8-2018

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ISSN 2165-7874

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Abstract

Mathematics teacher quality has become a major focus in national education reform efforts. In addition, there is an increasing interest in the effectiveness of teacher preparation programs and the undergraduate preparation of elementary mathematics teachers. Empirical evidence suggests that teacher attitudes, behaviors and values, or dispositions, towards teaching have a significant impact on student outcomes. The purpose of this study is to survey juniors and seniors in an undergraduate teacher preparation program to gauge their perceptions of self-efficacy and comfort with teaching mathematics. The results have implications for, and reaffirm concerns about the undergraduate preparation of elementary mathematics teachers.

Keywords: preservice teacher, self-efficacy, mathematics education, undergraduate students

Introduction

There is an increasing interest in the quality and effectiveness of teacher preparation programs across the United States. The perceptions of pre-service teachers' sense of efficacy in their teacher preparation programs is a critical factor to examine as it has major implications for the teacher candidate and program. Mathematics is a discipline that has caused fear and anxiety in some students. Pre-service teachers are no exception to this experience (Bates, Latham, & Kim, 2011). Mathematics self-efficacy refers to one's belief in the ability to do mathematics, usually assessed by one's successfulness in completing math-based college courses, math tasks, math problems, and teach mathematics to others (Betz & Hackett, 1983).

Additionally, generalist elementary education degrees are among the most completed in the U.S. (NCES, 2012), yet many of these teachers have limited preparation for effectively teaching mathematics (Conference Board of the Mathematical Sciences (CBMS; 2010). Mathematics teacher education is complex and requires knowledge of teaching and learning as well as knowledge of mathematics. According to state and national standards, undergraduate mathematics programs must prepare preservice teachers for the challenges of teaching. Hence, it is critical for teacher preparation programs to ensure the mathematicians and mathematics teacher educators collaborate and make connections between the undergraduate courses that they teach and PK-12 mathematics for the preservice teacher (CBMS, 2010).

In this paper, the perceptions of pre-service teachers' efficacy in teaching mathematics will be explored to understand how to enhance the teacher preparation programs and better meet the needs of students seeking their elementary generalist teaching certification. We have included a review of the literature to highlight the importance of teacher efficacy for pre-service teacher preparation.

Review of the Research

Given its importance to their instructional practices and student outcomes, researchers have examined factors that might impact teacher self-efficacy. Some studies have supported the notion that teachers' sense of efficacy can vary based on the experience level of teachers (Fives & Buehl, 2010; Klassen & Chiu, 2010; Wolters & Daugherty, 2007). According to McDonnough and Matkins (2010), factors impacting pre-service teachers' self-efficacy are critical, given the connection between teachers' self-efficacy and their student's achievement. Prior studies have indicated that both pre-service and in-service teachers lack the confidence to teach basic math, which influences their teaching (Newton, Leonard, Evans, & Eastburn, 2012).

In a study of factors examining the difference between novice and experienced teachers' self-efficacy, Tschannen-Moran and Woolfolk-Hoy (2007) found teaching resources impacted novice teachers' efficacy and their satisfaction with job performance is related to family and community support. In a mixed-methods study of 156 pre-service teachers, Gresham (2009) found a moderate negative relationship between mathematics teacher efficacy and mathematics anxiety (p. 25). In the follow-up study of 10 of the 156 pre-service teachers with the highest mathematics anxiety who elected to participate in the qualitative phase of the study, those participants expressed negativity *towards* mathematics (Gresham, 2009, p. 26). Consequently, 9 of the 10 teachers with the highest anxiety about mathematics had negative elementary school experiences with mathematics and experienced stress regarding their mathematics content knowledge base.

Socio-Cognitive Theory as a Teacher Efficacy Framework

We employed Socio-cognitive theory (SCT) derived from Bandura's work on self-efficacy (1977) as the primary theoretical framework for this study. SCT was used to better understand the connections among areas of pre-service teachers' self-confidence. In the current literature, SCT has been used to explain how the environment, teacher beliefs and teacher behaviors interact. Additionally, researchers have examined the role of teachers' sense of efficacy (i.e., teacher self-efficacy) in instructional decisions and classroom climate (Hardre & Sullivan, 2008; Wolters & Daugherty, 2007). SCT assumes that learning and behavior are shaped by a triadic reciprocity among cognitive, behavioral, and environmental factors, which interact bi-directionally (Bandura, 1977). Furthermore, researchers have established that self-efficacy beliefs and behavior changes and outcomes are highly correlated. The purpose of this study was to assess elementary education majors' perceptions of self-efficacy in teaching mathematics.

