Background Research Paper No. 20

Early Science Teaching Experiences in a Campus-based Hands-on Lab Increases Confidence and Capacity of Undergraduates for Teaching Science

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Paper presented at the NSEUS national conference on Research Based Undergraduate Science Teaching: Investigating Reform in Classrooms, Bryant Conference Center, University of Alabama, Tuscaloosa AL June 19-21, 2011

There is general agreement among educators, as expressed in the Taking Science To School report from the Committee on Science Learning: Kindergarten Through Eighth Grade, that improvements in science education in the United States in the last 15 years have lagged in comparison to students in other countries (National Research Council [NRC], 2007). This committee states that teachers need “opportunities to learn how to teach science as an integrated body of knowledge and practice – to teach for scientific proficiency.” The committee also recommends that teachers learn how to teach science to diverse populations, including English learners and students in low socioeconomic groups, “to provide adequate opportunities for all students to learn science” (NRC, 2007). We report, here, on the impact on attitude change and content learned via an early teaching opportunity for undergraduates planning to become teachers in grades Kindergarten-8.
With the implementation of standards in all disciplines and particularly with an emphasis on standardized testing in language arts and mathematics, teachers at the elementary level spend less time teaching science than any of the other content areas. The Center for Education Policy reported that science instruction time in elementary schools has decreased since the No Child Left Behind (NCLB) legislation was instituted in 2002 (McMurrer, 2008). Local teachers have reported the same effect: that increased instructional time requirements for English language arts and mathematics have led to decreased time spent on other subjects, especially science. This finding is particularly true for the primary grades, Kindergarten-3, since science testing in California occurs only in the 5th grade and only covers standards from the 4th and 5th grades.

Other factors compounding the problem for science education in the elementary grades include inadequate resources for laboratory and field based science investigations, teachers’ lack of science content knowledge, and the negative self efficacy of many elementary teachers about their ability to teach science (Czerniak & Chiarelott, 1990). It also has been reported that the negative attitudes of teachers can be correlated to students’ negative attitudes about science (Czerniak & Chiarelott). More locally, and with unpublished results, a fourth grade teacher who brought her classes each year to California State University, Chico’s science lab surveyed her incoming 4th graders and found that approximately 40% of the students report that they either: (1) think science is more difficult than other subjects, (2) say they don’t like science as much as other subjects, and (3) think that they are not as good in science as they are in other subjects. This is a remarkable finding for students coming from the 3rd grade since the school where this survey was conducted focused almost exclusively on English language arts and mathematics in grades Kindergarten-3 and science was not part of the instructional program for the 4th grade students being surveyed.

Even when elementary school teachers are given time for science, they may not be enthusiastic about teaching it. One of the most overlooked problems with the implementation of science education standards was that many teachers were not prepared for them. Downing, (1997) found that teachers who were already in the classroom were less confident about teaching science compared to teachers who are just completing their training programs and that some teachers avoided science instruction as much as possible in order to avoid having to deal with a subject they feel uneasy teaching. These teachers did not possess the appropriate science background to be able to teach the content nor did they have the necessary experience in using the materials that are required to teach science effectively (Ritter, Boone, & Rubba, 2001).

Teachers’ being under-prepared to teach science at the elementary level reflects negatively on teacher preparation programs. Undergraduate science classes for future teachers typically are taught by science faculty in the disciplines of biology, chemistry, physics, and/or Earth science and an emphasis is placed on content specific to each discipline. Science courses for undergraduates planning to teach often are part of the program of general education science for non-science majors and consist of an overview of the discipline. In many cases, the classes consist of a collection of factual information with little relevance or mechanism of transfer for the future teacher and do not include teaching experiences working with children from diverse backgrounds.
Science content is being emphasized in some teacher preparation programs, as is instruction in pedagogy and teaching strategies (Kelly, 2000). Because teachers teach the way they were taught, much research is focusing on the need for college faculty in teacher training programs to model effective teaching styles in undergraduate classrooms (NRC, 1997; Gibson, 2001). In one study the confidence of undergraduate pre-service teachers was shown to improve after teaching in elementary classrooms (Murphy, 2003). Tosun focused on prior science experiences and achievement in science classes and the effect on pre-service elementary teachers attitudes toward science (Tosun, 2000). One interesting finding of Tosun’s research was that no matter how high students scored on content exams, they still were likely to have negative feelings toward science and the teaching of science. Students with low scores and minimal science experience showed a lack of confidence toward sharing science content. Tosun recommends frequent successful field experiences for pre-service elementary teachers to help improve their self-efficacy.

Another four year project documented the development of a constructivist-based elementary science methods course for pre-service teachers. The course included science methods content, journal writing, curriculum development, creating science inquiry activities for a science museum, evaluating lessons and participating in a teaching experience (Kelly, 2000). Results from this project showed a significant change in the pre-service teachers’ attitude toward teaching science. Prior to the course, the students did not like science and felt that it was hard to master, or that it was boring. After the course, the student’s views of science improved. Results also showed a significant improvement in their confidence to teach science.

Marzano (2001) makes a strong case for a direct connection between the teacher and the success of elementary students. Variables affecting the ability of elementary school children to learn were identified and studied; the most important factor among all variables was found to be the teacher. An effective teacher can transcend any number of barriers to learning to create effective learning environments. Undergraduate students with positive attitudes and an appropriate level of content knowledge seem likely to become more effective teachers. The attitude of the pre-service teacher toward science is strongly correlated with his or her ability and attitude toward teaching. Having successful science experiences helps create positive attitudes. Positively effecting students’ belief about their abilities to learn and teach science may be increased by ‘doing’ the science activities (Cochran, 1997).

