Pre-Service Elementary Teachers' Scientific Literacy and Self-Efficacy in Teaching Science

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Abstract

Many educators and educational institutions worldwide have agreed that the main goal of science education is to produce a scientifically literate community. Science teachers are key to the achievement of scientific literacy at all levels of education because of the essential role they play in preparing scientifically literate individuals. Studies show that pre-service elementary teachers need to build more confidence in teaching science and scientific literacy during their teacher education programs in order for them to successfully teach science knowledge to their students. Therefore, the purpose of this study is threefold. First, pre-service elementary teachers' scientific literacy levels were examined. Second, pre-service teachers' self-efficacy beliefs were measured by distinguishing between their personal and subject-specific self-efficacy beliefs. Third, the extent to which pre-service elementary teachers' scientific literacy levels and self-efficacy levels are related was investigated. Participants were 49 pre-service elementary teachers registered in two science methods courses (introductory and advanced) at a mid-sized university in the United States. Quantitative data were collected using the Test of Basic Scientific Literacy, the Science Teaching Efficacy Belief Instrument-Preservice, and Beliefs about Teaching. Results showed that participants had a satisfactory level of scientific literacy. However, pre-service teachers had borderline scores on the Nature of Science scale. Regarding self-efficacy, findings showed that both groups had the highest self-efficacy in teaching biology and the lowest in teaching physics. Participants in the advanced science methods course exhibited a moderate preexisting positive relationship between scientific literacy and subject-specific self-efficacy in teaching science.

Keywords: elementary education, pre-service teachers, scientific literacy, self-efficacy

Introduction

Having an enriched, scientifically literate society is important because understanding and resolving many public issues require some scientific background. Since people encounter science and its laws from the moment they wake up till the moment they go to sleep, all citizens should have some level of scientific literacy (Hazen & Trefil, 1991). In the context of the public, scientific literacy refers to the understanding of science that allows an individual to participate in socio-scientific topics and to make informed decisions on these issues, as well as the appreciation of processes, values, and ethics related to science (Dawson & Venville, 2009).

Furthermore, science teachers are key to the achievement of scientific literacy at all levels of education because of the essential role that science teachers play in preparing scientifically literate individuals (Chin, 2005). To achieve this goal of having a scientifically literate society, one must ask how to effectively prepare pre-service teachers for science teaching. Despite the number of science methods courses and science courses taken, pre-service teachers continue to enter their student teaching semesters and professional careers with low science teaching efficacy beliefs (Harlen, 1997; Murphy, Neil, & Beggs, 2007; Tosun, 2000). These studies attributed the cause of low self-efficacy among pre-service teachers to the lack of understanding of scientific ideas, challenges in applying certain required teaching skills, a lack of science content, and misconceptions about science.

This study provides additional insight for educators in teacher-preparation programs seeking to identify pre-service teachers who are experiencing the Dunning-Kruger effect, a psychological concept described by Kruger and Dunning (2009). Pavel, Robertson, and Harrison (2012) offered a useful explanation about this effect:

> Kruger and Dunning identified a tendency for people with relatively lower skill levels and knowledge to overestimate their ability to accomplish a task, whereas people with relatively higher skill levels and knowledge would tend to underestimate their ability to complete a task. (p. 126)

On the basis of this concept, educators in teacher-preparation programs should identify pre-service teachers with high levels of self-efficacy in teaching science and those with low levels of scientific literacy. In other words, these pre-service teachers will have a false sense of confidence about teaching science. These groups of pre-service teachers are at high risk of making errors and reaching mistaken conclusions when they teach science due to their low scientific literacy levels. What makes the matter more concerning is that they will not realize their mistakes due to overestimated levels of self-efficacy in teaching science (Kruger & Dunning, 2009). As such, educators in teacher-preparation programs should take into account the relationship between scientific literacy and self-efficacy beliefs toward teaching science when evaluating their pre-service teachers. Therefore, the purpose of this study is threefold. First, pre-service elementary teachers' scientific literacy levels were examined. Second, accurately measuring pre-service teachers' self-efficacy beliefs by distinguishing between their personal and subject-specific self-efficacy beliefs. Third, the extent to which pre-service elementary teachers' scientific literacy levels and self-efficacy levels are related was investigated.

