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Research projects and secondary mathematics pre-service teachers' sense of efficacy

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ABSTRACT

This two-year study investigated the differences in the level and amounts of change in teaching efficacy of secondary pre-service mathematics teachers who completed one of two different research projects during a methods course. The first type, field research, involved a three day trip to an urban school to investigate successful mathematics teaching and learning from engaging directly with practitioners. For the second type, text-based research, participants remained on campus and investigated successful mathematics teaching and learning through text-based literature. Pre-service teachers were separated into two self-selected groups based on the type of research project they completed. The two types of research projects were focused and grounded one source of self-efficacy: vicarious experience. Within the possible vicarious experiences that inform pre-service teachers' sense of efficacy, two are readily applicable for teacher educators: watching others teach followed by discussing results (field research) and reading professional literature followed by discussions of enacting those ideas (text-based research). Data revealed that pre-service mathematics teachers showed improved teaching efficacy. Those who did field-based research had a higher level and greater increase on measures of teaching efficacy compared to peers completing text-based research. Implications for mathematics teacher educators are discussed.

KEYWORDS
Efficacy; mathematics; pre-service; research projects

Literature review

Mathematics teacher educators actively seek to design programs and develop specific and focused assignments that prepare pre-service teachers (PSTs) to be ready to enter the field. Although there have been many studies on PSTs' efficacy at the program and course level (Cakiroglu, 2008; Hoy, 2000; Hoy & Woolfolk, 1990; Huinker & Madison, 1997; Moseley & Utley, 2006; Swars, Smith, Smith, & Hart, 2009) as well as research connecting PSTs' attributes with efficacy (Bates, Latham, & Kim, 2011; Brown, 2012; Gresham, 2008; Isiksal, 2010; Kahle, 2008; Swars, Daane, & Giesen, 2006), the specific assignments given in methods courses and their nuances across universities tend to remain in relative obscurity within efficacy research literature. It is essential that teacher educators determine what experiences are necessary for PSTs, investigate the ways in which these experiences are offered and fit within the program, and share with other teacher educators the extent to which they are valuable.

Inadequate preparation can have negative consequences for teachers, their students, and the field. One consequence of note is the plague of K–12 teacher instability. Attrition rates are highest in the first five years of teaching (Moon, 2007), and as many as 50% of teachers leave the profession within the first five years of beginning their teaching career (Ingersoll, 2003). It is also well documented that

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science and mathematics teachers have higher attrition rates than teachers of other subjects (Borman & Dowling, 2008; Guarino, Santibanez, & Daley, 2006) and that schools in low-income and urban areas with minority students have higher attrition rates than wealthier and rural areas (Ingersoll, 2001; Kersaint, Lewis, Potter, & Meisels, 2007; Lankford, Loeb, & Wyckoff, 2002). There are a host of factors contributing to these teacher turnover rates, including teacher stress (Fisher, 2011; Macdonald, 1999; Webb, 2006), teacher pay (Guarino et al., 2006; Ingersoll & Alsalam, 1997; Johnson & Birkeland, 2003), and lack of administrator support and resources (Ingersoll, 2001). We know that teachers with higher efficacy are better at overcoming difficulties (Ashton & Webb, 1986), have less stress (Parkay, Greenwood, Olejnik, & Proller, 1988), and are more resilient and stay in the profession longer (Glickman & Tamashiro, 1982). There is also evidence that much of a teacher's efficacy is developed during his or her pre-service years (Smith, 1996), and that during these years it is amenable to change (Charalambous, Philippou, & Kyriakides, 2008). A potential solution for overcoming the challenges of the mathematics teaching profession may be for teacher educators to find and incorporate effective ways of increasing teaching efficacy during pre-service mathematics programs.

Urban mathematics teaching

One possible way to build mathematics PSTs' efficacy might be to have them investigate successful mathematics teaching in urban areas of poverty, or as Siwatu (2011) classifies them, "America's most challenging schools" (p. 357). Research has indicated that self-efficacy beliefs are context-specific (Bandura, 1997), and that PSTs' university programs create teachers who feel less prepared and confident to teach in urban settings (Siwatu, 2011). How can mathematics educators better prepare self-efficacious PSTs for teaching in urban settings? This question is particularly relevant to teacher preparation institutions far from urban centers. These institutions may have a high number of PSTs with little or no life experiences in urban contexts, yet some of them go on to find teaching positions in urban contexts early in their careers.

The difficulties that contribute to urban teachers' attrition and burnout include several stress-related factors such as limited resources, excessive workload, poverty, and lack of preparation to deal with the diversity of culture and language (Shernoff, Mehta, Atkins, Torf, & Spencer, 2011). In spite of these difficulties, there has been research on schools and teachers that overcome these difficulties through mathematics learning environments that promote authenticity (Fleener & Matney, 2007; Matney, 2004), student-centered approaches that focus on mathematical meaning and understanding (Black, 2007; Matney, 2004), collaborative decision making, supportive leadership, relationships with parents and community, and high expectations (Black, 2006; Edmonds, 1979; Kannapel & Clements, 2005). The research points to several factors that work together to make a positive difference in the learning of students in mathematics classes in urban areas of poverty. Understanding these factors may influence PSTs' beliefs about what is possible and how they can make a difference with their teaching.

