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CHANGES IN PRESERVICE ELEMENTARY TEACHERS' SCIENCE TEACHING SELF-EFFICACY BELIEFS

Isil Koc[i]
Department of Mathematics and Science Education,
Hasan Ali Yucel College of Education,
Istanbul University, 34452, Istanbul, Turkey

Abstract:
The purpose of this study was to investigate the effect of the inquiry-based science methods course on preservice elementary teachers' self-efficacy beliefs about science teaching. Eighty-six preservice elementary education majors enrolled in the elementary science methods course participated in the study. Data were collected through Science Teaching Efficacy Belief Instrument- Form B (STEBI-B), a participant information form, and semi-structured interviews. Findings from the quantitative data revealed that there was significant difference between pre-test and post-test scores on both the Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE), which are two subscales of STEBI-B. The qualitative findings of the study were utilized to further clarify the quantitative results. Overall, findings from the study indicated a positive relationship between participating in the elementary science methods course and changes in science teaching self- efficacy beliefs.

Keywords: teacher efficacy, self-efficacy beliefs; preservice elementary teachers; science teaching; teacher education

1. Introduction

Teacher efficacy has emerged as an important construct in teacher education over the past twenty-five years (Cantrell, Young & Moore, 2003). Teacher efficacy is mainly based upon the Bandura's (1977) social cognitive theory, which roots human agency in a sense of self-efficacy. According to Bandura, "*self-efficacy beliefs foster people toward specific actions in all aspects of their lives, and therefore have predictive value. The construct of*

[i] Correspondence: email isilkoc@istanbul.edu.tr

self-efficacy beliefs consists of two dimensions: personal self-efficacy and outcome expectancy. Personal self-efficacy is a judgment of one's capabilities to organize and execute given types of performance, whereas outcome expectancy is a judgment of the likely consequence such performances will produce" (Bandura, 1997, p. 21). When applied to science teaching, self-efficacy beliefs have generally been identified as teacher's belief that he/she has the ability to teach science effectively and can affect students' behavior and achievement positively (Dembo & Gibson, 1985).

Teachers' attitudes, beliefs, and interactions are critical elements in the success of scientific literacy for all students (Ritter, Boone & Rubba, 2001). A relationship among teacher self-efficacy, teacher effectiveness, and student achievement has been studying by various studies (Ashton, 1984; Ashton & Webb, 1986; Czerniak, 1989; Czerniak & Chiarelott, 1990; Czerniak & Shriver, 1994; Dembo & Gibson, 1985; Enochs, Scharmann & Riggs, 1995; Ramey-Gassert & Shroyer, 1992; Ross, 1992; Woolfolk, Rosoff & Hoy, 1990). Based on research, teachers with high self-efficacy show greater awareness of student achievement and have higher expectations for their students. In addition, such teachers have a tendency to take personal responsibility for student learning and achievement and use innovative teaching techniques.

Changes in teacher preparation programs will be necessary to produce teachers who possess attitudes and skills to make the necessary changes in the elementary science classroom (Wingfield, Freeman & Ramsey, 2000). Actually, the elementary science methods course provides preservice elementary teachers prepare for teaching in their future classrooms. By interacting with content in life, earth, and physical sciences through hands-on and engaging inquiry-based activities across the K-8 science curriculum in science, preservice elementary teachers have a chance to learn and practice strategies and teaching methods. As preservice elementary teachers engage in the methods and practicum experiences, their beliefs and attitudes about science teaching may change.

2. Purpose

The purpose of this study was to investigate the effect of the inquiry-based elementary science methods course experience on preservice elementary teachers' self-efficacy beliefs about science teaching. The answers to the following questions were sought in line with this objective:

1. Does participating in an elementary science methods course influence preservice elementary teachers' personal teaching efficacy about science teaching?

2. Does participating in an elementary science methods course influence preservice elementary teachers' outcome expectancy about science teaching?

