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The Impact of a Standards-Based Science Course for Preservice Elementary Teachers on Teacher Attitudes Toward Science Teaching

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Abstract

This study reports on the measured change in the attitude of students toward teaching science as a result of their experiences in an elementary activity-based science course for preservice elementary teachers. Overall, the students in this study showed a positive shift in attitude as measured by the Revised Science Attitude Scale instrument that was administered at the beginning and the end of the semester. When the researchers looked at specific subscales within the instrument, one of the four subscales did not show a statistically significant change in attitude. The course is required for all elementary preservice teachers.

Introduction

Student and teacher attitudes continue to be of interest to science education researchers for many reasons. Teacher attitudes have an influence on student attitudes toward science and, therefore, the science education community should pay greater attention to factors that positively impact teacher attitudes. Despite widespread calls for improved scientific literacy, science instruction in the elementary school continues to be a low priority (Appleton & Kindt, 2002; Ross & Mason, 2001). Science education research has consistently demonstrated a link between teacher beliefs and instruction (Hubbard & Abell, 2005). Haney, Czerniak, and Lumpe (1996) found that teachers' beliefs toward standards-based science instruction contributed significantly to behavioral intention. Beck, Czerniak, and Lumpe (2000) demonstrated the impact of teachers' beliefs on their intentions to implement constructivist science teaching strategies. A study showing a link between beliefs and practice includes a case study done by Smith (2003). More evidence for this concern about teacher attitudes toward science and science teaching comes from the identification of factors that influence the type and amount of science instruction in classrooms (Smith & Gess-Newsome, 2004). Factors, both internal and external have been identified as directly linked to teacher attitudes (Hone, 1970). Koballa and Crawley (1985) identified attitude itself as an obstacle to effectively teaching science. Based on past and current research, the importance of cultivating student and teacher attitudes remains vital to the basic framework of science curricula and pedagogy. Haney et al. (1996) suggest that preservice teacher education programs may be the best time for students to gain experiences that develop favorable beliefs about the nature of science teaching.

National reform documents have called for changes in elementary science teaching that in turn require subsequent changes in the preparation of science teachers (NRC, 1996). One suggested change calls for science courses that combine content and methods (NRC, 1996; Prestt, 1982; Yager & Penick, 1990). Other recommended changes include experience with a variety of teaching experiences (Lunetta, 1975; Sunal, 1980) along with an emphasis on improving science teachers' attitudes regarding science teaching (Cox & Carpenter, 1989). Richardson (1996) claimed that beliefs must be a focus for preservice instruction because teachers' incoming beliefs strongly influence what and how they learn. Brown and Borko (1992) emphasize the importance of teacher preparation programs when stating their belief that teachers teach as they are taught.

Tosun (2000) found that preservice teachers bring their negative attitudes toward science into their teacher preparation program. Without reform, these beliefs can only be enforced by a traditional undergraduate science course in which students may spend as many as 100 hours in what Stuart and Thurlow (2000) call an apprenticeship of observation. These traditional courses tend to reinforce insecurities held by preservice teachers (Stevens & Wenner, 1996, Watters & Ginns, 2000). Research has also found that "the typical experience in college science courses has not fostered meaningful learning in science nor the development of favorable attitudes toward science or science teaching among entering elementary education students" (Briscoe, Peters, & O'Brien, 1993, p. 3). Research by Morrell and Carroll (2003) reported that the nine credits of traditional science courses their students completed resulted in no significant positive change of students' attitudes toward science teaching.

Changes are being made in science teacher preparation programs including changes in the sequence of courses, the amount of time and emphasis spent on various components of programs, and the courses themselves. Primarily, course changes can be grouped as changes in science methods courses, changes in field experience courses, and changes in science content courses. The impact of these three areas on teacher content understanding, attitude, and teacher practice has been examined (Butts, Koballa, and Elliott, 1997, Eiriksson, 1997; Spector & Strong, 2001; Stuart & Thurlow, 2000). Science teachers have reported that field or school experiences are the most beneficial segments of teacher education programs (Guyton & McIntyre, 1990). When teachers leave the university to learn the work of real teaching, however, they bring along "cognitive baggage," specific ideas of what teaching and learning should be based on their own educational experiences learning science (Dana, 1991). This would suggest a need to look much more closely at what the science learning experiences are like and the impact of these experiences on teacher knowledge, attitudes, and efficacy.

