The Effect of Early Fieldwork on Mathematics Efficacy Beliefs for Pre-service Teachers

Heidi Hunt-Ruiz: Northwest Vista College
Scott B. Watson: Liberty University

The purpose of this study was to investigate the impact of an early fieldwork experience on preservice teachers' mathematics efficacy beliefs. This quasi-experimental study included 127 preservice teachers from two community colleges who were enrolled in mathematics for teachers' two-course sequence. The Personal Mathematics Teaching Efficacy portion of the Mathematics for Teaching Efficacy Beliefs Instrument was used to gather data. Fieldwork was not determined to be a significant factor in personal mathematics efficacy. However, personal mathematics teaching efficacy did significantly increase for both experimental and control groups.

Introduction

Over the last twenty years, more and more focus has been placed on understanding a mathematics topic conceptually rather than simply being able to complete blind calculations in order to get the answer in the back of the book. This change in focus requires that teachers understand mathematics at a deeper level. Standards issued by the National Council of Teachers of Mathematics, a national organization that has a vision to bring reform to the traditional way that mathematics is taught, envision students not only able to acquire basic skills but to look for patterns, to explore and investigate, and to think logically (National Council for Teachers of Mathematics, 2000).

Preservice teachers are not always open to relearning mathematics content in a deeper, more conceptual way than they learned in elementary school because of the belief that knowing a procedure without conceptual knowledge is, in fact, understanding (Phillip, Ambrose, Lamb, Sowder, Shappelle, Thanheiser, & Chauvot, 2007). For example, many individuals in the general population remember that to divide a fraction by a fraction, they must invert the divisor and multiply. Even though they have no idea why the algorithm works, they believe it is correct because that is how they were taught. Their resistant views about teaching and learning "do not align well with the national standards for teaching practice" (Lee & Krapfl, 2002, p. 247).

Rotter: Social Learning Theory

Rotter is more commonly known for a branch of his social cognitive theory known as Locus of Control, which refers to people's beliefs about what determines what happens in their lives (Mearns, 2009). An individual's locus of control can be classified along a continuum of possibilities, ranging from internal to external control. In general, a person with more of an internal locus of control believes that he has control over events, whereas a person with more of an external locus of control believes that the environment controls events, leaving the individual with little influence in outcomes. In a classroom setting, a teacher's locus of control will impact such things as how he or she manages the class and interacts with students, how he or she handles conflict, and what classroom management style is used.

Bandura: Self-efficacy Theory

Self-efficacy is defined as "people's beliefs about their capability to produce designated levels of performance that exercise influence over events that affect their lives" (Bandura, 1977, p. 71). Bandura distinguished between self-efficacy beliefs and expectancy beliefs. Self-efficacy beliefs are beliefs about one's capability, the internal perspective, whereas, outcome expectancy beliefs are beliefs about one's ability to affect a situation, the external perspective. The Theory of Locus of Control deals with causation, whereas Self-Efficacy Theory deals with perceived capability. Self-efficacy is a measure of one's beliefs, and is therefore a construct that can be influenced. Bandura reports four main sources of influence: enactive experiences (one's competence is strengthened by success), vicarious experiences (observing someone successfully perform a task influences one's own belief about performing that task), social persuasion (feedback from others increases or decreases efficacy beliefs), and physiological and emotional arousal (positive feelings signal assurance and impact beliefs) (1994).

Challenging Current Beliefs

Currently, there is a misalignment between what preservice teachers believe and learn in their coursework, and the expectations that national standards set forth (Phillip et al., 2007; Lee & Krapfl, 2002). Therefore, teacher preservice programs must "model reform efforts both in content and methods", and that over a period of time, changes will come (Lee & Krapfl, 2002, p. 247).

At what point should a preservice program begin modeling reform? By the time a student enters college, their beliefs are well established (Swars, Hart, Smith, Smith, & Tolar, 2007), which implies that teacher preparation programs have a limited amount of time to change a preservice teacher's pedagogical beliefs. If beliefs are well established when a student enters college, then it seems clear that the earlier those beliefs are challenged, the more likely they could be changed. Although it is typical for preservice teachers to have intensive field experiences at the end of their education (namely student teaching), an earlier field experience would be appropriate if preparation programs have a vested interest in challenging preservice teachers' beliefs.

