Journal of Elementary Science Education, Vol. 18, No. 2 (Fall 2006), pp. 1-12.

The Effect of an Integrated Science and Mathematics Content-Based Course on Science and Mathematics Teaching Efficacy of Preservice Elementary Teachers

Christine Moseley, University of Texas, San Antonio
Juliana Utley, Oklahoma State University

Abstract

The purpose of this study was to determine the effect of an earth systems science course (integrated mathematics and science content) on preservice elementary teachers' mathematics and science teaching efficacy. Paired t-tests revealed that the personal mathematics and science teaching efficacy and science teaching outcome expectancy significantly increased over the course of the semester for the experimental group (those students enrolled in the earth systems science course). For the control group (those students not enrolled in the course), however, there was no significant increase.

Introduction

Current reform in both teacher education and science education has focused on the need for improvement of preservice teacher education (APA 1993; Siverstein 1993). Recommendations for model preservice programs include revised science courses designed for teachers that combine content and methods (NRC, 1996), exposure to a variety of teaching experiences (Sunal, 1980), and an emphasis on improving preservice teacher attitudes regarding science teaching (Cox & Carpenter, 1989). One trend in preservice teacher education reform strongly suggests increases in the content knowledge base, especially in the areas of science and mathematics. Many states now require elementary preservice teachers to pursue additional coursework in science and mathematics. There is concern that by requiring more content courses, however, many potential elementary teachers experience lowered teaching efficacy thereby avoiding teaching science or mathematics.

This study examines the effects of a content-based course on science and mathematics personal teaching efficacy and outcome expectancy of elementary preservice teachers. A comparison is made between two groups of elementary preservice teachers during the same semester: (1) those preservice teachers who participated in an earth systems science course and (2) those preservice teachers who did not participate in the course. Additionally, pre/post changes in science and mathematics personal teaching efficacy and outcome expectancy of elementary preservice teachers for each group is reported.

Theoretical Framework

Self-efficacy, a component of social learning theory, is a psychological construct concerned with judgments about how well one can organize and execute courses of action required to deal with prospective situations (Bandura, 1977). Bandura claims that efficacy expectations are a major determinant of choice of activities, how much effort is expended, and how the effort is sustained in those activities. If Bandura's theory of self-efficacy is applied to the study of teachers, one might predict that . . .

> . . . teachers who believe student learning can be influenced by effective teaching (outcome expectancy beliefs) and who also have confidence in their own teaching abilities (self efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning. (Gibson & Dembo, 1984, p. 570)

Effective teachers tend to have a high sense of efficacy about their own teaching. They believe that they can help almost all of their students learn, including those who are the most difficult to teach (Berman & McLauglin, 1977). A high sense of efficacy has been identified as one of the teacher dispositions associated with effective practice, along with job satisfaction, professional engagement, and commitment to teaching.

Examination of self-efficacy in relation to teaching has been the focus of study by several researchers (Enochs & Riggs, 1990; Gibson & Dembo, 1984; Guskey, 1988). Bandura (1977) defines *self-efficacy* as a person's perception of his or her ability to perform a behavior. Gibson and Dembo (1984) applied Bandura's theory to teachers and suggested that sense of efficacy accounted for variations in teaching ability. Tracz and Gibson (1986) further identified efficacy as an important variable in both teacher and school effectiveness. Their study showed that the teachers' sense of efficacy related significantly to both achievement and grouping of students.

The importance of self-efficacy for a single task is evidenced by Bandura's (1977) assertion that feelings of low self-efficacy can lead to less effort, less flexibility in the face of failure, and more stress or depression as a result of demands. He also suggests that efficacy can be influenced the most during the early stages of a teacher's career, leading researchers to address preservice teacher efficacy (Tshchannen-Moran, Hoy, & Hoy, 1998). Self-efficacy can be improved through experience based on research findings on science-teacher-perceived efficacy (Chun & Oliver, 2000; Finson, 2000; Wingfield & Ramsey, 1999).

Bandura (1997) indicated that efficacy beliefs depend upon situational specificity; that is, efficacy beliefs depend on the situation or context relative to the action or task to be performed. Efficiency is task- or context-specific (Tschannen-Moran et al., 1998) in that feelings of efficacy about a single task, such as teaching science, may not affect feelings of efficacy concerning another skill or teaching responsibility, such as mathematics, making self-efficacy a specific concern even when preservice teachers appear to have high self-efficacy in other areas.

