THE EFFECT OF A LABORATORY-BASED, IN-CONTEXT, CONSTRUCTIVIST
TEACHING APPROACH ON PRESERVICE TEACHERS’ SCIENCE KNOWLEDGE
AND TEACHING EFFICACY

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This study began with a concern about elementary teachers, as a whole, avoiding the teaching of science in the elementary classroom. The three main factors noted as reasons for this avoidance were: (1) minimum science requirements to reach certification, leading to a lack of preparedness; (2) lack of exposure to science in elementary school; and (3) general dislike for and understanding of science leading to a low self-efficacy in science teaching. The goal of the Environmental Science Lab for Elementary Educators (ESLEE) was to conduct an intervention. The intervention was lab-based and utilized in-context, constructivist approaches to positively influence participants’ abilities to retain science content knowledge and to affect their belief in themselves as teachers. This intervention was created to respond to all three of the main avoidance factors noted above.

The research utilized a quasi-experimental, pretest-posttest control group design. Two pretests and two posttests (science teaching efficacy and content knowledge) were given to all 1,100 environmental science lab students at the participating institution over two long semesters. Three experimental/control groups were formed from this population. The Experimental Group was comprised of 46 students who participated in the ESLEE Intervention. Control Group 1 was comprised of
232 self-described preservice educators (SDPEEs) in “regular” labs. Control Group 2 was comprised of 62 nonSDPEEs taught by ESLEE instructors in “regular” lab settings.

A DM MANOVA was used to analyze the data. The results demonstrated that the ESLEE Intervention was statistically significant at the $p > .05$ level for science teaching efficacy between the Experimental Group and Control Group 1, and was statistically significant for both content knowledge and efficacy between the Experimental Group and Control Group 2. More notably, the effect size (delta) results ranged from .19 to .71 and .06 to .55 (partial eta squared) and demonstrated the practical significance of implementing the ESLEE Intervention.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF ILLUSTRATIONS</td>
<td>vi</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td></td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td></td>
</tr>
<tr>
<td>Research Questions</td>
<td></td>
</tr>
<tr>
<td>Definition of Terms</td>
<td></td>
</tr>
<tr>
<td>Assumptions</td>
<td></td>
</tr>
<tr>
<td>Limitations</td>
<td></td>
</tr>
<tr>
<td>Description of Design</td>
<td></td>
</tr>
<tr>
<td>2. LITERATURE SURVEY</td>
<td>29</td>
</tr>
<tr>
<td>Overview of the Literature</td>
<td></td>
</tr>
<tr>
<td>Factor One: Lack of Preparation in Science Content</td>
<td></td>
</tr>
<tr>
<td>Factor Two: Science Teaching Efficacy</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td></td>
</tr>
<tr>
<td>3. MATERIALS AND METHODS</td>
<td>52</td>
</tr>
<tr>
<td>Rationale</td>
<td></td>
</tr>
<tr>
<td>Research Hypotheses</td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td></td>
</tr>
<tr>
<td>Population Sample</td>
<td></td>
</tr>
<tr>
<td>Instruments</td>
<td></td>
</tr>
<tr>
<td>Procedures</td>
<td></td>
</tr>
<tr>
<td>Analysis of Data</td>
<td></td>
</tr>
<tr>
<td>4. RESULTS AND DISCUSSION</td>
<td>74</td>
</tr>
<tr>
<td>Internal Consistency</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 1 - Lab Intervention</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 2 - Significance of Relationships</td>
<td></td>
</tr>
</tbody>
</table>
5. CONCLUSIONS AND RECOMMENDATIONS ........................................... 93
   Discussion
   Research Questions and Hypotheses
   Conclusions
   Implications
   Recommendations

