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The Relationship among Elementary Teachers' Mathematics Anxiety, Mathematics Instructional Practices, and Student Mathematics Achievement

Kristin M. Hadley
Weber State University

Jim Dorward
Utah State University

Abstract

Many elementary teachers have been found to have high levels of mathematics anxiety but the impact on student achievement was unknown. Elementary teachers (*N* = 692) completed the modified Mathematics Anxiety Rating Scale-Revised (Hopko, 2003) along with a questionnaire probing anxiety about teaching mathematics and current mathematics instructional practices. Student mathematics achievement data were collected for the classrooms taught by the teachers. A positive relationship was found between anxiety about mathematics and anxiety about teaching mathematics. Increased student mathematics achievement was related to lower levels of anxiety about teaching mathematics, but was not related to general anxiety about mathematics. Anxiety about mathematics was positively related to more National Council of Teachers of Mathematics (NCTM) Standards-based instructional practices.

Mathematics anxiety and an accompanying lack of mathematical competence are often a factor in major life decisions of individuals. Mathematically anxious people steer their lives and careers away from mathematical applications, impacting their career development and future potential. The National Council of Teachers of Mathematics (NCTM) notes that "those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures" (NCTM, 2000, p. 5). When people struggle with mathematics, they are limited in their career options (Betz, 1978; Dew, Galassi, & Galassi, 1983).

The current focus on teacher accountability with testing measuring student achievement places a great emphasis on the teacher's ability to teach the mathematics that students should know and be able to do based on state standards. These concepts are then tested to assess mastery. In explaining the No Child Left Behind Act of 2001, the U.S. Department of Education noted that "student progress and achievement will be measured according to state tests designed to match those state standards and given to every child, every year" (U.S. Department of Education, 2004). The emphasis on observable results has increased stress for teachers, which may exacerbate some elementary teachers' math anxiety. Mathematics anxiety, if carried over into anxiety

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about teaching elementary mathematics, could have a negative impact on students' ability to learn mathematics appropriately.

Mathematics Anxiety and Elementary Teachers

Mathematics anxiety can be defined as "a general fear of contact with mathematics, including classes, homework, and tests" (Hembree, 1990, p. 34). Math anxiety has been found to be related to several different variables, including manipulative experience, learning style, personality type, and math beliefs (Austin & Wadlington, 1992; Hadfield & McNeil, 1994; McCoy, 1990; Sloan, Daane, & Giesen, 2002). Other correlates with increased math anxiety include gender (female), age (older), test anxiety, lower level of high school math, lower math ACT score, decreased mathematical achievement, lack of use of manipulatives in previous math classes, tactile-kinesthetic learning style, and college major (Bessant, 1995; Betz, 1978; Calvert, 1981; Ma, 1999; Malinsky, Ross, Pannells, & McJunkin, 2006; McCoy, 1990).

Mathematics anxiety is particularly prevalent among college students majoring in elementary education. Studies have consistently shown that elementary education majors have one of the highest levels of mathematics anxiety on college campuses (Kelly & Tomhave, 1985; Hembree, 1990). Rech, Hartzell, and Stephens (1993) compared preservice teachers to the general college population and found that preservice teachers had poorer attitudes about math and decreased math competence. Math anxious preservice teachers also had lower levels of mathematics teaching self-efficacy (Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006).

Several researchers investigated elementary math methods courses as a means of decreasing mathematics anxiety. Using pre-post data, researchers were able to show a substantial decrease in anxiety after learning appropriate methods of teaching mathematics (Battista, 1986; Gresham, 2007; Harper & Daane, 1998; Quinn, 1998; Sloan, Vinson, Haynes, & Gresham, 1997; Tooke & Lindstrom, 1998, Vinson, 2001). These results conclusively indicated that math methods courses can reduce reported anxiety in preservice elementary teachers. However, none of these studies investigated whether the anxiety reduction endures after the conclusion of the methods courses.