Significance and impacts of teacher efficacy

Research on teacher efficacy indicates that a teacher's classroom behavior, including instructional strategies, willingness to embrace reform, commitment to teaching, and dedication to student achievement, is affected by his or her degree of efficacy (Swars, Daane, & Giesen, 2006). Behaviors such as persistence at a task, risk-taking, and innovations are related to degrees of efficacy (Ashton & Webb, 1986). Ashton and Webb (1986) suggest that teachers' self-efficacy varies depending on what subject is being considered. If a teacher's efficacy is low in mathematics, for example, perhaps less time in preparation and implementation would be devoted to the subject.

Gibson and Dembo (1984) found that there are differences in classroom behavior when comparing teachers with low and high efficacy. When students in classrooms with low efficacy teachers asked questions, 4% of the teacher reactions involved criticism; whereas, with high efficacy teachers, there was no criticism. Low efficacy teachers were more likely to respond to wrong answers by giving the answer or asking another student, while high efficacy teachers chose to lead the students to the correct response.

Low efficacy teachers appeared flustered by interruptions to their schedule while high efficacy teachers seemed more at ease with change. A teacher's low efficacy may result in reduced quality of teaching the topic, and the negative belief is often transferred to the student, whereas teachers with positive beliefs cultivate similar beliefs among their students (Wilson, 1996).

Fieldwork

Fieldwork gives future teachers opportunities to implement what they have learned. Fieldwork is highly beneficial to preservice teachers' development in attitudes, beliefs, and skills (Bright, 1994; Emenaker, 1995; Johnston, 2001; Steele, 1994). It is in the field where future teachers can "make their first steps as teachers and observe experienced teachers, having sometimes the role of teachers and sometimes as learners" (Krainer & Goffree, n.d., p. 233). It is the field that provides opportunity for early teaching experiences to help preservice teachers connect theory to practice (Davis, Petish, & Smithey, 2006).

In a meta-analysis, Davis, Petish, and Smithey found that fieldwork within a methods course contributes to the maturation of preservice teachers' understanding of content as well as an increase in teaching efficacy (2006). Similar findings indicate that after six months of fieldwork, preservice teachers showed a large increase in efficacy rates (Wilson, 1996), and that preservice teachers made positive gains when involved with one-on-one tutoring sessions while concurrently enrolled in a subject-specific methods course that matched the content being tutored (Hedrick, McGee, & Mittag, 2000).

Research reveals inconclusive results regarding fieldwork taken with method courses. Woolfolk and Hoy (1990) studied preservice teachers' orientations of control and found that during student teaching, student teachers' personal teaching efficacy improved but outcome expectancy (termed general teaching efficacy in their study) decreased during student teaching. A possible explanation suggested that during student teaching, the reality of all that is expected of a teacher sets in.

Methodology

Design of the Study

To quantitatively determine if fieldwork had an effect on preservice teachers' mathematics efficacy beliefs, a Quasi-Experimental design was used. More specifically, a nonequivalent control group design was utilized.

Questions and hypotheses

This study sought to investigate the effect of fieldwork on preservice teachers' personal efficacy beliefs. It was expected that there would be a significant difference in mathematics teaching efficacy between those students who participated in fieldwork while going through mathematics for teachers' courses and those students who went through the courses only. The following research question and hypothesis were generated:

Question: Is there a difference in personal efficacy scores between preservice teachers who participate in fieldwork, and preservice teachers who do not participate in fieldwork?

Hypothesis: There will be a significant difference in the means of personal mathematics teaching efficacy (PMTE) scores for groups of students which participate in school-based fieldwork as compared to groups which do not, with the fieldwork groups exhibiting significantly higher personal efficacy scores.

Subjects

The subjects in this study were an accessible population of freshmen and sophomores enrolled in mathematics for teachers' two-course sequence at the community college level. Students entered this course sequence with varying mathematical ability, but all students had, at minimum, completed college algebra. Females accounted for approximately seventy percent of the enrollment in the courses. The students ranged in age from early twenties to late forties. Many of the participants were nontraditional students, and many were first generation college students. The sample's ethnicity is reflective of the surrounding community at large: approximately 40% Hispanic, 40% non-Hispanic Caucasian, 15% African American and 5% other.

Procedures.