In formulating this study we noted that our PSTs came mostly from rural, small town, or small city populations. To give PSTs experience in considering the challenges of urban mathematics education, we purposefully sought out a school context in which the challenges mentioned above were apparent yet the school's mathematics teachers were implementing meaningful mathematics engagements. We hypothesized that if PSTs devoted a significant effort to researching how experienced mathematics teachers in urban schools with high poverty overcome difficult situations, then they might become more confident in overcoming these difficulties themselves.

Self-efficacy

For the purpose of this study, we ascribe to the definition of teaching efficacy as the extent to which teachers believe they can strongly influence student achievement and motivation in learning

(Ashton, 1985; Tschannen-Moran, Wookfolk Hoy, & Hoy, 1998). Studies have consistently shown that there are two dimensions of efficacy: personal teaching efficacy and general teaching efficacy. *Personal teaching efficacy* (PTE) is a measure of the teacher's belief in his or her own ability to help any student learn. *General teaching efficacy* (GTE) is a measure of the teacher's beliefs about the general effect that teaching can have on helping students learn (Hoy & Woolfolk, 1990). The level of efficacy for these two dimensions may vary for each teacher. For example, one teacher may feel inept about his or her own ability to reach students but still believe that teaching can have a profound influence on learning, while another teacher may believe his or her ability to teach students is strong and that teaching greatly affects student learning.

Bandura's social cognitive theory (Bandura, 1977, 1986, 1993, 1997) had a large influence on the development of the meaning of teaching efficacy. Bandura claimed that those who are less efficacious will tend to give less effort and encounter more stress in performing the associated activity. In educative contexts this means that the amount teachers believe they can strongly influence student achievement and motivation in learning affects the amount of effort and stress encountered in the teaching endeavor. In support of these claims, research spanning across several decades has established many positive relationships associated with teachers who have higher levels of efficacy. Higher levels of teaching efficacy connect to lower levels of stress (Parkay et al., 1988), a greater likelihood of staying in the field (Glickman & Tamashiro, 1982), more capability to aid students in attaining higher measures of achievement (Allinder, 1995; Ashton & Webb, 1986), a greater persistence in working with struggling students (Ashton & Webb, 1986; Gibson & Dembo, 1984), a more profound inclination to try innovative curricula to reach all students (Guskey, 1988), and increased student achievement, attitude, and affective growth (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). These findings encourage teacher educators to seek out ways to foster PSTs' growth of teaching efficacy.

As the construct of teaching efficacy has evolved, a discipline-specific instrument called the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) was developed for mathematics teaching efficacy. The MTEBI is the only instrument available to measure self-efficacy of PSTs who will teach mathematics to students (Ward, 2009). However, the MTEBI was designed for and shown to be valid with pre-service *elementary* teachers (Enochs, Smith, & Huinker, 2000) but not secondary teachers. Several studies have utilized it and other instruments to observe the effects of courses and programmatic structures on PSTs' mathematics teaching efficacy. For example, when PSTs took an integrated science/mathematics course in addition to their methods block, their teaching efficacy increased, while those who did not take the course showed no change in teaching efficacy (Moseley & Utley, 2006). PSTs' mathematics self-efficacy has been found to be highly correlated to confidence in teaching mathematics (Bates, Latham, & Kim, 2011; Kahle, 2008) and mathematics self-concept (Isiksal, 2010) but negatively correlated with mathematics anxiety (Gresham, 2008; Swars et al., 2006). A study by Brown (2012) involving nontraditional PSTs found that older PSTs tended to have higher efficacy.

More recently, educators have been looking to improve the instrumentation related to measures involving secondary mathematics PSTs' self-efficacy. These include attempts to improve the MTEBI (Kieftenbeld, Natesan, & Eddy, 2011; Ward & Johnston, 2014) and conceptual models that focus on self-efficacy for particular kinds of mathematics knowledge, such as knowledge of teaching algebra (Eddy et al., 2014). As such, the field of mathematics education continues to work on parsing the nuances of Bandura's (1997) assertion that one's self-efficacy depends on the context.

Due to the malleable nature of pre-service and novice teachers' self-efficacy (Bandura, 1997; Woolfolk Hoy & Spero, 2005) and research literature suggesting that teachers who leave the profession have lower self-efficacy (Tschannen-Moran & Woolfolk Hoy, 2007), several researchers have called for more research on what kinds of supports produce strong efficacy beliefs (Albayrak & Unal, 2011; Hoy & Woolfolk, 1990; Moseley & Utley, 2006; Pajares, 1992; Siwatu, 2011; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998; Woolfolk Hoy & Spero, 2005). The literature has established significant relationships between mathematics teacher efficacy and several qualities necessary for successful teaching and learning of mathematics. However, it is difficult to discern from these studies what specific types of experiences and academic engagements teacher educators should use during methods course work to foster teaching efficacy. Many studies have shown that when PSTs take methods courses, their teaching efficacy increases (Albayrak & Unal, 2011; Huinker & Madison, 1997; Utley, Moseley, & Bryant, 2005; Vinson, 1995; Woolfolk Hoy & Spero, 2005). However, the literature remains thin in studies containing specific details about the kinds of tasks completed in these methods classes and the degree to which these tasks affect teaching efficacy.

