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Mathematics Anxiety and Mathematics Self-Efficacy as Predictors of Mathematics Teaching Self-Efficacy

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The purpose of this mixed methods study was to (1) explore whether elementary mathematics teachers' mathematics anxiety and/or mathematical self-efficacy predict their mathematical teaching self-efficacy and (2) explore the impact of the mathematical instructional strategies used by elementary teachers that had low mathematics anxiety and high mathematics teaching self-efficacy. The findings indicated that there is an inconsistency among teachers' mathematical teaching efficacy and the instructional practices that they utilize in their mathematics instruction. This inconsistency indicated that either the teachers did not understand what it means to teach mathematics using best practices or they did not feel confident enough to teach mathematics using these practices. Because of this inconsistency, there is a need for additional support to help elementary mathematics teachers overcome the anxiety and/or lack of self-efficacy in order to foster best practices in mathematics instruction.

Introduction

The emphasis on teacher accountability and student achievement, as well as the development of the Common Core State Standards for Mathematics, has placed greater importance on the teacher's ability to teach mathematical concepts and skills using strategies that promote best practice and conceptual understanding as well as provide the level of rigor that students should know (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). For some elementary teachers, the constructs of mathematics anxiety, mathematics self-efficacy, and/or mathematics teaching self-efficacy hinder them from providing students with the necessary environment, instructional strategies, or level of rigor called for in the Common Core and by the National Council of Teachers of Mathematics. On the other hand, teachers that score low in mathematics anxiety and high in mathematics teaching self-efficacy have the ability to offer mathematics instruction that is rigorous, engaging, and promotes best practices (Ashton, 1984; Tobias & Piercey, 2014). However, is mathematics instruction really being taught in this manner? Are elementary teachers that have low mathematics anxiety and high mathematics teaching self-efficacy providing students the opportunity to learn mathematics using rigorous mathematical tasks and strategies that promote best practice? Therefore, this study sought to (1) explore whether elementary mathematics teachers' mathematics anxiety and/or mathematical self-efficacy predict their mathematical teaching self-efficacy and (2) explore the impact of the mathematical instructional strategies used by elementary teachers that had low mathematics anxiety and high mathematics teaching self-efficacy.

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Mathematics Anxiety

Mathematics anxiety is defined as a tense feeling that interferes with the manipulation and understanding of how to work with numbers causing a negative attitude toward mathematics, avoidance of mathematical thinking, lack of self- confidence, and fear of the content (Ashcraft, 2002; Richardson & Suinn, 1972; Tobias, 1978). Jackson and Leffingwell (1999) suggested that mathematics anxiety in students could be influenced by elementary teachers' personal mathematics anxiety, beginning as early as third or fourth grade. An individual's anxiety about mathematics often has led to an avoidance of the subject altogether (Hembree, 1990). Therefore, many college students choose to not take many college mathematics foundational courses (Hembree, 1990). This results in teachers not being prepared to teach mathematics due to their backgrounds and personal anxieties regarding the subject matter (Ball, Thames, & Phelps, 2008; Hill, Rowan, & Ball, 2005; Malzahn, 2002).

Teachers' Mathematics Anxiety and Instructional Practices

Teaching mathematics from a conceptual standpoint remains the main goal of the current mathematics reform movement. However, it is viewed by many prospective and practicing elementary teachers as threatening (Tobias & Piercey, 2014; Uusimaki & Nason, 2004). It is not surprising that many classroom teachers feel isolated from this reform process; for teaching mathematics using inquiry based strategies can be intimidating and extremely difficult, even for those who have training and experience (Ernest, 1998; Thompson, 2014). Many teachers are asked to teach mathematics in a way that is completely different from the way in which they learned mathematics. Furthermore, first year teachers especially have difficulty and experience anxiety in teaching using inquiry based instructional practices (Raymond, 1997).