Literature Review

Pre-Service Teachers' Scientific Literacy

Many educators and science education organizations have attempted to define the term scientific literacy. Some researchers view scientific literacy as a person's ability to think critically and rationally about science in relation to potential personal, social, political, and economic challenges and problems encountered in everyday life (Bacanak & Gokdere, 2009; Karamustafaoğlu, Cakir & Kaya, 2013). Other researchers argue that a scientifically literate person should understand clearly both the impact of science and technology on society and the nature of the science itself (Altun-Yalcin, Acisli & Turgut, 2011; Chin, 2005; Cavas, P., Ozdem, Cavas, B., Cakiroglu & Ertepinar., 2013; Ozdemir, 2010). Despite some disagreement over the precise definition of scientific literacy, there is a consensus that an aim of science education is to ensure that learners are scientifically literate. In this study, scientific literacy will be defined in line with that of the National Research Council [NRC] (1996), which stated that scientific literacy is an individual's ability to identify scientific matters underlying national and local decisions, to express positions that are scientifically and technologically informed, and to assess the quality of scientific information on the basis of its sources and the methods used to generate such information. The NRC's (1996) definition of scientific literacy, unlike other definitions, includes the ability to discuss and assess scientific and technological material.

Several studies have examined the levels of scientific literacy of pre-service elementary teachers in teacher preparation programs. The results, which compared the scientific literacy levels of pre-service teachers in the first and fourth years of the teacher preparation programs (e.g., Cavas et al., 2013; Karamustafaoğlu et al., 2013), demonstrated that pre-service teachers in both grade levels have borderline to low scientific literacy levels (e.g., 68 out of 110 items and 48.35 out of 100 items, respectively) and require improvement. Other studies examining pre-service teachers throughout their four-year teacher preparation program (e.g., Altun-Yalcin et al., 2011; Ozdemir, 2010) demonstrated that pre-service teachers in their final year have the highest scientific literacy levels.

The majority of research (Altun-Yalcin et al., 2011; Bacanak & Gokdere, 2009; Cavas et al., 2013; Chin, 2005; Karamustafaoğlu et al., 2013; Ozdemir, 2010) about pre-service elementary teachers applies quantitative research approaches to examine scientific literacy levels. For example, Karamustafaoğlu et al. (2013) sought to determine the level of scientific literacy and information technology literacy among pre-service science teachers. Additionally, the researchers intended to find out if there was a relationship between scientific literacy and information technology literacy among the science teacher candidates. Furthermore, the researchers collected data from the participants by administrating two instruments: the Scientific Literacy Test (SLT) and the Information Technology Literacy Scale (ITLS). The SLT consists of 100 items that focus on the participant's knowledge in scientific literacy, which is closely related to this study. However, the ITLS aims to measure the participant's literacy in Information and Communication Technologies (ICT), such as problem-solving capabilities in ICT and technical skills in ICT. The researchers found that the participants had low scientific literacy levels (48.35 out of 100) and had satisfactory information technology literacy levels. Finally, Karamustafaoğlu et al. (2013) encouraged decision makers to enrich the teacher preparation program with additional topics that address scientific literacy. Based on the reviewed literature, researchers seem to have reached a consensus that pre-service teachers with low scientific literacy levels cannot be expected to grow scientifically literate individuals or to apply the science curriculum effectively.