Teacher efficacy has been defined as both context- and subject-matter-specific; however, it is not clear as to the appropriate level of specificity for its measure (Tschannen-Moran et al., 1998). Pintrich and Schunk (1996) have noted that the level of specificity is one of the most difficult issues to be resolved for cognitive or motivational theories that propose domain specificity. Thus, instruments have been developed to measure teacher efficacy within specific curriculum areas. Riggs (1988) and Riggs and Enochs (1990) developed the Science Teaching Efficacy Belief Instrument (STEBI) to measure efficacy of science teaching and identified two uncorrelated factors within STEBI, which they named personal science teaching efficacy (PTSE) and science teaching outcome expectancy (STOE). Enochs and Riggs (1990) developed the STEBI-B, which modified the STEBI in order to measure science teaching efficacy beliefs in preservice teachers.

Several instruments were subsequently developed during the 1990s that were based directly on the STEBI-B. Exploring an even greater level of specificity, Rubeck and Enochs (1991) distinguished chemistry teaching efficacy from science teaching efficacy in developing the STEBI-CHEM. Likewise, the Self Efficacy Beliefs About Equitable Science Teaching (SEBEST) instrument, which measures teacher beliefs toward science teaching and learning in regard to considerations of ethnicity, language minorities, gender, and socioeconomic factors, was developed (Ritter, Boone, & Rubba, 2002). Enochs, Smith, and Huniker (2000) further developed a similar instrument to measure efficacy of mathematics teaching (MTEBI) while Coladarci and Breton (1997) used a modified instrument to explore efficacy in the context of special education.

Science self-efficacy has been identified as an influential construct in science teaching (Enochs & Riggs, 1990; Riggs, 1988; Vinson, 1995). Preservice teachers ideally should possess a high degree of self-efficacy involving the teaching of science in order for their students to be positively influenced about learning science. In science teaching contexts, self-efficacy is an individual's belief that one has the ability to effectively perform science teaching behaviors (personal science teaching efficacy) as well as one's belief that his or her students can learn science given facts external to the teacher (science teaching outcome expectancy) such as gender or ethnicity (Ramey-Gassert, Shroyer, & Staver, 1996).

Rubeck and Enochs (1991) reported that teachers who were weak in science content background tended to have significantly lower personal efficacy than did teachers with strong content backgrounds. In contrast, teachers with high self-efficacy teach in ways characterized by the use of inquiry approaches, more student-centered thought, beliefs that they can help any student overcome learning problems and succeed, and more knowledge of their students' developmental levels. One logical conclusion is that the way preservice teachers view themselves and their roles in a science-teaching context is at least partially derived from their self-efficacy (Finson, 2000).

Teacher efficacy has also been found to be positively correlated to student achievement in mathematics (Allinder, 1995). Additionally, Peterson, Fennema, Carpenter, and Loef (1989) found that teachers' beliefs about teaching and learning mathematics were associated not only with how they taught but also with what their students learned. Wenner (2001) found that low mathematics teaching efficacy tended to be a contributing factor to both inservice and preservice teachers' reluctance to teach mathematics.

It has been suggested that studies of teacher beliefs are becoming one of the most valuable psychological constructs of teacher education in a field in which attitudes and values already have been the prevailing constructs (Pajares, 1992). According to Pajares (1997), however, the interest and fascination about teacher beliefs of educators and researchers have not focused explicitly on the implications for either educational practice or research. To find out the practical implications, empirical based research should be conducted to provide evidence. It is the rationale of this study to provide empirical evidence to show the process of change in teacher beliefs by analyzing the data measured in a quantitative method.

Purpose

Assessment of content-specific efficacy beliefs is an important consideration in understanding teacher competency in elementary subjects. It is logical that research on the development of teaching efficacy, including mathematics and science teaching efficacy, should begin with preservice teachers. Although there are studies that examine teacher efficacy after methods courses and after student teaching, there is little research that tracks the subject-matter specific teacher efficacy of elementary preservice teachers throughout their preservice education (Tschannen-Moran et al., 1998). It is the purpose of this study to investigate the change in teachers' efficacy beliefs, personal teaching, and outcome expectancy, about mathematics and science teaching as a result of participation in an integrated mathematics and science content-based, earth systems science course.