Theoretical framework

In designing research questions to look more closely at what might be done specifically to improve PSTs' efficacy, we chose to examine different vicarious experiences (Bandura, 1986, 1997). Bandura discusses four classifications by which one comes to know about teaching and construct self-perceptions about teaching ability. These four classifications are mastery experiences, *vicarious experiences*, physiological and emotional states, and verbal persuasion. Enactive mastery experiences provide the most influence on efficacy because they provide the most genuine knowledge about one's own ability to teach (Bandura, 1997). Vicarious experiences also act to inform teachers' sense of efficacy as the teacher observes the teaching of others and reads teacher-related literature. Through vicarious experiences PSTs are informed about the meaning and ways of teaching by communicating with others about teaching, observing others teach, reading professional literature, or engaging in tasks given in teacher education courses. PSTs use these experiences to cultivate ideas about what good teaching looks like, what methods of teaching lead to successful outcomes, and whether they can instantiate the methods and actions necessary for success. PSTs most often have little or no prior teaching experience on which to base their competency, and as a result their efficacy may be readily changed by observing appropriate modeling by more experienced teachers (Labone, 2004). Furthermore, the observation of those who model teaching effectively can boost the efficacy of those who have had many inefficacious experiences (Bandura, 1977) and can even raise the efficacy of those who already perceive themselves to be great teachers if the presented teaching model reveals better ways of teaching (Bandura, 1997).

Building from this theoretical perspective, we were interested in the kinds of vicarious experiences provided through tasks in methods courses and wondered which of these tasks would nurture the development of a stronger sense of personal and general teaching efficacy. In this study we investigated two specific vicarious experiences associated with research projects in a secondary mathematics methods course. PSTs engaged in either text-based research or field research. Both tasks allowed students opportunity to consider vicariously what is known about effective teaching. However, since the field-based research involved observations of mathematics teaching moments, it was more closely connected with a mastery experience, which is the greatest source of efficacy information (Bandura, 1997). Thus, we hypothesized that those secondary mathematics PSTs doing research in the field by observing effective teachers would see greater gains in efficacy.

To understand better the relationship between the use of research projects and the teaching efficacy of mathematics PSTs, the following research questions were addressed.

(1) Did each type of research project used in this study increase general and personal teaching efficacy in pre-service mathematics teachers?
(2) Did the type of research project affect the level and amount of increase in general and personal teaching efficacy of pre-service mathematics teachers?

Method

Participants and study sampling

The sample of the study was 30 undergraduate students enrolled in a secondary mathematics methods course at a university in the Mid-south United States. General and personal efficacy levels of these undergraduates were measured both before and after the research experience using the Teacher Efficacy Scale Short Form (Hoy & Woolfolk, 1993). The study was conducted over a two-year period.

No changes in any assignments given in the mathematics methods courses were made across the two years encompassing this study. All participants were given the same methods assignments regardless of the semester and year they were enrolled in the course, excepting the one research assignment that had two possibilities. In the latter case, each participant self-selected to complete either the text-based research or the field research about mathematics teaching in urban areas of poverty.

Research projects

At the beginning of each semester, both research project types were described and the dates of the field research project were announced. Participants self-selected which project they would complete prior to the study. The field research option involved researching a school in an urban context too far away to allow for daily commuting. Although participants showed great desire to do this project, it simply was not possible in all cases. The reasons for not electing to do the field research included life scheduling issues such as weddings, illness, child care, and work schedules. Each participant chose the type of research to complete according to his or her own availability and circumstance.

Prior to the start of the research projects, all participants read Chapter 1 of *Mathematics Teaching Today* by Herrera, Kanold, Koss, Ryan, and Speer (2007), which is a publication of the National Council of Teachers of Mathematics. The participants used this resource and its descriptions as a basis on which to understand "good mathematics teaching." Next, participants were tasked to find literature relating to factors, inside or outside the mathematics classroom, that affect teaching and learning. The participants' findings and subsequent discussions involved ideas including school, local community, and state education policy, curriculum, health, and socioeconomic status. Upon completion of the search, participants brought their findings to class, where they were presented and discussed as a whole group. The participants were asked to draw on their findings from the literature and continue to develop their own ideas about "good mathematics teaching" throughout the duration of the research. Other than the course reading from *Mathematics Teaching Today*, the participants did not receive any suggestions for potential articles or resources by their methods professor, so as to put the onus of finding related research on the PSTs. A list of example articles found and cited by students can be found in Appendix A. After collaboration on "good mathematics teaching" and other possible effects on teaching and learning, the participants broke into their text-based and field-based research groups.