Self-Efficacy

Based on the reviewed literature, researchers who conducted studies related to self-efficacy (Avery & Meyer, 2012; Aydin & Boz, 2010; Bayraktar, 2011; Bleicher & Lindgren, 2005; Bursal, 2008, 2012; Ebrahim, 2012; Kahraman, Yilmaz, Bayrak, & Gunes, 2014; McDonnough & Matkins, 2010; Murphy, Neil & Beggs, 2007; Onen & Kaygisiz, 2013; Tosun, 2000; Yılmaz & Cavas, 2008; Yilmaz-Tuzun, 2008) are in agreement with Bandura's (1977) definition of perceived self-efficacy as the belief "in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 2). Bandura (1986) differentiated between self-efficacy and outcome expectations in that "individuals can believe that a particular course of action will produce certain outcomes, but they do not act on that outcome belief because they question whether they can actually execute the necessary activities" (p. 392). For example, individuals are motivated to act if they believe the action will have a positive result (outcome expectation) and if they can perform that action successfully (self-efficacy).

Personal self-efficacy. Based on Bandura's (1977) theory, Ashton and Webb (1986) identified two types of teaching efficacy: personal teaching efficacy and outcome teaching efficacy. In this study, personal self-efficacy will be defined in line with Ashton and Webb's (1986) definition of personal teaching efficacy, in which personal self-efficacy refers to teachers' confidence in their experiences to develop strategies for overcoming obstacles to student learning.

Enochs and Riggs (1990) developed a research instrument based on Bandura's self-efficacy theory that stressed the critical importance of early detection of pre-service science teachers with low self-efficacy levels. Enochs and Riggs' (1990) contribution is the development of a valid and reliable instrument – the Science Teaching Efficacy Belief Instrument for pre-service teachers (STEBI-B) – which can be administered to measure personal self-efficacy levels of pre-service teachers. Many studies of personal self-efficacy (Aydin & Boz, 2010; Bayraktar, 2011; Bleicher & Lindgren, 2005; Bursal, 2008, 2012; Ebrahim, 2012; Kahraman et al., 2014; McDonnough & Matkins, 2010; Murphy et al., 2007; Onen & Kaygisiz, 2013; Tosun, 2000; Yılmaz & Cavas, 2008) have used the STEBI-B to measure the impact of certain variables on pre-service teachers' personal self-efficacy levels.

Several researchers have investigated the impact of science methods courses on pre-service teachers' personal self-efficacy levels (Avery & Meyer, 2012; Bayraktar, 2011; Bursal, 2008; Ebrahim, 2012). Some have reported that science methods courses have a positive impact on participants' personal self-efficacy beliefs, attributing their results to the pedagogical use of inquiry-based learning and authentic science teaching methods (Avery & Meyer, 2012; Ebrahim, 2012). However, others reported no effect on participants' personal self-efficacy beliefs, which, in regard to science, remain low (Bayraktar, 2011; Bursal, 2008). The researchers agreed that the participants' low self-efficacy toward teaching science results from their limited teaching experience, which should be incorporated into science methods courses.

A number of authors (Bleicher & Lindgren, 2005; Murphy et al., 2007; Tosun, 2000) investigated the relationship between science-related knowledge and pre-service teachers' personal self-efficacy beliefs. Bleicher and Lindgren (2005) found a positive relationship between participants' conceptual understanding of science and their self-efficacy beliefs about teaching and determined that more science courses were needed in teacher preparation programs to help future teachers maintain high levels of confidence in teaching science.

However, Murphy et al. (2007) and Tosun (2000) concluded that, although study participants had a good scientific background and high achievement levels in science, they still demonstrated a negative attitude toward teaching science. The researchers attributed their results to insufficient professional development and previous personal failures during the teacher preparation program.

Subject-specific self-efficacy. Similarly derived from Bandura's (1977) philosophy of self-efficacy, subject-specific self-efficacy refers to a teacher's judgment of his or her capabilities to effectively teach subject areas such as physics, chemistry, biology, and earth science (Yilmaz-Tuzun, 2008). Only Yilmaz-Tuzun (2008) addressed subject-specific self-efficacy levels among pre-service teachers in a study devoted to developing an instrument to measure pre-service elementary teachers' confidence levels with assessment techniques, classroom management, teaching methods, and Science Concept Knowledge (SCK). The SCK section is in line with this study's definition of subject-specific self-efficacy with regard to teaching science. Furthermore, Yilmaz-Tuzun (2008) concluded that pre-service elementary teachers "felt more confident teaching content in biology, earth science, or both than teaching content in physics, chemistry, or both" (p. 197).