To evaluate this earth systems science course's effectiveness at preparing preservice teachers to teach science and mathematics, two specific research questions were addressed:

1. What effect did the science and mathematics content-based earth systems science course have on elementary preservice teacher personal science teaching efficacy and science teaching outcome expectancy?
2. What effect did the science and mathematics content-based earth systems science course have on elementary preservice teacher personal mathematics teaching efficacy and mathematics teaching outcome expectancy?

Methodology

The design of this study was a nonrandomized control group pretest-posttest design. The STEBI-B and MTEBI instruments were administered to two groups of preservice elementary teachers (control and experimental) on the first day of class (pretest) and at the end of the semester (posttest).

Sample

Participants in this study included two convenient nonrandom groups of preservice elementary teachers (elementary education majors, certification grades 1-8) who were enrolled in a cohort block of 15 credit hours of content specific methods courses the semester prior to student teaching. The experimental group consisted of 20 students who participated in an earth systems science course (3 credit hours) in addition to participating in the required cohort 15 credit hours of content specific methods courses. These 15 credit hours included methodology courses in social studies, science, intermediate mathematics, and language arts and a course in classroom management. The control group consisted of 42 students who were enrolled in the 15 credit hours of methodology courses but did not participate in the earth systems science course.

All 62 students were seniors who had completed a minimum of four science and four mathematics content courses prior to enrolling in the methods courses block as partial fulfillment of general education requirements. For their science content, a majority of the participants completed general education science courses that were specifically developed with support of a National Science Foundation grant for the incorporation of inquiry-based instruction– (e.g., Chemistry, Biology, Earth Science, and Physics). For their mathematics content, all participants completed two courses, mathematical structures and geometric structures, that were specifically designed for elementary education majors along with an additional six credit hours, which might include college algebra, mathematical functions, or any other mathematics or statistics course.

Course Description

In response to the suggested need to increase the content knowledge and develop the inquiry skills of preservice elementary teachers, an earth systems science course that relates to the NASA earth science mission was created. This course was created with support from the NASA Opportunities for Visionary Academics (NOVA) program to give potential elementary school teachers a knowledge base in earth and atmospheric science and an opportunity to apply hands-on, technology-based science to real-world situations.

This earth systems science course took place the semester prior to student teaching. The elementary preservice students spent one full day per week for six weeks receiving content and instruction in basic earth systems science principles. In addition, the students were assigned an elementary classroom, in which they were required to conduct an earth systems science investigation with K-5 children.

The curriculum of the new earth systems science course had as its basis a content-driven, inquiry-based model program, the Global Learning and Observations to Benefit the Environment (GLOBE) K-12 curriculum. The conceptual framework of the course included the earth systems science content topics of Atmospheric Chemistry, Land Cover and Use, Hydrological and Energy Cycles, Soil Science, and Global Informational Systems (GIS) mapping and data analysis.

The GLOBE Program was selected as the basis for the earth systems science course because it is a worldwide environmental science and education program designed for use in K-12 schools that integrates mathematics, science, and technology. It involves students, teachers, and scientists in collecting, sharing, and analyzing data about Earth's land, air, water, and biology systems.

As GLOBE participants, teachers and students make observations using standardized protocols at or near their schools in one or more of four domains: (1) atmosphere, (2) hydrology, (3) soil, and (4) land cover/biology. Students then enter their data on the World Wide Web, where they can view global images based on GLOBE student data and interact with scientists, who use the student data in their scientific research. GLOBE improves student understanding because it involves students in performing real science—taking measurements and analyzing data.

Instruments

The instruments used in this investigation included the Science Teaching Efficacy Belief Instrument (STEBI-B) (Riggs & Enochs, 1990) and the Mathematics Teaching Efficacy Belief Instrument (MTEBI) (Huniker & Enochs, 1995). STEBI-B consists of 23 items, using a 5-point Likert-scale, that measure two aspects of science teaching efficacy, personal science teaching efficacy (PSTE), and science teaching outcome expectancy (STOE). Acceptable validity and reliability criteria were established for the STEBI-B by the developers during trials administered during the early 1990s (Enochs & Riggs, 1990). Since that time, the STEBI-B has become an essential tool for science education researchers. For the current study, reliability analysis yielded Cronbach alphas of 0.84 and 0.64 for the STOE subscale and 0.89 and 0.91 for the PSTE subscale for the pre- and post-administrations, respectively.

