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Elementary Pre-service Teachers' Environmental Literacy and Views Toward Science, Technology, and Society (STS) Issues

The study explored elementary pre-service teachers' attitudes toward environmental and STS issues, their levels of environmental literacy and knowledge about STS, and their views about teaching environmental and STS issues.

A quick glance at our modern world reveals a deep interrelationship between science, technology, and society. Science and technology are increasingly influencing numerous aspects of contemporary life and are, in turn, affected by societal values and norms. In fact, it is estimated that more than 90% of all current societal issues are grounded in science and technology (Yager, 1987). Hickman, Patrick, and Bybee argue, "The success of individuals and their society is tied to the quality of their choice, which varies with the knowledge and cognitive skills of decision makers." Furthermore, he argues that the success of democracies hinge upon the "ability of citizens to think effectively about developments in science and technology and their effects on the world" (1987, p. 5). It is therefore imperative that citizens understand the interconnections between science, technology, and society and take an active and responsible role in the decision making processes related to the social application of science and technology. Many individuals remain poorly equipped to deal with multifaceted societal issues that are intertwined with science and technology (Cheek, 1992).

Achieving scientific literacy involves educating students about complex social issues and their underlying scientific and technological principles.

Cognizant of the urgent need for scientific literacy in various arenas including the workforce, scientific literacy for all students has become the centerpiece of science education reform movements for the past several decades and has been touted by major reform documents such as the National Science Education Standards (National Research Council [NRC], 1996). Boyer argued that there is a definite place in the core curriculum for the interconnections between science, technology, and society "because these relationships are among the most important ideas, experiences and traditions common to all of us" (1983, p. 302). Achieving scientific literacy involves educating students about complex social issues and their underlying scientific and technological principles. Hence, learning science in its social context is vital to the success of science education reform.

The Science-Technology-Society (STS) movement flourished in the late seventies and early eighties in an effort to tackle the societal concerns of the time which demanded, as Hofstein and Yager argued, "a different kind of science curriculum" (1982, p. 540). Such issues as overpopulation, various types of pollution, dangers of nuclear proliferation, and shortage of water and other natural resources continue to cause concern and stir debates on all sides. The STS movement aimed to address the need to develop a scientific literate society by providing students with real-world connections between the classroom and society and a richer understanding of societal issues whose root causes or solutions can be found in science and technology. STS curricula have been designed to help students develop skills that will enable them to be responsible citizens who are able to make educated and well-informed decisions.

Not surprisingly, in 1982, the NSTA position statement called for STS as a new emphasis in K-12 science education and recommended dedicating 15-20% of science instruction to STS issues (Yager & Roy, 1993). The STS framework is based on an interdisciplinary constructivist philosophy that promotes the genuine and active engagement of students in the learning process. According to Yager, the process should "give the students practice in identifying potential problems, collecting data with regard to the problem, considering alternative solutions, and considering the consequences based on a particular decision" (1990, pp. 198-200). The STS approach allows the development of particular skills needed to address a wide range of social and technological endeavors (Bybee, 1987) and, consequently, promotes social responsibility and active engagement (Aikenhead, 1984). The STS curriculum focuses on the reciprocal relationships between social, political, and cultural values and scientific research and technological innovations.

The aforementioned complex interactions between science, technology, and society have generated numerous societal issues which are the foci of the STS curriculum framework. Examples of STS issues include pollution, deforestation, global warming, energy depletion, genetic engineering, stem cell research, biological and chemical warfare, and nuclear and toxic waste disposal. It is important to note that all environmental issues are STS issues, but not all STS issues are environmental. In fact, the STS curricula have been significantly influenced by the Environmental Education (EE) curricula, which also aim to produce a responsible citizenry. The goal of EE is environmental literacy, which is defined by Roth as "essentially the degree of our capacity to perceive and interpret the relative health of environmental systems and to take appropriate action to maintain, restore, or improve the health of those systems" (1992, p. 14). This echoes an earlier and well documented claim by Stapp (1969) that the goal of environmental education is to create a citizenry that is well-informed about the biophysical environment and its related problems, conscious of ways to help solve those issues, and motivated to work toward the resolution of these issues. The various definitions of the term environmental literacy include several overlapping and related dimensions: environmental sensitivity, knowledge, skills, attitudes and values, personal investment and responsibility, and active invo1vement (Disinger & Roth, 1992). The aim of STS education is to enhance students' scientific and environmental literacy in an effort to bring about changes in personal perception and public policies and, ultimately, to bring about the resolution of STS issues.