In summary, the researchers in this paper were unable to locate a study that investigated the difference between pre-service elementary teachers' personal and subject-specific self-efficacy beliefs. Studies that addressed self-efficacy focused primarily on the personal aspect of self-efficacy, which is pre-service teachers' general self-efficacy towards teaching science. As a result, pre-service teachers were usually labeled as having high, medium, or low levels of self-efficacy towards teaching science without specifying (subject-specific self-efficacy) the exact science subjects they lack confidence to teach, such as biology, chemistry, and physics.

Methodology

Participants

Participants in this study were undergraduates in an elementary teacher education program known as the Teacher Education Program (TEP) at a mid-sized university in the Midwestern United States. Two groups from the TEP participated in this study. The first group was pre-service teachers enrolled in an introductory science methods course. These participants had just started the TEP and had not yet experienced major education and teaching methods courses. The second group was pre-service teachers enrolled in an advanced science methods course. These participants, however, had experienced major education and teaching methods courses.

Furthermore, the participants in this study responded to a demographic information survey, which included three parameters as shown in Table 1. 49 pre-service elementary teachers registered in two science methods courses participated in this study. This included 25 participants in the introductory science methods course (2 male and 23 female) and 24 participants in the advanced science methods course (2 male and 22 female). In addition, 53.1% of all participants reported having a good experience in science during high school. Also, 51.3% of them reported having a good current experience with science during teacher preparation at the university.

Table 1: Demographic Information

Category	N	%
Gender		
Male	4	8.2
Female	45	91.8
Science experience in high school		
Very poor	0	0
Poor	4	8.2
Acceptable	14	28.6
Good	26	53.1
Very good	5	10.1
Current Science experience		
Very poor	1	2
Poor	2	4.1
Acceptable	15	30.6
Good	26	53.1
Very good	5	10.2

Data Collection Instrument

This exploratory educational research study used a quantitative approach that employed quantitative data collection, analysis, and procedures. Participants in this study completed three instruments: Test of Basic Scientific Literacy (TBSL), Science Teaching Efficacy Belief Instrument (STEBI-B), and Beliefs About Teaching (BAT).

Created by Laugksch and Spargo (1996), the TBSL includes 110 items: the Nature of Science [NOS] (22 items), SCK (72 items), and the impact of science and technology on society [STS] (16 items). SCK covers four areas of test items: (a) earth science, (b) life science, (c) physical science, and (d) health science. The second instrument is the STEBI-B, developed by Enochs and Riggs (1990) to determine the personal self-efficacy beliefs of pre-service teachers toward teaching science. The STEBI-B includes two subscales, which are the Personal Science Teaching Efficacy Belief (PSTE) and Science Teaching Outcome Expectancy (STOE). Only the PSTE instrument was used because it is directly related to the study's topic. The third instrument is the BAT, developed by Yilmaz-Tuzun (2008) to determine the subject-specific self-efficacy beliefs of pre-service teachers.

Research Questions

1. How did the participants in the introductory and advanced science methods course perform on the TBSL?
    1a. How did the participants in the introductory science methods course perform on the six scales of TBSL?
    1b: How did the participants in the advanced science methods course perform on the six scales of TBSL?
2. What is the self-efficacy level among the four scales of the BAT in the introductory and advanced science methods course?
3. What is the difference between the level of personal and subject-specific self-efficacy among the pre-service elementary science teachers in both science methods courses?

4. What is the relationship between scientific literacy and subject-specific self-efficacy among the pre-service elementary teachers in both the introductory and advanced science methods course?

Results

Level of Scientific Literacy

Descriptive statistical analysis was used to determine the performance level of the pre-service teachers in the introductory and advanced science methods course. According to Laugksch and Spargo (1996), the satisfactory level (i.e. cut-off point) of the TBSL is expected to be 68 out of 110 items. The pre-service elementary teachers in both groups had a satisfactory level of scientific literacy. The pre-service teachers in the advanced course (M = 84.29, SD = 10.719) on average had a higher scientific literacy level compared with those in the introductory course (M = 76.24, SD = 13.772). It is important to note that six of the participants from the introductory and two from the advanced science methods courses did not achieve the satisfactory level of 68.

