	
Confident teaching Math	0.2206*	−0.0673	0.0930	0.3148*	−0.2746*	0.1741*	1.0000

Note: Includes controls for teachers' age and school district.
*Statistically significant at 5%.

1.4826 for a normal distribution); finally, (4) define an outlier as an observation that is below the median-3*MAD and above median-3*MAD. This led to 42 observations removed for standard 2 students, and 61 removed for standard 5.

Teachers' Attitudes and Anxiety

The relationships between teachers' knowledge of mathematics and their attitudes toward the subject were assessed first. Table 3 provides zero-order correlations for the teacher variables. Correlations reveal a statistically significant positive correlation between gender, with male teachers scoring higher than females on mathematic and pedagogical content tests. Male teachers were also more confident in teaching mathematics. Collapsing across gender, teachers' mathematics test scores were positively correlated with both their pedagogical content knowledge and their confidence in teaching mathematics. Teachers' years of experience were positively correlated with their math and pedagogical content test scores, though these scores were negatively correlated with age.

On the other hand, teachers' math anxiety scores are negatively correlated with male teachers, teachers' math and pedagogical content test scores, and their confidence teaching math. These significant correlations hold when each grade level is analyzed separately, with the exception that math anxiety was not related to teacher knowledge variables at Grade 4 though it is at Grade 7 (see Supplemental Materials for full tables of zero-order correlations by grade level).

The HLM analysis was next conducted to predict teacher math anxiety in schools, using the following model:

$$score_j = \beta_0 + \beta_1 X_j + \beta_2 Z_k + e_j$$

where $score_j$ is the math anxiety score obtained by teacher j, β_0 is the mean across all schools, β_1, β_2 are coefficients, and X_j are teacher level covariates that control for demographic factors including teachers' years of experience, gender, and age, and that compare relative relationships to teacher attitudes (confidence), and knowledge (pedagogical content knowledge and content knowledge). Lastly, Z_k are school level variables (school district) and e_j is the residual error term, which is assumed to follow a normal distribution with mean zero and constant variance. Analyses were first conducted for all teachers, and then separately for teachers in each of the two grade levels in order to examine any cross-sectional differences that might indicate changes over time as children moved through the grade levels. The regression coefficients are provided in Table 4.

These data in some ways were in line with the literature from other international regions, though teacher knowledge and attitudes are much less well studied than that of students. In this sample, teachers at both grade levels who had greater mathematics anxiety expressed less confidence in teaching mathematics ($\beta_{All} = -0.81$, $SE_{All} = 0.16$; $\beta_{Grade4} = -0.89$, $SE_{Grade4} = 0.23$; $\beta_{Grade7} = -0.87$; $SE_{Grade7} = 0.19$) and showed somewhat less pedagogical content knowledge for teaching ($\beta_{All} = -0.15$, $SE_{All} = 0.06$; $\beta_{Grade4} = -0.15$, $SE_{Grade4} = 0.08$; $\beta_{Grade7} = -0.17$; $SE_{Grade7} = 0.08$). At the same time, neither gender nor teacher content knowledge was related to teachers' mathematics anxiety scores. These data suggest that if teachers' mathematics anxiety impacts students, it might be due to teachers' pedagogical practices, rather than their knowledge of mathematics, which is an inference due to the relation between teachers' math anxiety and their confidence and pedagogical content knowledge for teaching.

Students' Attitudes and Anxiety

Students' attitudes toward mathematics were assessed next. We began by calculating zero-order correlations, shown in Table 5. The results show a positive correlation between male students and their math test scores, and agreeing to being good in math. Also, students' math test scores are positively correlated with their family income and agreeing to being good in math. However, students' math anxiety scores are negatively correlated with male students, students' math test scores, their family income and agreeing to being good in

Table 4
Estimators of Teacher Math Anxiety

	All		*Grade 4*		*Grade 7*	
Variables	*Coefficient*	SE	*Coefficient*	SE	*Coefficient*	SE
Teacher: Years of experience	0.01	0.01	0.03**	0.01	−0.00	0.01
Teacher: Math score	−0.07	0.06	−0.11	0.10	−0.12	0.10
Teacher: Pedagogical content knowledge	−0.15**	0.06	−0.15**	0.08	−0.17**	0.08
Teacher: Gender	—	—	—	—	—	—
Male	−0.03	0.11	−0.15	0.16	0.13	0.11
Female	—	—	—	—	—	—
Teacher: Self-efficacy in math						
Not confident	—	—	—	—	—	—
Confident	−0.44**	0.14	−0.45**	0.19	−0.47**	0.19
Very confident	−0.81***	0.16	−0.89***	0.23	−0.87***	0.19
Constant	0.19	0.26	0.10	0.27	0.09	0.31
Number of observations	350		177		173	

Notes: Includes controls for teachers' age and school district.
**p* < .05, ***p* < .01, ****p* < .001.