To counter some of the negative impacts of typical science courses for future teachers and provide relevance to teaching science in the elementary grades, an early science teaching experience for undergraduates at California State University, Chico was instituted through a NASA/NOVA integrated science teaching grant in 2002. This course, the Internship in Science Teaching, is now a required class for liberal studies students planning to enter the multiple subject credential program in the College of Communication and Education. A multiple subject credential is the credential of choice for most elementary teachers and in the state of California qualifies them to teach grades K-8. Additionally, science majors who are considering teaching as a career may also take the internship class to gain teaching experience.

In the Internship in Science Teaching class, undergraduates are the facilitators for elementary and middle school students who visit campus and participate in the Hands-on Lab Science
Education experience. In the safe and supervised environment of the Hands-on Lab, undergraduates have the opportunity to experiment with teaching strategies, obtain practical experience managing science materials, learn to ask strategic questions, and assess for understanding. Children are organized into small groups and rotate to different, but related, mini lessons on specific topics. Topics were originally selected from the California Science Content Standards for 4th and 5th grades to provide additional support to in-service teachers of grades which are tested in science.

The same content lessons are repeated in a second week with a different visiting class of In-service students. In addition to teaching experience, the lab includes a debriefing and training component during which the science faculty facilitate discussions on pedagogy and content related to the teaching experience. The discussions and journal entries that are part of the course provide undergraduates the opportunity to practice reflective teaching and learn from the experiences of their peers as well as their own. Since initiating the program in 2002, nearly 1,800 undergraduates, 500 teachers, and 27,000 school children have experienced science teaching and learning in the Hands-on Lab. Teachers within an 80 mile radius have brought their classes to campus for this experience. We have a waiting list of classes that would like to attend. We also have been able to utilize separate professional development and partnership funding for teachers and specific school districts to ensure a diverse student population with whom our undergraduates interact.

The research investigation on this class was undertaken to provide data on the effectiveness of the class in reaching two of the goals: improving attitudes toward science and increasing content knowledge in science. The research project constituted partial fulfillment of a Master’s Degree in Science Teaching for the first author, Tanya Heaston. The study group consisted mostly of undergraduate Liberal Studies majors who ranged from sophomore to senior level based on the number of units of college coursework completed. The intent of this study was to determine if a guided teaching experience in science positively influenced student attitudes toward science and toward science teaching. Previous research has shown that the attitude toward science of pre-service teachers improved when they participated in presenting science curriculum to an elementary classroom (Gibson, 2001, Kelly, 2000). The instrument used in the current study was developed by McGinnis (1998) and used for attitudinal and belief studies of pre-service teachers in college science courses. This study focused on the teaching experience in a controlled setting in a laboratory on campus with no more than six students per intern. In addition, standards based content knowledge for each intern was measured at the beginning and at the end of the class.

The current study is unique in that college undergraduates have the opportunity to learn and to teach science in a small group setting to visiting elementary students multiple times. Because the short lab activities are repeated as groups of elementary students move through the lab, interns facilitating the mini lessons can quickly reflect on, and change, their approach to presenting materials and asking questions to assess understanding. The same theme is taught during two consecutive weeks which allows the college students an opportunity to discuss the activity with their instructors and peers.
Development of the Internship in Science Teaching Course

California State University, Chico had offered local elementary school teachers the option of bringing their classes to campus for science experiences for many years before it was developed into an early teaching experience course for undergraduates. Two different laboratory experiences had been developed by faculty in the chemistry department to expose children to some basic techniques and concepts in science. Two to four students each semester volunteered to conduct the science experiments, *Purple Cabbage Chemistry* and *Mystery Powders*, for the visiting children. Teachers brought their students to campus either by school bus, by city bus, by parent drivers, or by walking. Some laboratory supplies for the program were obtained through small grants.

Funding from the NASA/NOVA program made it possible to establish a special science class for a population of undergraduates interested in teaching, and this class utilized the science teaching experience as part of the laboratory. This project was originally entitled: *Lowering the Learning Barriers in Science for Pre-service Elementary Teachers*. The goals of this project were to:

1. Positively impact the motivation of future elementary school teachers to understand biological concepts pertaining to their health, and the health of the environment, by providing a stimulating venue that is viewed as relevant to the pre-service teachers.

2. Increase knowledge of the nature of scientific investigation by incorporating investigative procedures into the course.

3. Enhance confidence in communicating science content accurately by providing a forum for information exchange through written and oral language.

4. Provide experiences that foster lifelong learning of science.

5. Provide early experiences for teaching science to children.

Students from an accelerated program, called *Teaching Links* constituted the first group of interns for science teaching. *Teaching Links* was funded by a Title VII grant awarded to the College of Communication and Education to recruit, advise, and financially support bilingual undergraduates to become credentialed teachers to serve English learners, children for whom English is a second language. The Liberal Studies Advising Office and the Center for Bilingual and Multicultural Studies placed the *Teaching Links* freshmen in the integrated NASA/NOVA science class the first semester it was taught in the fall, 2002. In subsequent semesters additional Liberal Studies students were enrolled into the course and the class became a required course for Liberal Studies majors in the fall, 2004. This course now has 200 undergraduate students enrolled each year.