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Prior studies have suggested a multitude of benefits brought about through STS education, including the development and promotion of scientific "habits of mind" (Hungerford & Volk, 1990; Roth, 1992), positive attitude toward science, increased interest in learning (Yager & Penick, 1991), decision making skills, creativity, and overall science process skills (National Science Teachers Association [NSTA], 1990; Yager, 1989). STS curriculum components encourage students to gain experience in "identifying potential problems, collecting data with regards to the problem, considering alternative solutions, and the consequences based on a particular decision" (Yager, 1990). Similarly, Zoller argues that the STS-oriented approach fosters critical thinking as students become "experts at problem solving, asking questioning, and drawing conclusions based on their interpretation of the societal events" (1992, pp. 289-290). Brunkhorst and Yager (1990) also suggest that STS programs promote higher order thinking skills. STS issues are motivating and thought provoking, and STS education provides students opportunities to 1) interact with their peers, teachers, school, and community, 2) apply their knowledge to real world situations (Yager, Mackinnu, & Blunk, 1992), and 3) experience science outside classroom boundaries.

However, despite the numerous benefits STS education offers, it has, regrettably, not been as widely embraced as originally anticipated. One possible explanation is that teachers are inadequately trained to address science in its social context, and this is due, in part, to the fact that STS education simply does not "fit with the way education is now structured and presented" (Hausbeck, Milbrath, & Enright, 1992, pp. 32-33). Hence, a logical precursor to the implementation of STS education is to better prepare teachers to adopt this type of science instruction. Teachers are crucial change agents whose classroom practices are immensely influenced by their beliefs (Rubba, 1991). Furthermore, teachers' beliefs have been demonstrated to extensively impact the success of science education reforms in the classroom. Therefore, as Rubba (1991) argues, the development and implementation of an STS curriculum necessitates compatibility between teachers' beliefs and the goals of STS education. Consequently, it is imperative that teacher training involves ample opportunity for teachers to examine their beliefs and confront possible inconsistencies in their beliefs.

Although there have been a number of studies that have explored secondary in-service and pre-service teachers' beliefs about STS education, levels of environmental literacy, attitudes toward teaching STS or environmental issues, and/or the impact of teacher education programs on teacher beliefs and attitudes, studies involving elementary pre-service teachers are extremely scarce. In an effort to begin to bridge this gap in the literature, the current study was initiated to serve as a descriptive exploratory field test for a subsequent study that intends to examine the impact that a STS-oriented science methods course has on pre-service elementary teachers' level of environmental literacy, their views and perceptions toward STS issues, and the instruction of such issues in their classrooms. The aim of the current study was to gain a better understanding of elementary pre-service teachers' attitudes toward environmental and STS issues, their levels of environmental literacy and knowledge about STS, and their views about teaching environmental and STS issues to their prospective students.

Methodology

Sample

This pilot study, which took place at a large Midwestern university in the spring of 2006, is intended to serve as a prelude to a larger study that focuses on the impact of a STS-oriented science methods course on elementary pre-service teachers' environmental literacy and views and perceptions regarding STS issues and instructions. Therefore, it was the intention of the current study to explore the abovementioned factors in this particular population of pre-service teachers to ascertain whether such intervention was necessary. The sample consisted of two sections of the elementary science methods course (n = 41) that were conveniently selected based on the author's and course instructors' schedules. This course was the only science methods course in which elementary education candidates were required to enroll as part of the program. The prerequisite to this course was an introductory science content course especially designed for elementary education majors focusing on scientific inquiry and basic elementary science concepts. Some students had also enrolled in one or both of the science content courses (physics and biology) required for elementary education candidates concurrent with their enrollment in the science methods course. The demographic survey at the beginning of one of the two instruments that were administered revealed several possibly relevant features of this group (summarized in Figures 1-3). The majority of the participants were female (85%), Caucasian students from suburban communities who were completing their last year in the program.