The same students were enrolled in the first and second mathematics for teachers' courses, making it possible to track progress over the two-sequence period. Students attended the same college and had the same instructor for the two-course sequence. Preservice teachers were placed in a school that had a partnership with their community college. Each preservice student was to meet the same ten-hour fieldwork requirement. Although the grade levels assigned ranged from pre-K to middle school to reflect topics in the two courses, most placements occurred at the elementary school level. Both the experimental and the control groups had the same experience in the first mathematics for teachers' course. However, only the treatment group was required to do fieldwork in the second course. The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) was given to all students twice to measure change over time. The independent variable was fieldwork and the dependent variable was mathematics teaching efficacy.

A total of six class sections of students were part of this study. Three sections served as the control group and were not required to participate in fieldwork. Three sections served as the treatment group, and were required to participate in fieldwork. Data collection took place during 2010 through 2012 fall and spring semesters.

Instrumentation.

The Personal Mathematics Teaching Efficacy (PMTE) portion of the Mathematics Teaching Efficacy Beliefs Instrument was used to measure preservice teachers' teaching efficacy beliefs. The Mathematics Teaching Efficacy Beliefs Instrument is a Likert-type survey that yields numerical data in two categories: personal teaching efficacy and outcome expectancy. Personal teaching efficacy is confidence in one's own teaching ability, and outcome expectancy is the degree to which one believes that student learning can be influenced by effective teaching.

The Mathematics Teaching Efficacy Beliefs Instrument (Enochs & Riggs, 1990) is a modification of the Science Teaching Efficacy Beliefs Instrument. It consists of 21 items. Thirteen items measure personal mathematics teaching efficacy (PMTE), with scores ranging from 13 to 65 on this section. The validity and reliability of this instrument were established and found to be acceptable in a study by Enochs, Smith, and Huinker (2000). The first version of the Mathematics Teaching Efficacy Beliefs Instrument consisted of 23 items; however, two items were deleted as they were found to be invalid. The current version of the Mathematics Teaching Efficacy Beliefs Instrument now has 21 items. "Reliability analysis produced an alpha coefficient of 0.88 for the PMTE scale (Enochs, Smith, & Huinker, 2000).

Data Analysis.

Descriptive statistics (means and standard deviations) were calculated for the pretest and posttest for the control group and the treatment group. Gall, Gall & Borg (2003) note that when using the nonequivalent control group design, "If properly carried out, the nonequivalent control group design effectively controls for eight threats to internal validity: history, maturation, testing, instrumentation, statistical regression, differential selection, experimental mortality, and selection-maturation interaction." (p. 392)

Results

The data collected from preservice teachers were organized by the following categories: personal mathematics teaching efficacy pretest and posttest, and field experience group (control or experimental). An alpha level of 0.05 was used for all tests. The same instrument was used for the pretest and posttest.

Analysis of Covariance (ANCOVA) Summary

Levene's Test for Equality of Variances determined the p-value for the dependent variable to be 0.258 when testing personal mathematics teaching efficacy, which met the equality of variance assumption. The Analysis of Covariance (ANCOVA) controlled for initial differences between the treatment group and the control group before making comparisons of within-groups variance and between-groups variance (Gall, Gall, & Borg, 2003). An ANCOVA was run to test the following hypothesis: There will be a significant difference in the means of personal mathematics teaching efficacy (PMTE) scores for groups of students which participate in school-based fieldwork as compared to groups which do not, with the fieldwork groups exhibiting significantly higher personal efficacy scores.

Pretest scores were the covariates, field experience group (control/experimental) was the independent variable, and the dependent variables were posttest scores. The ANCOVA results analyzed the mean posttest scores of the control group and the treatment group, and determined the differences in posttest scores were not statistically significant. Thus, the statistical findings failed to reject the null hypothesis. Results for personal mathematics teaching efficacy are shown in Table 1.

The treatment group's ($n = 65$) personal mathematics teaching efficacy mean score increased from 3.583 ($SD=0.523$) on the pretest to 4.154 ($SD = 0.478$) on the posttest. The control group's ($n = 61$) personal mathematics teaching efficacy mean score increased from 3.825 ($SD=0.608$) on the pretest to 4.272 ($SD=0.472$) on the posttest. The increase in personal mathematics teaching efficacy scores was significant for the treatment group ($p< 0.001$), and for the control group ($p< 0.001$), indicating that both the experimental and control groups had significant gains during the treatment period.