Table 5
Zero-Order Correlations Of Student Variables

Variables	*Male*	*Math test score*	*Math anxiety score*	*Agree they are good in math*	*Wealth index*
Male	1.0000				
Math test score	0.0288*	1.0000			
Math anxiety score	−0.1087*	−0.0957*	1.0000		
Agree they are good in math	0.0395*	0.1432*	−0.1021*	1.0000	
Wealth index	0.0148	0.1411*	−0.0627*	0.0725*	1.0000

Note: Includes controls for teachers' age and school district.
*Statistically significant at 5%.

math. Lastly, there is a positive correlation between students' family income and agreeing to being good in math. Even though all correlations are statistically significant at the 5% level, except for the correlation between male students and family income, they seem to be small in magnitude (the highest correlation reaches 0.14).

The HLM analysis was conducted next to predict student math anxiety in the classrooms, using the following model:

$$score_{ijk} = \beta_0 + \beta_1 S_{ijk} + \beta_2 X_{jk} + \beta_3 Z_k + u_{jk} + e_{ijk}$$

where $score_{ijk}$ is the math anxiety score obtained by student i in classroom j in school k, β_0 is the mean across all schools, β_1, β_2, β_3 are coefficients, S_{ijk} are student level variables, X_{jk} are classroom level variables, Z_k are school level variables (school district), u_{jk} is the effect of classroom j within school k on the math anxiety scores, and e_{ijk} is the student-level residual error term. The classroom effects u_{jk}, referred to as classroom (or level 2) residuals, and the student level residual errors are assumed to follow a normal distribution with mean zero and constant variance.

Both student and teacher variables were included as predictor variables to compare their relative contributions. Student variables were gender, mathematics self-efficacy, mathematics achievement score, and wealth index. We also included teacher variables to determine whether, by the end of a school year, teachers had a relationship to their students' mathematics anxiety above the individual student characteristics. Teacher variables included age, gender, years of experience, pedagogical content knowledge, math content knowledge, and math anxiety. Analyses were first conducted for all students, and then separately for students in each of the two grade levels.

The regression coefficients are provided in Table 6. Unlike teachers, children's anxiety levels were predicted by gender ($\beta_{All} = -0.20, SE_{All} = 0.02$; $\beta_{Grade4} = -0.18$, $SE_{Grade4} = 0.03$; $\beta_{Grade7} = -0.21$, $SE_{Grade7} = 0.03$), replicating global findings that girls were more math anxious than their male peers. Students' math anxiety was also predicted by their mathematics test score ($\beta_{All} = -0.08$, $SE_{All} = 0.01$; $\beta_{Grade4} = -0.03$, $SE_{Grade4} = 0.02$; $\beta_{Grade7} = -0.12$, $SE_{Grade7} = 0.02$) and self-efficacy ($\beta_{All} = -0.19$, $SE_{All} = 0.03$; $\beta_{Grade7} = -0.32$, $SE_{Grade7} = 0.04$), again replicating international findings that high math anxiety was associated with lower test scores.

Table 6
Estimators of student math anxiety

	All		*Grade 4*		*Grade 7*	
Variables	*Coefficient*	SE	*Coefficient*	SE	*Coefficient*	*SE*
Student: Gender						
Male	-0.20^{***}	0.02	-0.18^{***}	0.03	-0.21^{***}	0.03
Female	—	—	—	—	—	—
Student: Math score	-0.08^{***}	0.01	-0.03 **	0.02	-0.12^{***}	0.02
Student: Self-efficacy						
Good in math: Disagree	—	—	—	—	—	—
Good in math: Agree	-0.19^{***}	0.03	-0.03	0.04	-0.32^{***}	0.04
Teacher: Math score	0.04	0.03	0.05	0.03	0.04	0.04
Teacher: Pedagogical content knowledge	0.00	0.03	0.03	0.04	-0.03	0.04
Teacher: Gender						
Male	-0.01	0.05	-0.08	0.07	0.05	0.06
Female	—	—	—	—	—	—
Teacher: Math anxiety	0.04^{*}	0.02	0.04	0.03	0.04	0.04
Constant	0.45^{***}	0.12	0.35^{**}	0.16	0.61^{***}	0.16
Number of observations	5, 720		2, 795		2, 925	