Figure 1: Participants' Residential Communities

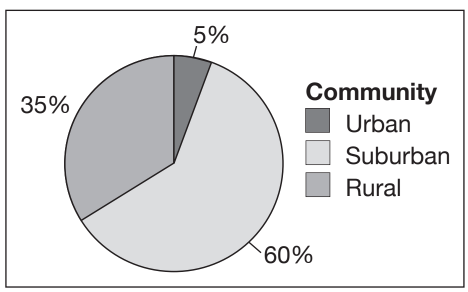


Figure 2: Participants' Racial Backgrounds

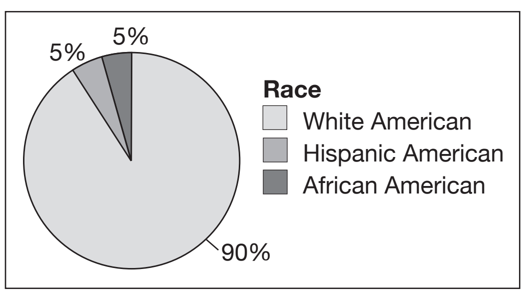
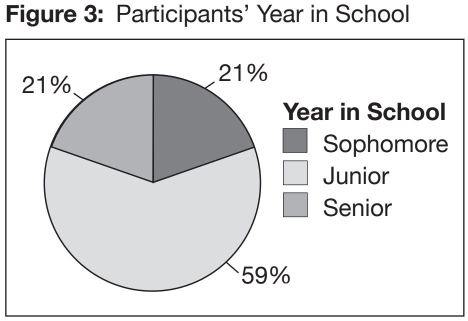


Figure 3: Participants' Year in School



Data Collection

Data collection consisted of the administration of two separate instruments toward the end of the spring semester. The first survey, the Environmental Literacy Instrument

(ELI-7th edition), was developed by Wilke, Hungerford, Volk, and Bluhm (1995) and measures seven subscales: Issue Familiarity, Perceived Knowledge, Perceived Skills, Personal Action History, Issue Identification, Issue Analysis, and Action Plan. Face and content validity for the ELI were established by a national panel of 19 science/environmental education professionals, including university professors, teacher educators, and non-formal professionals (Ngwidibah, 1997). The instruments' reliability measures, which were not reported in the original study, were determined in this current study and will be reported in the results section. The ELI begins with a section that deals with demographics and familial/personal environmental sensitivity indicators.

The main body of the ELI consists of two major tests labeled Test One and Test Two, respectively, plus 12 subsections (see Table 1).

The second instrument, The Perception of STS Issues (PSTSI), was developed by Jamuluddin (unpublished dissertation, 1990) and revised by Ngwidibah (1997). It measures participants' perception of STS issues and the teaching of such issues to elementary students. The Perception of STS Issues (PSTSI) instrument consists of two parts, each containing four questions that utilize a five point Likert Scale (0 = "to no extent"; 4 = "to a great extent"). Part 1, "You and STS Issues", asks participants to answer questions related to: 1) their views regarding the importance of understanding STS issues, 2) their personal interest in understanding STS issues, 3) their perceptions of their own skills to investigate and evaluate STS issues, and 4) their perceptions of their own skills to help resolve STS issues. Questions in part 2, "Teaching STS to Children in Elementary School", focus on: 1) participants' belief about the importance of elementary school students' understanding of STS issues, 2) their willingness to teach elementary school students to understand STS issues, 3) perceptions about their ability to teach elementary school students to investigate and evaluate STS issues, and 4) perceptions about their ability to teach them how to resolve STS issues.