Table 1
Dependent Variable: Personal Mathematics Teaching Efficacy Posttest

Source	Df	MS	F	Sig.
Corrected Model	21	0.429	2.374	0.002
Intercept	1	18.839	104.29	0.000
Pretest	1	5.622	31.343	0.000
Group	1	0.070	0.389	0.534
Error	100	0.181	-	-
Total	122	-	-	-
R Squared = .333 (Adjusted R Squared = .193)				

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Discussion of Findings

All three instructors in this study, for both the experimental and control groups, promoted a constructivist philosophy in the mathematics for teachers courses. Pedagogical content knowledge mathematics coursework has been shown to have a positive impact on teaching efficacy (Swars, n.d.; Cooper & Robinson, 1991; Vinson, 2001; Strawhecker, 2005; Quinn, 2001; Huinker & Madison, 1997; Utley, Moseley, & Bryant, 2005; Palmer, 2006). Preservice teachers' attitudes toward mathematics as well as their pedagogical content knowledge of mathematics improve significantly as a result of the mathematics content course (Quinn, 2001). Preservice teachers' personal teaching efficacy and outcome expectancy both significantly increased during a mathematics content course in which emphasis was placed on shifting thinking from traditional to constructivist (Huinker & Madison, 1997).

The Mathematics for Teachers Course

Since the control group was not required to participate in fieldwork, and since the control group's personal mathematics teaching efficacy scores significantly increased, the pedagogical content knowledge mathematics course, without fieldwork, can be viewed as a factor that positively impacts preservice teachers' personal efficacy. This finding supports already established research about the impact a pedagogy course can have on personal efficacy beliefs (Swars, n.d.; Cooper & Robinson, 1991; Vinson, 2001; Strawhecker, 2005; Quinn, 2001; Huinker & Madison, 1997; Utley, Moseley, & Bryant, 2005; Palmer, 2006).

Preservice teachers' beliefs in their ability to effectively teach have profound implications. According to Bandura's Theory of Self-Efficacy (1994), cognitively, people with high self-efficacy believe they are capable of achieving, which will result in high goal setting, firm commitment to those goals, mentally rehearsed successes, and analytical thinking in stressful situations. According to this theory, preservice teachers whose self-efficacy has been positively impacted will be more likely to show a high level of commitment to teaching and persist until success is achieved, because they believe they are capable. Conversely, preservice teachers with a low self-efficacy may view themselves as unable to control aspects of teaching, and as a result give up.

The Fieldwork Experience

Changes in preservice teachers' personal teaching efficacy—or self-efficacy—resulted from their participation in the course itself. Because preservice teachers enter their programs with well-established beliefs (Ball, 1990) which are malleable only during schooling and the first few years of teaching (Swars, Hart, Smith, Smith, & Tolar, 2007), the earlier preservice teachers' negative beliefs are challenged, the more time there is to modify them in a way that will adequately prepare them for successful experiences in their future classrooms. If preservice teachers do not have opportunity to be meaningfully engaged in elementary classroom settings until student teaching, then their outcome expectancy beliefs will not be impacted until they are basically finished with their education.

Conclusion

The call for instructors to help develop students who can solve complex problems as well as build arguments, implies that teachers are capable of fostering these deeper levels of knowledge in their students. Likewise, it implies that preservice programs be exposed to this kind of teaching in their pedagogical content courses. Results from this study, along with others, suggest that a constructivist-based pedagogical content knowledge course, even taken without fieldwork, has the potential to positively impact personal teaching efficacy.

References

Ashton, P. T., & Webb, R. B. (1986). Making a difference: Teacher's sense of efficacy and student achievement. New York: Longman.

Ball, D., & Wilson, S. (1990). Knowing the subject and learning to teach it: Examining assumptions about becoming a mathematics teacher. Paper presented at the meeting of the American Research Association, Boston, MA.

Bandura, A. (1994). Self-efficacy. Encyclopedia of Human Behavior, 4, 71-81. New York: American Press.

Bandura, A. (1977). Self-efficacy: The exercise of control. New York: W. H. Freeman and Co.

Bright, G. (1994). Changes in undergraduate preservice teachers' beliefs during an elementary teacher-certification program. Speeches/Meeting Papers. (ERIC Documentation Service No. ED375087)

Cooper, S. E., & Robinson, D. (1991). The relationship of mathematics self-efficacy beliefs to mathematics anxiety and performance. Measurement & Evaluation in Counseling & Development, 24(1), 4-12. Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teacher's face. Review of Educational Research, 93, 189-217. Emenaker, C. (1995). The influence of a problem-solving approach to teaching mathematics on preservice teachers' mathematics beliefs. Speeches/Meeting Paper. (ERIC Document Service No. ED391657)

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy beliefs instrument: A preservice elementary scale. School Science and Mathematics, 90, 695-706.