Text-based research

There were two stages in this project. Following the investigation of "good mathematics teaching" (Herrera et al., 2007), the participants in the text-based group explored and read about challenges teachers face in urban areas of poverty and how mathematics teachers within their school context are adapting to overcome these challenges. Participants sought out research literature to form an educated belief on these topics. In the second stage of the project, participants were required to write individually about the ways they would overcome challenges and explain why they believed their methods would ensure significant mathematics learning in their classroom.

Field-based research

There were four stages in this project. Following the investigation of "good mathematics teaching" (Herrera et al., 2007), the participants in the field-based group were given two one-hour training sessions on classroom observation and interviewing techniques. In the second stage, participants created a set of interview questions and observation outlines to investigate the teaching of mathematics within the school context from which to analyze how mathematics teachers are overcoming challenges they encounter. All interview questions, observations, and data recordings were designed and collected by the participants. The third stage consisted of compiling and analyzing the data. In the fourth and final stage, they were required to write individually about the ways they would overcome challenges and explain why they believed their methods would ensure significant mathematics learning in their classroom.

The participants traveled and conducted observations and interviews with administrators, mathematics teachers, parents, and students in grades 6 through 12 in an urban school district with a high incidence of poverty. Due to the participants' university not being close to a large urban context, the group traveled out of state and stayed for three days.

Urban school context for field research

For the field research it was necessary to find an urban area school with middle-level and high school students coming from high-poverty backgrounds, with mathematics teachers adapting to overcome challenges, and a staff willing to allow our cohort to investigate and learn from their experience. The school that was chosen met all of these criteria. The school had also been able to reduce the number of dropouts to nearly half that of neighboring schools with similar populations and had 100% of its students in eighth-grade Algebra 1 pass the state's mandated exam for graduation. The passage rate on the state exam was about five times greater than those in neighboring schools, and there were a greater percentage of students taking Algebra 1 in the eighth grade in this school than in the surrounding schools. Students entering in the sixth grade had the same range of achievement scores and urban poverty contexts as students of the neighboring schools. The administration and teachers at the school worked hard to develop a relational environment and utilize practices such as looping, year-round schooling, and parent involvement.

The participants researched the same school, administration, and teachers each year of the study. Participants observed mathematics teaching and conducted interviews with teachers and other school officials to connect mathematics teaching with the local school's systemic approaches for overcoming the challenges faced. The school was located in a metropolitan area of more than 1.2 million residents and was situated in the middle of a historically low economic area as indicated by an 86% free and reduced lunch rate. The population of the school was comprised of 73% Hispanic, 15% Caucasian, 7% Native American, and 5% African American students.

Teaching efficacy instrument

The study examined questions related to pre-service secondary mathematics teachers' personal and general teaching efficacy and involved pre-service mathematics teachers researching the teaching of mathematics in urban areas of poverty. At the time of the study, the only valid content-specific mathematics teaching efficacy instrument was the MTEBI (Ward, 2009), which was not validated for use with our participant population, secondary mathematics PSTs. For this reason the MTEBI instrument could not be used with the participants in this study. We chose to investigate changes in efficacy with the Teacher Efficacy Scale Short Form (Hoy & Woolfolk, 1993), which involved secondary pre-service mathematics teachers as part of its validation (Hoy & Woolfolk, 1990, 1993).

The Teacher Efficacy Scale Short Form instrument had respondents rate their level of agreement with each of the ten items on a 6-point Likert scale and identified two independent dimensions of efficacy, personal teaching efficacy (PTE) and general teaching efficacy (GTE). See Appendix B for the list of items. On PTE questions, PSTs' responses were assigned a number from 1 (Strongly Agree) to 6 (Strongly Disagree), whereas the scale for the GTE questions was reversed, so that a higher score consistently corresponded to a higher sense of efficacy. Questions 1, 2, 4, 5, and 10 measured GTE, and their scores were averaged to obtain the GTE score. The remaining questions, 3, 6, 7, 8, and 9, measured PTE, and their average score was the PTE score.

When Hoy and Woolfolk (1993) originally developed and used the Teacher Efficacy Scale Short Form, they tested the reliability of the test with a relatively large and diverse population of PSTs at both the elementary and secondary levels and at three points in their undergraduate careers. This instrument was not specific to level and subject domain, so it is not surprising that they reported no significant difference in the efficacy of secondary and elementary PSTs. Reliability was reported as alpha = 0.77 for PTE and 0.72 for GTE in the original use of the test. These reported reliabilities use Cronbach's alpha. This test measures internal consistency of the questions. For each construct, the higher the pairwise correlations in the individual question responses, the greater is the value of alpha (Cronbach, 1951). Since the participants of our study come from a subset of this general population of all PSTs, this indicates that this test is appropriate to measure PTE and GTE in the population of interest to this study.

Data analysis

The 30 participants from the two cohorts of this study were scored using the instrument prior to and after the research experience. For this study, Cronbach alphas for the PTE and GTE are 0.84 and 0.67, respectively.