In spite of efforts to alleviate the mathematics anxiety through math methods courses, between 17% (Chavez & Widmer, 1982) and 40% (Meyer, 1980) of in-service elementary teachers have math anxiety; however, research is mixed on whether this impacts their ability to teach mathematics effectively (Battista, 1986; Trujillo & Hadfield, 1999). While the literature does not support the contention that *most* elementary teachers hate or fear mathematics, it does indicate that a significant minority have those feelings (Wood, 1988). Karp (1991) found that elementary teachers with poor attitudes toward mathematics employed teaching methods that fostered dependency, such as the teacher as the main source of information. Their teaching was more algorithmic, neglected cognitive thought processes and mathematical reasoning, and provided

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teacher-driven practice and commercially prepared worksheets with practice on algorithms. Teachers with positive attitudes toward math were found to encourage student initiative and independence. They modeled persistent behaviors and presented active demonstrations; however, no measures of student achievement were collected.

Bush (1989) found that math anxious elementary teachers spent a greater amount of class time devoted to whole class instruction and fielded fewer student questions during lessons. Students with non-math anxious teachers asked twice as many questions as students in classes with math anxious teachers; however, there was no significant relationship between teachers' mathematics anxiety and changes in student mathematics anxiety. Math anxious teachers did not teach drastically differently from non-math anxious teachers, but there was a slight tendency to be more traditional. Bush hypothesized that "perhaps teachers who are aware of their own negative attitudes and their sources of mathematics anxiety seek ways to provide students with a different mathematics environment, and unaware teachers simply perpetuate mathematics anxiety" (p. 508).

The connection between elementary teacher mathematics anxiety and student achievement remains unclear, although experts in the field (Aiken, 1970; Chavez & Widmer, 1982) have theorized a connection. Little research has been completed to confirm or deny the connection. Other factors such as mathematics instructional practices have been investigated concerning their effect on student mathematics achievement, particularly in light of the changes in teaching practices recommended by the NCTM (1989, 2000). Student achievement increased when teachers discussed practical problems related to everyday life in learning mathematics concepts with students, employed more active learning strategies, had additional training about cognitive process, and taught in a way that focused on these processes (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; House, 2002; Jacobsen & Lehrer, 2000). An increase in NCTM Standards-based teaching practices resulted from increased teacher training which led to increased student achievement (Hiebert, 1999). Huffman, Thomas, and Lawrenz (2003) also demonstrated that curriculum development training, in particular, helped increase student achievement. Due to the interconnected-ness of these many factors influencing student mathematics achievement, additional study is warranted.

The purpose of the present study was to investigate the relationship between elementary teacher anxiety about mathematics, specific anxiety about teaching mathematics, student mathematics achievement, and self-reported classroom mathematics instructional practices. The study also investigated potential intervening variables, such as teacher gender, teaching experience, grade level taught, and college teaching minor or emphasis, which may influence the relationships.

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Method

Participants

The participants were 692 teachers in grades one through six from 49 elementary schools in the western United States. There were 48 male and 644 female respondents. They ranged in experience from first-year teachers to teachers with more than 20 years of experience. The instruments were administered at a faculty meeting at the participants' respective schools.

Instruments

General Mathematics Anxiety. The participants were given a questionnaire comprised of three parts. The first part was the modified *Mathematics Anxiety Rating Scale-Revised* (modified MARS-R; Hopko, 2003). The modified MARS-R was developed from Plake and Parker's (1982) revision of the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972). Hopko administered the MARS-R to 815 participants and conducted a factor analysis of each item. Based on the results of the factor analysis, Hopko dropped 12 out of the 24 items from MARS-R. The resulting modified MARS-R had a strong relationship with the original MARS-R ($r = .97$, $p < .001$). For the current study, test-retest reliability of the modified MARS-R was .80 and when evaluated for internal consistency, the modified MARS-R had a Cronbach's alpha for internal consistency of $\alpha = .95$. Responses to the 12 Likert-scaled items were summed for a minimum possible score of 12, indicating no anxiety, to a maximum possible score of 60, indicating high anxiety.

Anxiety about Teaching Mathematics. The second part of the questionnaire was 12 Likert-scaled items designed to investigate elementary teacher anxiety about teaching mathematics. This measure was created for this study in an effort to mirror the modified MARS-R (Hopko, 2003) but with an emphasis on teaching mathematics. A panel of mathematics education researchers and educators was used to evaluate the content validity of the items. The measure was pilot tested with a group of 20 elementary teachers and two questions were slightly modified. Test-retest reliability of this measure was found to be .83 for this administration and the Cronbach's alpha measure of internal consistency was found to be $\alpha = .90$. Responses were summed for a minimum possible score of 12, indicating no anxiety, to a maximum possible score of 60, indicating high anxiety. See Table 1 for scale item means and standard deviation.