ISSN 2165-7874

Rationale and Purpose of the Study

In their validation study of the Teacher Self Efficacy Scale, Duffin, French, and Patrick (2012) recommended additional research to examine the types of mastery experiences that pre-service teachers receive during their teacher preparation experiences and which of those experiences influence teacher efficacy belief development. In terms of impact of field experiences on teaching, Pendergast, Garvis, and Keogh (2011) found teachers rated their self-efficacy higher during initial phases or enrollment in teacher education programs, but during their final semester in the programs, they rated themselves lower than prior ratings.

Additionally, Pendergast, Garvis, and Keogh (2011) identified the need for additional research on efficacy development phases and sources of self-efficacy during the initial stages of teaching. Participants in their study included post-graduate, first-semester, and pre-service teachers. Through conducting their research study, Duffin et al. (2012) questioned,

What other specific sources of efficacy information are most prominent during teacher preparation? How much of an impact do these efficacy sources have on the formation of efficacy beliefs for teaching and influence pre-service teachers' perceptions of the teaching tasks? (p. 832).

We have conducted this research study, in part, to support the knowledge base on research on the role of efficacy and the development of pre-service teachers. Furthermore, in the state of the research sites of this study, executive leaders of university systems have charged member institutions to conduct research on the effective preparation of elementary mathematics teachers. Given the focus on science, technology, engineering, and mathematics (STEM) professions and economic impact in this state, it is important to understand how to prepare future teachers who will prepare the future workforce in STEM industries.

Mathematics teacher quality has become a major focus in national education reform efforts. The purpose of this research study was to examine junior and senior level pre-service teachers' perceptions of self-efficacy to teach mathematics. Specifically, we examined elementary level pre-service teachers who were enrolled in teacher preparation programs in five member institutions of one of the largest university systems in the state of Texas. Elementary education majors in this state seek certification referred to as EC-6 i.e. Early Childhood through Grade 6 licensure.

Methods

We conducted the research across five university campuses with a large four-year university system in the state of Texas. Students enrolled in the Early Childhood to 6th grade (EC-6) generalist programs participated in this study. To participate in the survey, students must have held junior or senior status and have completed at least 1 semester in a field experience course. While 191 total surveys were initiated, 84 participants did not meet inclusionary criteria. In addition, 31 we excluded incomplete profiles from the sample resulting in a total of 76 surveys of participants who completed all questions.

The study sample consisted of 76 elementary education preservice teachers, i.e. teacher education students, (70 female and 6 male students). The ethnicities of student participants were as follows: 63% White, 15% Black, 19% Hispanic, 2% Asian, and 2% American Indian. Fifty percent of the sample had experienced one semester of field experience, 29% had completed two semesters of field experience coursework, and 21% had completed three or more semesters. The ages of participants ranged from 20 to 60 years and the majority of the sample (65%) were 25 years old or younger. Please see Table 1 for the demographic profile of participants organized by participating institution.

Table 1
Participant Characteristics by Campus

	Campus					
Demographic	Campus A *n* = 5 %	Campus B *n* = 10 %	Campus C *n* = 38 %	Campus D *n* = 17 %	Campus E *n* = 5 %	Total *n* = 75 %
Class Status						
Junior	40	-	45	6	60	31
Senior	60	100	55	94	40	69
Gender						
Male	20	-	5	6	-	5
Female	80	100	96	94	100	95
Ethnicity						
Asian	-	-	-	6	-	2
Black	100	-	11	12	-	15
Hispanic/Latino	-	-	8	38	100	18
Native American	-	-	79	-	-	2
Caucasian	-	100	2	44	-	63
Field Exp.						
One Semester	60	20	53	65	20	50
Two Semester	-	10	34	35	20	29
Three or More Semesters	40	70	13	-	40	21

Instrumentation. We distributed the Mathematics Teaching Efficacy Belief Instrument (MTEBI) developed by Enochs, Smith, and Huinker (2000) to pre-service teachers enrolled in five institutions in the state of Texas via Survey Monkey®, an e-survey distribution and collection system. The MTEBI is a 21item scale instrument which measures efficacy beliefs in pre-service teachers in mathematics (Enochs et al. 2000). The instrument consisted of three sections: (a) demographic section and (b) two sub-scales categories. Each item includes a specific statement regarding future mathematics teaching beliefs and utilizing a 5-point Likert scale, the preservice teacher responds to the degree in which they strongly agree, agree, are uncertain, disagree, or strongly disagree.