Teacher Self-Efficacy

According to Guskey and Passaro (1994), teacher self-efficacy is identified as a teacher's belief that he/she can make a difference in how well a student learns or the extent to which they can affect students' achievement. Teacher self-efficacy is separated into two categories, general teaching efficacy and personal teaching efficacy (Coleman, 2001). Teachers who have high teaching efficacy take responsibility for student learning. However, teachers who have a low sense of general teaching efficacy feel powerless in helping challenging or struggling students. Teachers with low teaching efficacy feel that motivation, ability level, and family influence are the key determinants in student progress, rather than teacher influence(Coleman, 2001).

Teachers' personal efficacy affects their beliefs regarding their individual abilities to teach, manage the classroom, and effectively instruct (Muijs & Reynolds, 2002). Teachers with high personal efficacy encourage student learning through support, academic challenges, and structured, warm environments (Muijs & Reynolds, 2002). However, teachers with low personal self-efficacy avoid topics, subjects, and situations where they feel incompetent. Further, these teachers with low personal efficacy experience higher levels of stress that negatively impact classroom effectiveness (Muijs & Reynolds, 2002). Efficacious teachers exude confidence, enthusiasm, and an expectation of success that illicit enthusiasm and motivated learning from their students, and they are less likely to criticize students that give incorrect responses (Muijs & Reynolds, 2002).

Mathematical teaching efficacy reflects the confidence that teachers are adequately trained to teach mathematics or that teachers have enough experience to develop strategies for overcoming obstacles to student learning in the content area of mathematics (Ashton, 1984). Mathematical teaching efficacy is more specific and individualized than a belief about what teachers in general can accomplish because it is related not only to personal teaching beliefs, but also to a specified content area (Tschannen-Moran, Hoy, & Hoy, 1998).

Purpose of Study

The purpose of this study was to (1) explore whether elementary mathematics teachers' mathematics anxiety and/or mathematical efficacy predict their mathematical teaching efficacy and (2) to explore the impact of the mathematical instructional strategies used by elementary teachers that had low mathematics anxiety and high mathematics teaching self-efficacy.

The research questions that guided this study were:

1. Do mathematics anxiety and mathematics self-efficacy predict mathematical teaching efficacy in elementary mathematics teachers?

2. Are elementary teachers with low anxiety and high mathematics self-efficacy more likely to use best practices in mathematics instruction versus traditional mathematics instruction?

3. How does mathematics anxiety and mathematics self-efficacy impact the strategies teachers use in their mathematics instruction?

Methodology

In order to gain a deeper understanding of the issues expressed in the study, a multiple methods approach was utilized. The quantitative data consist of the summed total of the Mathematics Anxiety Rating Scale Instrument, the summed total of the Mathematics Self Efficacy Scale, and the summed total of the Mathematics Teaching Efficacy Beliefs Instrument. The researcher utilized a step-wise multiple regression to determine whether mathematics anxiety and/or mathematics self-efficacy contributed to the prediction of mathematics teaching efficacy. The qualitative data (classroom observation and semi structured interviews) were analyzed using grounded theory.

Setting and Participants

This study took place in a school system in a rural southeastern state. The school system was comprised of fifteen schools that serve more than 11,000 students. The researcher chose to recruit elementary teachers from the entire school district to represent diverse backgrounds and teaching practices. The 51 participants for the first phase of the study were elementary mathematics teachers in grades one through six. The participants brought a variety of experiences in teaching mathematics in terms of years of teaching, degree(s) held, and professional development. The four participants that were selected to participate in the classroom observations and semi structured interviews taught at different elementary schools within the district and had a vast range of teaching experience.

Instruments

The first instrument used to collect data was the Revised Mathematics Anxiety Rating Scale (MARS-R). The original MARS instrument was a 98-item inventory. Despite the usefulness of the original scale, researchers sought a shorter version of the scale to reduce the administration time of the original 98-item inventory (Alexander & Martray, 1989; Levitt & Hutton, 1984; Plake & Parker, 1982; Rounds & Hendel, 1980). Although all of the shorter versions were promising, each had some difficulties (Suinn & Winston, 2003). Therefore, Suinn and Winston (2003) conducted a study to develop a shorter version of the original scale. Since the MARS has been a measure of mathematics anxiety for many studies over the years, correlations and comparisons were calculated between the short version and the original version. The study relied upon a reasonably large sample size (n = 124), which included both men and women, as well as students who were from an undergraduate course at a state university, which typically attracted a broad representation of undergraduate students. Internal consistency was measured to estimate the reliability of the 30-item MARS. A Cronbach alpha of .96 was found, indicating high internal consistency. This finding is consistent with previous findings of .97 for the original MARS 98-item scale (Richardson & Suinn, 1972). The one week test-retest reliability for the MARS 30-item was .90 ($p < .001$), which is equivalent to the test-retest reliability of .91 ($p < .001$) of the longer MARS 98-item instrument.