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Table 1

Anxiety about Teaching Mathematics Item Means

Item	Mean	*SD*
Looking through the pages in your math series teacher's manual.	1.48	.81
Teaching students how to use and interpret tables, graphs, and charts.	1.44	.77
Preparing students for a "standardized" math test throughout the week before.	2.42	1.12
Working out math equations on the board in front of a class of students.	1.42	.85
Preparing a presentation for parents about the math curriculum you teach.	2.19	1.11
Preparing to teach students a new concept that will be challenging to them.	1.95	.98
Explaining your rationale for the math curriculum to a parent who stopped by your classroom after school.	1.95	.95
Talking to a student who wanted to use a different way to solve a math problem than the way taught in class.	1.36	.70
Writing a lesson plan for teaching a new math concept.	1.63	.83
Waiting for the results of your students' year-end math tests.	2.35	1.09
Having a surprise evaluation by an administrator during a math lesson you are teaching.	2.46	1.18
Walking into school and thinking about teaching a math lesson.	1.40	.72

As evident in Table 1, issues surrounding student assessment and teacher evaluation resulted in higher anxiety responses (item means over 2.0), as compared with planning, preparing, and teaching the math lessons.

Mathematics Instructional Practices. The third part of the questionnaire investigated elementary teacher mathematics instructional practices. This measure was created to evaluate the level of adherence to the NCTM (2000) Standards in the participants' classroom instructional practices. Questions included how often the participants involved their students in writing about mathematics, using manipulatives, working together with other students, and doing non-routine problem-solving tasks. A panel of mathematics education researchers and educators was also used to evaluate

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the content validity of the items. The measure was pilot tested with a group of 20 elementary teachers and showed a test-retest reliability of r = .62 and the Cronbach's alpha measure of internal consistency was α = .72. Due to concerns about self-report data, 20 observations were completed to verify the responses to this section of the questionnaire. A subset of the sample (n = 20) was randomly selected for observation of a math lesson in the classroom, with the observer unaware of the questionnaire results, to validate self-report information. Each teacher was observed for the entire math lesson, which ranged from 25 to 90 minutes in length. Instructional practices, time spent teaching, and availability of math tools and manipulatives were noted. Observation results were tabulated on a scale of 0 to 10, with 0 indicating very traditional teaching practices and 10 indicating a high degree of alignment with NCTM Standards-based teaching practices. The mean for the observed reform scale was 6.3 with a high of 10 and a low of 2. The results were then correlated with the teachers' *Mathematics Instructional Practices* score. The correlation between the two measures was .75 (p < .01) indicating that this section of the questionnaire was a valid measure of the actual instructional practices in the classroom. For scoring purposes, two questions required recoding (*assigned independent work* and *listening to instructions or directions*) so that the NCTM Standards-based instructional practices were represented by a higher number and then the nine questions in the measure were summed. The minimum possible score was 9, indicating very traditional classroom pedagogy and the maximum possible score was 45, indicating a high degree of alignment with NCTM Standards-based instructional practices. See Table 2 for scale item means and standard deviation.

Table 2

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Elementary Teacher Mathematics Instructional Practices Item Means

Item	Mean	*SD*
In a typical week of math class, students spend approximately this percent of time on the following (1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%):		
Assigned independent work.	2.19	.86
Assigned group work.	1.78	.83
Listening to instructions or directions.	2.02	.77
Optional independent work such as using centers or manipulatives to help solve problems.	1.77	.91
Please indicate the number of times in a typical week (1 = 0, 2 = 1, 3 = 2, 4 = 3, 5 = 4 or more):		
You have used math manipulatives to demonstrate math concepts to students.	3.52	1.20
Your students have used math manipulatives, pictures, or other models to represent a math concept.	3.63	1.14
Your students have participated in small group learning activities during math time.	2.98	1.18
Your students have written about their math experiences.	2.16	1.23
Your students have engaged in mathematical problem solving beyond traditional textbook story problems.	2.97	1.22

As indicated in Table 2, the use of manipulatives was the most frequently reported teaching activity consistent with NCTM Standards. Group work and independent work were reported to be used infrequently, indicating that teacher-directed lessons were prevalent.