APPENDIX ........................................................................................................ 107

REFERENCE LIST .......................................................................................... 127
<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Testing design for determining affects of Intervention and Occasion</td>
<td>26</td>
</tr>
<tr>
<td>2. Testing design for Intervention and Occasion</td>
<td>56</td>
</tr>
<tr>
<td>3. Intervention Groups</td>
<td>59</td>
</tr>
<tr>
<td>4. Likert-type answers transformed and recoded into numerical values</td>
<td>73</td>
</tr>
<tr>
<td>5. Alpha Reliability Coefficients for internal consistency of the STEBI</td>
<td>75</td>
</tr>
<tr>
<td>6. Content assessment Reliability Coefficients (KR21)</td>
<td>75</td>
</tr>
<tr>
<td>7. Descriptive Statistics for the Experimental Group and Control Group 1</td>
<td>77</td>
</tr>
<tr>
<td>8. Levene’s Test of for Experimental Group and Control Group 1</td>
<td>78</td>
</tr>
<tr>
<td>9. Univariate Tests for Occasion and Intervention by Occasion</td>
<td>78</td>
</tr>
<tr>
<td>10. Descriptive Statistics for the Experimental Group and Control Group 2</td>
<td>84</td>
</tr>
<tr>
<td>11. Levene’s Test for the Experimental Group and Control Group 2</td>
<td>85</td>
</tr>
<tr>
<td>12. Univariate Tests for Intervention, Occasion, &amp; Intervention by Occasion</td>
<td>85</td>
</tr>
<tr>
<td>13. Correlations for Avg CAT score, Avg Efficacy Score, and Avg Lab grade</td>
<td>90</td>
</tr>
</tbody>
</table>
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a.</td>
<td>1-Way MANOVA</td>
<td>69</td>
</tr>
<tr>
<td>1b.</td>
<td>2-Way ANOVA with Repeated Measures</td>
<td>70</td>
</tr>
<tr>
<td>1c.</td>
<td>DM MANOVA</td>
<td>70</td>
</tr>
<tr>
<td>2.</td>
<td>Knowledge Mean difference for Experimental Group and Control Group 1</td>
<td>79</td>
</tr>
<tr>
<td>3.</td>
<td>Efficacy Mean difference for Experimental Group and Control Group 1</td>
<td>79</td>
</tr>
<tr>
<td>4.</td>
<td>Knowledge Mean difference for Experimental Group and Control Group 2</td>
<td>86</td>
</tr>
<tr>
<td>5.</td>
<td>Efficacy Mean difference for Experimental Group and Control Group 2</td>
<td>86</td>
</tr>
<tr>
<td>6.</td>
<td>Average CAT Scores</td>
<td>91</td>
</tr>
<tr>
<td>7.</td>
<td>Average Efficacy Scores</td>
<td>92</td>
</tr>
<tr>
<td>8.</td>
<td>Average Lab Grades</td>
<td>92</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Elementary teachers, as a whole, have avoided teaching science in the elementary classroom (Gess-Newsome, 1999). Three factors cited for this avoidance have been as follows: (1) minimum science requirements to reach certification, leading to a lack of preparedness; (2) lack of exposure to science in elementary school; and (3) a general dislike for and understanding of science, leading to a low self-efficacy in science teaching (Anderson & Smith, 1987; Feistritzer & Boyer, 1983). Instead of teaching science, teachers have tended to teach those subjects that engender more confidence in the teacher (Gess-Newsome, 1999). Historically and currently, science has not been one of those subjects (Tilgner, 1990). Due to the stated factors, one can see how the problem has continued to sustain itself over many decades. Whether due to lack of preparedness in science content, lack of early exposure to science, or low science self-efficacy, the reality has been and continues to be that when elementary teachers avoid the teaching of science, elementary students are often deprived of an exposure to the wonders of science during a critical period of natural curiosity.

The roots of this spiraling cycle of avoidance may be deeply imbedded in the history of American education. According to Urban (1990), during the first two centuries of our nation’s history, teachers were not educated in a formal manner for the occupation they were to perform. This was not to say that teachers were not prepared at all, but only that this preparation was not part of any formal educational curriculum.
devoted solely to the preparation of teachers. Teachers were teaching, however, in a variety of settings that included the homes of wealthy clients (as tutors for their children) and even their own homes (in what were known as “dame schools”) (p. 60). Other teachers taught in facilities that were labeled as schools or academies. Most teachers had little preparation for their positions other than they were able to “read, write, and cypher, the tasks for which they were to prepare their pupils” (p. 60.) Early in the nineteenth century, the common school opened its doors. Shortly after the appearance of the common school the first public normal school, dedicated to the preparation of teachers for the common schools was opened in Lexington, Massachusetts. Teacher preparation in the normal schools was dedicated to reading, writing, spelling, geography, grammar, and arithmetic. Science was notably absent.