Level of Scientific Literacy across the Six Scales of TBSL

According to Laugksch and Spargo (1996), pre-service teachers are expected to obtain at least 13 out of 22 on the NOS subsection, 45 out of 72 on the SCK subsection, and 10 out of 16 on the STS subsection. The SCK includes earth, life, physical, and health sciences. Participants in the introductory and advanced science methods group achieved the scientific literacy expectation. The difference between the two groups' achievement across the six scales of TBSL are highlighted in Table 2.

Table 2: Levels of Scientific Literacy across the six Scales of TBSL

	Science Methods Courses			
	Introductory (N= 25)		Advanced (N=24)	
Scale	Mean	SD	Mean	SD
Earth	9.80	1.803	10.92	1.932
Life	16.84	3.579	18.25	3.542
Physical	9.48	2.417	10.71	2.312
Health	15.24	3.632	16.96	1.574
NOS	14.56	2.740	14.88	2.833
STS	10.32	2.954	12.58	2.283
SCK	51.36	9.385	56.83	7.179

It can be seen from the data in Table 2 that the participants in the introductory science methods course achieved the scientific literacy expectation by scoring 14.56 out of 22 on the NOS subsection, 51.36 out of 72 on the SCK subsection, and 10.32 out of 16 on the STS subsection. The participants' teachers in the advanced science methods course also fulfilled the TBSL criteria, which is scoring 14.88 out of 22 on the NOS subsection, 56.83 out of 72 on the SCK subsection, and 12.58 out of 16 on the STS subsection.

Table 3 provides the percentage of correct answers for the two groups. What stands out in the table is that the highest percentage score for the introductory and advanced science methods course was on health science (80.21% and 89.26%, respectively). The lowest percentage score for the introductory science methods course was on STS (64.5%) and NOS (67.63%) for the advanced science methods course.

Table 3: Percentage of Correct Answers

	Science Methods Courses	
Scale	Introductory (N= 25)	Advanced (N= 24)
Earth	65.33%	76.8%
Life	70.16%	76.04%
Physical	67.71%	76.5%
Health	80.21%	89.26%
NOS	66.18%	67.63%
STS	64.5%	78.62%

Self-Efficacy Level among the Four Scales of the BAT

Table 4 shows the descriptive statistics of the participants' responses in both science methods courses. What is interesting about the data in this table is that the introductory and advanced science methods course had the highest level of self-efficacy in biology (M= 4.1920, SD= .45270 and M= 4.35, SD= .624, respectively) and the lowest self-efficacy level in physics (M= 3.0914, SD= .71771 and M = 2.9464, SD =. 54409, respectively).

Table 4: Descriptive Statistics of the Participants' Responses on the BAT

	Science Methods Courses			
	Introductory (N= 25)		Advanced (N=24)	
Scale	Mean	SD	Mean	SD
Physics	3.0914	.71771	2.9464	.54409
Chemistry	3.7867	.53472	3.5000	.46104
Biology	4.1920	.45270	4.3500	.62485
Earth	3.7360	.71349	3.7667	.62878

A one-way ANOVA was conducted to investigate the self-efficacy level of the participants in the four scales of the BAT. Table 5 indicates a statistically significant difference among the four scales of the BAT, F (15.531, 36.361) = 13.668, p =.000 for the introductory science methods courses. In addition, a statistically significant difference among the four scales for the advanced science methods course was present, F (24.499, 29.771) = 25.236, p = .000.

Table 5: One-way ANOVA test

Science Methods Courses	Score	Sum of Squares	df	Mean Square	F	*p-value*
Introductory	Between Groups	15.531	3	5.177	13.668	.000
	Within Groups	36.361	96	.379		
	Total	51.891	99			
Advanced	Between Groups	24.499	3	8.166	25.236	.000
	Within Groups	29.771	92	.324		
	Total	54.270	95			

*Significant at $p < .05$

In order to determine exactly where the differences were, the study included a Tukey post hoc test (Morgan, Leech, Gloeckner, & Barrett, 2007). For the introductory science methods course, the differences were significant between physics and chemistry, between physics and biology, and between physics and earth science. The differences were significant between physics and biology, between physics and earth science, and between chemistry and biology.