Notes: Controls include student wealth, teachers' age, teachers' years of experience, and school district.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

The teacher variables were also informative, revealing that teachers' mathematics anxiety was related to, and contributed to explaining, their students' mathematics anxiety, though the effects were small and only observed when analyzing all students ($\beta_{\text{All}} = 0.04, SE_{\text{All}} = 0.02$). When we do separated analysis by grade level, this effect is no longer statistically significant, even though the value of the effect is the same by grade as in the combined sample ($\beta_{\text{Grade4}} = 0.04$, $SE_{\text{Grade4}} = 0.03$; $\beta_{\text{Grade7}} = 0.04$, $SE_{\text{Grade7}} = 0.04$). This may be due to the sample being underpowered when split by grade level, requiring sample sizes of 3,981 and 6,556 in the Grade 4 and Grade 7 analysis, respectively, to detect a statistically significant effect of the size identified in the full population with power of 0.8. These high samples are necessary because the size of the effect of the population is small, but in a national context where cycles of low mathematics skill in both teachers and students remain persistent despite national efforts focused on improving these skills, and where the diversity of the population creates high variability in measurement, this analysis suggests it may be meaningful to follow-up and better understand the robustness of this effect in further studies.

These results provide a novel datapoint toward building a comprehensive theory of mathematics anxiety's relationship to achievement across cultural, gender and age contexts. These data raise the possibility that math anxiety can be passed from teachers to their students. If this is observed, even at a low level, in a context where overall variability across students and teachers is extremely high, and math anxiety is high, it is possible that this transmission could be a mechanism by which mathematical achievement at the national level is systematically hindered. Neither teacher mathematical knowledge nor teacher pedagogical knowledge was related to student math anxiety. This suggests that this transmission of attitudes may be distinct from mathematical content knowledge transmission.

Students' Mathematics Knowledge

The same analysis was repeated, but this time using students' mathematics achievement scores as the dependent variable to determine whether teachers' and students' attitudes had a meaningful relationship to students' mathematics achievement. All regression results are provided in Table 7. The results revealed that students' attitudes toward mathematics were positively related to their performance, with both lower mathematics anxiety ($\beta_{\text{All}} = -0.08$, $SE_{\text{All}} = 0.01$; $\beta_{\text{Grade4}} = -0.03$, $SE_{\text{Grade4}} = 0.02$; $\beta_{\text{Grade7}} = -0.11$, $SE_{\text{Grade7}} = 0.02$) and higher self-efficacy ($\beta_{\text{All}} = 0.28$, $SE_{\text{All}} = 0.03$; $\beta_{\text{Grade4}} = 0.22$, $SE_{\text{Grade4}} = 0.04$; $\beta_{\text{Grade7}} = 0.32$, $SE_{\text{Grade7}} = 0.04$) associated with higher mathematics scores. Additionally, a negative relationship at grade 4 was observed between teacher math anxiety and mathematics scores ($\beta_{\text{Grade4}} = -0.06$, $SE_{\text{Grade4}} = 0.03$), replicating findings in the United States such that the greater the teacher math anxiety, the lower the student scores. This was identified in the United States only in girls, but in Belize this relationship was observed across the student population (Beilock et al., 2010).

DISCUSSION

Around the globe, mathematics anxiety has been found to relate to mathematics achievement: students who demonstrate high levels of mathematics anxiety also have

Table 7
Estimators of student math scores

	All		*Grade 4*		*Grade 7*	
Variables	*Coefficient*	SE	*Coefficient*	SE	*Coefficient*	SE
Student: Gender						
Male	0.02	0.02	−0.00	0.03	0.04	0.03
Female	—	—	—	—	—	—
Student: Math anxiety	−0.08***	0.01	−0.03 **	0.02	−0.11***	0.02
Student: Self-efficacy						
Good in Math: Disagree	—	—	—	—	—	—
Good in Math: Agree	0.28***	0.03	0.22***	0.04	0.32***	0.04
Teacher: Math score	0.03	0.03	0.03	0.03	0.03	0.05
Teacher: Pedagogical content knowledge	0.02	0.03	0.03	0.04	0.01	0.04
Teacher: Gender						
Male	0.05	0.05	0.03	0.07	0.09	0.07
Female	—	—	—	—	—	—
Teacher: Math anxiety	−0.03	0.03	−0.06*	0.03	−0.01	0.04
Constant	−0.25**	0.13	−0.24	0.16	−0.34*	0.19
Number of observations	*5,720*		*2,795*		*2,925*	