Twelve of the participants completed the field research (7 in 2010 and 5 in 2011) and 18 completed the text-based research (3 in 2010 and 15 in 2011). A general teaching efficacy score was computed for each student on both the pretest and posttest assessments. The difference in these individual GTE scores from pretest to posttest was computed, so that a positive value indicates an increase in efficacy. Similar computations were performed for the PTE scores. These changes in efficacy scores were examined to resolve our research questions.

Research question 1 required testing for evidence of an increase in average efficacy level in each of PTE and GTE of each research group versus a null hypothesis of no change. Thus, all hypothesis tests used for this question were right-tailed, one-sample tests of change in the center of the distributions. Because of the relatively small sample sizes of the two subgroups and the underlying ordinal nature of the data, nonparametric methods were used to obtain all results in this article. Wilcoxon signed rank tests were used to investigate for a positive change in median of the PTE and GTE scores of each subgroup of participants. The Wilcoxon test does not have a normality assumption on the underlying distribution. To further support the conclusions made using the nonparametric methods, one-sample t tests were used to provide additional evidence of a positive change in mean GTE and PTE score of each subgroup. The needed assumption for normality of the distribution of sample means was suspect, so this evidence was strictly ancillary to the results from the nonparametric tests.

Research question 2 required tests of differences in the average PTE and GTE scores of the two research groups and tests of differences in the average gain on these measures. Each of these tests compares two independent samples testing for a difference in center. Again, a nonparametric method was chosen, for the reasons stated above. The appropriate nonparametric test for two independent samples used here was a right-tailed Mann-Whitney test with correction for ties. Again, this test has no normality assumption on the underlying distribution. A series of right-tailed, two-sample t tests was performed to provide further corroborating evidence of a higher mean in the field research group.

Note that all confidence intervals listed were at the 95% level, and an alpha level of 0.05 was used to determine significance on all hypothesis tests. Unless noted otherwise, all hypothesis tests in this article are right-tailed tests for a greater median (Mann-Whitney or Wilcoxon) or mean (t test). Note that if two-tailed tests were performed instead, the reported p values would double, but no differences in conclusions would be reached. Mann-Whitney, Wilcoxon, and t tests are standard hypothesis tests and are discussed in many entry-level statistics textbooks such as Weiss (2012).

Results

Research question 1. *Did each type of research project used in this study increase general and personal teaching efficacy in pre-service mathematics teachers?*

This research question considered increases in the efficacy of all 30 participants disaggregated by research type. Figure 1 shows the dot plot for the distribution of the changes in the individual GTE and PTE scores for all 30 participants disaggregated by research type. Notice that 27 (90%) of the participants showed some gain in PTE, and only one outlying participant showed a decrease. Similarly, 27 (90%) of the participants showed some gain in GTE, and only two participants showed a decrease.

For each of the two research groups, the mean and median amount of change in GTE and PTE score were computed, analyzed, and tabulated in Table 1. Wilcoxon tests were performed to test for significance of the increases in median. Supplemental analysis included *t* tests for increases in mean. Note that all eight tests returned statistically significant *p* values of 0.004 or less. These results provided sufficient evidence to support the conclusion that both the text-based research and field research were successful in increasing each of PTE and GTE.

The changes in mean and median for each research group are broken down by individual question in Table 2. We notice that both research groups showed some gain in mean and median on every question of the instrument. The gains are statistically significant for PTE questions 6, 7, 8, and 9 and for GTE questions 1, 4, and 10 for the text-based research group. The gains were statistically significant for all ten questions in the field-based research group.

Research question 2. *Did the type of research project affect the level and amount of increase in general and personal teaching efficacy of pre-service mathematics teachers?*

A comparison of efficacy levels on the pretest is summarized in Table 3. From this analysis we saw a slightly lower efficacy level of the field research group as measured on the pretest, but this difference was not significant, as evidenced by the large *p* values. This indicates that there is no inherent correlation between the self-selection of research type and initial efficacy level. In fact, the selection of research type was influenced primarily by personal factors affecting the ability to participate in the field research.

A similar comparison of efficacy levels on the posttest is summarized in Table 4. Notice that the *p* values of 0.001 on the Mann-Whitney tests indicated that there was a significantly higher level of

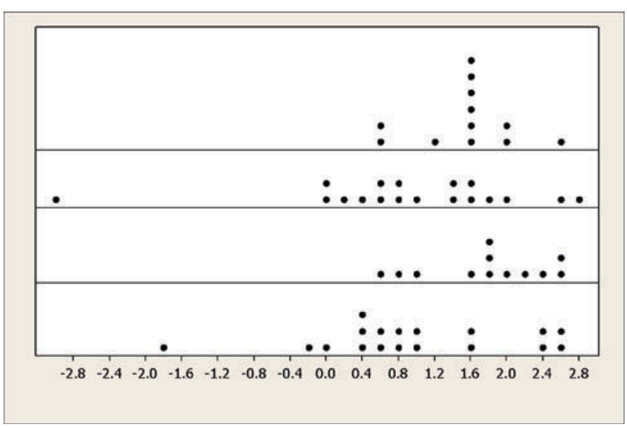

Figure 1. Dot plot of individual changes in efficacy scores.