Concurrent validity for the MARS 30-item version was first measured by calculating Pearson correlations with the MARS 98-item scale. Tests from both Weeks 1 and 2 correlated significantly. At Week 1, $r = .92$ ($p < .001$) between the two scales, and at Week 2, $r = .94$ ($p < .001$). A factor analysis was calculated to assess whether the MARS 30-item scale showed similar factor loadings as reported for the MARS 98-item scale. Two main factors emerged. The first factor, mathematics test anxiety, accounted for 59.2% of the variance. The other factor, numerical anxiety, accounted for 11.1% of the variance. The data confirm that the MARS 30-item scale has acceptable reliabilities and validity comparable to the original MARS.

The second instrument used to collect data was the Mathematics Self- Efficacy Scale by Hackett and Betz (1989). The Mathematics Self-Efficacy Scale contains 52 items identified as "relevant to the study of mathematics-related self-efficacy expectations and beliefs regarding the ability to perform various mathematical tasks and behaviors" (Hackett & Betz, 1989, p. 122). The scale is composed of three subscales: (a) the Mathematics Tasks sub-scale, consisting of 18 items involving "everyday" mathematics tasks, e.g., balancing a checkbook, (b) Mathematics Courses sub-scale, consisting of 16 mathematics courses; and (c) the Mathematics Problems sub-scale, consisting of arithmetic, algebra, and geometry problems.

For the courses sub-scale, the students were instructed to rate their confidence in their ability to complete each course with a grade of B or better. For the tasks and problems sub-scales, the students simply rated their confidence successfully perform the task or solve the problem. Confidence ratings for all scales were elicited on a 10-point continuum from no confidence at all (0) to complete confidence (9). Mean scores were calculated for overall mathematics self-efficacy (total scale score) as well as for each sub-scale. Betz and Hackett (1983) reported moderate item-total score correlations for the MSES sub-scales and high internal consistency reliabilities (coefficient alpha) for the three sub-scales .92, respectively, for the tasks, courses, and problems sub-scales item scale (.96). Hackett and O'Halloran (1985) (as cited in Hackett & Betz, 1989, p. 264) demonstrated moderate test-retest reliabilities for the total scale ($r = .88$) and all three sub-scales (r = .79, .91, and .82, respectively, for the tasks, courses, and problems subscales).

The third instrument used to collect data was the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) (Enochs, Smith, & Huinker, 2010). The MTEBI consists of 21 items, 13 on the Personal Mathematics Teaching Efficacy sub-scale and 8 on the Mathematics Teaching Outcome Expectancy sub-scale (Enochs et al., 2010). Reliability analysis produced an alpha coefficient of .88 for the Personal Mathematics Teaching Efficacy sub-scale and an alpha coefficient of .75 for the Mathematics Teaching Outcome Expectancy sub-scale (n = 324) (Enochs et al., 2010). Confirmatory factor analysis indicated that the two sub-scales are independent, adding to the construct validity (Enochs et al., 2010).

The fourth instrument used to collect data was the Mathematics Classroom Observation Protocol for Practices (Gleason, Livers, & Zelkowski, 2017). The Mathematics Classroom Observation Protocol for Practices ($MCOP^2$) is a K-16 mathematics classroom instrument designed to measure the degree of alignment of the mathematics classroom with the mathematics standards set out by various national organizations which include the Common Core State Standards in Mathematics: Standards for Mathematical Practice (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). The $MCOP^2$ measures two distinct factors: teacher facilitation and student engagement. Gleason et al. (2017) reported reliability coefficients of .897 for the student engagement sub-scale and .850 for the teacher facilitation sub-scale.