Three basic types of science experiences appear to be currently available to preservice elementary teachers: (1) science courses designed for science majors, (2) general education science courses, and (3) science courses specifically developed for elementary education majors. This final group seems to be the smallest group, but it appears to be increasing in number (McLaughlin & Dana, 1999) with the realization that elementary teachers respond better to learning science content when it is set within a context of teaching and learning. No clear pattern emerges as to the specific nature of these special science courses for elementary teachers, but research into the impact of these courses is beginning to appear. Research by Morrell and Carroll (2003) reports that the new course they examined had no impact on science teaching attitude in preservice teachers.

Loucks-Horsley, Schmidt, and Raizen (1989) suggests that exemplary science courses would teach science in an investigative manner emphasizing the central concepts and tools of inquiry unique to the discipline. These courses would adopt a less-is-more emphasis and be developed by teams of scientists and educators. McLoughlin and Dana (1999) reported on their investigation of a course with the features Loucks-Horsley et al. (1989) described. They found that when concepts were framed within a context of science and pedagogy, student learning was most meaningful. The participants felt more confident about their abilities to be teachers of science and successfully use activities in future classrooms. Hall (1992) and Kramer (1979, 1988) found similar positive attitudes toward teaching science in a biology course specifically developed for elementary teachers. The course reported on by Hall and Kramer was a previous version of the course discussed in this study, with a specific focus on biology.

Other recent studies on the impact of science courses for elementary teachers include the study of an introductory biology course that changed the laboratory portion of the class to reflect the pedagogical and curricular needs of the teachers. Reisert and Kielbasa (1999) were able to demonstrate improved appreciation for science and the likelihood of teaching science with a hands-on strategy after completion of their course. Weld and Funk (2005) found that an Inquiry into Life Science course for elementary education majors found significant growth in self perceptions of effectiveness as a biology teacher, subject matter command, curriculum development competence, and pedagogical skills. Examination of a physical science course by Fones, Wagner, and Caldwell (1999) found growth in participants' confidence to teach physical science. Hubbard and Abell (2005) also report the positive impact of an inquiry-based physical science course on students enrolled in a science methods course.

Purpose

The purpose of this study was to extend the previous studies on the impact of an experiential biology course on the attitudes of preservice elementary teachers completed by Hall (1992) and Kramer (1979, 1988). While their findings showed a significant positive change in the attitude of students toward teaching science as a result of the biology course, new research was needed on the current version of the course due to significant course changes that resulted from a change in state licensure standards and a change in the elementary education program at the university. As a result of licensure and program changes, more content topics from all areas of science are now included in a single course, Science 226. This course is currently required of all elementary education majors at the institution.

Course and Program Description

The university recently changed from a quarter to semester base, and with this change, the number of credits available to individual programs and departments was decreased. The approval of new state licensure standards at about the same time led to significant changes in the elementary education program. These changes resulted in a reduction in the number of specific elementary education science courses available to our students from two, three-credit quarter courses to one, three-credit semester course. Rather than completing one life science course and one physical science course, students now complete a single course addressing concepts in the life, earth, and physical sciences. A drop in credits did not reduce the students' weekly contact time in the course, which remained at four hours per week.

The above changes did result in the development of a new course, Science 226, jointly designed by science educators and science specialists in the College of Science and Engineering. The course topics were drawn from the NSES (NRC, 1996) standards for K-4, and the course instruction followed the recommendations made by the NSES teaching standards. The course is experientially based with instruction on a topic routinely beginning with first-hand student experiences followed by class discussion, additional experiences, and further discussion and activities on related subtopics. Class size is limited to 24 students who work in teams of four. Communication and student interaction is encouraged throughout the semester. Activities are drawn from STC, Insights, and FOSS. A majority of the student field experiences begin with FOSS, as this is the most commonly used kit series associated with local schools. Instruction emphasizes the science teacher content needed to implement the activity, but discussion also focuses on safety, methodology, and information that students will need in order to obtain, organize, and maintain classrooms and materials for the teaching of science. Student assignments require a full inquiry on phenology along with investigations into journals and web-based teacher resources associated with science. Assessments are performance- and paper-based. Student comments typically identify this course as the best science course they have ever taken. In addition to this course required of all elementary majors, students are also allowed to select from a variety of general education science courses for six additional credits. Recent changes in the elementary education program will soon allow us to once again require two three-credit special elementary science courses for preservice teachers. This change also suggests the importance of examining the current course so that information obtained through research can be used in the design of the new course.