There are two subscales within the MTEBI, the Personal Mathematics Teaching Efficacy (PMTE) scale and the Mathematics Teaching Outcome Expectancy (MTOE) scale. The PMTE reflects more of the pre-service teacher's beliefs about his or her own teaching abilities, while the MTOE is more related to the expectancy of student outcomes based on the teacher abilities. Reliability coefficients for the MTEBI have been found to be strong with a Cronbach alpha of .88 for the PMTE and .77 for the MTOE (Enochs et al., 2000).

In the demographic portion of the instrument, we gathered information related to age, ethnicity, academic rank (junior or senior), campus of enrollment, as well as the number of

ISSN 2165-7874

semesters of field experience. Next, the survey asked participants to disclose the types of math courses taken in both high school and college. Participants identified the type of mathematics courses taken in high school from a list of common courses (i.e. algebra, geometry, calculus, etc). When asked about college mathematics courses, participants indicated the courses taken as well as the setting in which the courses were taken and provided the following categories: Dual Credit, Advance Placement credit, Community College, Other 4 Year University/College, Current University in the College of Education or Current University, Non-College of Education. Participants identified the type of mathematics courses taken in high school from a list of common courses (i.e. algebra, geometry, calculus, etc.) and were also asked to identify college mathematics courses completed. A total number of mathematics courses in high school and a total number of mathematics courses in college were computed.

Procedures. The survey consisted of the MTEBI questionnaire and the demographic questions as detailed above. After administration, the MTEBI was scored following procedures outlined in research by Enochs et al., (2000) and we calculated the summed scores for the PMTE and MTOE scales for each participant. We calculated the internal consistency using SPSS. Internal consistency analysis revealed similar Cronbach's alpha coefficients to those reported by Enochs et al. (2000), with .84 for the PMTE and .75 for the MTOE with the current sample of participants.

Data Analysis and Results

Analysis. Table 2 displays descriptive statistics for the two MTEBI scales, the PMTE and the MTOE, as well as background characteristics of the teacher candidates. Most variables were continuous. However, four variables, Black, Hispanic/Latino, White, and Year in Program, were binary categorical variables. The first three reflect categorical variables for three of the five ethnic groups identified in the sample. Because too few students identified as Asian or Native American (one each in the final sample) as the race/ethnicity, we were unable to conduct any analysis for these groups. Approximately 63% of the sample identified as White, while 70% of the sample represented senior-level teacher candidates.

Table 2
Descriptive Statistics

	Mean	SD	Min. Value	Max. Value
MTEBI Scales N=75				
PMTE Scale	49.59	8.64	21	65
MTOE Scale	29.45	4.22	17	39
Background Characteristics				
Age	26.85	8.30	20	60
Ethnicity	.36	.48	0	1
Year in Program	.69	.46	0	1
Semesters of Field Experience	1.77	.91	1	4
Total # HS Math classes	2.63	1.0	1	5
Total # College Math Classes	3.46	1.49	1	8

To compare teacher candidates' perceptions of their teaching abilities by background characteristics, we divided the sample into two groups, depending on participants' PMTE scores. Participants who scored below the PMTE mean score of 49.59 were grouped together, as were those who scored above the PMTE mean score. We then compared groups using a t-test to determine whether there were any significant differences in background characteristics for those who scored below average and those who scored above average on the PMTE.

Table 3 provides these results. We found statistically significant differences for age, ethnicity, and the total number of math class taken in high school. On average, the group who scored below the average PMTE score was older, had a higher share of Hispanic/Latino participants, and took fewer high school math classes than the above average group.

Table 3

T Test Results Comparing Mean Background Characteristics of Teacher Candidates by PMTE Mean Score Groups

Characteristic	Below average PMTE score	Above average PMTE score	ttest
Age	29.64	25.19	*
Black	.14	.15	
Caucasian	.46	.72	*
Hispanic/Latino	.32	.10	*
Year in Program	.67	.70	
Semesters of Field Experience	1.64	1.85	
Total # HS Math Classes	2.21	2.87	**
Total # College Math Classes	3.5	3.7	

$^{**}p<0.01$, $^{*}p<0.05$

We followed a similar process to compare teacher candidates' expectations of student outcomes by background characteristics. Participants who scored below the MTOE mean score of 25.19 were grouped together, as were those who scored above the MTOE mean score. Table 4 provides these results. There were no statistically significant differences in the background characteristics of teacher candidates who had below average expectations of student outcomes relative to those who had above average expectations.

Tables 4 and 5 present the results for the 13 individual survey items on the PMTE scale and the eight items on the MTOE scale, respectively.

ISSN 2165-7874

Discussion and Conclusions

Again, the two MTEBI has two subscales which the PMTE and the MTOE. For the PMTE categories (see Table 5), participants indicated that they strongly agreed or agreed on their efficacy for the specific category for 6 out of 12 areas. The sub-scale areas are included below.