Comparing Personal and Subject-Specific Self-Efficacy

The researchers calculated an independent sample *t*-Test for the participants in the introductory and advanced science methods course to determine if there was a statistical difference between the participants' personal self-efficacy and subject-specific self-efficacy. It can be seen in Table 6 that there is no significant difference in the score for personal self-efficacy and subject-specific self-efficacy in the introductory science methods course. The participants had the same self-efficacy levels in both measurements of self-efficacy: STEBI-B (to measure personal self-efficacy) and BAT (to measure subject-specific self-efficacy). Regarding the participants in the advanced methods course, there was a significant difference in the score for personal self-efficacy and subject-specific self-efficacy t (-3.817) = 46, p = .000, d = -1.108. This indicates that the participants had different self-efficacy levels in both measurements of self-efficacy. Specifically, the participants held a high belief that they could teach science when they responded to the STEBI-B. However, the participants reported a lower level of belief that they could teach science when they responded to the BAT.

Table 6: Comparison of Personal and Subject-Specific Self-Efficacy

Science Methods Course	Self-efficacy Instrument	Mean (SD)	t	df	*p-value*
Introductory (N=25)	STEBI-B	3.63 (.492)	-.447	48	.657
	BAT	3.69 (.460)			
Advanced (N=24)	STEBI-B	4.11 (.507)	-3.817	46	.000
	BAT	3.58 (.447)			

*Significant at $p < .05$

Relationship between Scientific Literacy and Subject-Specific Self-Efficacy

The study computed correlation coefficients between the participants' scientific literacy levels and subject-specific self-efficacy levels. A Pearson product-moment correlation was calculated to investigate the strength of the relationship between the variables. Table 7 shows that only the advanced science methods course had an existing relationship between the two variables, r = .472, n = 24, p = .020.

Table 7: Pearson Correlation for Scientific Literacy and Subject-Specific Self-Efficacy

Science Methods Course	Pearson Correlation (*r* value)		
	Scientific Literacy	Subject-specific Self-efficacy	*p-value*
Introductory (Scientific Literacy)	1	.225	.279
Advanced (Scientific Literacy)	1	.472	.020*

*Significant at p < .05 (2-tailed)

Discussion

The results of this study show that the pre-service elementary teachers had satisfactory scientific literacy levels, which is calculated as 68 out of 110. Judging from the correct response rate of the mean score for the introductory and advanced science methods courses (M = 76.24, M = 84.291, respectively), the basic scientific literacy of pre-service elementary teachers is at a satisfactory level. This indicates that the TEP had a significant impact on the pre-service elementary teachers' knowledge in scientific literacy.

Comparing these results with results from other studies, the scientific literacy level of the participants in this study was higher than results from Cavas, P., Ozdem, Cavas, B., Cakiroglu and Ertepinar (2013) where the mean score for the pre-service teachers in their first year was 68.47 and in their fourth year 73.79. However, the results were slightly lower than Chin's (2005) findings when scientific literacy was investigated among science education majors and elementary education majors with a mean score of M = 107.47 and M = 99.11, respectively.

A possible explanation for these different results may be related to pre-service teachers' achievement level in science in high school, which can be drawn from the participants' response to the demographic question, "How would you describe your prior science experiences in high school?" Approximately 63.3% of the pre-service elementary teachers had a positive experience with science subjects. Chin (2005) stressed that "previous science-related experiences in school will have an influence on their scientific literacy" (p. 1568).