Table 1. Changes in teaching efficacy.

	Personal teaching efficacy			General teaching efficacy		
Statistic	Text-based research	Field research	Difference	Text-based research	Field research	Difference
Sample size	18	12		18	12	
Mean of changes	**0.92** [0.29, 1.56]	**1.55** [1.19, 1.91]	**0.63** [0.4, 1.21]	**0.96** [0.40, 1.51]	**1.77** [1.34, 2.19]	**0.81** [0.25, 1.37]
Standard deviation	1.28	0.56		1.12	0.67	
t Test for positive change, *p* value	0.004	0.000		0.001	0.000	
t Test for difference in research type, *p* value			0.39			0.010
Median of changes	**0.90** [0.50, 1.60]	**1.60** [1.31, 1.89]	**0.70** [0.00, 1.40]	**0.80** [0.40, 1.60]	**1.80** [1.16, 2.35]	**1.0** [0.00, 1.60]
Wilcoxon test for positive change *p* value	**0.004**	**0.001**		**0.002**	**0.001**	
Mann-Whitney test for difference in research type *p* value			**0.014**			**0.016**

Table 2. Item details for differences in changes in teaching efficacy by type of research experience.

	PTE question					GTE question				
Statistic	3	6	7	8	9	1	2	4	5	10
Mean, text-based research *n* = 18	0.56	0.83	1.56	0.72	0.94	1.11	0.89	1.28	0.72	0.78
Mean, field research *n* = 12	1.50	1.25	1.83	1.67	1.50	1.33	2.17	2.00	1.33	2.00
Difference in means	**0.94**	**0.42**	**0.27**	**0.95**	**0.56**	**0.22**	**1.28**	**0.72**	**0.61**	**1.22**
Median, text-based research	1.00	1.00	1.50	0.50	1.00	2.00	1.00	2.00	1.00	1.00
Median, field research	1.00	2.00	2.00	2.00	1.00	1.50	2.00	2.00	1.00	2.00
Difference in medians	**0.00**	**1.00**	**0.50**	**1.50**	**0.00**	**−0.50**	**1.00**	**0.00**	**0.00**	**1.00**
Two-tailed Wilcoxon test for increase in research type, *p* value, text-based research	0.286	**0.038**	**0.009**	**0.023**	**0.017**	**0.047**	0.059	**0.028**	0.109	**0.043**
Two-tailed Wilcoxon test for increase in research type, *p* value, field research	**0.006**	**0.026**	**0.003**	**0.006**	**0.009**	**0.018**	**0.003**	**0.003**	**0.021**	**0.004**
Two-tailed Mann-Whitney test for difference in research type, *p* value	0.280	0.472	0.800	**0.036**	0.672	0.983	**0.029**	0.352	0.435	**0.020**

Table 3. Pretest levels of teaching efficacy.

	Personal teaching efficacy			General teaching efficacy		
Statistic	Text-based research	Field research	Difference	Text-based research	Field research	Difference
Sample size	18	12		18	12	
Mean	3.57 [3.37, 3.77]	3.48 [3.17, 3.80]	−0.09 [−0.44, 2.73]	3.11 [2.86, 3.36]	2.92 [2.58, 3.26]	−0.19 [−0.21, 0.60]
Standard deviation	0.40	0.49		0.50	0.54	
Two-tailed *t* test for difference in research type, *p* value			0.631			0.328
Median	3.50 [3.20, 3.80]	3.50 [3.2, 3.75]	0 [−0.20, 0.40]	3.20 [2.70, 3.40]	2.80 [2.60, 3.40]	−0.40 [−0.60, 0.20]
Two-tailed Mann-Whitney test for difference in research type, *p* value			**0.816**			**0.374**

Table 4. Posttest levels of teaching efficacy.

Statistic	Personal teaching efficacy			General teaching efficacy		
	Text-based research	Field research	Difference	Text-based research	Field research	Difference
Sample size	18	12		18	12	
Mean	**4.09**	**4.97**	**0.88**	**3.71**	**4.42**	**0.71**
	[3.67, 4.51]	[4.71, 5.23]	[0.48, 1.24]	[3.34, 4.08]	[4.01, 4.83]	[0.27, 1.15]
Standard deviation	1.04	0.56		0.92	0.87	
One-tailed *t* test for difference in research type, *p* value			0.000			0.005
Median	**4.00**	**5.10**	**1.10**	**3.90**	**4.40**	**0.50**
	[3.60, 4.67]	[4.65, 5.20]	[0.40, 1.40]	[3.2, 4.2]	[4.20, 5.15]	[0.20, 1.20]
One-tailed Mann-Whitney test for difference in research type, *p* value			**0.001**			**0.001**

both PTE and GTE in the field research group. These results agreed with the results from a similar analysis performed in the preliminary study on an earlier cohort of 16 students from 2009, who participated in the same research but who were given only the posttest. That study also found a significantly higher level of PTE and GTE in the field-based researchgroup after completion of the research projects (Matney & Jackson, 2010).