Research Study Design and Methodology

The science course used in this study is designed and taught to help students gain valuable knowledge that they can apply in later situations as professionals or in their daily lives. The assessment of student achievement is most often measured through paper-and-pencil instruments that assess the extent of the knowledge gained. Attitudes of the students are often not a part of the assessment formula in many courses. In this study, the researchers were interested in the attitudes toward teaching science of the preservice elementary students. The Revised Science Attitude Scale (Thompson & Shrigley, 1986) was used as a pre and post instrument in this study to measure the impact of the Science 226 course on the attitudes toward teaching science. The instrument was given to a total of 118 students in each of the course sections at the beginning of the 15-week semester course and again at the end of the course. All students were encouraged to fill out the instrument to the best of their ability. Students were assured that their responses would not be shared with their instructors. The researchers were able to match the pre and the post instruments, and SPSS was utilized for computing the statistics.

The Instrument

The Revised Science Attitude Scale (Thompson & Shrigley, 1986) was developed to measure preservice teachers' attitudes toward science teaching. The revised version is a Likert-type instrument that was devised to improve the content and construct validity of the original instrument. The instrument consists of 12 positive and 10 negative statements to which students respond by choosing one of five Likert intervals.

The 22 attitude statements are grouped into four general subscales. Nine items represent the major subscale, ease and comfort of teaching science. Five items represent the need for science; five items represent science equipment; and the final three items address the time needed to teach science. The internal consistency reliability for the entire scale is 0.89. Subcomponent alpha values range from 0.63 to 0.73, with subcomponent r-values ranging from 0.46 to 0.73. Thompson and Shrigley (1986) identify this instrument to be reasonably valid and reliable for use with preservice teachers to determine their attitudes toward teaching science. This instrument was selected because it had been used by researchers to examine previous versions of the course.

Description of Students and Instructors

The 120 students participating in this study were preservice elementary education students. The participants were enrolled in the Science 226 course, the blended science content and pedagogy course that all elementary preservice teachers take. There were 95 female and 14 male students who participated in this study, and they were all at the beginning of the university's elementary education program. The students' experiences in previous science courses varied widely. The mean number of science courses taken prior to this course was six for the female students and five for the male students.

The Science 226 course was taught by instructors from the Departments of Biology, Earth Science, and Chemistry in the College of Science and Engineering. Their backgrounds ranged from a bachelor's degree in a specific science discipline to a PhD. They had majored in biology, chemistry, or earth science. Two of the instructors have K-12 teaching experience, and all instructors hold PhDs in Geology, Hydrology, and/or Curriculum and Instruction. Teaching strategies, teacher behaviors, and classroom environment are given careful attention throughout the course in order to promote learning, develop an understanding of the nature of science, and create a positive classroom environment. For example, when contradictory observations are made during an activity, the focus is first on differences in procedure or other factors like the definition of a variable rather than student error. The instructors believe that this strategy improves student attitude and also models the reality of scientific investigation. All of the instructors are active in science education at the state level, and they all work as a team to improve both their teaching and content knowledge. The instructors meet weekly as a group to discuss the course content and coordinate the activities used in the Science 226 course.

Results

For this study, matched pairs were analyzed. The means were calculated using a five-point Likert-type frequency response scale, which included the following choices: strongly agree (1 point), agree (2 points), undecided (3 points), disagree (4 points), and strongly disagree (5 points). A score of 22 to 110 would be possible for all 22 items of the instrument. For all negatively worded items, the numerical score was reversed. This was true for items 1, 3, 4, 6, 9, 11, 14, 17, 20, and 21. This data is presented for all of the items of the instrument in Table 1.

Comparison of the pretest and posttest mean scores showed that 19 of the items showed a positive shift, and 3 items (numbers 8, 11, and 13) showed a small negative shift. Posttest mean scores overall had a positive shift.

Table 1. Mean Pretest and Posttest Scores for Each Attitude Item

Item	Statements	Subscale*	Mean Pretest Score	Mean Posttest Score
1.	I will feel uncomfortable teaching science.	I	2.59	2.56
2.	The teaching of science processes is important in the elementary classroom.	II	1.62	1.60
3.	I fear that I will be unable to teach science adequately.	I	2.47	2.07
4.	Teaching science takes too much time.	IV	1.91	1.69
5.	I will enjoy the lab period in the science courses that I teach.	III	1.95	1.86
6.	I have a difficult time understanding science.	I	2.53	2.17
7.	I feel comfortable with the science content in the elementary science curriculum.	I	2.34	1.92
8.	I would be interested in working in an experimental elementary science classroom.	II	2.42	2.45
9.	I dread teaching science.	I	2.15	1.83
10.	I am not afraid to demonstrate science phenomena in the classroom.	III	2.39	2.12
11.	I am not looking forward to teaching science in my elementary classroom.	I	2.48	2.49
12.	I will enjoy helping students construct science equipment.	III	1.83	1.77
13.	I am willing to spend time setting up equipment for a lab.	IV	1.73	1.77
14.	I am afraid that students will ask me questions that I cannot answer.	I	2.83	2.42
15.	Science is as important as the 3 Rs.	II	2.03	1.90
16.	I enjoy manipulating science equipment.	III	2.32	2.12
17.	In the classroom, I fear science experiments won't turn out as expected.	III	2.61	2.34
18.	Science would be one of my preferred subjects to teach, if given a choice.	I	2.98	2.68
19.	I hope to be able to excite my students about science.	I	1.58	1.53
20.	Teaching science takes too much effort.	IV	1.83	1.67
21.	Children are not curious about scientific matter.	II	1.54	1.46
22.	I plan to integrate science into other subject areas.	II	1.92	1.85