Note: Controls include student wealth, teachers' age, teachers' years of experience, and school district.
*$p < .05$, **$p < .01$, ***$p < .001$.

lower-than-expected levels of mathematics achievement (OECD, 2013). Here, we examined the pattern of relationships between students' and teachers' mathematics achievement, self-efficacy, and anxiety in Belize. Belize offers an interesting opportunity to explore these relationships because it is a low resourced country characterized by lower-than-average mathematics achievement among students, and great diversity in teachers' and students' characteristics. Also, it offers an opportunity to study mathematics anxiety in a national sample outside the normative, "WEIRD" societies. Nevertheless, a limitation of the study was that the great diversity that makes Belize unique is challenging from a psychometric perspective. The diversity of the student population (and associated environmental and other constraints on children's school performance) added layers of complexity to the work of capturing and analyzing performance variation. Specifically, the different languages, dialects, and varying levels of literacy across Belize put the test developers to the test. Because of the levels of variation across the sample, we did not anticipate our effect sizes to be large, and this was indeed the case. Even so, the study results provide important new insights into the broad role that math anxiety at the teacher and student level may play in classroom mathematics learning across diverse contexts.

Our findings suggest that one source of children's affective relationships to mathematics may stem from teachers' levels of mathematics anxiety. In the overall sample, students' mathematics anxiety was related to that of their teachers. Research in the United States has shown that teacher math anxiety was related to students' gender stereotyped beliefs about math, as well as students' math achievement (Beilock et al., 2010; Ramirez, Chang, Maloney, Levine, & Beilock, 2016), but students' math anxiety was not tested. Here we find that, in Belize, teacher math anxiety predicted students' math anxiety, though this result only held when the whole sample was analyzed as a group, and it was significant but very small. Thus, the effect size of this relationship is not clear and may simply be due to the highly variable contexts of the Belizean children's lives. Alternatively, this finding may not be robust, but these data provide an indication that measuring and considering teacher math anxiety may be a crucial additional mechanism by which teachers not only convey mathematical content in classrooms but also attitudes about mathematics. This raises the possibility that addressing teachers' mathematics anxiety might play a role in supporting more students in gaining the self-efficacy in mathematics that could lead to greater entrance into the STEM pipeline. This could be particularly important for girls, who had the highest math anxiety in Belize, in order to support them in pursuing careers that include mathematical skills.

Interestingly, in this context there were no differences in math anxiety that stemmed from teacher gender, such that female teachers in Belize were not more math anxious than their male peers, nor were female students more influenced by math anxiety in their teachers than male students. We find that teacher math anxiety is more related to student math anxiety than to their math achievement, though at fourth grade, teacher math anxiety was related to students' achievement. As the children age this relationship may have become embedded into the children's math attitudes, which then explained the variance in student achievement scores at Grade 7.

To better understand teachers' mathematics anxiety in this context, we examined the contributions of mathematical knowledge and confidence, controlling for other environmental variations such as school district (which has significant implications for a broad range of school characteristics). Teachers in Belize who had more mathematics anxiety also received lower scores on measures of mathematics pedagogical content knowledge, and expressed less confidence in teaching mathematics, though this did not differ by gender. First, there was little difference between male and female teachers' self-report of mathematics anxiety, with the majority of teachers reporting either low or moderate levels and only 2.3% reporting the highest levels of mathematics anxiety. This finding was in contrast to our prediction that mathematics anxiety would be high in a low-income nation with low overall mathematics achievement. Alternatively, this finding may be due to a systematic gender effect on choice of careers in this national context. It could be that men who are more STEM inclined go into other STEM fields, while STEM-inclined women might enter the teaching workforce instead, though an analysis of these or other possible workplace dynamics is beyond the scope of this paper.

Many of the other study results do support and extend findings from higher wealth nations. As in most global contexts, these data revealed higher mathematics anxiety in girls than in boys, despite no differences in achievement. Also as predicted, students who had high self-efficacy and low mathematics anxiety scored relatively high on the mathematics tests.