Student Achievement. The class average of the student scores on the state end-of-year mathematics test for each participating teacher was collected. This test is a criterion-referenced test designed by the state Office of Education to evaluate the level of proficiency of students with respect to the state mathematics core curriculum, based on the NCTM (2000) Standards.

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Results

The distribution of anxiety about mathematics, anxiety about teaching mathematics, and mathematics instructional practices appeared normal when graphed and showed no unusual outliers or other unexplained anomalies. Anxiety about teaching mathematics showed a positive skew indicating more teachers were clustered at the lower (less anxious) portion of the scale (see Table 3).

Table 3

Descriptive Statistics for Teacher Anxiety and Instruction Practices Measures

	N	Min	Max	Mean	*SD*	Skew	Kurtosis
Anxiety about mathematics	692	12	60	31.34	12.03	.35	-.73
Anxiety about teaching mathematics	692	12	57	21.55	7.41	1.27	1.98
Mathematics instructional practices	690	14	41	26.75	5.28	.26	-.41

A Pearson correlation was calculated to investigate the relationship between anxiety about mathematics and anxiety about teaching mathematics. A positive relationship ($r = .42$, $p < .001$) was found between these two variables indicating that teachers who were anxious about mathematics tended to also be anxious about teaching mathematics (see Table 4). To further investigate the relationship, the data were split at the mean for anxiety about mathematics ($\bar{x} = 31.34$) and a correlation subsequently determined for each half of the data. The correlation for the subset of the data below the mean for anxiety about mathematics was $r = .45$ ($p < .001$); however, the subset above the mean did not indicate any relationship ($r = .02$, *ns*). This analysis indicates that for teachers with higher levels of anxiety about mathematics, there was no relationship with anxiety about teaching mathematics. Some of these teachers had very high anxiety about teaching mathematics, while others had moderate or even low anxiety about teaching mathematics.

Student mathematics achievement was correlated with the two anxiety variables. Increased student mathematics achievement demonstrated a low, but statistically significant relationship with lower levels of anxiety about teaching mathematics ($r = -.09$, $p < .05$); however, it was not related to general anxiety about mathematics. This result indicates that when teachers were comfortable about teaching mathematics, students

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achieved somewhat higher test scores, regardless of whether the teacher experienced general math anxiety.

A small, but statistically significant, positive relationship was found between mathematics instructional practices and anxiety about mathematics (r = .11, p < .004). This relationship indicates that increased anxiety about mathematics was related to slightly more NCTM Standards-based teaching practices. No relationship was found between anxiety about teaching mathematics and mathematics instructional practices. These relationships are summarized in Table 4.

Table 4

Relationships between Math Anxiety, Teaching Math Anxiety, Instructional Practices, and Student Math Achievement

	Teaching anxiety	Instructional practices	Student math achievement
Math anxiety	.42**	.11**	-.07[a]
Teaching anxiety	--	-.08	-.09* [a]
Instructional practices		--	.08[b]

Note. ** p < .01; * p < .05; n = 692; [a]n = 586; [b]n = 584

Respondents were split into three groups based on the mathematics instructional practices variable: traditional teaching, mixed methods, and NCTM Standards-based teaching. Group membership was determined by subdividing the data at one standard deviation above and below the mean ($\bar{x}$= 26.75, SD = 5.28) of self-reported classroom mathematics instructional practices. The two outlying groups were analyzed further to see if any relationships strengthened or weakened within these instructional subgroups. Positive relationships were again found between anxiety about mathematics and anxiety about teaching mathematics. For teachers using NCTM Standards-based instructional practices (n = 116), there was a positive relationship (r = .25, p < .005) between anxiety about mathematics and anxiety about teaching mathematics. Teachers within the traditional teaching group (n = 99) had an even stronger relationship between the two anxiety measures (r = .52, p < .001).