While secondary teacher preparation in the sciences had its infancy just prior to 1900, elementary teacher preparation in the sciences was virtually nonexistent until much later (Yager & Penick, 1990). However, this does not mean that science was not being “taught” in the elementary schools. According to Victor (1989),

Science was the last of the major subject areas to be included in the elementary school curriculum. Until 1875 practically no science was taught in the elementary school, the emphasis being upon reading, writing, spelling, and arithmetic. Shortly thereafter, nature study was introduced in a few scattered schools (p. 4).

Though not formally prepared to do so, a number of experienced and confident master teachers were willing and able to make nature studies both exciting and memorable. This movement was short lived, however, due to an increasing number of inexperienced teachers entering the profession. These teachers were often ill prepared
to teach and not at all prepared to teach science. Thus, they often placed undue emphasis on identification, classification and reading about nature from textbooks (Victor, 1989). According to Yager and Penick (1990), the nature study movement was almost extinct by 1920, and it was not until 1957, with the Soviet launching of *Sputnik*, that major changes in science education were seen. “During the twenty-five year period following *Sputnik*, two billion dollars were allocated for reforms” (p. 658). This first great wave of reform was deeply inspiring though flawed. After twenty years of intense funding, the science education and preparation movement took a large decline. It took President Reagan’s National Commission on Excellence in Education and its 1983 report, *A Nation at Risk*, to turn the tide around once more. This time, research such as the Research on Science Education Survey (ROSES) report was used, as well as a variety of reports assembled by a number of accrediting institutions. With all of this new research, a number of new projects began - - all intended to promote science education in K-12 schools. These projects included *Project 2061*, the National Science Teachers Association’s (NSTAs) *Scope, Sequence and Coordination Project*, and the *National Science Education Standards*, published in 1996. According to Coble and Koballa (1996) “These science reform initiatives and others are attempting to change what science is taught, the way science is taught, and how students’ learning is assessed” (p. 460).

Science reforms for K-12 education have translated into science reforms for the teachers who teach K-12 science. Through projects like *2061 Benchmarks for Science Literacy*, *Science for all Americans*, and the *National Science Education Standards*, it
became quite evident that there was a new vision for science. In essence, there was a new need. As was true from the onset of the normal school, as needs within common schools became evident, this translated into response sets from the teaching institutions—the normal schools. Following in the same pattern, current institutions that prepare teachers were looked to once again to fulfill the current science needs within schools. As Coble and Koballa (1996) so aptly state,

A new conception of teaching is critical to realizing a new vision of science education. Consistent with the new vision, the teacher must assist students to construct new knowledge. The teacher can no longer be the giver of factual information; rather the teacher must be ‘a facilitator and role model who gently guides students through the adventure of learning, encouraging them with questions, and feedback and sharing their curiosities and excitement’ (p. 462).

As a systemic response, the National Research Council, via the National Science Education Standards (1996), recommended a minimum of twelve hours of science for the preservice elementary educator. Some research (i.e. Darling-Hammond, 2000) has shown that adding more science courses to the preservice program does help, and a number of teacher education programs have responded by implementing the twelve credit hour recommendation. Thus, one factor cited as a reason for avoiding the teaching of science in the classroom has been addressed through systemic reform. Yet, this does not address the second obstacle, a teacher’s lack of exposure to science when they themselves were elementary students. Nor does it address the third and possibly greatest obstacle, the teacher’s attitudes, perceptions, and/or self-efficacy in science teaching. As Talsma (1996) stated, simply adding more content will not change teachers’ attitudes toward science, and it may be here, in the affective domain, that one will find the greatest obstacle and possibly the greatest gain.
Statement of Problem

The reality has been and continues to be that elementary teachers, as a whole, have been avoiding the teaching of science, whether due to lack of preparation in science content, lack of early exposure to science, and/or low science self-efficacy (Gess-Newsome, 1999). This may be the reason that United States’ students consistently lag behind in science, according to the National Center for Education Statistics (1995). In 1995, United States twelfth graders scored below the international average and were among the lowest of the twenty-one nations in the Third International Math and Science Study (TIMSS) in both mathematics and science general knowledge. According to the Center (1996), average science achievement scores for seventeen-year-olds were lower in 1996 than in 1970. Based on these findings, there have been concerns, according to the National Science Education Standards (1996), regarding the ability of the United States to maintain its economic competitiveness. According to the National Research Council (1996), Americans live in a world filled with the products of scientific inquiry; thus, scientific literacy is a must for everyone, not a select few. Everyone needs to be able to use scientific information to make everyday decisions, let alone to be able to discuss and/or debate the issues and merits of advances in the field of science and technology. Further, everyone deserves to share in the excitement and personal fulfillment that comes with understanding and learning about the world in which they live (National Research Council, 1996).