The reliability of the scoring protocol had been established using the inter-rater reliability method of three-way scoring procedure based on random selection of 10 responses from Part I. The original study reported Pearson Correlation Coefficients of .98, .97, and .92 (Ngwidibah, 1997)

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which correspond to coefficient of determination (r^2) values of .96, .94, and .85 that indicate high level of consistency among the three scorers.

Data Analysis and Results

The different sections of the instruments were scored by the author and a second scorer based on the rubric provided in the instruments (Appendix A). The Cronbach's Alpha for the entire ELI instrument was determined to be 0.75. Because each of the subscales consists of only one item, the reliability for individual subscales cannot be reported. However, since tests 2.1 and 2.2 each consists of three subscales Cronbach's Alpha scores are reported for these two tests as 0.59 and 0.63 respectively. Descriptive statistical analysis, including measures of central tendency, measures of dispersion, and frequency distribution, for the two total scores (ELI & STS totals) were performed and will be discussed in this section.

Table 2 summarizes the results of the ELI. The maximum and minimum scores, the mean, and standard deviation for each of the seven subsections as well as the total score for the entire survey are reported. Due to the lack of similar studies in the literature, the maximum

Table 1: Environmental Literacy Instrument (ELI) sections and scoring rubric

Title	Focus/ Measured Variables	Scale	Maximum Score
Test 1: The Issues with Which I am Familiar [Issue Awareness]	Familiarity with environmental/STS issues	0-4 point each	24
Test 2.1 How I feel About Things and What I Do about Things	Perceived knowledge	0-4	16
	Perceived skill	0-4	16
	Self-reported actions	0-5	140
Test 2.2 [Issue Analysis & Citizenship Action]	Issue Identification	0-6	6
	Issue Analysis	0-16	16
	Citizen Action Skills	0-20	20

Table 2: Results of the ELI Instrument

	Maximum possible score	Minimum score	Maximum score	Mean	Standard deviation
Issue Familiarity	24	0	16	3.27	3.362
Perceived Knowledge	15	0	10	5.22	2.253
Perceived Skills	15	0	11	4.78	2.715
Personal Action	140	5	59	25.53	12.743
History Issue	15	0	5	4.29	2.251
Identification Issue	15	0	15	8.24	7.003
Analysis Action Plan	20	0	20	11.75	5.350
Grand Total for ELI	238	16	100	63.68	19.150

possible scores for each section and the entire instrument served as a point of reference in the interpretation of the data. The data indicate low scores on all subsections and the overall instrument. The mean scores were incredibly low for the first five sections: Issue Familiarity (M=3.27, SD=3.362), Perceived Knowledge (M=5.22, SD=2.25), Perceived Skills (M=4.78, SD= 2.715), Personal Action History (M=25.53, SD=12.74), and Issue Identification (M=4.29, SD=2.25) and failed to reach even one half of the total possible score for each respective section. Participants' mean scores on the last two sections, Issue Analysis (M= 8.24, SD=7.00), and Action Plan (M=11.75, SD=5.35) fared better than the aforementioned ones and slightly exceeded 50% of the total possible score for these sections. These sections differed from the first five in that they either provided participants choices to select from or background stories that they could read and extract necessary information from. These differences might serve as a possible explanation for the higher scores on these sections than the other sections. The mean grand total score for the ELI instrument (M=63.68, SD=19.15) failed to reach even one third of the total possible score. The maximum score of 100, obtained by only one participant, was still considerably lower than the total possible score of 230.

Figure 4 provides a visual of the frequency distribution of the Grand Total ELI scores. Most participants scored between 60 and 90 on this instrument. These scores indicate that the results are skewed to the left.