The MTEBI is a modification of the STEBI-B (Huniker & Enochs, 1995). The MTEBI contains 21 items on a 5-point Likert-scale that measure two constructs: (1) personal mathematics teaching efficacy (PMTE) and (2) mathematics teaching outcome expectancy (MTOE). Enochs, Smith, and Huniker (2000) found the MTEBI to be a valid and reliable assessment of mathematics teaching self-efficacy. For the current study, reliability analysis yielded Cronbach alphas of 0.78 and 0.81 for the MTOE subscale and 0.84 and 0.88 for the PMTE subscale for the pre- and post-administrations, respectively.

Data Analysis

Pre/post STEBI-B and MTEBI data obtained from the experimental group was compared to pre/post STEBI-B and MTEBI data collected from the control group. The experimental treatment was the student participation in the content-based earth systems science course.

The data was coded on a 5-point Likert-type scale from 5 for strongly agree to 1 for strongly disagree. After coding, the data were analyzed through a series of parametric t-tests to determine what differences, if any, exist among and between the experimental group and control group responses on the pretest and posttest. Additionally, an ANCOVA was used on the MTOE subscale.

Results

In order to determine whether there was a difference between the experimental and control groups at the beginning of the semester, a series of independent sample t-tests were conducted on data for each of the subscales of the MTEBI and STEBI-B. No significant difference was found between the two groups on the PMTE ($t(54) = -0.353$, $p = 0.725$), the PSTE ($t(49) = 1.503$, $p = 0.099$), and the STOE ($t(49) = -0.913$, $p = 0.366$) subscales; however, there was a significant difference between the two groups initially on the MTOE subscale ($t(54) = -2.680$, $p = 0.010$) (see Table 1). Analysis of the post-test data on each of the four subscales revealed that the two groups were significantly different only on the PSTE subscale ($t(47) = 2.462$, $p = 0.018$) at the end of the semester.

Since there was a significant difference between the two groups on the pretest for the MTOE subscale, an ANCOVA was conducted to adjust the post MTOE scores for differences among the two groups of preservice elementary teachers. Table 3 shows the results of the ANCOVA. These results show that there was not a significant effect ($F(1, 51) = 0.907$, $p = 0.345$) of group affiliation on MTOE of the preservice elementary teachers after controlling for the effect of beginning levels of MTOE.

Further examination of data revealed that the experimental group ($M = 26.25$) started off with a significantly lower MTOE score than the control group ($M = 28.94$), but the experimental group ($M = 29.95$) ended up with a slightly higher MTOE score than the control group ($M = 29.88$). Thus, an independent samples t-test between the two groups on the MTOE was conducted after the experimental group took the earth systems science course. Results revealed that while the two groups' MTOE means differed significantly prior to the experimental group taking the earth systems science course, there was no significant difference ($t(54) = 0.201$, $p = 0.84$) between the two groups after the experimental group took the earth systems science course.

Table 1. Group Differences for the Subscales of the STEBI-B and MTEBI Prior to and After Integrated Content Course

Variable	Control Group		Experimental Group						95% Confidence Interval of the Difference	
	M	SD	M	SD	*t*	*df*	*p*	Mean Difference	Lower	Upper
PSTE										
Pre-test	50.88	7.18	53.63	4.51	1.503	49	0.10	2.76	-0.54	6.05
Post-test	53.20	7.43	57.84	4.38	2.462	47	0.02*	4.64	0.85	8.43
STOE										
Pre-test	34.94	4.46	33.68	5.19	-0.913	49	0.37	-1.25	-4.01	1.50
Post-test	36.65	3.44	35.74	4.29	-0.824	48	0.41	-0.91	-3.12	1.31
PMTE										
Pre-test	53.94	5.64	53.25	9.09	-0.353	54	0.73	-0.69	-4.64	3.25
Post-test	55.75	5.23	57.90	6.48	1.352	54	0.18	2.15	-1.04	5.34
MTOE										
Pre-test	28.94	3.57	26.25	3.67	-2.680	54	0.01*	-2.69	-4.71	-0.68
Post-test	29.75	3.07	29.95	4.35	0.201	54	0.84	0.20	-1.80	2.20