3. Methodology

3.1 Research Design

A one-group pre-test/post-test design was utilized in this study. The research design for the study was a mixed-method approach, including both qualitative and quantitative research methods (Greene & Caracelli, 1997). It is argued that using the mixed-method design could enhance confidence in the findings, in particular by increasing the ability to evaluate convergent and discriminant validity (Dixon-Woods et al., 2004). The mixed-method study involves using more than one type of research technique or data source within a study. In this way, a researcher can achieve convergence of results, examine overlapping and different facets of a phenomenon, use the methods of sequentially, find contradictions and new perspectives, add scope and breadth to a study (Creswell, 1994). Additionally, the purpose of use of combined qualitative and quantitative methods is first to "triangulation", in which the aim is corroboration (one method is used to verify the findings of the other). The second is to "facilitation", in which one strategy facilitates or assists the other, and "complementarity", in which two strategies are employed to investigate different aspects of a problem (Hammersley, 1996).

In particular, quantitative data for the study were derived from the administration of Science Teaching Efficacy Belief Instrument- Form B (STEBI-B) developed by Enochs and Riggs (1990), a participant information form, and qualitative data for the study were obtained from the utilization of semi-structured interviews to complement quantitative data. The choice of semi-structured questions was aimed at encouraging participants to give free responses to elaborate on their views.

3.2 Participants

Eighty-six preservice elementary teachers who were enrolled in four sections of the three-credit course titled "Methods Elementary School Science" participated in the study. The majority of the participants were juniors and seniors in college who had completed a substantial portion of the science coursework required by their respective programs and would be student teaching for one full academic year or less. The ages of participants ranged from 19 to 35 with an average age of 21. The majority of the participants (81) in the sample were Caucasian. There were 81 females and five males. Given that almost 95% of the participants in this study were females and Caucasian, no attempts were made to compare and differentiate results by gender and ethnicity.

3.3 The Elementary Science Methods Course

"Methods Elementary School Science" is a required course for preservice elementary teachers. Prerequisites for the course enrollment include successful completion of several general courses in Elementary Teacher Education Program and a minimum 2.5 or above grade point average. This course mainly focuses on providing meaningful and practical learning experiences that will prepare preservice elementary teachers to create effective science learning environments for elementary school students. The course aims to create an environment where the participants actively participate in discussions and hands-on science activities rather than being passive receivers of information. The course contents include the participation in several hands-on science lessons to model a guided-inquiry approach to science teaching and learning, the exploration and application of the 5E (Engage, Explore, Explain, Elaborate, Evaluate) instructional model for guided inquiry, and the cooperative learning strategies for science teaching, which are emphasized in the National Science Education Standards. Assignments will be substantially "authentic", which means that students will do things that exemplary practicing teachers regularly do as part of their professional development experiences.

3.4 Data Collection

As stated previously, preservice elementary teachers enrolled in science methods course participated in this study. The participation in the study was voluntary. A total of eighty-six preservice elementary teachers volunteered to participate in the study. Quantitative data for the study were collected at the beginning and end of the science methods course by the researcher. At first, preservice elementary teachers asked to complete a participant information form in order to provide descriptive data. Participants then completed the Science Teaching Efficacy Belief Instrument- Form B (STEBI-B), (Enochs & Riggs, 1990). Administration of these instruments required approximately 25 minutes. For this, class time was arranged in case that the instructor's schedule permitted the use of approximately 25 minutes of class time. At the end of the course, preservice elementary teachers requested to complete the STEBI-B again. After administration of the STEBI-B, individual interviews were conducted with selected preservice elementary teachers. The preservice elementary teachers selected for the interviews were chosen randomly among those who received high and low mean STEBI-B scores. A total of eight (six females and two males) preservice elementary teachers accepted to be interviewed willingly. The interviews were semi-structured and conducted by the researcher at the end of the course. Each interview lasted for about 20-25 minutes and was conducted as one event. All the interviews were audio-taped with the permission of the interviewees. The audio-taped records were later transcribed for the analysis.