Figure 4: Frequency Distribution of the Grand Total ELI Scores

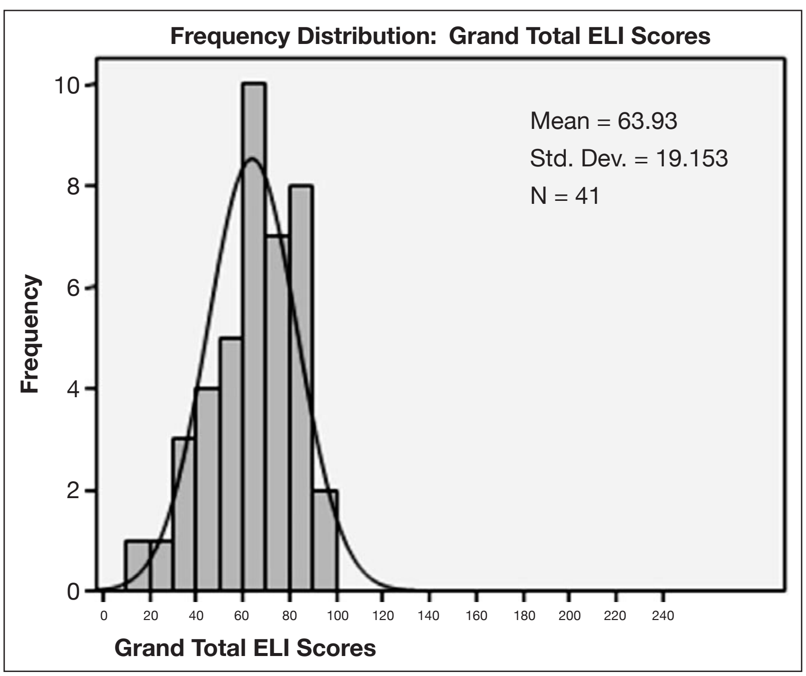


Table 3 indicates the results of the PSTS survey. Similar to the ELI instrument, the data for this instrument were also interpreted based on the maximum possible scores. However, a quick glance at the data from the two instruments reveals that the participant scores on this instrument were comparatively better than the ELI scores. For example, the grand total mean score (M=15.32, SD=5.25) for this instrument was found to approximate 50% of the total possible score of 32. Figure 5 shows the frequency distribution of the Grand Total scores for the PSTS instrument. The frequency distribution of participants' scores on this instrument is not as skewed as the other instrument. The majority of the scores fell between 10 and 22. Their overall score for the perceptions of teaching STS in the classroom section [M=8.85 (55%)] was higher than the overall score for the section on personal views of STS [M=6.46 (40%)], which indicates that these teacher candidates had a more positive attitude toward *teaching* STS issues than toward personal awareness of these issues. The mean scores for the sections dealing with their views about the importance of understanding STS issues (M=2.27) and teaching students about