I – Ease and comfort, **II** – Need for science, **III** – Science equipment, **IV** – Time to teach

T-tests were then performed to detect the presence of significant differences between the means of the pre- and posttest scores on the Revised Attitude Instrument. For the overall instrument, including all four subscales, a significant change was recorded for the 120 students, with a t score of 3.898, with p=.000. This data is presented in Table 2.

Table 2. Paired Sample T-Test for Overall Pretest and Posttest of the Attitude Instrument

Overall	Mean	SD	T	df	Sig. (P value)
Pretest and Posttest	4.101	11.475	3.898	118	.000

For this study, t-tests were performed to detect the presence of significant differences between the means of the pretest and posttest scores for each of the subscales on the Revised Attitude Instrument. For the Ease and Comfort subscale, a significant change was reported for the 120 students (t of 4.30, p=.000); for the Need for Science subscale, a significant change was not reported for the 120 students (t of 1.057, p=.293); for the Science Equipment subscale, a significant change was reported for the 120 students (t of 2.816, p=.006); and finally, for the Time to Teach subscale, a significant change was reported for the 120 students (t of 2.179, p=.031). This data is presented in Table 3.

Table 3. Paired Sample T-Test for Subscales of the Attitude Instrument

Subscale	Mean	SD	t	df	Sig. (P value)
Ease and Comfort	2.308	5.786	4.370	119	.000
Need for Science	.294	3.035	1.057	118	.293
Science Equipment	.892	3.468	2.816	119	.006
Time to Teach	.342	1.717	2.179	119	.031

Discussion

The results of this study showed that there were overall positive changes made in the preservice students' attitudes at the end of the semester-long Science 226 course. When a paired sample t-test was conducted on each subscale, three of the four subscales (Ease and Comfort, Science Equipment, Time to Teach) showed a positive change in attitude in the students at a significant level, while one of the subscales (Need for Science) did not show a change in the attitude of the students at a significant level. It can be said of these students that after taking the Science 226 course, they generally had a shift toward an attitude of agreement for all subscales, even though one subscale (Need for Science) did not show a significance of $<.05$.

Despite the fact that three of the four subscales shifted towards a more positive attitude, the students in this study surprised the researchers with responses to three individual items. These three items that indicated a slight negative shift in the students' attitudes were spread across three of the four subscales. The students indicated in the Ease and Comfort subscale that they generally improved their attitude concerning their comfort with teaching science, but there was a small negative .01 shift in the mean for item number 11., which states "I am not looking forward to teaching science in my elementary classroom." In searching for a reason for this result, it was noted that these students responded as generally having no difficulty in understanding the science, that they felt comfortable with the content in the elementary curriculum, and that they felt comfortable teaching science. These students gave overall positive responses in the subscales of Science Equipment and Time to Teach. These results concerning confidence in their ability to be teachers of science and their ability to successfully use activities support the findings of those researchers who looked at specialty courses developed for elementary preservice teachers (Hall, 1992; Kramer, 1979, 1988; McLoughlin, & Dana, 1999). The researchers believe that a very slight shift to a more negative attitude for item 11. may relate to the amount of time these students see is required by the faculty to prepare, organize, and maintain the materials needed to teach hands-on science in the classroom.

To support the above statement, we can look at the Time to Teach subscale, item 13., which indicated that the students are not willing to spend the time setting up equipment for a lab, even though they showed a positive shift when responding to other items that teaching science does not take too much time or too much effort. It may be that the setting up or time allotted for activity preparation has a negative effect on their attitude toward teaching experimental science. Even though the students generally believe science activities are necessary, they are not convinced they want to spend the time needed to prepare for those activities.