At the same time, there may be a progression over time of the role of math attitudes. Students' math anxiety was not related to self-efficacy at Grade 4, though it was by Grade 7, at which point self-efficacy had a strong relationship with achievement. Though the student data are cross-sectional and were only tested once per student, the difference across the grade levels suggests that there may be change over time. These data indicate that math attitudes may go from early anxiety that is not understood by students as a reason that they would do poorly in mathematics, to becoming incorporated into negative self-efficacy in mathematics by 11 or 12 years. Teachers' mathematical content scores were also negatively related to students' mathematics scores, replicating findings that teachers' mathematics knowledge is crucial to the teaching of even basic, elementary mathematics courses. Therefore, while not surprising, it is important to note that improving mathematics educational systems in low-income nations must include mathematics training. In addition, these data suggest that there should be a corresponding focus on teachers' confidence in mathematics.

Overall, these results provide new insights into how teachers' knowledge of mathematics, and their attitudes toward the subject, may relate to their students' mathematics learning in a low resourced region, and also how attitudes may be transmitted from teacher to student. The cross-sectional data also show how a combination of math achievement and changing math attitudes, together with teacher inputs, may lead students to more negative attitudes that in the long term could impact students', and particularly girls', decisions to pursue mathematics-relevant education and employment opportunities.

Acknowledgments—The authors are thankful to the Inter-American Development Bank for funding the research presented in this paper. The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the Inter-American Development Bank, its Board of Directors, or the countries they represent. The authors have no conflicts of interests or financial or material interests in the results.

NOTE

1 In 2015, the country also had 40 privately funded primary schools that did not participate in the study.

REFERENCES

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*, 224–237.

Bandura, A. (1986). Fearful expectations and avoidant actions as coeffects of perceived self-inefficacy. *American Psychologist*, *41*(12), 1389–1391.

Bandura, A., Barbaranelli, C., Caprara, G.V. & Pastorelli, C. (2001) Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development*, *72*, 187–206. http://dx.doi.org/10.1111/1467-8624.00273.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(5), 1860–1863.

Bian, L., Leslie, S. J., Murphy, M. C., & Cimpian, A. (2018). Messages about brilliance undermine women's interest in educational and professional opportunities. *Journal of Experimental Social Psychology*, *76*, 404–420.

Bieg, M., Goetz, T., Wolter, I., & Hall, N. C. (2015). Gender stereotype endorsement differentially predicts girls' and boys' trait-state discrepancy in math anxiety. *Frontiers in Psychology*, *6*, 1404.

British Broadcasting Corporation. (2013, March 26). *Global migrants: Which are the most wanted professions?* Retrieved from http://www.bbc.com/news/business-21938085

Chipman, S. F., Krantz, D. H., & Silver, R. (1992). Mathematics anxiety and science careers among able college women. *Psychological Science*, *3*(5), 292–295.

Collins, J. L. (1982). Self-efficacy and ability in achievement behavior. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

Devine, A., Fawcett, K., Szũcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and Brain Functions*, *8*, 1–9. https://doi.org/10.1186/1744-9081-8-33

Dweck, C.S., Walton, G.M., & Cohen, G.L. (2014). Academic Tenacity: Mindsets and Skills that Promote Long-Term Learning, Bill and Melinda Gates Foundation.

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and gender differences in children's self-and task perceptions during elementary school. *Child Development*, *64*(3), 830–847.

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-National Patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin*, *136*(1), 103–127. https://doi.org/10.1037/a0018053

Erden, M., & Akgül, S. (2010). Predictive power of math anxiety and perceived social support from teacher for primary students' mathematics achievement. *Journal of Theory & Practice in Education (JTPE)*, *6*(1), 3–16.

Erturan, S., & Jansen, B. (2015). An investigation of boys' and girls' emotional experience of math, their math performance, and the relation between these variables. *European Journal of Psychology of Education*, *30*(4), 421–435.

Fast, L. A., Lewis, J. L., Bryant, M. J., Bocian, K. A., Cardullo, R. A., Rettig, M., & Hammond, K. A. (2010). Does math self-efficacy mediate the effect of the perceived classroom environment on standardized math test performance? *Journal of Educational Psychology*, *102*(3), 729–740.

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link: A global phenomenon. *Current Directions in Psychological Science*, *26*(1), 52–58.