Data Collection

Data were collected in three phases. The first phase consisted of the researcher recruiting and consenting all participants after receiving approval from the Institutional

Review Board. During the first phase of the study, the researcher visited each elementary school and administered the Revised Mathematics Anxiety Rating Scale Survey (R-MARS), the Mathematics Self-Efficacy Scale (MSES), and the Mathematics Teaching Efficacy Beliefs Survey (MTEBI). The researcher collected the participant surveys and calculated a summed total for each survey administered.

The second phase of data collection utilized a purposeful sampling method based on the data results of the surveys. From the consented participants, the researcher selected two teachers that scored lowest on the R-MARS and two that scored highest on the Mathematics Self-Efficacy (MSES) survey. The researcher visited the teachers' classrooms twice to observe them teach a mathematics lesson. The researcher utilized the Mathematics Classroom Observation Protocol for Practices ($MCOP^2$) to score the observation and generate data. Each of the observations lasted approximately one hour.

The third phase of data collection consisted of semi-structured interviews with the same four participants from the second phase. The researcher consulted with practicing teacher educators to develop the structured interview protocol.

Data Analysis

By utilizing a multiple methods design, different information or data sets were obtained which provided a clearer understanding and helped validate the research. Quantitative data gathered from the surveys were analyzed utilizing a stepwise multiple regression. Multiple regression is the practice of building successive linear regression models, each adding more predictors. The predictors are added to the regression models in stages in order to determine if they predict the dependent variable (mathematics teaching efficacy) above and beyond the effect of the controlled variables Creswell (2003).

The qualitative data (classroom observation and semi structured interviews) were analyzed using grounded theory. Berg and Lune (2012) stated that by allowing the data to speak for itself, thus allowing for the likelihood of theory to be produced, more attention can be given to contradictory cases, and the researcher will not become too attached to another perspective or assumption. In addition, new questions are more likely to be raised. Following the procedures presented by Strauss and Corbin (1998), the data collection process began with the collected data first being analyzed individually using a coding process called open coding. The codes were then analyzed using axial coding to form themes and categories.

Table 1
Summary of Inter-correlations, Means, and Standard Deviations

Measure	MTEBI	MSES	R-MARS	Mean	SD
MTEBI	1	–	–	59.82	4.93
MSES	.326**	1	–	79.13	20.59
R-MARS	.040	.476**	1	68.803	17.95

** Correlation is significant at the 0.01 level (2-tailed).

Results

Research Question One:

Do mathematics anxiety and mathematics self-efficacy predict mathematical teaching efficacy in elementary mathematics teachers?

Multiple regression was conducted to determine whether mathematics self-efficacy scores and/or mathematics anxiety scores could be used to reliably predict mathematics teaching self-efficacy scores. Using a stepwise selection procedure (p-value of $F \leq .05$ to enter, $F \leq .1$ to remove), only the mathematics self-efficacy variable was selected, $F(1, 49) = 5.831$, $p = .02$, which accounted for 11% of the variance in the mathematics teaching self-efficacy variable ($R^2 = .11$). This result is supported by the data provided in the correlation matrix in Table 1, which reveals a significant, inverse correlation ($r = -.326$, $p < .01$) between mathematics self-efficacy scores and mathematics teaching self-efficacy scores. Although mathematics anxiety and mathematics self-efficacy scores were significantly correlated ($r = .476$, $p < .01$) no significant relationship between math anxiety and teaching self-efficacy scores was found.

Research Question Two:

Are elementary teachers with low anxiety and high mathematics self-efficacy more likely to use best practices in mathematics instruction?

Four participants, two teachers that scored low on the R-MARS and two that scored high on the Mathematics Self-Efficacy (MSES) survey were purposely selected and were observed teaching a mathematics lesson on two separate occasions. The Mathematics Classroom Observation Protocol for Practices ($MCOP^2$) observation instrument served as the means of gathering data. The data from the $MCOP^2$ indicated that while all four participants provided structure to their lessons, all of the lessons were teacher directed and there were no opportunities given for students to problem solve on their own or to build conceptual understanding. All of the lessons focused on procedural strategies instead of giving the students a mathematical task that allowed them to critically assess the thinking and the strategies they used.