$^*p < .05$

In order to determine differences among the experimental and control groups, paired t-tests were conducted for each of the subscales. The paired t-tests for data from the control group revealed no significant differences in participants' scores on the subscales of the MTEBI and STEBI-B (see Table 2), thus, indicating that for the control group, there was no significant increase in personal mathematics teaching efficacy (PMTE), mathematics teaching outcome expectancy (MTOE), personal science teaching efficacy (PSTE), or science teaching outcome expectancy (STOE). Paired t-tests for data from the experimental group suggested a significant increase in personal science teaching efficacy (PSTE) (t (17) = -6.297, p = 0.00), science teaching outcome expectancy (STOE) (t (17) = -2.378, p = 0.03), and mathematics teaching outcome expectancy (MTOE) (t (19) = -3.832, p = 0.00); however, for the experimental group, there was no significant increase in personal mathematics teaching efficacy (PMTE) (t (19) = -2.077, p = 0.05.

Table 2. Paired Samples T-Test for Control and Experimental Groups

	Pretest		Posttest						95% Confidence Interval of the Difference	
Variable	M	SD	M	SD	*t*	*df*	*p*	Mean Difference	Lower	Upper
PSTE										
Control	51.27	6.85	53.12	7.95	-1.733	25	0.10	-1.85	-0.40	0.35
Experimental	53.44	4.57	57.89	4.50	-6.297	17	0.00*	-4.44	-5.93	-2.96
STOE										
Control	35.63	4.29	36.78	3.08	-1.332	26	0.19	-1.15	-2.92	0.62
Experimental	33.39	5.17	35.61	4.39	-2.378	17	0.03*	-2.22	-4.19	-0.25
PMTE										
Control	54.44	5.40	55.44	5.21	-1.024	33	0.31	-1.00	-2.99	0.99
Experimental	53.25	9.09	57.90	6.48	-2.077	19	0.05	-4.65	-9.34	0.04
MTOE										
Control	28.94	3.60	29.88	2.90	-1.385	33	0.18	-0.94	-2.32	0.44
Experimental	26.25	3.67	29.95	4.57	-3.832	19	0.00*	-3.83	-5.72	-1.68

$^*p < .05$

Table 3. Results of the One-Way Analysis of Covariance for Mathematics Teaching Outcome Expectancy

Variable and Source	*df*	*SS*	*F*	*p*
Group	1	10.017	0.907	0.345
Covariate: Pre-MOTE	1	73.406	6.649	0.013*
Error	51	563.074		
Total	53	636.537		

$^*p < .05$

Discussion

The purpose of this study was to investigate the change in teacher efficacy beliefs about mathematics and science teaching after participation in an integrated mathematics and science content-based course. As the preservice elementary teachers in the experimental group progressed in the content course, their PSTE, STOE, and MTOE significantly increased; however, their PMTE did not increase. In contrast, there was no significant increase in the teaching efficacies (i.e., PSTE, STOE, PMTE, or MTOE) of the students who did not take the content course. This suggests that a content course that emphasizes science and mathematics taken in conjunction with methods courses in mathematics and science can affect the teaching efficacies of preservice elementary teachers, particularly their belief in their influence on student outcomes.

Despite the significant increase in STOE, MTOE, and PMTE for the experimental group, however, there was no significant increase in PMTE, even though there was an increase in mean values. PMTE is the belief in one's ability to teach mathematics effectively. The earth science course was intended to be an integrated science and mathematics course. The mathematics emphasized in the GLOBE curriculum are the collection of quantitative data, graphing of that data, and analysis and interpretation of data. Perhaps the elementary preservice teachers do not perceive this to be "true" mathematics or the mathematics for which they think they will be responsible in future teaching. Additionally, the primary instructor for this content course was a faculty member whose area of emphasis is science; thus, this could have had an effect on the lack of increase in the PMTE. The authors of this study are thus left with the question: Would the PMTE have increased significantly if the mathematics content had been emphasized more and the mathematics instruction had been more explicit?