Maintaining competitiveness for the United States and recognizing the effects of science in our every day lives have been and continue to be issues for concern; yet, in
education, the problem has been compounded by the fact that the students of yesterday will also be the teachers of tomorrow. Furthermore, it does not appear that these problems will be diminished since “25% of all elementary teachers do not teach science at all and, among those who do, science accounts for less than 2 hours of instructional time each week” (Gess-Newsome, 1999, p.1). The problem may be further compounded by the issue of the apprenticeship of observation (Lorti, 1975), which proposes that, unlike any other profession, education students actually observe their own teachers for a minimum of thirteen years prior to entering the preservice education program. Cohen and Nath (2001), noted that many education students have not observed their own teachers teaching science and thus may not see science as a part of their “well developed conception of schooling” (p. 11) based on their many years of experience within the school system. Those elementary students who have not received science instruction today will be our future elementary teachers. As Steussy & Thomas (1998) stated, “Preservice elementary teachers, who come to college with limited science knowledge and confidence are legacies of their own under-prepared elementary teachers” (p. 91). Thus, the problem of avoidance of science teaching, whether due to lack of preparation, lack of exposure, or lack of science self-efficacy, has led to under-prepared students, which has led to under-prepared teachers who avoid teaching science. A vicious cycle has been created and one, by all appearances, which could continue unbroken.
Purpose of the Study

The purpose of this study was to determine whether learning environmental science content in context, using a constructivist approach, would influence preservice educators’ ability to retain science content knowledge, and effect their belief in themselves as science teachers (i.e. their science teaching efficacy). Determining whether this factor positively affected a preservice educator’s ability to retain content knowledge, and/or their belief in themselves as teachers of science may provide a possible means of breaking the science teaching avoidance cycle. Though this study was conducted at a single higher education institution in north central Texas, there may be enough similarities in science content requirements at other four-year accrediting institutions that generalizability of findings may be possible and may have the potential to assist other teaching institutions in the development of science content courses and other subject area content courses for preservice educators.

Research Questions

Utilizing an Environmental Science Lab for Elementary Educators (ESLEE) set-aside for Self-Described Preservice Elementary Educators (SDPEE), the following questions were investigated:

1. Are science content knowledge and self-efficacy, functions of the type of lab intervention? Will using an in-context, constructivist approach in an environmental science lab to teach environmental science knowledge and skills to self-identified preservice educators make a positive difference in their content knowledge achievement and/or their self-efficacy scores?
2. Is content knowledge, and/or self-efficacy significantly related to the student’s lab grade? Can one predict a student’s lab score based on their content knowledge achievement or on their self-efficacy?

Definition of Terms

The terms used in this study are listed in alphabetical order below:

Constructivism: “A theory of knowledge used to explain how we know what we know” (Lorsbach & Tobin, 1997, p. 1).

Constructivist epistemology: “It is only through seeing, hearing, touching, smelling, and tasting that an individual interacts with the environment. With these messages from the senses, the individual builds a picture of the world” (Lorsbach & Tobin, 1997, p. 2).

Constructivist approach to environmental science instruction:

Though the environmental science content remained the same in both constructivist and traditional approaches, the constructivist approach followed the “5E” (Engage, Explore, Explain, Elaborate and Evaluate) model developed by Rodger Bybee (1993).

Traditional approach to environmental science instruction:

Though the environmental science content remained the same in both constructivist and traditional approaches, the traditional approach followed a standard content delivery model – delivery of content through lecture presentation, implementation of step-by-step laboratory activity, and teacher evaluation of results.

Environmental science: The study of how humans interact with their environments and of what can be done to improve these interactions (Enger & Smith, 2000).
ESLEE: Environmental Science Lab for preservice Elementary Educators. This lab was designed for self-described preservice elementary educators and was taught utilizing an inquiry-based, in-context, and constructivist approach.

In-Context: “Non-science majors are more motivated to learn science when it is placed within a context or issue that is relevant and interesting” (Adams, 1998, p. 105).