Furthermore, the researchers found interesting results regarding the achievement level of the pre-service elementary teachers on the six scales of scientific literacy. One of the unexpected findings is that health science had the highest correct response rate in both the introductory and advanced science methods courses (80.21% and 89.26%, respectively). A possible explanation for the participants' knowledge in "health" is due to their everyday life experience with health-related issues such as hand washing, tooth brushing, bathing, and dealing with a fever (Lee et al., 2008). In fact, Sonu and Amarjeet's (2007) study of high school students' health awareness showed that the majority of the participants had adequate knowledge about management of injuries, skin infections, and drowning. The study by Sobal, Klein, Graham, and Black (1988) of 831 high school students' health concerns offered another explanation for the participant's high achievement in health science: 92% of the students often thought about their health.

Furthermore, participants in the introductory science methods course had borderline scores in NOS, STS, and SCK (i.e. earth science, life science, physical science). These results are likely to be related to the participants' experience in the TEP. They have not yet experienced major science and science education courses that will allow them to perform more positively on the TBSL.

The pre-service elementary teachers in the advanced methods course, however, are expected to have adequate correct response rates because they are a semester away from beginning their professional career as elementary teachers. They had sufficient knowledge in all of the scales except for the NOS subscale with a 67.63% correct response rate. Interestingly, researchers in previous studies reported that pre-service teachers did not acquire adequate conceptions of the NOS (Cavas et al., 2013; Chin, 2005). Lederman (1992) summarized the reasons for the low understanding of the NOS:

> (a) science teachers do not possess adequate conceptions of the NOS, irrespective of instrument used to assess understanding; (b) techniques to improve teachers' conceptions have met with some success when they have included either historical aspects of scientific knowledge or direct attention to the NOS; (c) academic background variables are not significantly related to teachers' conception of the NOS. (p. 345)

Therefore, it is reasonable to suggest that the domains of the NOS require particular emphasis in pre-service teacher education programs.

With respect to the level of subject-specific self-efficacy among pre-service teachers, very little in the literature was found regarding this topic. However, one interesting finding is that in both science methods courses the participants had the highest self-efficacy in teaching biology and the lowest self-efficacy in teaching physics. These results are in agreement with Yilmaz-Tuzun's (2008) findings that pre-service elementary teachers had a higher self-efficacy level in teaching biology and earth science concepts than physics and chemistry concepts.

A possible explanation for the low self-efficacy in teaching physics and the high self-efficacy in teaching biology is the nature of this subject. Unlike biology, the main challenge of teaching physics concepts at the elementary level is the abstract nature of this knowledge. Elementary students are required to develop mental images of a complex subject that they have never observed first hand. This raises a challenge for teachers to find out how to present and explain such fundamental and abstract concepts such as circuits, conductors, insulators, series circuits, among others, which are essential to a basic understanding of physics concepts at the elementary level (Azaiza, Bar, & Galili, 2006). This explanation is in agreement with data obtained from the BAT, specifically the participants' response to the following question: "I believe that I am able to teach thoroughly the following concept: electrical energy." Only 20.8% of the pre-service elementary teachers "agreed" with this statement, and none of them picked the "strongly agree" response. This means that the TEP needs to empower pre-service elementary teachers with teaching strategies and methods that can help them overcome their low confidence level in teaching physics topics.

With respect to self-efficacy, many studies focused on pre-service teachers' self-efficacy in teaching science have applied the STEBI-B as a main indicator of pre-service teachers' self-efficacy levels. Researchers made major decisions and conclusions based on its results. One question that needs to be asked, however, is whether using the STEBI-B as a primary measurement is enough to adequately measure pre-service elementary teachers' self-efficacy levels?

In the current study, the results of the introductory science methods course indicated no significant difference between the participant's personal and subject-specific self-efficacy. This means that on both instruments that measured self-efficacy – STEBI-B for personal self-efficacy and BAT for subject-specific self-efficacy – the participants had the same moderate level of self-efficacy in teaching science. This implies that both instruments were able to measure the overall self-efficacy levels of the participants. A possible explanation for this might be that pre-service elementary teachers who have just begun the TEP have not had the opportunity to develop self-efficacy beliefs in teaching science.