Research Question Three:

How does mathematics anxiety and mathematics self-efficacy impact the strategies teachers use in their mathematics instruction?

Research question three explored how mathematics anxiety and mathematics self-efficacy impacted the strategies that elementary mathematics teachers used in their mathematics instruction. The triangulation of data from the semi-structured interviews as well as the classroom observations revealed major themes and subthemes. The major themes that emerged were (1) attitudes and beliefs about mathematics, (2) teaching the way I was taught, (3) developing mathematics lessons, (4) strategies used to teach mathematics, and (5) administrative decisions. The following is a summary of the major themes and subthemes data that emerged.

Attitudes and Beliefs about Mathematics

Mathematical high self-confidence. The observational and semi-structured interview data suggested that the teachers with high self-efficacy thought that they had confidence with mathematics because of the strategies and methods they used to teach mathematics. However, the strategies that the teachers used did not allow students to make the necessary connections to build conceptual understanding nor did it provide opportunities for students to problem solve and discover solutions for themselves. By designing mathematics lessons that focused on traditional methods of instruction, the teachers structured the context of the mathematics instruction to fit their efficacy and needs and not the needs of the students.

Mathematical low self-confidence. The data confirmed that mathematics teachers with low confidence do not exude a positive attitude about mathematics to their students. They tend to teach the very basic math skills using traditional methods and do not portray math as fun, exciting, and engaging to their students, which leads to poor student achievement. Mathematics teachers with low confidence did not provide opportunities for student to engage in real world tasks that would allow students to develop their mathematical confidence. Therefore, this negative perception and attitude of mathematics transfers from the teachers to their students.

Low expectations of students. The data revealed that all four teachers utilized traditional methods and procedures to teach mathematics. By using traditional methods that focus on algorithms and procedures in their mathematics instruction, the teachers set low expectations for students Boaler, Wiliam, and Brown (2000). Thus, teachers that scored high in self-efficacy in teaching mathematics reported that they support more student risk taking, use more inquiry-based learning, use more student-centered teaching strategies, attend to students' prior knowledge, support equity, and encourage collaboration between students and teachers (Ottmar, Rimm-Kaufman, Berry, & Larsen, 2013).

Teaching the Way I was Taught. The four participants were all taught mathematics using traditional methods and strategies. They discussed that they would learn to work math problems by watching the teacher solve problems using steps and procedures. After they had watched the teacher work a few problems, then the class would be assigned a few problems to work for practice. During the classroom observations, the researcher noted that the teachers modeled how to solve problems on the board using traditional approaches such as the standard algorithm. They assigned problems for the students to complete and then reviewed the answers with them.

Developing Mathematics Lessons- Professional Development

The data revealed that all four teachers had participated in professional development concerning mathematics instruction. All four teachers were able to discuss mathematics utilizing the best practices terminology and phrases. However, the two teachers that scored low on the MSES survey stated that they would like more professional development to feel comfortable with what they are supposed to teach in mathematics. The two teachers that scored high on the MSES survey did not mention professional development during their semi-structured interviews. However, the classroom observations indicated that while they feel comfortable teaching mathematics, they teach using traditional strategies and do not utilize best practices in their mathematics instruction.

Strategies Used to Teach Mathematics

All four teachers were able to use the correct educational terminology when discussing the strategies that they used in their mathematics instruction. They discussed that students should be active participants of their learning and that they should participate in hands-on activities that allow the students to explore. However, the classroom observations indicated that the teachers were doing something completely different. The teachers used centers and group work, but it was extremely controlled by the teacher. The students usually were working on review skills or a worksheet using traditional methods. There were no opportunities for students to explore the mathematical skill on their own and make connections in order to build conceptual understanding. Possible reasons for the findings are that the teachers were just using the educational language that they heard used at professional development sessions they have attended and really did not know what the language meant in terms of mathematics instruction. Perhaps the teachers did not want to relinquish the control of the classroom and continued to utilize a teacher centered approach when they thought that they were teaching mathematics from a inquiry based approach.