Analysis of variance (ANOVA) was used to investigate differences between the NCTM Standards-based and traditional instructional practices groups. In addition to the anxiety variables, differences between demographic characteristics were investigated. Significant differences between groups were found for general mathematics anxiety, anxiety about teaching mathematics, grade level taught, teacher gender, and amount of mathematics in-service attended. Student achievement was not compared as

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differences in the grade level tests confounded results. The NCTM Standards-based teaching group had higher general anxiety about mathematics but lower anxiety about teaching mathematics. The NCTM Standards-based teachers taught at a lower grade level, were more likely to be female, and attended more mathematics in-service courses. Results from the ANOVA are summarized in Table 5.

Table 5

NCTM Standards-based Compared to Traditional Teaching Groups

	NCTM Standards-based Mean	Traditional Mean	*F*	Sig.	Standardized mean difference
Math anxiety	35.97	31.07	8.04 (1, 213)	.005**	.41
Teaching anxiety	20.06	22.10	3.90 (1, 213)	.050*	.28
Grade level	2.47	4.36	190.26 (1, 213)	.001**	1.13
Gender	1.99	1.83	17.09 (1, 213)	.001**	.64
In-service	3.01	2.31	25.58 (1, 213)	.001**	.65

Note. Scores for Gender above a mean of 1 indicate more female respondents.

Additionally, differences in the means of anxiety about mathematics, anxiety about teaching mathematics, and student mathematics achievement were analyzed using ANOVA when grouped according to gender, grade level taught, and years of teaching experience.

Research has frequently shown gender differences in the area of mathematics anxiety and this study is no exception. Male teachers had lower anxiety about mathematics; however, this did not translate to lower anxiety about teaching mathematics. Interestingly, the students of female teachers had slightly higher mathematics achievement (see Table 6).

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Table 6

Gender Differences

Variable	*F*	Sig.
Anxiety about mathematics	7.59 (2, 689)	.006**
Anxiety about teaching	.38 (2, 689)	.540
Student math achievement	17.98 (2, 583)	.001**

Note. ** $p < .01$

Teachers who choose to teach at different grade levels do so for a variety of reasons including comfort with the curriculum. Anxiety about mathematics could be a determining factor in whether a teacher is comfortable and successful teaching a certain grade level. An ANOVA was performed using the grade bands of first-second, third-fourth, and fifth-sixth as shown in Table 7. Student mathematics achievement was excluded from this analysis as the variation in the scores across grade levels made comparisons ineffective. Anxiety about mathematics was highest for first and second grade teachers and lowest for fifth and sixth grade teachers.

Table 7

Grade-Level Differences

Variable	*F*	Sig.
Anxiety about mathematics	4.81 (2, 688)	.008**
Anxiety about teaching	.06 (2, 688)	.942

Note. ** $p < .01$

Differing levels of teaching experience could explain changing levels of the variables of interest. Table 8 displays the analysis for teaching experience grouped by less than 1 year, 1 to 5 years, 6 to 10 years, 11 to 20 years, and more than 20 years. Significant differences were found for anxiety about teaching mathematics which was highest in the first year of teaching and then steadily declined as more experience was

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gained. As teachers become more experienced and comfortable in the classroom and with the curriculum, they become much less anxious about teaching mathematics.

Table 8

Teaching Experience Differences

Variable	*F*	Sig.
Anxiety about mathematics	1.20	.121
	(4, 687)	
Anxiety about teaching	13.53	.001**
	(4, 687)	
Student mathematics achievement	1.52	.196
	(4, 581)	

Note. ** $p < .01$

Discussion

The results of this study show that there is a positive relationship between anxiety about mathematics and anxiety about teaching mathematics. The distribution of the relationship showed that the relationship occurred primarily at lower levels of anxiety about mathematics.

When elementary teachers exhibited higher anxiety about mathematics, there was no relationship with anxiety about teaching mathematics. Some teachers continued to have high anxiety about the mathematics they taught in the classroom while others had moderate or low anxiety about teaching the mathematics curriculum. The math anxious teachers who had lower anxiety about teaching mathematics tended to have more teaching experience and were more likely to teach using NCTM Standards-based instructional practices.

These findings suggest that teachers who are not anxious about math will likely not be anxious about teaching mathematics. As math anxiety increases, some teachers show an increase in anxiety about teaching mathematics while others have low anxiety about teaching. While the results do not indicate why this is the case, there is some indication that the low teaching anxiety teachers may choose to teach at a grade level where they feel comfortable with the curriculum and become confident in their teaching through the use of NCTM Standards-based instructional practices.