The results of this study do show a positive impact of the GLOBE curriculum as the framework for an earth systems science course on science and mathematics teaching efficacies. All of the participants in both the experimental and control groups were involved in the same common methodology courses at the same time. The only difference was the additional earth systems science course that the experimental group took alongside the methods courses. Thus, the authentic experiences provided by the earth systems science course, and specifically the GLOBE curriculum, did positively influence the science teaching efficacy of the preservice teachers.

The GLOBE curriculum does advertise itself as an integrated science and mathematics curriculum, and it was hypothesized prior to the study that both science and mathematics teaching efficacy would significantly increase; however, PMTE was not significantly impacted as a result of participation in GLOBE. Thus, several issues need to be considered when implementing the GLOBE curriculum as a content-based course. Rather than being a true integrated science and mathematics content-based curriculum, perhaps GLOBE is a science-based curriculum supported by mathematics, especially in the areas of data collection and measurements, graphing techniques, and data analysis. If GLOBE is actually an integrated curriculum, then the instructional techniques used by the facilitators play a large role in whether the participants can distinguish the content specificity of the mathematics and science within the curriculum. Both the mathematics and science content, and their interconnections, need to be emphasized.

The literature has abundant data supporting the notion that teachers are reluctant to teach science (Wenner, 1993) and to a lesser extent mathematics (Steven & Wenner, 1996). Several studies (Baker, 1991; Riggs & Enochs, 1990; Wenner, 2001) suggest that efficacy is a significant factor contributing to this reluctance. The results of this study point to a link between increased content knowledge and positive self-efficacy towards the teaching of science and mathematics, especially in the area of personal science teaching efficacy.

Future studies are needed to follow the long-term effects on preservice teachers as they continue in student teaching and further into their careers in teaching science and mathematics. Some researchers have found that a high sense of self-efficacy declines in the first years of teaching; however, evidence from this study seems to point to positive trends of preservice self-efficacy beliefs regarding the teaching of science and mathematics. Through research done by Bandura (1997), it is known that if self-efficacy is high, there will be less fear of failure and longer persistence on unfamiliar tasks. Also, according to Gibson and Dembro (1984), teachers will devote more time to academic instruction and take greater responsibility for students who have difficulty in learning. The authors of this study agree with Wingfield, Nath, Freeman, and Cohen (2000) that preservice teachers who enter teaching with a higher self-efficacy in science and mathematics more than likely will begin their careers better prepared and be more apt to stay in the teaching profession.

There is an increased emphasis in teacher education programs for students to receive more content background in science and mathematics; however, does this make students better teachers? Using science and mathematics efficacy as a basis for evaluating the effectiveness of this increased knowledge base has promise of adding to the knowledge base of teacher educators and to the improvement of science and mathematics education programs.

References

Allinder, R. M. (1995). An examination of the relationship between teacher efficacy and curriculum-based measurement and student achievement. *Remedial & Special Education, 16*, 247-254.

American Psychological Association (APA). (1993). *Restructuring the education of teachers: Report of the Commission on the Education of Teachers into the 21st Century*. Washington, DC: Author.

Baker, D. R. (1991). A summary of research in science education – 1989. *Science Education*, *75*, 1-35.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychology Review, 84*, 191-215.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W. H. Freeman.

Berman, P., & McLauglin, M. (1977). *Federal programs supporting education change: Vol. 7. Factors affecting implementation and continuation* (Rep. No. R-1589/7-HEW). Santa Monica, CA: Rand. (ERIC Document Reproduction Service No. 140 432).

Coladarci, T., & Breton, W. (1997). Teacher efficacy, supervision, and the special education resource-room teacher. *Journal of Educational Research, 90*, 230-239.

Chun, S., & Oliver, J. S. (2000, January). *A quantitative examination of teacher self-efficacy and knowledge of the nature of science*. Paper presented at the annual meeting of the Association for the Education of Teachers in Science, Akron, OH.

Cox, C. A., & Carpenter, J. R. (1989). Improving attitudes toward teaching science and reducing science anxiety through increasing confidence in science ability in inservice elementary school teachers. *Journal of Elementary Science Education, 1*(2), 14-35.

Enochs, L., & Riggs, L. (1990). Further development of an elementary science teaching efficacy belief instrument: A pre-service elementary scale. *School Science and Mathematics, 90*(8), 694-706.

Enochs, L., Smith, P., & Huniker, D. (2000). Establishing factorial validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics, 100*(4), 194-202.