- I will continually find better ways to teach mathematics.
- I know the steps necessary to teach mathematics concepts effectively.
- I understand mathematics concepts well enough to be effective in teaching mathematics.
- I am typically able to answer students' mathematics questions.
- I wonder if I have the necessary skills to teach mathematics.
- When teaching mathematics, I usually welcome student questions.

For the MTOE categories (see Table 5), participants indicated that they strongly agreed or agreed on their efficacy for the specific category for all eight areas of this sub-scale. The sub-scale areas are included below.

- When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.
- When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.
- If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.
- The inadequacy of a student's mathematics background can be overcome by good teaching.
- When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.
- The teacher is generally responsible for the achievement of students in mathematics.
- Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.

Participants provided a positive rating of their efficacy in 50% of the PMTE categories and 100% of the MTOE categories. On the converse, for six of the PMTE categories, (see Table 5), participants indicated that they disagreed or strongly disagreed on their efficacy for the specific category for six out of 12 areas. The sub-scale areas are included below.

- Even if I try very hard, I do not teach mathematics as well as I do most subjects.
- I generally teach mathematics ineffectively.
- I find it difficult to use manipulatives to explain to students why mathematics works.
- Given a choice, I would not invite the principal to evaluate my mathematics teaching.
- When a student has difficulty understanding a mathematics concept, I am usually at a loss as to how to help the student understand it better.
- I do not know what to do to turn students on to mathematics.

Limitations. One major limitation would be the sample might not be large enough to generalize findings to large populations of students in teacher education. We recognize that these results come from a limited sample of individuals in one specific area of population of teacher candidates who are enrolled in teacher education programs at five institutions in a single

Southwestern state. In addition, all responses to the questionnaires were self-reported which may or may not accurately depict teacher candidate perceptions.

Table 4
Test Results Comparing Mean Background Characteristics of Teacher Candidates by MTOE Mean Score Groups

	Below average MTOE score	Above average MTOE score	ttest
Age	26.91	26.81	
Black	.06	.04	
Caucasian	.27	.11	
Hispanic/Latino	.60	.64	
Year in Program	.64	.74	
Semesters of Field Experience	1.82	1.74	
Total Number HS Math Classes	2.61	2.64	
Total Number College Math Classes	3.67	3.60	

$**p<0.01$, $*p<0.05$

Practical Implications and Future Directions. We recommend the administration of self-efficacy evaluations as a continued and best practice for educator preparation programs. Our findings here indicate an additional need for teacher education programs to ensure teacher candidates and pre-service teachers have multiple experiences for self-evaluation as well as clinical supervision experiences with university faculty and/or supervisors. Conversations around mathematics pre-service teacher efficacy can help instructors and supervisors identify actual and perceived weaknesses from the onset and work to ensure teacher candidates matriculate and graduate from programs prepared for work in the profession. In many instances, colleges of education do not teach the mathematics content courses. Therefore, education faculty and mathematics faculty (typically housed in schools/colleges of arts and sciences) can collaborate to address deficiencies related to mathematics content knowledge or application of mathematics content knowledge. In this respect, education preparation programs can ensure undergraduate preservice teachers are equipped with the necessary knowledge and skills to become highly qualified and effective educators who will in turn impact PK-12 students in a positive manner.

ISSN 2165-7874

Table 5

Mathematics Teaching Efficacy Belief Instrument (MTEBI)

Personal Mathematics Teaching Efficacy (PMTE) Scale, Individual Item Responses	Strongly Agree (%)	Agree (%)	Uncertain (%)	Disagree (%)	Strongly Disagree (%)
I will continually find better ways to teach mathematics.	65	27	8	--	--
Even if I try very hard, I do not teach mathematics as well as I do most subjects.	8	12	27	37	16
I know the steps necessary to teach mathematics concepts effectively.	9	59	20	9	3
I generally teach mathematics ineffectively.	1	5	13	53	27
I understand mathematics concepts well enough to be effective in teaching mathematics.	21	57	9	8	4
I find it difficult to use manipulatives to explain to students why mathematics works.	--	8	9	44	39
I am typically able to answer students' mathematics questions.	16	69	9	5	--
I wonder if I have the necessary skills to teach mathematics.	5	36	19	28	12
Given a choice, I would not invite the principal to evaluate my mathematics teaching.	9	9	15	44	23
When a student has difficulty understanding a mathematics concept, I am usually at a loss as to how to help the student understand it better.	1	12	16	48	23
When teaching mathematics, I usually welcome student questions.	40	45	8	5	1
I do not know what to do to turn students on to mathematics.	1	11	20	57	11

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