3.5 Instruments

3.5.1 Science Teaching Efficacy Belief Instrument- Form B (STEBI-B)

Enochs and Riggs's (1990), Science Teaching Efficacy Belief Instrument for preservice elementary teachers was the primary source of quantitative data. The STEBI-B contains 23 Likert type items. Each item has five- response categories-"strongly agree", "agree", "uncertain", "disagree", and "strongly disagree". The STEBI-B is composed of two subscales that were consistent with the theory of social learning by Bandura (1977), and applied to science teaching by Gibson and Dembo (1984). The first subscale, Personal Science Teaching Efficacy (PSTE) consists of 13 items and it measures teachers' beliefs about their own capabilities to teach science. PSTE is based on statements such as: "I will continually find better ways to teach science." The second subscale, Science Teaching Outcome Expectancy (STOE) consists of 10 items and it measures teachers' belief that students can learn science. STOE is based on statements such as: "Students' achievement in science is directly related to their teacher's effectiveness in science teaching." Possible scores on the PSTE subscale range from 13 to 65 and STOE scores may range from 10 to 50. High scores on the PSTE indicate a strong belief in one's ability to teach science and High scores on the STOE indicate high expectations as regards the outcomes of science teaching. STEBI-B was reported as a valid and reliable instrument. Reliability analysis produced the Cronbach's alpha coefficient of .90 for the PSTE subscale, and the Cronbach's alpha coefficient of .76 for the STOE subscale (Enoch & Riggs, 1990). Within this study, reliability for the sample of eighty-six preservice elementary teachers was established for the STEBI-B. Resultant Cronbach's alpha coefficient was .88 for the PSTE subscale and .71 for the STOE subscale.

3.5.2 Participant Information Form

A participant information form was used to gather detailed information about preservice elementary teachers so that their responses to the STEBI-B could be better comprehended. The form consists of questions including gender, age, ethnicity, grade level, and intended time for student teaching. In addition, quantity of science courses regarding semester hours and credits that each of the preservice elementary teachers completed both in high school and college were requested to see if there was a relationship between the number of courses and preservice elementary teachers' science teaching efficacy beliefs. A last part of the form investigates the preservice elementary teachers' level of interest in teaching science, the level of preparedness to teach science, and how confident they feel they will teach science in the future. For this, preservice elementary teachers were asked to rate their interests and preparedness level to teach science in general and earth science, life science, physical science in particular from 1(very low) to 5(very high).

3.5.3 Interview Protocol

The preservice elementary teachers for the interview were purposely selected from the four sections and interviewed by the researcher after the administration of the STEBI-B. The interviews were semi-structured so as to allow the researcher to probe for clarification, justification, extension, or to respond to the intensity of the participants' responses (Guba & Lincoln, 1981). In particular, during the interviews participants were given the opportunity to respond to questions and to further explain their responses before the next question was asked. If answers were unclear, probing questions were used to give respondents a chance to clarify answers and to generate more accurate representations of their views. Questions such as, "Can you tell me more about that?" or "Could you clarify what you mean?" were acceptable. The interviews ranged from 20 to 25 minutes in length, and were audio taped for transcription and analysis.

3.6 Data Analysis

In this study, quantitative and qualitative data were analyzed separately. For the purpose of the quantitative data analysis, the SPSS 18.0 statistical program was used. At first, the results of the STEBI-B were reported by descriptive statistics. A paired sample t-test was selected to compare of means on the pre-test and post-test administrations of STEBI–B. Frequency distributions of participants' demographic information were also reported to investigate any potential effects of demographic variables on the pre and post STEBI-B data. Additionally, preservice elementary teachers' self- reported choices concerning the number of high school/college science courses completed, the choice of science teaching delivery, the amount of time spent in performing "hands-on" science, and the perceived effectiveness of future science teachers in elementary schools association with their science teaching efficacy beliefs including the two subscales of the STEBI-B were investigated using a Pearson Product-Moment Correlation Coefficient.