Ganley, C. M., & Lubienski, S. T. (2016). Mathematics confidence, interest, and performance: Gender patterns and reciprocal relations. *Learning and Individual Differences*, *47*, 182–193.

Ganley, C. M., & Vasilyeva, M. (2014). The role of anxiety and working memory in gender differences in mathematics. *Journal of Educational Psychology*, *106*(1), 105–120.

Goetz, T., Bieg, M., Ludtke, O., Pekrun, R., & Hall, N. C. (2013). Do girls really experience more anxiety in mathematics? *Psychological Science*, *24*(10), 2079–2087. https://doi.org/10.1177/0956797613486989

Gunderson, E. A., Park, D., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2018a). Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school. *Journal of Cognition and Development*, *19*, 21–46. https://doi.org/10.1080/15248372.2017.1421538

Gunderson, E. A., Ramirez, G., Beilock, S. L., & Levine, S. C. (2013). Teachers' spatial anxiety relates to 1st- and 2nd-graders' spatial learning. *Mind, Brain, and Education*, *7*(3), 196–199. https://doi.org/10.1111/mbe.12027

Hanushek, E. A., & Woessmann, L. (2012a). Schooling, educational achievement, and the Latin American growth puzzle. *Journal of Development Economics*, *99*(2), 497–512.

Hanushek, E. A., & Woessmann, L. (2012b). Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation. *Journal of Economic Growth*, *17*(4), 267–321.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33–46.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Most people are not WEIRD. *Nature*, *466*(7302), 29.

Hiebert, J., Stigler, J.W., Jacobs, J.K., Givvin, K.B., Garnier, H., Smith, M., … Gallimore, R. (2005). Mathematics teaching in the United States toda (and tomorrow): results from the TIMSS 1999 video study. *Educ. Eval. Policy Anal. 27*(2), 111–132.

Hill, H., Blunk, M. L., Charalambous, C. Y., Lewis, J. M., Phelps, G. C., Sleep, L., & Ball, D. L. (2008). Mathematical knowledge for teaching and the mathematical quality of instruction: An exploratory study. *Cognition and Instruction*, *26*(4), 430–511. https://doi.org/10.1080/07370000802177235

Hill, H. C., Charalambous, C. Y., & Chin, M. J. (2018). Teacher characteristics and student learning in mathematics: A comprehensive assessment. *Educational Policy*, *33*, 1103–1134. https://doi.org/10.1177/0895904818755468

Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). Developing measures of teachers' mathematics knowledge for teaching. *The Elementary School Journal*, *105*(1), 11–30.

Ho, H.-Z., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S., Okamoto, Y., … Wang, C.-P. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education*, *31*(3), 362–379.

Hoffman, B. (2010). "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem-solving efficiency. *Learning and Individual Differences*, *20*(3), 276–283.

Honicke, T., & Broadbent, J. (2016). The influence of academic self-efficacy on academic performance: A systematic review. *Educational Research Review*, *17*, 63–84.

Hyde, J. S., Fennema, E., Ryan, M., Frost, L. A., & Hopp, C. (1990). Gender comparisons of mathematics attitudes and affect—A metaanalysis. *Psychology of Women Quarterly*, *14*(3), 299–324.

Lacey, T. A., & Wright, B. (2009). Employment outlook: 2008-18-occupational employment projections to 2018. *Monthly Labor Review*, *132*, 82–123.

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences*, *19*(3), 355–365.

Lemke, M., Williams, T., Roey, S., Smith, C., Kastberg, D., Jocelyn, L., & Ferraro, D. (2003). The Program for International Student Assessment (PISA) 2003 Data Analysis User's Guide. (NCES 2007-048). U.S. Department of Education, NCES. Washington, DC: U.S. Government Printing Office.

Leslie, S. J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science*, *347*(6219), 262–265.

Leys, C., Ley, C., Klein, O., Bernard, P., & Licata, L. (2013). Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. *Journal of Experimental Social Psychology*, *49*(4), 764–766. https://doi.org/10.1016/j.jesp.2013.03.013.

Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, *26*(9), 1480–1488.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology*, *38*(1), 30–38.

Näslund-Hadley, E., Alonzo, H. & Martin, D. 2013. *Challenges and opportunities in the Belize education sector*. IDB-TN-538, Inter-American Development Bank, Washington, DC.