Higher anxiety about teaching mathematics was related to lower student mathematics achievement. However, anxiety about mathematics in general was not related to student mathematics achievement. This suggests that efforts to decrease teachers' anxiety about mathematics per se may be unproductive. More efforts should

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be expended to help teachers feel comfortable about the mathematics curriculum they teach in the classroom through professional development focusing on improving understanding of the curriculum and implementing an NCTM (2000) Standards-based curriculum.

The results of this study indicate that mathematics instructional practices and anxiety about mathematics are also related. Teachers who have experienced math anxiety tended to teach in a slightly more NCTM Standards-based manner. However, teachers who were anxious about teaching mathematics tended to teach in a more traditional manner. These results support Battista's (1986) findings that math anxious preservice teachers claimed they would teach in a more progressive manner while refuting Trujillo and Hadfield's (1999) conjecture that preservice teachers with math anxiety would tend to teach in a more traditional fashion. It is not the existence of math anxiety that is problematic; in fact, for some teachers it may spur them to take action to improve their mathematics instructional practices. On the other hand, some teachers let their mathematics anxiety continue to be exhibited through anxiety about the mathematics they teach.

In this study, NCTM Standards-based instructional practices and student mathematics achievement were not related to each other. However, many studies have displayed the opposite to be true (Fennema et al., 1996; Hiebert, 1999; Jacobson & Lehrer, 2000). Failure to find a relationship in this study might be due to the nature of student mathematics achievement measure used which consisted of strictly multiple-choice items, as well as the limitations of self-reported data.

In this study, many relationships were found for different teacher characteristics such as gender, grade level, and teaching experience. Research has frequently shown gender differences in the area of mathematics anxiety (Bessant, 1995; Betz, 1978; Calvert, 1981; McCoy, 1990) and this current study is no exception. As expected, male teachers had lower math anxiety as students; however, this did not translate to lower anxiety about teaching mathematics. Interestingly, female teachers had slightly higher student mathematics achievement in their classes. Therefore, the widely acknowledged difference in anxiety between males and females does not appear to translate to any differences in the classroom.

Grade level differences were investigated as it was assumed that teachers who choose to teach at different grade levels do so for a variety of reasons including comfort with the curriculum. Math anxiety could be a determining factor in whether a teacher is comfortable and successful teaching a certain grade level. The results indicate that teachers with less anxiety about mathematics were more likely to be teaching in the upper elementary grades.

Differences between years of teaching experience were analyzed to determine impact upon the variables of interest. Teachers with less experience were more anxious

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about teaching elementary mathematics. Anxiety about teaching mathematics was the highest among first year teachers and then steadily declined as more experience was gained. This trend makes sense as teachers increase their comfort and expertise with the curriculum as they become more experienced.

Conclusion

In today's educational climate with a strong emphasis on accountability and results, it is important to identify factors that influence student achievement. The results of this study indicate anxiety about mathematics is not such a concern, but anxiety about teaching mathematics is related to student achievement. Professional development focused on helping teachers become comfortable in teaching the mathematics curriculum by gaining a deep understanding of the concepts they teach, along with understanding conceptually-based instruction (Hiebert & Wearne, 1992), and children's mathematical thinking (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989) could show stronger achievement gains and warrants further research.

Educational administrators would do well to provide opportunities for additional professional development for teachers in NCTM Standards-based instructional practices and then build a school climate that supports such teaching practices. Additionally, administrators may need to assign teachers to grade levels where they are comfortable with the mathematics curriculum. Mathematics educators need to train preservice teachers in pedagogically sound, research-based, NCTM Standards-based mathematics instructional practices so that they are comfortable and confident in teaching mathematics.

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About the Authors

Kristin M. Hadley, Ph.D., is an Associate Professor in the Teacher Education Department at Weber State University in Ogden, Utah. Her teaching focuses primarily on math methods for elementary teachers and research interests include mathematics anxiety, math teaching self-efficacy, and mathematics visualization. E-mail: kristinhadley@weber.edu

Jim Dorward, Ph.D., is a Professor in the School of Teacher Education and Leadership and is Associate Dean for Research at Utah State University. His research interests include the digital learning resources, the use of virtual manipulatives, and program evaluation. E-mail: jim.dorward@usu.edu