For the purpose of the qualitative data analysis, participants' responses to the interview questions were transcribed verbatim. To seek similarities and distinctions in the data, each audio-taped record was coded systematically based on topics, themes and issues.

4. Results

This part describes the results from the analysis of the preservice elementary teachers' responses to the questionnaire and the interview questions, including descriptive statistics and other appropriate statistical analyses.

4.1 Questionnaire Results

4.1.1 Participant Information Form

The first section of the data analysis was comprised of computing descriptive statistics with respect to demographic and background information collected from preservice elementary teachers. Table 1 illustrates the frequency distributions of participants' information.

The majority of the participants in the study were juniors (20.9%) and seniors (76.8%) in college who would be student teaching in one full academic year or less (90.7%). The ages of the participants ranged from 19(2.3%) to 35(1.2%), with an average of 21(50.0%). The majority of the participants in the sample were Caucasian (non-Hispanic) (94.2%). There were 81 (94.2%) females and five (5.8%) males. Because of a large difference in the number of male and female students, no comparison was made on gender difference bases in the study.

Table 1: Frequency distributions of participants' demographic information (N=86)

Variable(s)	Frequency	Percent
Gender		
Female	81	94.2%
Male	5	5.8%
Age		
19-22	74	86.0%
23-26	8	9.3%
27-30	1	1.2%
31-35	3	3.5%
Ethnicity		
Hispanic	1	1.2%
Asian	2	2.3%
Caucasian (non-Hispanic)	81	94.2%
Other	2	2.3%
College classification		
Undergraduate	84	97.7%
Certification	2	2.3%
Intended time for student teaching		
Next semester	23	26.7%
Next school year	59	68.6%
Other	4	4.7%
Science courses completed		
High school		
1-2	3	3.5%
3-4	54	62.8%
5-7	29	33.7%
College		

1-2	35	40.7%
3-4	41	47.7%
5-8	10	11.6%

Table 1 also revealed that participants' number of science courses that they completed in high school ranged from 1 to 7 and in college ranged from 1 to 8. In particular, 3.5% of the participants completed two or less science courses, 62.8% completed three or four courses, and 33.7% completed five to seven courses during high school. On the other hand, participants' number of taken science courses in college was fewer than in high schools. Curiously, 40.7% of the participants completed two or less science courses, 47.7% completed three or four courses, and 11.6% completed five to eight science courses in college. These demographic variables were applied as grouping variables to test for any possible effects on self-efficacy beliefs.

In addition to the background information shown in Table 1, a part of the questionnaire investigated the preservice elementary teachers' expressed levels of interest in teaching science; particularly earth/space science, life science, physical science and the adequacy of their background knowledge for teaching them. For this, preservice elementary teachers were asked to rate their interests in teaching science; particularly earth/space science, life science, and physical science. The majority of preservice elementary teachers tended to a have high interest in teaching science (68.6%), particularly earth/space science (58.1%), life science (62.8%), and physical science (45.3%). Many of them also felt that they were well prepared to teach science (64.0%), earth/space science (55.8%), life science (60.5%), and physical science (46.5%). When preservice elementary teachers were asked their self-perceptions of confidence as a future teacher, many of them showed a high degree of confidence about teaching science (68.2%).

In developing and enhanced understanding of the self-efficacy construct, each subscales of the STEBI-B is considered with the following variables: number of high school science courses; number of college science courses; personal preference for teaching science; expected time to be allocated to textbook vs. activity-based science instruction; and perceived future effectiveness in the teaching science. A series of Pearson Product-Moment correlations were generated for each subscales of the STEBI-B to provide a basis upon which to interpret comparisons and establish possible relationships.