Premised on this statement, this study utilized the context of elementary education, the future career of the self-described preservice educators to generate interest and provide relevance. To create this context the ESLEE lab was aligned with elementary science Texas Essential Knowledge and Skills (TEKS) and provided opportunities for the students to participate in the very science they will be teaching their own students in their own elementary classrooms.

Knowledge/content achievement: A difference score obtained between the pretest and posttest Content Assessment derived from Environmental Science, A Study of Interrelationships (Copyright © 2000 McGraw-Hill, Inc., www.mcgraw-hill.com/).

Laboratory skill score: The final lab score obtained by the self-described elementary education student in the ESLEE lab.

Self-described preservice elementary educator: (SDPEE) a university student who may or may not yet be accepted into a university-based teacher education program but stated that elementary education is his/her future career choice.

Personal science teaching efficacy: A self-judgment of a teachers’ capability to bring about the desired outcomes of student engagement and learning in science (Riggs & Enochs, 1990).
“Regular” environmental science lab: An environmental science lab for any/all non-science majors.

Science Teaching Efficacy Belief Instrument (STEBI): an instrument developed by Riggs & Enochs consisting of twenty-five questions which utilized a rating scale ranging from strongly agree to strongly disagree and asking questions pertaining to a person’s belief in his/her ability to teach science (© 1990 Wiley Periodicals, Inc., www.interscience.wiley.com).


Teacher efficacy: A self-judgment of a teacher’s capability to bring about the desired outcomes of student engagement and learning (Tschannen-Moran & Hoy, 2001).

Assumptions

The following assumptions were made for this study:

1. Students’ responses on the Science Teaching Efficacy Belief Instrument (STEBI) actually reflected their honest evaluation of themselves as future elementary educators who will be teaching all subjects, including science.

2. None of the students had prior science teaching experience in public or private schools.

Limitations

One limitation of the study was that self-ratings of teaching efficacy were used as a basis of measurement. The subjectivity involved in self-ratings has the potential to diminish the accuracy of the data; however, according to Pajares (1996), when the self-
efficacy perceptions are paired with performance assessments, they can be highly predictive. Another possible limitation of the study involved the instrument used to collect data about the preservice educators’ teaching efficacy. The researcher had confidence in the validity and reliability of the instrument based on the results reported by its developers Riggs and Enochs (1990) and by its use in a variety of other studies (Wingfield & Ramsey, 1999; Keating & Ihara, 1997; Ginns & Watters, 1990). However, the instrument had not been used prior to this study on preservice elementary educators in an environmental science lab; and therefore, experience with the instrument in this research setting was unprecedented. This study was further limited by the following factors:

- Conducted at one university in north-central Texas; thus, generalizability may be limited.
- Conducted with self-described preservice elementary educators.
- Conducted in an environmental science course only.
- The teacher differences were not totally controlled.
- There was little variability in the factors of race/ethnicity, gender, and age because most of the SDPEE students tended to be white female undergraduate students.
- Demographic data was not collected on any of the students enrolled in the environmental science labs.
Description of Design

Special labs were offered for self-described preservice elementary educators (SDPEEs). These labs were entitled Environmental Science Labs for Elementary Educators (ESLEEs). The students who enrolled in these labs may or may not have been accepted into the participating higher education institution’s College of Education but did identify themselves as potential elementary teachers. Only SDPEE’s were allowed in the two special labs offered over two long semesters (See Appendix A for Course Announcement flyer). There were a maximum of twenty-five students and a minimum of ten students per lab. There were two ESLEEs offered each long semester. For each of the labs there were two different instructors. Each of the ESLEE lab instructors had at least one year of public high-school teaching experience. One of the ESLEE instructors was the investigator for this study. The two instructors per semester also taught one “regular” lab each semester. Thus, the students in the “regular” labs taught by the ESLEE instructors served as one of the contrast groups in order to control for teacher effects. The other forty-nine labs at the institution were considered “regular” non-major labs and were taught by teaching assistants who did not have any public school teaching experience. The ESLEEs had the same environmental science content as taught in the “regular” non-major environmental science labs. The differences were as follows:

1. The ESLEEs were taught “in-context” with the context being elementary teaching. The Texas Essential Knowledge and Skills (TEKS) were utilized to provide this context and to provide direct relevance between what the SDPEE’s were learning
and what they in turn would be teaching their own students as elementary educators. Based on the premise that “Non-science majors are more motivated to learn science when it is placed within a context or issue that is relevant and interesting” (Adams, 1998, p. 105), and based on the fact that the students taking the ESLEE were self-described preservice elementary educators, it was proposed that utilizing the context of elementary teaching (the student’s future career) would increase the amount of participant motivation and interest in learning the science content.