An additional and important aspect of this program was the existence of a partnership between the University and the In-service community via the presence of a professional development network, the *California Science Project*, in the College of Natural Sciences. In 1991 the California legislature authorized a group of *Subject Matter Projects* to provide professional
development in various content areas for Kindergarten-12 teachers. Science was one of the subjects and Bev Marcum, a Co-PI for the NASA/NOVA grant, was the Director of the regional site of the California Science Project. This provided a ready network of teachers to advise and participate in the new course in science teaching. Information presented in the lab was completely aligned to the California Science Standards as well as the National Standards (NRC, 1996). A list of mini lessons and associated topics presented in the lab is given in Appendix 1.

**Conducting the Course**

Students involved in the study were taking part in the pre-service early teaching experience class, the *Internship in Science Teaching*, also known as the Hands-on Lab (HOL). This semester-long class met twice a week; two hours each week was devoted to a lecture/activities seminar, and one hour each week was spent teaching elementary students in the teaching lab. During the seminar portion of the class, the undergraduate interns were provided with background on science content, briefed on teaching strategies, encouraged to make changes in their own strategies, and were provided with writing prompts to help them reflect upon their experiences in their journals. During these two-hour periods the interns also were introduced to a variety of standards-based laboratory activities. Each activity was designed to last 15 minutes. Interns are expected to learn the science behind the activities and are given time to practice teaching the labs to one another.

During week 3 of the semester, elementary school students begin to visit the lab. Interns are scheduled into the HOL for 1 hour slots, at which time they teach science to the visiting elementary students. The elementary school students stay for two hours. A second set of interns enters the lab for the second hour and concludes the lab time.

The HOL lab consisted of six lab tables/stations, each with a different science activity for a particular science unit. The elementary school class was split into six groups of 4 - 6 students each. After 15 minutes at the initial starting table/station, the whole class rotated to the next station until each student had experienced all six activities. The rotation to all six stations took one hour and 45 minutes. The college interns stayed for one hour and overlapped with the next group of college interns. The lab units/themes changed every two weeks and by the end of the twelve week semester, the interns had taught six separate science units two times for each unit.

Each intern was able to teach his or her particular lab station three times during the teaching hour. The intern was able to work with small groups of students and experience different learning styles. This method of teaching the same lab multiple times allowed the intern to test different techniques for teaching a particular science concept. If the intern had problems helping students understand a concept, the intern would either self-correct or ask for help from the lab instructor. Interns also had to adjust their lessons for time, difficulty of content, age, and language abilities.
Conducting the Study

Assessment of the undergraduate interns from semesters previous to this study showed that the interns did not feel comfortable with the idea of teaching science as future elementary school teachers, their stated career choice. Analysis of the undergraduates’ journals showed that interns:

- don’t have much experience teaching elementary school students
- are uncomfortable teaching science
- lack science content knowledge
- prefer teaching reading over science
- have had few positive science experiences

After a semester learning and teaching in the Hands-On Lab (HOL) the interns reported that they:

- build confidence after teaching the same HOL lab 2-3 times
- understand content after teaching labs 2-3 times
- plan to teach science in their elementary classrooms
- feel that science can be fun, interesting and worthwhile

Based on these findings, it was hypothesized that if the students are allowed to teach science labs as undergraduates, as early in their coursework as possible, and that if it is a good experience for them, then they will have a better attitude toward science, see the relevance in learning the science content in their college classes and possibly teach more science when they are credentialed teachers. The first of these, an improved attitude toward science, was the focus of this study.

Seventy interns participated in the HOL during the Fall 2005 semester, when the study was conducted. Fifty six of these were Liberal Studies majors; 7 were Child Development majors and the remaining 7 were majoring in Biology or another science. Of the 70 participants, 20 were sophomores, 8 freshmen, 10 were juniors, and 32 were seniors. Twenty seven of the interns were associated with a cohort of students who are on an accelerated, fast track to complete their Bachelor’s degree and teaching credential within four years, instead of the usual five required for a preliminary credential in California. This group is known as the “ITC- LINKs” (Integrated Teaching Corps Linked classes) group. Twenty six of the ITC-LINKs students were female, one was male. Seventeen of these students were sophomores and 10 were juniors.

Altogether, 8 males and 62 females participated in the study. The majority of the group, n=56, were education majors. The rest of the group consisted of 4 math education, 4 science education, 2 math/science education and 4 ‘others’ majors. The survey showed that, of the 70 students, 65 intended to pursue an elementary teaching credential, two intended to enter the secondary math or science teaching credential program, and three students planned to go on to higher degree programs. The pre-surveys showed 40 students intended to teach grades Kindergarten-3, 20 were interested in teaching grades 4-8, one student intended to teach secondary education, and 9 students were undecided as to which grade level they would like to teach. The post test showed
a slight change, with 23 students wanting to teach 4th-8th grades and 37 wanting to teach Kindergarten-3rd grade. A student’s age and socioeconomic background were not considered in this study, although grade ranking (freshman, sophomore, junior, senior) was a consideration.

Most of the students involved in the study had taken at least two science classes in high school (see Figure 1). The fewest number of science classes taken by any single student was one and the most was five. High school science classes taken by the students ranged from Biology, Chemistry, and Physics, to Astronomy, Human Anatomy, Health, and Geology (see Figure 2). Only three of the students had taken Advance Placement (AP) classes through their high school education.