Table 2 provides an evidence of potential relationship between the PSTE subscale and other variables. Based on results, a significant correlation coefficient was revealed between the PSTE and participants' choice of science instruction delivery (CHOICE); and the PSTE and participants' perceived effectiveness in teaching science (EFFECT).

Table 2: Correlation coefficients of participants' PSTE scores and selected variables (N=86)

	PSTE	NHSSC	NCSC	CHOICE	TIME	EFFECT
PSTE	1.000	-.056	-.062	.322**	.105	.334*
NHSSC		1.000	.117	-.078	-.008	-.128
NCSC			1.000	-.025	-.033	-.006
CHOICE				1.000	-.016	.280**
TIME					1.000	-.030
EFFECT						1.000

Note: PSTE= personal science teaching efficacy, NHSSC= number of high school science courses, NCSC= number of college science courses, CHOICE= choice of teaching science instruction, TIME= expected time teaching science, and EFFECT= perceived effectiveness in teaching science.
**Correlation is significant at the 0.01 level.

On the other hand, Table 3 provides an evidence of potential relationship between the STOE subscale and other variables. Based on results, there is no significance was revealed. Additionally, a significant positive correlation is also revealed between mediating variables of CHOICE and EFFECT. Thus, from an idealistic perspective, if preservice elementary teachers report a desire to make use of a more activity-based instructional approach to science, it is likely that they would assess their future science teaching to be more effective.

Table 3: Correlation coefficients of participants' STOE scores and selected variables (N=86)

	STOE	NHSSC	NCSC	CHOICE	TIME	EFFECT
STOE	1.000	.061	.020	.089	.092	.042
NHSSC		1.000	.117	-.078	-.008	-.128
NCSC			1.000	-.025	-.033	-.006
CHOICE				1.000	-.016	.280**
TIME					1.000	-.030
EFFECT						1.000

Note: STOE= science teaching outcome expectancy, NHSSC= number of high school science courses, NCSC= number of college science courses, CHOICE= choice of teaching science instruction, TIME= expected time teaching science, and EFFECT= perceived effectiveness in teaching science.
**Correlation is significant at the 0.01 level.

4.1.2 Science Teaching Efficacy Beliefs

A paired samples t- test showed that there was a significant growth in self-efficacy beliefs as measured by STEBI-B. In specific, the mean of the PSTE between pre-test and post-test increased from 44.50 to 51.18, while the mean of the STOE between pre-test and post-test increased from 32.60 to 34.83. Table 4 presents the details of the statistical analysis.

Table 4: Paired sample t-test (two-tailed) results for PSTE and STOE Subscales (N=86)

Subscale	Mean	SD	t	p
PSTE				
Pre-test	44.50	5.58	-5.68	.003*
Post-test	51.18	6.46		
STOE				
Pre-test	32.60	3.80		
Post-test	34.83	3.42	-2.57	.038*

*p< .05

4.2 Interview Results

Semi-structured interviews were conducted with eight preservice elementary teachers for further approaching into their self-efficacy beliefs about science teaching. The responses were categorized in mainly preservice elementary teachers' willingness/ unwillingness to teach science and their confidence/anxiety about content knowledge in their future careers.

4.2.1 Willingness/ unwillingness to teach science

Preservice elementary teachers' responses related to their feelings about science teaching were positive. For instance, two participants stated their feelings about science teaching as following:

"I actually had a good feeling for science… I like science and it will be fun to teach. I do enjoy teaching it!"

"I think that teaching science to a group of students can be exciting and enjoyable learning experience for everyone in a classroom."

Furthermore, two participants mentioned that their feelings about science teaching have changed in a positive ways. For instance,

"My feelings about science have been changed. I actually enjoy science now."

"Science was never my strong subject. I never liked it as a child and it is not one of my areas of specialization, but I really enjoyed the class. Instructor showed us how we could have fun with science, I was excited and I wanted to learn a lot about science."