Table 3: Perceptions of STS & STS Teaching

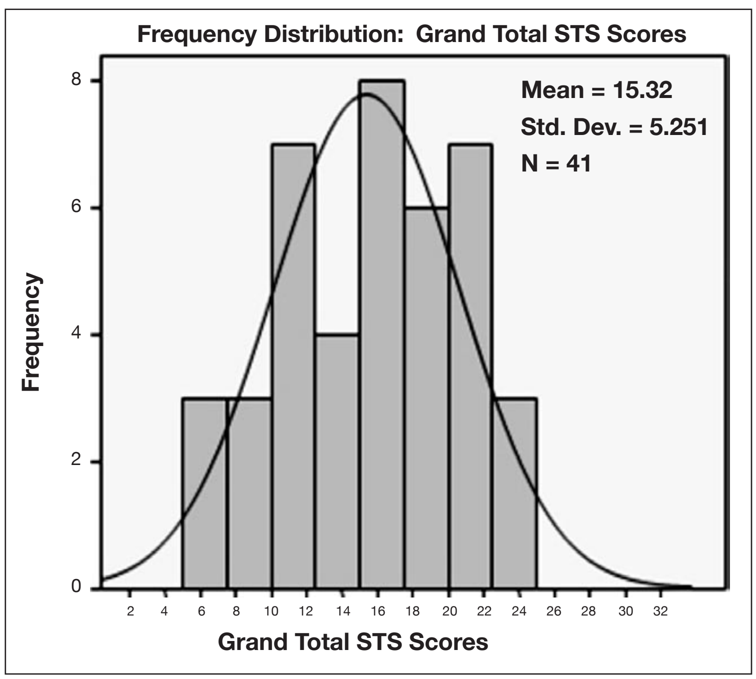
	Maximum possible score	Minimum score	Maximum score	Mean	Std. Deviation
STS Q1: Importance of Understanding STS issues	4	0	4	2.27	.923
STS Q2: Personal interest in understanding STS issues	4	0	3	1.56	.867
STS Q3: Skills to investigate & evaluate STS issues	4	0	3	1.39	.919
STS Q4: Skills to resolve STS issues	4	0	3	1.24	.734
STS Total	16	1	10	6.46	2.570
STS teaching Q1: Importance of knowledge of STS for elementary students	4	0	4	2.39	.972
STS teaching Q2: Willingness to teach STS to elementary students	4	0	4	2.44	.976
STS teaching Q3: Ability to teach elementary students to evaluate STS issues	4	0	4	2.10	.944
STS teaching Q4: Ability to teach elementary students to resolve STS issues	4	0	4	1.93	.959
STS teaching Total	16	0	16	8.85	3.461
Grand Total for STS Instrument	32	5	24	15.32	5.251

STS (M=2.39) as well as their willingness to teach STS (M=2.44) were the highest. Their personal interest in STS (M=1.56), perceptions of their skills to investigate STS issues (M=1.39), and perceptions of their skills to resolve STS issues (M=1.24) were the lowest scores.

Discussion and Implication

The results of this study indicated low levels of environmental literacy among this sample of elementary pre-service teachers. They were also indicative of low levels of personal interest in STS issues. The slightly better scores on the section of the PSTS instrument dealing with participants' views toward teaching STS in the classroom bode well and provide hope that if equipped with sufficient understanding of STS

Figure 5: Frequency Distribution of Grand Total PSTS Scores



and environmental issues and the STS instructional framework, these participants are willing and consider it important to teach their prospective students about these issues. Their low scores on the environmental literacy instrument and the STS section of the PSTS indicate that further training must be provided to augment elementary pre-service teachers' understanding of environmental and STS issues and enhance their own views about such issues. It is evident that their prior beliefs and understanding of such issues are not consistent with STS education reform. Teacher training programs must, therefore, allow prospective elementary teacher candidates the opportunity to critically reflect on their beliefs and knowledge regarding STS/EE issues and STS/EE education. Only when their beliefs are aligned with the STS-oriented framework of teaching science and their levels of environmental and STS literacy are enhanced can we expect prospective elementary education candidates to be willing and able to implement such instruction in their future classrooms.

There remain countless gaps in the literature on pre-service teachers' environmental literacy and views toward STS/EE. This is especially true for elementary pre-service teachers. Further research is necessary in several areas. First, there is a need for replication studies to further explore elementary pre-service teachers' environmental literacy and views toward STS issues and instruction. Second, possible factors affecting pre-service teachers' environmental literacy and beliefs about STS prior to entering teacher education programs must be explored. Third, factors within the teacher training programs that might influence prospective teachers' knowledge and beliefs in these areas must also be explored. The possible impact of STS-oriented science methods courses on teacher candidates' levels of environmental literacy and perceptions of STS demand significant attention. Furthermore, within such methods courses, factors that may lead to possible changes in participant beliefs and understanding should be explored to allow for replication of these types of courses in other programs. The aforementioned questions will be examined in the subsequent larger study following the pilot study. Finally, studies such as the current pilot study should be replicated in other geographical regions of the country with various groups of pre-service teachers to explore whether the same trends occur with other populations. Additionally, replication might enable science teacher educators to identify possible factors that influence teacher candidates' prior understanding and beliefs.

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