Although we have seen that both types of research led to significant gains in PTE and GTE, the field research group appeared to have higher gains. A series of two-sample, right-tailed Mann-Whitney tests was computed to determine whether the GTE and PTE of the field research group was significantly higher than the GTE and PTE of the text-based research group. Again this was supplemented by two-sample, right-tailed *t* tests. Results from these tests are summarized in Table 1.

The change for the field research group was an increase of 1.55 in mean PTE score compared to 0.92 for the text-based research group. The change for the field research group was an increase of 1.77 in mean GTE score compared to 0.96 for the text-based research group. Therefore, the field research group showed a greater increase than the text-based research group by 0.63 level on the PTE score and 0.81 level on the GTE score. Similar differences were found in the median GTE and PTE scores, with the median PTE score of the field research group 0.70 higher and the median GTE score of the field research group 1.00 higher than the text-based research group. The Mann-Whitney tests for significance of these differences in increase of efficacy score were statistically significant, with *p* values of 0.014 and 0.016 for PTE and GTE, respectively. These were supported by statistically significant *p* values of 0.039 and 0.010 for the corresponding *t* tests. Therefore, there was evidence to support the conclusion that the amount of increase in both PTE and GTE of the field-based research group is significantly more than the increases of the text-based research group.

The differences in the amounts of change in median and mean between the two research groups are broken down by question of the instrument in Table 2. Notice that the field research group showed more gain in mean than the text-based research group on all ten questions, and the field research group showed the same or more gain in median than the text-based group on all questions except for question 1. The differences in gains were statistically significant for PTE question 8 and for GTE questions 2 and 10. Thus, even though the mean change is higher in all cases for the field-based group, it is the difference in the changes in questions 8, 2, and 10 that are most affecting the overall significant difference in the gains made by the two research groups.

Summary

We have strong evidence that both the text-based research and the field research provided PSTs with opportunities for significant gains in both their general and personal teaching efficacy. However, both the amount of gain and the final overall level of general and personal teaching efficacy were higher in the participants who completed the field research than in those who completed the text-based research. This supports the original social cognitive theory–based hypothesis (Bandura, 1997) that the field group would exhibit greater gains due to the vicarious experience being more closely related to mastery experience. We conclude that carefully designed research projects given in methods course work can increase teaching efficacy in mathematics PSTs, and these projects can be more effective if they include appropriate experiences in the field.

Discussion

Limitations

The design of the study had some prescriptive elements that involved how much time PSTs spent on researching and writing but could not control for the amount of total time each individual spent on his or her research project. While the field research group was learning about classroom observation and interviewing, the text-based research group was allowed library time to begin their searches and reading. Within these parameters, all PSTs spent about the same amount of time on the project. The field research group spent five hours in observation time, two hours in interviews, and two more hours in collaboration with other group partners discussing themes across the interviews and observations. The text-based research group spent various amounts of time continuing to search for relevant literature and reading research they sometimes found very dense and difficult to process. Other factors involving the variability of time spent on the projects include: PSTs in the text-based group spent differing amounts of time searching for supporting literature; PSTs found and read a differing number of articles and read articles of different sizes and difficulties; and PSTs have different personal reading rates and comprehension levels. Since no data were collected on how much time PSTs spent on their individual research, reading, and writing, it cannot be determined whether the amount of time PSTs spent on these projects had an effect on teaching efficacy. Further research on this issue may be warranted.

The study described here is a beginning to understanding the ways mathematics teacher educators might give assignments that support the development of PSTs' efficacy. The generalizability of the findings may be mitigated by the small sample size drawn from a single university and the specifics of the assignments. In fact, the most significant barriers to replication of these results are likely due to details of the context. In particular, the level of success in increasing efficacy scores of the field-based group is likely tied closely to the effectiveness of the chosen field site in battling the negative effects of poverty. Furthermore, although we considered carefully the timing of the pre/post administrations of the efficacy instrument in relation to the research on teaching assignment, it is difficult to discern a single assignment's long-term effect on teaching efficacy. More research is needed about the possible long-term effects of method assignments involving vicarious experiences.

Any change in the practice of preparing PSTs will include barriers, and not all practices may be feasible for all universities. Those researching PSTs' teaching efficacy should be mindful not to relegate research to contexts that are 100% replicable by all universities. Doing so is inauthentic to the complexity of the mathematics teaching profession and those who study to become teachers. Research that challenges existing practices and indicates what is possible for PSTs of particular contexts should continue to be valued knowledge within the field. The context of this study involved a set of PSTs from rural, small town, and small cities who often find their first teaching positions in urban centers. We recognize the importance of seeking practices to prepare PSTs who have diverse life experiences and beliefs. We invite other researchers to seek similar types of methods course assignments to analyze the viability of those assignments for improving PSTs' teaching efficacy in these multifaceted contexts.