The range of college science classes students had taken was not quite as varied as were their high school courses. Students entered the Hands-on Lab (HOL) having taken an average of 1.2 science courses; the majority had taken 2 college science classes (see Figure 1). The Liberal Studies program requires four specific science courses for completion of the degree; two in the Life Sciences (Biology and Field Biology) and two in the Physical Sciences (Physical Science and Earth Science). The science backgrounds of the non-Liberal Studies majors in the class ranged from one student who had taken 8 science intensive courses, including two upper division courses, to a student with only a Field Biology class.

**Surveys**

During the first week of the semester, prior to the presentation of any content material, the interns enrolled in the HOL course were given an attitudinal survey. The instrument for the attitudinal survey was taken from the Maryland Collaborative for Teaching Preparation (MCTP). The MCTP Survey Instrument, the *Attitudes and Belief about the Nature of and the Teaching of Mathematics and Science* (McGinnis, 2003), has been tested and found to be robust. The survey was modified to include only those questions regarding science teaching and attitudes. Student responses were measured on a five point Likert scale.

The *Attitude Survey* used was compiled from surveys found on the National Science Foundation’s Online Evaluation Resource Library (OERL) website. The majority of the survey was from the Maryland Collaborative for Teaching Preparation (MCTP) Survey Instrument, the *Attitudes and Belief about the Nature of and the Teaching of Mathematics and Science* (McGinnis, 2003). Statements were also gleaned from the OERL Teacher/Faculty Survey and Student Attitude Survey. These surveys were tested and found to be reliable.

The survey compiled for this study, from those sources mentioned above, included:

- 8 statements on the belief about the nature of science,
- 6 questions relating to attitude toward science,
- 6 questions related to beliefs about the teaching of science,
- 4 questions regarding attitude toward learning to teach science,
- 8 questions about attitude toward teaching science,

The individual statements were scored on a five point Likert scale, ranging from 1 = “Strongly Disagree” to 5= “Strongly Agree”. The data was disaggregated for each question, and the means,
standard deviation and frequency counts recorded (Appendix 2). The disaggregated data were then compared by groups and the mean attitude charted. Three separate studies of the total population were made. The first comparison study looked at the numbers of college credits completed (Seniors-Juniors-Sophomore) and the whole population. The second group studied was split by the grades intended to teach and the third group studied was the accelerated ITC-LINKS group vs. the non-links regular college group.

The same attitude survey was given at the end of the semester with the inclusion of 10 questions asking for information on each intern’s science background and teaching preferences (Appendix 3).

**Pre-Post Content Test**

The pre-content test was given during the first week of the semester and consisted of 24 multiple choice and 11 short answer questions to determine the level of science background knowledge that each student brought to the class. The test covered six science content areas specific to the fourth through sixth grade California Content Standards. The themes were Water, Matter, Magnetism, Electricity, Plate Tectonics, and Photosynthesis. Questions on the exam were written at the eighth grade level (Appendix 4). The results from the pre-tests were used to guide the content lectures and help the instructor focus on misconceptions the interns had in science. The post-test consisted of 36 questions and was given at the end of the semester to see assess change in the student’s understanding of science content.

**Journals**

Each student kept a journal to record discussions on writing prompts, lab instructions, class lecture, and thoughts on the class activities. Journal prompts were taken from weekly discussions and trainings during the two hour class (Appendix 5). The prompts included questions on pedagogy, problems encountered during teaching, using materials correctly, dealing with parents, time constraints and management, questioning strategies, misconceptions, and science content. Students kept their weekly responses in a journal that was collected and scored twice during the semester; at week 7 and week 15. The final journal prompt was designed to specifically encourage students to write about any changes in their attitude toward teaching science that may have taken place throughout the semester. This prompt read as follows:

1. How has the Hands-on Lab made learning science relevant for you?
2. How do you think it makes science relevant for the elementary school students?

Journals were collected, read, and scored based on the attitude of the written work. A 5-point Likert scale was used to identify negative, slightly negative, neutral, slightly positive, and positive responses to the prompt.

Students also were required to document their teaching experience by explaining how they used scientific material and the manipulatives for each station they facilitated. Students had the opportunity to teach six labs, so they had six lab descriptions, one for each science theme. The lab write-ups were graded on a 5-point rubric, looking for understanding of the science concept, and whether materials were used to explain the concept. The labs varied from examples of magnetic fields, to concepts such as capillary action. The electricity lab included comparing parallel and series circuits, examining what is in a light bulb and how it works, and exploring
what materials serve as good conductors or insulators. Evidence of tectonic plate movement with puzzles and fossils, earthquakes, subduction boundaries, and convection currents were explored in the Plate Tectonics lab. In all, there were over 36 labs activities that each student was exposed to and of those, they had actual practice for six different labs on six different topics.

Post Survey and Journal Test

The journal entries and lab write-ups were collected for a final time during the last week of the semester. Post-tests and post surveys were compared to the pre-tests and pre surveys for significant changes in knowledge and attitude. The post attitudinal survey contained additional questions related to the student’s science background and desire to teach following graduation. The post-test was administered during final exam week.

Data Analysis Procedures

A paired t-test was used to determine if there was any significance increase in the science content knowledge of the students. The statistical program Statistical Package for the Social Sciences (SPSS), was used to form the analysis of the paired t-test and Minitab was used to create charts. The pre/post attitude surveys were tallied and the means, standard deviations, and frequency counts of the statements (1=Strongly Disagree, 2=Sort of Disagree, 3=Not Sure, 4=Sort of Agree, 5=Strongly Agree) given to the 70 interns were charted for analysis. Attitude samples from the Intern Journals were tallied on a 5-point Likert scale and data collected and analyzed qualitatively.