Finson, K. D. (2000, January). *Investigating pre-service elementary teachers' self-efficacy relative to self-image as a science teacher*. Paper presented at the annual meeting of the Association for the Education of Teachers in Science, Akron, OH.

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 503-511.

Guskey, T. (1988). Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching and Teacher Education, 4*(1), 63-69.

Huniker, D., & Enochs, L. (1995). Mathematics Teaching Efficacy Beliefs Instrument (MTEBI). Milwaukee: University of Wisconsin, Center for Mathematics and Science Education Research.

National Research Council (NRC). (1996). *National science education standards*. Washington, DC: National Academy Press.

Pajares, F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307-332.

Pajares, F. (2002). Current direction in self-efficacy research. In M. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement* (pp. 1-49). Greenwich, CT: JAI Press.

Peterson, P., Fennema, E., Carpenter, T., & Loef, M. (1989). Teachers' pedagogical content beliefs in mathematics. *Cognition and Instruction, 6*, 1-40.

Pintrich, P. R., & Schunk, D. H. (1996). *Motivation in education: Theory, research, and applications*. Englewood Cliffs, NJ: Merrill/Prentice Hall.

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education, 80*(3), 283-315.

Riggs, I. M. (1988). *The development of an elementary teachers' science teaching efficacy belief instrument*. Dissertation Abstracts International, Kansas State University, Manhattan.

Riggs, L., & Enochs, L. (1990). Toward the development of an elementary education teachers' science teaching efficacy belief instrument. *Science Education, 74*, 625-637.

Ritter, J., Boone, W., & Rubba, P. (2001). Development of an instrument to assess prospective elementary teacher self-efficacy beliefs about equitable science teaching and learning (SEBDST). *Journal of Science Teacher Education, 12*(3), 175-198.

Rubeck, M., & Enochs, L. (1991, April). *A path analytic model of variables that influence science and chemistry teaching self-efficacy and outcome expectancy in middle school science teachers*. Paper presented at the annual meeting of the National Association of Research in Science Teaching, Lake Geneva, WI.

Siverstein, M. (1993). *Transforming ideas for teaching and learning science: A guide for elementary science education* (U.S. Department of Education Publication No. 065-000-00599-9). Washington, DC: U.S. Government Printing Office.

Steven, C. A., & Wenner, G. (1996). Teachers' knowledge and beliefs regarding science and mathematics. *School Science and Mathematics, 96*, 2-9.

Sunal, D. W. (1980). Effect of field experience during elementary methods courses on pre-service teacher behavior. *Journal of Research in Science Teaching, 17*(1), 17-23.

Tracz, S. M., & Gibson, S. (1986, November). *Effects of efficacy on academic achievement*. Paper presented at the annual meeting of the California Educational Research Association, Marina del Rey, CA.

Tschannen-Moran, M., Hoy, A., & Hoy, W. (1998). Teacher efficacy and measure. *Review of Educational Research, 68*, 202-248.

Vinson, B. M. (1995). *A comparison of sense of efficacy before and after clinical experience for pre-student-teaching novices in an elementary methods program*. Paper presented at the annual meeting of the Mid-South Educational Research Association, Biloxi, MS.

Wenner, G. (1993). Relationship between science knowledge levels and beliefs toward science instruction held by pre-service elementary teachers. *Journal of Science Education and Technology, 2*, 461-468.

Wenner, G. (2001). Science and mathematics efficacy beliefs held by practicing and prospective teachers: A 5-year perspective. *Journal of Science Education and Technology, 10*(2), 181-187.

Wingfield, M., Nath, J., Freeman, L., & Cohen, M. (2000, April). *The effect of site-based pre-service experiences on elementary social studies, language arts, and mathematics teaching self-efficacy beliefs*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Wingfield, M. E., & Ramsey, J. (1999, January). *Improving science teaching self-efficacy of elementary pre-service teachers*. Paper presented at the Association for the Education of Teachers in Science Annual Meeting in Austin, TX.

Correspondence regarding this article should be directed to:

Dr. Christine Moseley
Department of Interdisciplinary Studies
University of Texas at San Antonio
2.210E MB
6900 North Loop 1604 West
San Antonio, TX 78249
Christine.Moseley@utsa.edu
Phone: (210) 458-5992
Fax: (210) 458-7281