Näslund-Hadley, E., Loera Varela, A., & Hepworth, K. (2014). What goes on in Latin American math and science classrooms: A video study of teaching practices. *Global Education Review*, *1*(3), 110–128.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. Reston, VA: The National Council of Teachers of Mathematics.

National Economic Council and Office of Science and Technology Policy. (2015). *A strategy for American innovation*. Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/strategy_for_american_innovation_october_2015.pdf

National Research Council. (2013). *Monitoring progress toward successful K–12 STEM education: A nation advancing?* Committee on the Evaluation Framework for Successful K–12 STEM Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press. Retrieved from https://www.nap.edu/catalog/13509/monitoring-progress-toward-successful-k-12-stem-education-a-nation

National Science Foundation. (2014a). *Table 2–17. Earned bachelor's degrees, by sex and field: 2000–11*. Retrieved from http://www.nsf.gov/statistics/seind14/index.cfm/appendix/tables.htm

National Science Foundation. (2014b). *Table 3–13. Employed scientists and engineers, by sex and occupation: 2010*. Retrieved from http://www.nsf.gov/statistics/seind14/index.cfm/appendix/tables.htm

Organisation for Economic Co-operation and Development. (2013). *PISA 2012 results: Ready to learn: Students' engagement, drive and self-beliefs*. (Vol. *III*). Paris, France: Author.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, *66*(4), 543–578.

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, *86*(2), 193–203.

Parker, P. D., Marsh, H. W., Ciarrochi, J., Marshall, S., & Abduljabbar, A. S. (2014). Juxtaposing math self-efficacy and self-concept as predictors of long-term achievement outcomes. *Educational Psychology*, *34*(1), 29–48.

Ramirez, G., Chang, H., Maloney, E., Levine, S., & Beilock, S. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology*, *141*, 83–100.

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development*, *14*(2), 187–202.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology*, *19*(6), 551–554.

Schunk, D. H. & Hanson, R. A. (1987). *Self-modeling and cognitive skill learning*. Paper presented at the American Psychological Association, New York.

Shimizu, Y., & Kaur, B. (2013). Learning from similarities and differences: A reflection on the potentials and constraints of cross-national studies in mathematics. *ZDM*, *45*(1), 1–5.

Siegel, R. G., Galassi, J. P., & Ware, W. B. (1985). A comparison of two models for predicting mathematics performance: Social learning versus math aptitude-anxiety. *Journal of Counseling Psychology*, *32*(4), 531–538.

Sims, L., Perry, M., McConney, M., Schleppenbach, M., Miller, K., & Wilson, T. (2008). Look who's talking: Differences in math talk in U.S. and Chinese classrooms. *Teaching Children Mathematics*, *15*(2), 120–124.

Skaalvik, E. M., Federici, R. A., & Klassen, R. M. (2015). Mathematics achievement and self-efficacy: Relations with motivation for mathematics. *International Journal of Educational Research*, *72*, 129–136.

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education*, *17*(2), 213–226.

Stoet, G., Bailey, D. H., Moore, A. M., & Geary, D. C. (2016). Countries with higher levels of gender equality show larger national sex differences in mathematics anxiety and relatively lower parental mathematics valuation for girls. *PLoS One*, *11*(4), e0153857. https://doi.org/10.1371/journal.pone.0153857

Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science*, *29*(4), 581–593.

Suinn, R. M., Taylor, S., & Edwards, R. W. (1988). Suinn mathematics anxiety rating scale for elementary school students (MARS-E): Psychometric and normative data. *Educational and Psychological Measurement*, *48*(4), 979–986.

Suinn, R. M., Taylor, S., & Edwards, R. W. (1989). The Suinn mathematics anxiety rating scale (MARS-E) for Hispanic elementary school students. *Hispanic Journal of Behavioral Sciences*, *11*(1), 83–90. https://doi.org/10.1177/07399863890111007

Suinn, R. M., & Winston, E. H. (2003). The mathematics anxiety rating scale, a brief version: Psychometric data. *Psychological Reports*, *92*(1), 167–173.

Tapia, M., & Marsh, G. (2004). The relationship of math anxiety and gender. *Academic Exchange Quarterly*, *8*(2), 130–134.

United Nations Educational Scientific and Cultural Organization. (2015). UNESCO Institute for Statistics Online database

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review*, *66*(5), 297–333.

Wilkins, J. L. M. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs, and practices. *Journal of Mathematics Teacher Education*, *11*(2), 139–164.