Results

Pre and Post Content Knowledge Test Results

Students in the class were given a pre-test at the beginning of the semester to assess current knowledge in the subject matter which would be covered throughout the semester. They were given a post-test at the end of the semester to determine how much knowledge they gained. In both administrations, the total possible score for the multiple choice section of the test was 24, and for the short answer section it was 32, for an overall total of 56 points possible. All students showed some improvement in their content knowledge, even the few science majors who had had up to 8 science courses.

The following bar chart compares the mean pre-test raw scores to the mean post-test raw scores, with 95% confidence interval bars included.
The paired samples t-test showed that the post-test scores were significantly greater than the pre-test scores. The data show the test was reliable and significant.

Means

The means data of the pre-post test indicates students who had completed 31-60 units of college credit (sophomores) had the lowest raw pre-scores, but showed the greatest improvement between pre- and post-test scores. The raw scores of the sophomores increased by 25.2% between the pre- and post-test administrations; juniors by 23.5%; and seniors by 21.6%.
In relationship to the grade they think they will teach, the students interested in teaching Kindergarten-3 had the greatest change in total raw score with 24.5%. Those students who wanted to teach 4th-8th grade showed a 23.5% change, while the scores of those who plan to teach high school improved by 19.2%. Students in the ITC-LINKS group had the greatest change in raw score at 25.77% compared to the average of all others which was 21.8%.

It was expected that students who have taken fewer science courses would have the most to gain from the content portion of the course. It also was expected that students interested in teaching the lower grades would have less interest in science content, and therefore, have more to learn from the science curriculum portion of the course. Following this same line of reasoning, students thinking about teaching 9th-12th grade science would have come to the lab with a better background in science and should have started with a high pre-score and ended with a high post-score. The pre-post data support these expectations.

Pre Post Survey Results

The results of the survey showed a significant increase in positive attitudes of the students. The individual statements were scored on a five point Likert scale. The data were disaggregated for each question, and the means, standard deviations, and frequency counts recorded (Appendix 2). The disaggregated data were then compared by groups and the mean attitude charted.
The total population was disaggregated into three different groups. The first comparison study looked at attitudes based on class standing (sophomore, junior, senior). The second comparison study looked at attitudes based on the grade level students intended to teach. The third method of disaggregating the data separated the attitudes of the ITC-LINKS group from those of the non-ITC-LINKS students.

The overall pre-post comparisons of the surveys show significant movement in the students’ attitudes. Changes were recognized as being significant when there was a change of 0.5 or more in the mean score between pre- and post-test. Data were reviewed and analyzed as to the amount of change in the pre-post surveys. The whole group data was plotted and reviewed for large shifts in attitude. The overall pre-post comparisons of the surveys show movement in many areas of the students’ attitude.

One of the largest shifts was seen in the sophomores on question #8. They increased their belief that using technology would improve students’ understanding of science from a mean score of 3.22 to a post mean of 4.19; with the mean-shift change of 0.97. The greatest pre-post change in the attitudes of juniors was on question #14; believing that students did not learn only by repeating problems (shift of 1.1). The largest gain made by seniors was with their feeling of preparedness to teach science to a variety of grade levels (#36, 1.03). The overall population showed a mean change of 0.67 on this question, the highest gain noted for any single question.

Juniors also increased their attitude toward how prepared they feel to teach and explain science (.90 for each of #33, #34, and #35). Seniors increased their attitude about attempting science (.64 mean increase in attitude for question #6). Other significant increases were in the junior group regarding liking science (#15), and using technologies for all students (#19). Both seniors and juniors specifically, and the group as a whole, showed a marked increase in confidence in science content knowledge (#26 with .61 and .50 respectively).

Both seniors and sophomores showed improved attitudes regarding their desire to turn students on to science (#28). This was the second highest gain for sophomores and total population. Seniors and juniors increased by .75 and .70 respectively in confidence of having the skills to teach science (#29).

Results of the attitude survey indicated that there were many areas where attitude was significantly improved after a semester working with children in the Hands-on Lab in the Internship in Science Teaching course. The survey showed the following significant changes:

- belief about the nature of science: 2 significant changes
- attitudes toward science: 5 significant changes
- beliefs about the teaching of science: 2 significant changes
- attitudes toward learning to teach science: 1 significant changes
- attitudes toward teaching science: 6 significant changes

The largest overall change came in the attitude of feeling prepared to teach science to a variety of grade levels and in knowing what to do to help students like science. This result was very encouraging since the class gave students the opportunity to teach a grade level that they thought
they would not enjoy teaching. Finding that teaching science can be enjoyable helped the students feel more positive about taking the content classes they need in order to be well prepared to teach the subject. Table 1 shows the individual percentage of responses to the pre- and post-survey questions. The complete breakdown of all the questions can be found in Appendix 3.