Enochs, L. G., Smith, P., & Huinker, D. M. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. School Science and Mathematics, 100(4), 194-202.

Gall, M., Gall, J., & Borg, W. (2003). Educational research an introduction. Boston, Massachusetts: Pearson Education.

Gibson, S., & Dembo, M. (1984). Teacher efficacy: A construct validation. Journal of Educational Psychology, 76(4), 669-682.

Hedrick, W. B., McGee, P., & Mittag, K. (2000). Pre-service teacher learning through one-on-one tutoring: Reporting perceptions through e-mail. Teaching and Teacher Education, 16, 47-63

Huinker, D., & Madison, S. K. (1997). Preparing efficacious elementary teachers in science and mathematics: The influence of methods courses. The Journal of Science Teacher Education, 8(2), 107-126.

Johnston, J. (2001). Using written reflection to identify preservice teachers' active instructional knowledge during mathematics mentoring. Speech/Meeting Paper. (ERIC Document Service No. ED460120)

Krainer, K., & Goffree, F. (n.d.) European research in mathematics education. Available at http://www.prof-dr-berger.de/pap/cerme1-3.pdf#page=229. Retrieved on May 5, 2009.

Lee, C., & Krapfl, L. (2002). Teaching as you would have them teach: An effective elementary science teacher preparation program. Journal of Science Teacher Education, 13(3), 247-265.

Mearns, J. (2009). The social learning theory of Julian B. Rotter. Available at: http://psych.fullerton.edu/jmearns/rotter.htm. Retrieved on May 5, 2009.

National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. Reston, VA: National Council of Teachers of Mathematics. Available at: http://www.nctm.org/standards.

Palmer, D. (2006). Durability of changes in self-efficacy of preservice primary teachers. International Journal of Science Education, 28(6), 655-671. doi: 10.1080/09500690500404599

Philipp, R. A., Ambrose, R., Lamb, L. L., Sowder, J. T., Schappelle, B. T., Sowder, L., Thanheiser, E., & Chauvot, J. (2007). Effects of early field experiences on the mathematics content knowledge and beliefs of prospective elementary school teachers: An experimental study. Journal for Research in Mathematics Education, 38(5), 438-476.

Quinn, R. (2001). Effects of mathematics methods courses on the mathematics attitudes and content knowledge of preservice teachers. The Journal of Educational Research, 91(2), 108-113.

Rotter, J. B. (1954). Social learning and clinical psychology. Available at http://psych.fullerton.edu/jmearns/rotter.htm. Retrieved on May 15, 2009.

Steele, D. (1994). Helping preservice teachers confront their conceptions about mathematics and mathematics teaching and learning. Speech/Meeting Paper. (ERIC Document Reproduction Service No. ED390848)

Strawhecker, J. (2005). Preparing elementary teachers to teach mathematics: How field experiences impact pedagogical content knowledge. JUMPST: The Journal, 4. Available at: www.k-12prep.mathematics.ttu.edu.

Swars, S. (n.d.). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. Journal of Instructional Psychology, 32(2), 139-147.

Swars, S., Daane, C. J. & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? School Science and Mathematics, 106(7), 306-315.

Swars, S., Hart, L.C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary preservice teachers‘ mathematics beliefs and content knowledge. School Science and Mathematics, 107(8), 325-336.

Utley, J., Moseley, C., & Bryant, R. (2005). The relationship between science and mathematics teaching efficacy of preservice elementary teachers. School Science and Mathematics, 105(2), 82-88.

Vinson, B. M. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. Early Childhood Education Journal, 29(2), 89-94).

Wilson, J.D. (1996). An evaluation of the field experiences of the innovative model for the preparation of elementary teachers for science, mathematics, and technology. Journal of Teacher Education, 47(1), 53-9.

Woolfolk, A. E., & Hoy, W. K. (1990). Prospective teachers‘ sense of efficacy and beliefs about control. Journal of Educational Psychology, 82(1), 81-91.

Authors' Note

Heidi Hunt-Ruiz is an Associate Professor of Mathematics at Northwest Vista College in San Antonio, Texas. Her areas of scholarship include math education and curriculum design.

Scott B. Watson is a Professor in the School of Education at Liberty University, Lynchburg, Virginia. His areas of scholarship include science education and educ