Administrative Decisions- Time Factors

All four teachers stated that they have 60 minutes to teach mathematics, which is not enough. The teachers stated that while mathematics instruction is viewed as being important, their administrators and school district deem reading instruction to be a higher priority and designate it as protected instructional time. The teachers stated that they usually use the time allocated for science or social studies at least one to two days a week to add additional time to their allocated mathematics time. They said that this is the only way that they have to work around the scheduling issue. However, none of the teachers mentioned the idea of using an integrated teaching approach as a solution for the time issue. By utilizing an integrated teaching approach, the teachers could have solved the issue of having enough time without cutting other essential instruction.

Discussion and Implications

The findings of this study have clear implications for mathematics education and specifically, elementary mathematics teachers. The findings noted that there is an inconsistency among teachers' mathematical teaching efficacy and the instructional practices that they utilize in their mathematics instruction. This inconsistency indicated that either the teachers did not understand what it means to teach mathematics using best practices or they did not feel confident enough to teach mathematics using these practices. Because of this inconsistency, there is a need for additional support to help elementary mathematics teachers overcome the anxiety and/or lack of self-efficacy in order to foster best practices in mathematics instruction.

Efforts should be made to help students learn the more complex and analytical skills they need to be successful in today's society. Kamii (2000) stated that students develop personal autonomy and begin to make sense of mathematics when they are allowed to hypothesize, discuss, and justify their thinking in the mathematics classroom. Teachers must learn to teach in ways that help students develop higher-order thinking skills and be able to apply those skills to solve real world problems. To develop this form of teaching, education systems and districts must offer more effective and ongoing professional development than has traditionally been available.

Professional development experiences must address how teachers learn. Active learning opportunities allow teachers to transform their teaching and not simply layer new strategies on top of the old (Snow-Renner & Lauer, 2005). Teachers need to experience learning mathematics the way that their students will, so that they develop the conceptual understanding they wish to develop in their students (Hughes, 2016). These opportunities often involve modeling the new strategies and constructing opportunities for teachers to practice and reflect on them (Garet, Porter, Desimone, Birman, & Yoon, 2001; Saxe, Gearhart, & Nasir, 2001; Supovitz & Turner, 2000).

The findings of this study also indicated that efforts should be made at the higher education level to assist elementary teacher candidates in becoming better prepared for teaching mathematics using best practices in instruction. Burton (2012) found that negative mathematics experiences by teacher candidates are often related to the classroom rather than real world mathematics. If elementary mathematics teachers are to teach from a conceptual standpoint, then, they must have a strong mathematics foundation, including making real world connections, as well as a strong mathematics teaching self-efficacy. Mathematics educators should assist teacher candidates in building a firm understanding of the mathematical content during the teacher candidates' foundational mathematics courses. Mathematics educators can plan experiences in the methods courses that allow the teacher candidate to reinforce these mathematical concepts and skills through participation in inquiry based activities that help allow them to make connections through exploration and investigation. Additionally, teacher candidates need opportunities to practice what they have learned through teaching instructional lessons in a safe environment that offers an opportunity for them to receive constructive feedback and build their self- efficacy.

Another way to provide opportunities for teacher candidates to make connections between the mathematics methods courses and the elementary mathematics classroom is through extensive field experiences. These experiences allow the teacher candidates to practice what they have been taught, including designing and teaching lessons that promote best practices in a real life classroom setting and to receive invaluable feedback from the practicing classroom teacher and university supervisors.

While extensive research on mathematics anxiety and self-efficacy has been conducted, the focus has been on how the constructs affect student achievement, gender, or teacher candidates. There is a need for more research involving teachers' mathematics anxiety, mathematical self-efficacy, mathematical teaching self-efficacy, and the instructional practices of elementary mathematics teachers. It is imperative as educators that we assist teacher candidates and practicing teachers in alleviating their mathematics anxiety and change their mathematical beliefs, so that they can design mathematics instruction that utilizes best practices which will, in turn, lead to students learning mathematics conceptually.

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