Table 1: Survey Questions % Spread, Group E. Attitude Towards Teaching Science

Group E. Attitudes towards teaching science = (8 Statements)

The means, standard deviations and frequency counts of the statements (1=Strongly Disagree, 2=Sort of Disagree, 3=Not Sure, 4=Sort of Agree, 5=Strongly Agree) given to the 70 interns are presented in the table below.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean(SD)</th>
<th>Strongly Disagree</th>
<th>Sort of Disagree</th>
<th>Not Sure</th>
<th>Sort of Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>26. I am confident that I will be able to answer students’ science questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3.14 (.97)</td>
<td>4 (6%)</td>
<td>14 (20%)</td>
<td>22 (31%)</td>
<td>28 (40%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Post</td>
<td>3.56 (.86)</td>
<td>1 (1%)</td>
<td>9 (13%)</td>
<td>15 (21%)</td>
<td>40 (57%)</td>
<td>5 (7%)</td>
</tr>
<tr>
<td>28. I do not know what to do to turn students on to science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>2.89 (1.15)</td>
<td>6 (9%)</td>
<td>26 (37%)</td>
<td>14 (20%)</td>
<td>18 (26%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>Post</td>
<td>2.24 (.91)</td>
<td>11 (16%)</td>
<td>41 (59%)</td>
<td>9 (13%)</td>
<td>8 (11%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>31. I think that I will enjoy answering student’s science questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3.56 (.93)</td>
<td>1 (1%)</td>
<td>8 (11%)</td>
<td>22 (31%)</td>
<td>29 (41%)</td>
<td>10 (14%)</td>
</tr>
<tr>
<td>Post</td>
<td>3.79 (.95)</td>
<td>1 (1%)</td>
<td>6 (9%)</td>
<td>16 (23%)</td>
<td>31 (44%)</td>
<td>16 (23%)</td>
</tr>
<tr>
<td>32. I think that I will prefer to teach mathematics and science emphasizing connections between the two disciplines.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>2.86 (1.05)</td>
<td>8 (11%)</td>
<td>17 (24%)</td>
<td>25 (36%)</td>
<td>17 (24%)</td>
<td>3 (4%)</td>
</tr>
<tr>
<td>Post</td>
<td>3.00 (1.05)</td>
<td>6 (9%)</td>
<td>14 (20%)</td>
<td>30 (43%)</td>
<td>14 (20%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>33. The idea of teaching science scares me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>2.96 (1.22)</td>
<td>9 (13%)</td>
<td>20 (29%)</td>
<td>12 (17%)</td>
<td>23 (33%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>Post</td>
<td>2.59 (1.22)</td>
<td>12 (17%)</td>
<td>30 (43%)</td>
<td>9 (13%)</td>
<td>13 (19%)</td>
<td>6 (9%)</td>
</tr>
</tbody>
</table>
34. When a student has difficulty understanding a science concept, I think that I will be at a loss as how to help the student understand it better.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Sort of Disagree</th>
<th>Not Sure</th>
<th>Sort of Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>2.53 (.93)</td>
<td>7 (10%)</td>
<td>32 (46%)</td>
<td>19 (27%)</td>
<td>11 (16%)</td>
</tr>
<tr>
<td>Post</td>
<td>2.31 (1.00)</td>
<td>11 (16%)</td>
<td>39 (56%)</td>
<td>10 (14%)</td>
<td>7 (10%)</td>
</tr>
</tbody>
</table>

35. I think that I will find it difficult to explain to students why science experiments work.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Sort of Disagree</th>
<th>Not Sure</th>
<th>Sort of Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>2.77 (1.04)</td>
<td>6 (9%)</td>
<td>27 (39%)</td>
<td>16 (23%)</td>
<td>19 (27%)</td>
</tr>
<tr>
<td>Post</td>
<td>2.31 (.96)</td>
<td>10 (14%)</td>
<td>40 (57%)</td>
<td>10 (14%)</td>
<td>8 (11%)</td>
</tr>
</tbody>
</table>

36. I feel prepared to teach science to a variety of grade levels.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Sort of Disagree</th>
<th>Not Sure</th>
<th>Sort of Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>2.60 (.98)</td>
<td>8 (11%)</td>
<td>27 (39%)</td>
<td>22 (31%)</td>
<td>11 (16%)</td>
</tr>
<tr>
<td>Post</td>
<td>3.27 (1.12)</td>
<td>4 (6%)</td>
<td>16 (23%)</td>
<td>15 (21%)</td>
<td>27 (39%)</td>
</tr>
</tbody>
</table>

**Qualitative Information from Student Journals**

Student interns were responsible for self evaluating their progress in the HOL through weekly journal entries. It became clear that student’s interest and skills increased as the semester progressed. Interns were able to adjust their teaching strategies in order to cover the appropriate content. They became more effective in asking questions and learned the importance of wait time before prompting the elementary students on toward formulating an answer. Interns became increasingly comfortable with the use of the lab equipment and discovered that they became more confident in their background knowledge.

During the debriefing meeting following the first lab, the interns discussed their fear of teaching for the first time, their frustration with teaching, their lack of confidence in their content knowledge, and their lack of skills in working with school age children and equipment. A typical example of a first journal entry is as follows:

> I am feeling very nervous. I am going to be uncomfortable with teaching these children. It feels very strange to know that I am jumping right into it. I have no idea what to expect. I am freaking out because it is very scary and new.

During the second week of teaching, the interns repeated the same unit and lab activity. This time at the debriefing meetings, the interns talked about their successes. They felt less anxious about teaching, they were prepared with content knowledge, and knew how to best use the material resources. They were comfortable with the timing of the labs, and able to complete each activity in the allotted time. Most interns reported seeing and recognizing the elementary
students’ grasp of the content, and/or were able to adjust their teaching/facilitating so that all of the students were able to make the connection between the materials and the content objective.

I feel like my teaching was pretty good—I used a visual example that really made the students understand cohesion and surface tension. So, overall my teaching and comfort level really improved.