2. The ESLEE utilized a loose-leaf notebook (See Appendix B for example pages from the ESLEE manual) format as a lab manual instead of a traditional bound lab manual. This change from a traditional lab manual allowed the instructor to provide relevant supplementary material and/or content readings, which were incorporated at appropriate times. This change also allowed for the use of both traditional “cook-book” style labs and non-traditional “inquiry-based” labs. Further additions and/or changes in the ESLEE manual that were not present in the “regular” manual were as follows:

- An Introduction that provided some background concerning the essence of environmental science and environmental education, and statistics concerning the amount of time elementary teachers spend teaching science.
- An added component to the Critical Thinking Question, which was a part of the homework assignment each week. For example, “Which soil type makes the best mud pie? Why? Can young students relate to this? Why?” These
questions, and others, were part of the ESLEE manual but were not present in the “regular” manual.

- Extra credit opportunities each week which entailed seeking on the Internet, through books, educational magazines, etc., for lesson plans which coincided with the lab of the week: for instance, the study of the Scientific Method. At the conclusion of this lab, on their own time, students could seek out lessons that would be useful for teaching the Scientific Method. Then, the students were to look at the TEKS listed on the Texas Education Agency (TEA) website and provide the appropriate TEK for the lesson. All of the lessons were copied each week and given to every student. In this manner, the students, at the end of the semester, could have as many as fifteen labs for each of the studied topics to place in their loose-leaf notebook. The ESLEE instructor provided a cover page for the notebook. Discussion took place throughout the semester concerning the future use of the notebook.

3. The lab supported the lecture in the provision of core environmental science knowledge and conceptual understandings about the nature of science, but did so through the utilization of the “5E” model developed by Bybee (1993). The Instructor first engaged the students at the onset of class with quotes, anecdotes, slides, and short video clips in order to introduce the topic and initiate interest and excitement about the science to be learned. Second they encouraged the students to explore the topic by creating an atmosphere of cooperative and interactive inquiry, which generated questions, and led to
investigations. Third, they provided an opportunity for the students to explain and describe to other students in the class what their group/team had discovered. Fourth, they provided time for the students to elaborate and investigate further on the topic. Finally, there was an evaluation done by both the teacher and the students to assess what they had learned.

The example provided below is an illustration of how the above stated methodology was used. Also, an example of the general methodology used in the “regular” lab has been provided in order to demonstrate the differences between the two.

**ESLEE – First lab** - for this lab the “big picture” or main point was the scientific method itself: not what it was used to test, not what the students will be testing, but the scientific method itself. The lab was about how the scientific method is used, why it is used, and when children begin to use it – both informally and formally. The ESLEE instructor began with a quote on the overhead which stated, “There is a story told of Edison, who made, say, 1,000 unsuccessful attempts before arriving at the light bulb. ‘How did it feel to fail 1,000 times?’ a reporter asked. ‘I didn’t fail 1,000 times,’ Edison replied. ‘The light bulb was an invention with 1,001 steps.”’ Discussion followed concerning what this quote meant to the SDPEEs. Further discussion followed concerning the elementary science experiences of the SDPEEs. The discussion traveled different paths in the different sections each semester; however, the ESLEE instructor eventually drew the discussion around to the Scientific Method
and its use in solving everyday problems. All of this was used in order to
engage the students, open the lines of communication, and ground
everyone in essence of the content to be learned. The instructor then led
with an “I wonder . . .” question and encouraged each of the students to
write down as many “I wonder . . .” questions as they could. This was
done in order to provide the opportunity for the students to explore the
first step (observation) of the scientific method. The students were then
couraged to turn their “I wonder . . .” questions into statements, thus
creating hypotheses, and null hypotheses (second step of the scientific
method). Next the instructor again restated the initial “I wonder . . .”
question. The instructor and students turned it into a hypothesis and it’s
null and then discussion ensued as to how they would go about testing
the statement. The students began a discussion on the different methods
(third step of the scientific method) that would be necessary to test the
stated hypothesis. The instructor then encouraged the students to form
teams, used agreed upon methodology formulated by the class and the
tools available, and tested the hypothesis. As the students were working,
the instructor walked around the classroom and asked pertinent questions
of each of the teams as they were gathering their data (fourth step of the
scientific method). This technique was used to provide some necessary
direction, encourage the students to analyze their listed methods for
effectiveness, and to model an interactive communication between
instructor and student. When the data was collected, the teams of
students shared and explained their results with their classmates (fifth
step of the scientific method). As a class, the students were asked to
average their results and determine whether they should reject or fail to
reject their null hypothesis. The students were then asked to elaborate
on their ability to use the scientific method by looking back at the “I
wonder . . .” questions they had generated earlier and to take one of
those questions and formulate a testable hypothesis and its null, and to
formulate the methods that would be necessary to test their hypothesis.
At the conclusion of the lab, for homework, the students were asked to
evaluate their use of the scientific method and to critically evaluate the
societal implications of the use of the scientific method. They were also
asked to determine at which grade level, as listed in the TEKS, the
scientific method was first formally introduced to elementary students.
The following week, the students turned in both their lab activity
worksheet and their critical thinking response. The ESLEE instructor
provided written evaluations of both the structure and the content of the
lab work and the critical thinking response to each student as well as a
percentage grade for both.