The Need for Science subscale did not have a significant positive attitude shift, even though four out of five of the individual statements within the subscale showed a slight positive shift. Item 8., which states, "I would be interested in working in an experimental elementary science classroom" showed a slight (.03) negative shift. The students indicated that they do not fear that science experiments will not turn out as expected, that they are not afraid that the students will ask questions that they are unable to answer, that they feel comfortable with science content, and that they will enjoy the lab period in the science courses that they teach. These results seem somewhat contradictory; if none of the above statements cause concern for these students, why are they not interested in working in an experimental science classroom? If time spent setting up an experimental activity-based classroom is the underlying issue for these students, that would be supported by previous research and the common belief among many teachers who say that time is a reason that teachers choose not to do experimental science. For these students, it may be the time involved for setting up the experiments that makes working in an experimental classroom unsatisfactory. Further investigation is needed concerning the students' feelings about working in an experimental classroom, and future research will require structured interviews with students to determine more specifically the reasons for their responses to individual statements in the instrument.

One important implication for the instructors of this course is the notion of the time it takes to set up, complete, and discuss classroom investigations. It may be that the university instructors not only must model the setting up and discussions necessary in an experimental activities course as is currently being done but also emphasize the importance of spending the extra time that it takes to make experimental classrooms effective. The importance of the time it takes to effectively conduct classroom investigations must be made absolutely clear to the preservice teachers, so they can take this belief and experience into the field when they begin teaching. There is only a limited amount of time available to all teachers, and being comfortable and confident in allotting the time necessary to conduct experimental classroom activities is vital if teachers are indeed expected to effectively manage experimental activities in their classrooms.

Although the absolute differences in the means between the pretest and the posttest is small, it is encouraging to see a positive shift of attitude in three of the subscales (Ease and Comfort, Science Equipment, and Time to Teach). The Science 226 blended course is designed to involve the preservice teacher in activities and investigations as well encourage a positive attitude toward science and the teaching of science. The researchers can utilize the results for each item of the instrument from Table 1 to determine what changes might be made during the course to put more emphasis on particular areas that showed little or no shift toward a more positive attitude. Based on this research, the instructors are now aware of the student beliefs that showed small negative shifts, allowing the instructors to focus on these particular student beliefs during the course.

Recommendations and Implications

Researchers must design studies and collect data that is useful and important for the profession. Perhaps more importantly, once a study is completed and the data is reported, how does that study influence current practice? This study should be viewed as a positive sign that the Science 226 course is meeting some of the stated goals, specifically that students will leave the course with a positive attitude toward science and the teaching of science. It is the intent of the researchers to pursue further investigation into how the course succeeds in making these attitude changes. By utilizing a qualitative interview of selected students, in conjunction with the current instrument, it is hoped that a more specific assessment of why and how these changes in attitude are taking place will be conducted. It may be possible to make more specific recommendations for significant changes in science courses once more information is known. These recommendations would go beyond the existing recommendation that the course instructors should constantly and consistently discuss the need for teachers of science to plan sufficient time for experimental classroom investigations and be confident that the extra time planned is pedagogically sound. The goal of the researchers in this study is to improve the Science 226 course to help preservice elementary science teachers enter the field of teaching with a more positive attitude. It is also the intent of the researchers to follow this study with continued assessment of the attitude and efficacy of these preservice teachers in other courses in the program and into their teaching careers.

Future Research

An area worth future investigation is the discrepancy between previous research on the special science for elementary teacher courses that showed overall positive change in all four subscales. Obvious differences between this course and previous course versions reported on by Kramer (1979) and Hall (1992) include a change in science content emphasis from only biology to all science disciplines and an increase in the number of content topics addressed by the course. In addition, there were multiple instructors involved in this study, with two instructors not having an advanced degree in science education and/or K-12 teaching experience. Future research can investigate the latest version of Science 226 and try to discern the impact of having the disciplines split more clearly into two courses, with life science separate from earth and physical science. In addition, it would be valuable to evaluate the impact of a change in the number of concepts studied in a course on student attitude.

An additional area of research interest relates to the impact of students' previous science courses on their initial attitudes toward science and about their understanding about the nature of science. This would involve the use of additional instruments and follow-up interviews. The researchers in this study tried to separate the students on the type and number of previous science coursework, but the results were unclear, and improvement in the way this data is collected and recorded is underway. Another area of interest is the analysis of classroom data based on teacher characteristics. This avenue of research may provide evidence for the impact of instructor characteristics on the students' attitude toward teaching science. What role does the instructor play in influencing attitudes toward teaching science in a preservice elementary blended science course?

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