I had the Mixture lab and I didn’t feel like what I knew was good enough, but when it came down to it, it went great! The lab actually turned out pretty well! I finally relaxed and communicated the material to the students casually and tried to make it as understandable as possible. The kids did great! I was worried about the flow, but it turned out great! After the first (group of kids) I had it figured out.

Today’s teaching experience was much better than last week. I was much more confident and comfortable with teaching.

By the fourth teaching week the interns felt so comfortable with the science content and lab activities that they were asking to switch labs with other interns. Most interns wanted to learn and teach all six of the lab activities by mid semester. It was evident that interns were feeling confident in their abilities to learn and teach each new lab activity more quickly than at the beginning of the semester.

Journal reflections at the end of the semester showed the interns had increased their belief in their ability to learn and teach science content to elementary school students. In general, the interns had enjoyed the experience, and reported that they intended to teach science in their elementary school classrooms. The majority found that they were excited at the prospect of teaching science.

I did implement a few changes. First, I quickly learned how important it was not to allow the lab material to sit in front of the students until I am ready for them to use them. It’s just too tempting to have cool stuff lying around! Also, I asked the students more questions the second time around and waited longer for them to answer. I tried really hard not to let the silences push me to give the answer/explanation. Instead, I rephrased the question or I went back to a previous comment, re-explained it, and then asked my question again.

It has made science relevant to me; it showed me how I could teach science to students. Science teaching is what scares me the most in teaching, this put concepts into teachable and learnable way. I felt like the labs not only helped the students, but also help to reinforce concepts and break misconceptions for me.
Overall, I feel much more confident in my teaching skills and I feel confident that the students that I taught fully grasped the concepts which were introduced.

**Quantitative Data from Journals**

The interns’ journals were collected during the semester and scored with respect to their attitudes. A 5-point Likert scale was used to chart responses to the journal prompts. A negative statement was given a double dash (---), a slightly negative statement a double dash/0 (--/0), a neutral statement was given (0), a slightly positive statement was given (0/+), and a positive statement received a plus (+). A journal writing prompt was given every week during the entire 15 week semester. The journals were reviewed by the day and hour that interns taught in the labs to determine if there was an attitude trend among a particular group of interns, within a theme, or depending upon which elementary classes were visiting the lab.

Overall attitudes were examined, and results compiled, to measure each intern’s responses to the prompts. There were 41 responses to the first question regarding previous experience in science assessing their feelings about their elementary or high school science. There was an even spread of responses with 17 interns having very negative experiences, 10 responses were neutral, 6 slightly positive and 18 positive experiences (Table 2).

<table>
<thead>
<tr>
<th>Attitudes from Journal Prompt</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(- -)</td>
<td>17</td>
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<td>6</td>
<td>18</td>
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<tr>
<td>(-/-0)</td>
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<td>(0/+ )</td>
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<tr>
<td>(+ )</td>
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<td></td>
</tr>
</tbody>
</table>

**Table 2: Likert Scale of Attitudes from Journal Prompts in Intern Journals**

Some of the most informative journal entries were those written during the first few weeks of the semester before, and just after, the interns’ first teaching experience. The “before” teaching prompt asked the interns to respond to their preparedness in terms of content knowledge and ability to use the teaching materials. Only 14 of 67 interns responded positively. There were 17 negative, 3 slightly negative, 26 neutral, and 7 slightly positive responses. In contrast, after teaching only one lab, 37 interns replied positively about their experience teaching, 10 slightly positive, 15 neutral, 2 slightly negative, and 3 negative. After the second week of teaching, the
positive responses grew to 48, with 8 slightly positive, 5 neutral, and zero negative or slightly negative. It was obvious that a shift in the interns’ attitude about science teaching and their ability to teach had already occurred by week 3 (see Figure 3).

![Attitudes in Intern Journals](image)

**Figure 3: Change in Attitudes as noted in Intern’s Journals**

### Discussion

One of the best arguments for having an activities-based class comes from a study done by Uline (2004),

Classroom management has long been a topic of serious interest for new teachers. Although pre-service teachers receive well-developed materials addressing classroom management and student behavior, the hands-on experience in the clinical setting creates an increased awareness of the complexity involved in managing student behavior.

Practicing with real materials and becoming familiar with science content help improve attitude toward science teaching. As Watters found, “the direct experience teaching children science in the field enhanced their outcome expectancy for the teaching of science” (Watters, 2000). Watters also found that working directly with children allowed pre-service teachers to become
more in tune with the variations in an individual child’s knowledge, understanding and capabilities (Watters).

In a previous study, Watters (1997) ascertained that these activities should occur in an environment allowing risk free, meaningful learning to take place. In order to improve or increase their attitude and desire to teach science, pre-service teachers need a non-threatening place to practice with supportive instruction and guidance. The HOL class is organized in such a manner that each intern is assigned to a small group of children, working with them for a short period of time, on a small amount of content. As Anita Woolfolk maintains (Shaughnessy, 2004). The preparation of teachers should be a gradual, continuing process where prospective teachers assume more and more responsibility. Starting with a small, snack-size, safe, and supportive experience in science teaching in the Hands-on Lab maximizes the likelihood of success which ultimately should translate into classroom implementation.