Considerations for mathematics teacher educators

The school context used in the field research is an important dynamic to take into consideration. The school used in the study had an administration that allowed the teachers to participate in decision making at all levels and actively sought teacher-developed ideas for school improvement. The administration allowed the space for innovation and encouraged mathematics teachers to reflect on their practice and seek out methods of teaching that work for each of their students. Although no measure of collective efficacy was given to the faculty to determine a level, from our many conversations, observations, and interviews it appeared they had a strong belief that their collective efforts had a positive effect on students and a belief that their principals were supportive and caring. Researchers have found that faculty's general teaching efficacy is higher when principals create an environment where there is an air of common purpose (Hipp & Bredeson, 1995), and personal teaching efficacy is higher when teachers feel they are a part of the school-wide decision-making process (Moore & Esselman, 1992). When teachers view their principal as caring and supportive, there is a greater sense of unity and cooperation (Newman, Rutter, & Smith, 1989). A school's academic performance is better for schools whose faculty have higher collective instructional efficacy (Bandura, 1993).

The elements of the school in this context, as well as the passion for education that was exhibited by the school officials, invites us to wonder what the effect on PSTs' efficacy would be if the field research had been done with a school whose teachers did not have high collective efficacy and were not seeing success in the classroom. Moreover, what impact do field placement experiences have on PSTs when they are placed with teachers who have low teaching efficacy? The answers to these questions could give important direction for teacher educators and the way PSTs are placed in local schools.

The results of this study suggest that research projects in mathematics methods coursework can improve pre-service secondary mathematics teachers' efficacy. Finding ways to strengthen and preserve strong efficacy for mathematics teachers entering the field can aid in retaining teachers, especially in school contexts in which attrition is highest. According to Ingersoll and Perda (2009), the major reason for the deficit of mathematics teachers is the loss of teachers long before their scheduled retirement. Teachers with higher efficacy exert greater effort, persist longer, and are more resilient (Pajares, 1996). Thus, one way mathematics teacher educators can contribute to the solution of the teacher shortage is to seek ways of strengthening PSTs' efficacy, preparing them to believe in their ability to overcome the challenges of the profession.

The findings of this study also lend evidence to the assertion that rigorous investigation of the results of good mathematics teaching may benefit PSTs (Kieftenbeld et al., 2011). Both of the research projects presented here involved examining the meaning of "good mathematics teaching" (Herrera et al., 2007). Both groups demonstrated increases in personal and general teaching efficacy. Thus, the results support engaging secondary pre-service mathematics teachers in text-based literature and/or in field research about good mathematics teaching. Since the field research demonstrated a significantly greater positive change in efficacy than the text-based research, we recommend that PSTs be engaged in field research during their methods coursework and potentially elsewhere. Furthermore, these findings align well with the National Council for Accreditation of Teacher Education Blue Ribbon Panel (2010) recommendations that PSTs need to be prepared to use research-based strategies, and clinical programs should offer opportunities to interweave academic content with experiences involving actual teaching. We may promote their preparedness and their efficacy as teachers by engaging PSTs in these ways.

There is a trend for universities and colleges of education to offer courses that either blend connective technologies with classroom instruction or go fully online. As teacher education programs look to meet the demands and pressures of the growing online market, the results of this study can inform the development and instantiation of the kinds of experiences that help foster PSTs' efficacy. With the field research component of this study yielding the largest change in efficacy, there is evidence to support that whether mathematics methods courses are classroom-based, blended, or online, they could benefit from having a robust field experience that connects PSTs with highly effective and efficacious mathematics mentor teachers.

Determining what kinds of professionally engaging tasks to give to PSTs to allow for growth in their teaching efficacy is important yet remains under-researched. Knowledge about such tasks can inform education programs about better equipping PSTs for a longer and more fruitful duration in the profession. This research study was designed to investigate two specific research projects given in a secondary mathematics methods course and their effects on PSTs' efficacy. Research projects that involve learning about good mathematics teaching may increase PSTs' efficacy. More research specific to the effects of other large tasks or groups of similar tasks that are given in methods course work is needed from the research community. From this study and future similar studies we can create more informed designs for PSTs' programs that will foster spaces of growth in PSTs' efficacy, giving them the confidence to persist, and the knowledge and ability to overcome the challenges of the profession.

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Appendix A. Example references of readings and citations found by participants

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Appendix B. Teacher efficacy scale short form (Hoy & Woolfolk, 1990)

(1) *The amount a student can learn is primarily related to family background.*
(2) *If students aren't disciplined at home, they aren't likely to accept any discipline.*
(3) *When I really try, I can get through to most difficult students.*
(4) *A teacher is very limited in what he/she can achieve because a student's home environment is a large influence on his/her achievement.*
(5) *If parents would do more for their children, I could do more.*
(6) *If a student did not remember information I gave in a previous lesson, I would know how to increase his/her retention in the next lesson.*
(7) *If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him/her quickly.*
(8) *If one of my students couldn't do a class assignment, I would be able to accurately assess whether the assignment was at the correct level of difficulty.*
(9) *If I really try hard, I can get through to even the most difficult or unmotivated students.*
(10) *When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment.*