What is surprising, however, were the results of the participants in the advanced science methods course. The results showed a significant difference between the participants' personal and subject-specific self-efficacy. A note of caution is due here when explaining the results, since the current study relied on quantitative data. However, a possible explanation is that the participants in the advanced course had experienced a significant number of science methods courses, science content courses, school observations, and field trips that allowed them to re-evaluate their confidence in teaching specific science concepts (i.e. physics, chemistry, biology, and earth science). By examining the BAT instrument, it can be seen that the instrument allows pre-service elementary teachers to document their challenges towards teaching specific science topics. Regarding the high self-efficacy levels reported by the participants in the STEBI-B, this may be due to the participants responding to the questions with a positive self-efficacy level in a certain science subject. For example, a participant may have a high self-efficacy level in teaching biology and earth science concepts and a low self-efficacy level in teaching physics and chemistry. Therefore, this participant may respond to the STEBI-B in either a positive or a negative way. These findings may help future researchers find new ways to address the level of self-efficacy among pre-service teachers that do not depend on one instrument to draw conclusions about self-efficacy.

Furthermore, the results of the Pearson product–moment correlation revealed a moderately positive relationship between scientific literacy and subject-specific self-efficacy among the participants in the advanced science methods course. The score on the Pearson product–moment correlation indicated that the pre-service elementary teachers with higher levels of scientific literacy had high subject-specific self-efficacy levels in teaching science, and the pre-service elementary teachers with low levels of scientific literacy had low levels of subject-specific self-efficacy.

To date, no study has been found that studied the relationship between scientific literacy and self-efficacy among pre-service teachers. However, if self-efficacy is considered a dimension of attitude, then these current results agree with the findings of other prior studies of scientific literacy and attitudes toward science. Cavas, P., Ozdem, Cavas, B., Cakiroglu and Ertepinar (2013) and Chin (2005) came to similar results when they examined the relationship between scientific literacy and attitudes toward science. They found that the pre-service teachers had a positive correlation among the participants in their study.

In future research, a mixed methods design is an appropriate approach. This approach will provide qualitative interpretations, such as providing reasons why participants exhibit certain scientific literacy and self-efficacy levels (e.g. high levels, low levels, or satisfactory levels).

In addition, this study could be expanded to other teacher preparation programs that prepare students to teach at the secondary level.

Conclusion

Pre-service teachers' scientific levels and self-efficacy in teaching science could have an effect on how pre-service teachers teach science. The teacher remains the most important element in providing high-quality and effective science education to the average student (Shamos, 1995). It is critical for pre-service elementary teachers to have high levels of scientific literacy and confidence in teaching science; therefore, universities are encouraged to help their students gain abilities and knowledge that will help them achieve this goal (Avery & Meyer, 2012; Bacanak & Gokdere, 2009).

The findings of this study have implications for teacher preparation programs. Specifically, pre-service elementary teachers at the end of the program (i.e. advanced pre-service teachers) should make sure that they are adequately prepared for the teaching profession. The findings of this study indicate that advanced pre-service elementary teachers have satisfactory scientific literacy levels. However, the evidence from this study suggests that an emphasis on the NOS domain is required in pre-service teaching education programs. In addition, the findings of this study indicate that advanced pre-service elementary teachers have low self-efficacy levels in teaching physics. Therefore, decision makers in TEP are encouraged to provide pre-service teachers with knowledge and skills on how to teach students the abstract concepts in physics. The finding also revealed a positive relationship between scientific literacy and self-efficacy among advanced pre-service elementary teachers. Therefore, curriculum designers in the TEP are encouraged to stress the dimension of scientific literacy in the curriculum, which may have a positive result on the pre-service teachers' confidence levels.

The findings of this study have implications for science education research. The current data highlight the importance of distinguishing between personal and subject-specific self-efficacy towards teaching science. The results of this study showed that there is a statistically significant difference between subject-specific self-efficacy (measured by the BAT) and personal self-efficacy (STEBI-B) among this sample of advanced pre-service teachers. Therefore, future research in self-efficacy is encouraged to consider the type of instrument used to measure pre-service teacher self-efficacy levels.

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