4.2.2 Confidence/ anxiety about content knowledge

In order to understand participants' confidence about content knowledge interviewees were asked how confident they feel about science teaching at the elementary school level. Two participants were very confident like one stated:

"I am very comfortable with it. I have a strong background in science and what I need to do is try and get science across to my students and make it fun!"

Three participants expressed an increased confidence that they would be able to teach it effectively. That they feel confident in subjects in science as one of them stated:

"I was not very confident in science. I felt that I could not be a good teacher. I still have a lot to learn about it but I realize my confidence level is going up."

On the other hand, some participants mentioned their anxiety about teaching science by expressing their thoughts as following:

"I fear of never knowing enough of the subject matter but I think that this is not exclusive to me."

"I just feel like I need to spend some extra time on basic science. My concern is how to get students interested in science."

"I am anxious about supplies and my own experience level."

5. Conclusion, Discussion and Implications

The purpose of this study was to investigate the effect of an elementary science methods course experience on preservice elementary teachers' self-efficacy beliefs about science teaching. The research design for this study was a mixed-method involved both quantitative and qualitative research methodologies to strength through triangulation of findings from different data sources. Overall, the findings from the study concluded important evidence of the effect that inquiry-based elementary science methods courses could have on changing preservice elementary teachers' sense of self-efficacy beliefs about science teaching and learning in a positive way and influence their future instructional practices.

Teacher self-efficacy beliefs, in particular, have been found to be valid predictors of teachers' behavior regarding science teaching and learning. As mentioned previously, research supports that an unwillingness to teach science in the elementary grades can arise from a lack of confidence so it is crucial to address the factors that can improve the science teaching self-efficacy of preservice elementary teachers. Science methods courses might be a good opportunity for preservice elementary teachers to first explore their own learning in the context; investigate the thought processes of students in the context of the elementary science classroom; and finally, integrate these two experiences to inform their curricular design decisions. Knowing the variables that influences the growth of positive efficacy beliefs of preservice elementary teachers and how they change over time might be useful in planning for coursework and practicum experiences that improve teaching efficacy throughout the teacher preparatory years. Thus, it is suggested that educators in science education preparatory programs be aware that it is necessary to promote and sustain self-efficacy beliefs during the entire

preparation program and attempt to determine which aspects that facilitate an enduring increase in teacher's self-efficacy beliefs.

One might conclude that the more science preservice elementary teachers exposed to, the greater their self-efficacy beliefs. This claim is also supported by a number of studies that preservice elementary teachers should complete more science content and methods courses (Arambula-Greenfield, & Feldman, 1997; Czerniak, & Chiarelott, 1990; Ginns, & Watters, 1999; Riggs, 1995). However, Jarrett (1999) reported no relationship between the number of science courses completed by teachers and their level of understanding of science concepts, nor their attitudes and their confidence and comfort level for teaching science. Additionally, one implication from Bleicher's and Lindgren's (2005) study was that increasing the quantity of science content courses that preservice elementary teachers are required to complete may not be sufficient to overcome their reluctance to teach science if some of their learning does not take place in a constructivist environment. Data of this study regarding the relationship between STEBI-B subscales and the number of science courses completed in high school and college suggest that science courses completed in high school and college do not appear to influence preservice elementary teachers' self-efficacy beliefs regarding science teaching. It might be assumed that science teacher educators should structure existing and any new courses to include experiences that make students aware of, and able to confront, their existing beliefs about their ability to teach science.

Developing self-confidence (i.e., self-efficacy) among preservice elementary teachers for teaching science is of paramount importance. Results of this study indicated that STEBI-B is a valid and a reliable instrument for studying preservice elementary teachers' beliefs about science teaching and learning. With this instrument, a more complete perspective of elementary science teaching is possible. For instance, the preservice elementary teachers who are low in STOE should receive a much different training than those who are low in PSTE. Training to increase STOE might focus on teacher expectations and their relationship to student achievement, while training to enhance PSTE should deal with improvement of teachers' actual science teaching skills.

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