The first author’s experience in the Hands-on Lab from the six previous semesters to the one in which the study was conducted, allowed her to study the interns’ attitudes toward science in an informal way. Through journal reflections and short surveys it was discovered that the students came into the class with a mixed view of and varied experiences in science. The majority of students had little science in elementary school, and they typically reported having had neutral or negative experiences or only one limited positive experience. These findings were supported by Bell in his Reflective Journal studies that showed that pre-service teachers’ attitudes and beliefs about science teaching are greatly influenced by their personal experiences in learning science (Bell, 2001; Waters, 1997).

Other studies have also shown that undergraduates lack experience in science content and in the actual teaching of science. Downing reported that “studies have indicated that elementary pre-service teachers do not feel adequately prepared for teaching science content areas (Rice & Roychouldhury, 1994)” (cited in Dowling, Jan E.; Filer, Janet D.; Chamberlain, Robert A. 1997). Research also shows that undergraduate pre-service teachers haven’t had sufficient science background, are afraid to teach science, and prefer to teach reading and math. Downing showed a significant positive correlation between elementary pre-service teachers’ ability to perform science process skills and their attitudes toward science (Dowling, Jan E.; Filer, Janet D.; Chamberlain, Robert A., 1997).

It is imperative that higher education institutions include teaching strategies designed to increase their students’ attitudes toward science education in required science classes. Journal writing is one such strategy college instructors can easily utilize. Uline (2004) found that allowing pre-service teachers to reflect on clinical experiences can improve the quality of their learning significantly. Research also supports the idea that pre-service teachers who participate in science courses that were taught using constructivist instructional methods developed a positive attitude toward science. It was stated by Gibson (2001) that this may translate into their interest in teaching science in the elementary classroom. Experiences that impact the college student should be as positive as possible. A change from lecture halls to science teaching labs such as
the Hands-on Lab and the Internship in Science Teaching class will help motivate perspective teachers to engage in more science teaching. In 1995 Watters found that science teaching outcome expectancy increases during experiences that involve children learning science. He found that observation of the successful impact of science teaching on children appears to be necessary to help change the attitudes of pre-service teachers. Learning by textbook alone did not result in significant gain in understanding of science or in the confidence of pre-service teachers to teach science. Education that includes the exploration of materials and ideas strengthens the knowledge base and the attitude of the learner.

**Conclusion**

Liberal Studies students, who are already in the teaching pathway, demonstrate an increase in positive attitudes toward science and an increase in content knowledge after taking the Internship in Science Teaching class as undergraduates, gaining experience teaching science to elementary school children. Liberal Studies students enter the lab with limited content knowledge and most of them claim to dislike science. Some students have had positive experiences in high school and some have had few or no positive experiences in science anywhere in their educational past. Prior experience greatly affects the attitudes and beliefs of students toward subject matter. The HOL experience provided these students with a guided, positive approach to learning and teaching science.

Of the 70 students who took part in this study, 70% now claim that they like science. Seventy five percent (up from 46%) claim they know what to do to help their students like science, and 50% say they are prepared to teach science (up from 18%) and know that they have the skills to do so. In addition, because of the change in attitude toward science, the experience may help the students have a clearer understanding of the relevance of other, more content based, college science courses to their teaching careers.

This study shows that the intern’s science content knowledge improved after a semester in the HOL. The pre-post tests of science knowledge showed significant increases on both multiple choice and short answer scores with the latter indicating that students improved their deeper understanding of science concepts. The mean improvement in the total raw score was 23.3 points or about 42%. All students showed improvement in content knowledge and, students with the weakest science backgrounds showed the greatest percent improvement.

Based on the change in attitude toward science and the increased science content knowledge on the part of the interns, this study demonstrates that the Hands-On Lab experience contributes to students’ positive sense of self-efficacy. This has implications for the future teaching practices of these students since self-efficacy as related to teaching is defined by Gibson and Dembo (1984) as a belief that “one’s abilities can bring about positive changes in students’ behaviors and achievement”.

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Summary/Extensions

The HOL is not just an exciting place for the college student, but for the elementary students as well. The enthusiasm shown by the elementary students helps the college students realize the value of teaching science using hands-on activities. Teachers who bring their students to the HOL may use the experience as an introduction, enhancement, or conclusion to their own science units. The HOL provides the elementary class with vocabulary, pre-post tests, and additional standards based activities. Teachers who escort their students to the HOL see their students being engaged in the learning of science. This is the first time, for some teachers, to view their students in a hands-on science learning environment. The HOL provides the visiting classroom teacher with a professional development opportunities associated with the HOL learning experience. These opportunities contribute to the continuation of the Hands-On Lab experience into the curriculum of the classroom. Additionally, many of the classroom teachers tell the college students that they are impressed at how well the college students understand and present their content. This interactive exchange between in-service and pre-service teachers provides positive feedback for the college students as well as a positive science example for the teachers.

Specialized professional development workshops and institutes have been conducted focusing on English language development strategies for the lessons provided in the Hands-On Lab. The lab has been utilized to develop hands-on lab exercises for grades Kindergarten-3. Also, middle school teachers have brought their students to the Hands-On Lab to learn the mini lessons in order to teach them to elementary school students in service learning projects back in their home districts. The HOL represents a positive experience for all participants and represents a productive bridge between the Kindergarten-12 environment and institutions of higher education.

Authors’ Note

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Sarah Tanya Heaston is a science educator, at California State University, Chico. Tanya has developed pre-K–12 science curricula and teaching materials. She currently instructs science courses to pre-service teachers for the Science Education Department. Tanya has a secondary education credential in science and a master’s degree in science education.

References