"Regular” lab – First lab - for this lab the “big picture” or main point
was how scientists use the scientific method to answer questions. The
instructor began with a brief lecture, utilizing transparencies on the
overhead projector, as to what the scientific method is, how it is used, and its steps. Examples of hypotheses were provided and students were encouraged to either write a hypothesis concerning the relationship between arm span and height or the size of conventional lima beans versus organic lima beans. As a class, a hypothesis was selected. Students were placed into teams, and the teams were encouraged to write the methods they were to use to test their hypothesis. The instructor was available to answer questions. When all of the data was collected, as a class, the students finished their worksheet and recorded their results. For homework, the students were to draw conclusions from their experiment and to determine whether their results concerning either arm span versus height or conventional lima beans versus organic lima beans, had any implications for human society. The instructor provided written evaluations concerning the structure and content of the critical thinking response for each student as well as a percentage grade.

Testing Process

Two pretests and two posttests were given to all of the approximately 1,100 students taking the environmental science lab at the institution over two long semesters. One of the tests was the Science Teaching Efficacy Belief Instrument and the other was a content knowledge assessment derived from the lecture text entitled Environmental Science, A Study of Interrelationships. There were three treatment/comparison groups in the study:
Experimental Group: This treatment/experimental group was comprised of the SDPEE’s in the four ESLEE labs (two labs per semester over two long semesters for a total of four labs).

Control Group 1: This contrast/control group was comprised of the SDPEE’s in the forty-nine “regular” environmental science labs (twenty-six labs in the first long semester and twenty-three labs in the second long semester).

Control Group 2: This contrast/control group was comprised of the non-science majors (minus any SDPEE’s) in the two “regular” labs taught by the two ESLEE instructors (two labs per semester over two long semesters for a total of four labs).

Table 1
Testing design for determining affects of Intervention and Occasion

<table>
<thead>
<tr>
<th>Intervention</th>
<th># of Participants</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>46</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td>Control Group 1</td>
<td>232</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td>Control Group 2</td>
<td>62</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td>Group 4 – remaining students</td>
<td>399</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td>(not used in study)</td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
</tbody>
</table>

The data from these tests will be analyzed in three ways:

1. For the Experimental Group by Control Group 1, a 2X2 (Intervention by Occasion) design was used since there were two dependent variables and two occasions: Pre and post efficacy beliefs and content assessments of the SDPEE’s
in the four ESLEE labs (two labs per semester, two long semesters for a total of forty-six students) versus the efficacy beliefs and content assessment, pre and post of the SDPEE’s in the forty-nine “regular” environmental science labs (a total of two hundred and thirty-two students). A DM MANOVA was used to determine if there was a statistically significant difference between the two groups (Intervention), on the two Occasions, or the Intervention by Occasion interaction.

2. For the Experimental Group by Control Group 2, a 2X2 (Intervention by Occasion) design was used since there were two dependent variables and two occasions: Pre and post efficacy beliefs and content assessments of the SDPEE’s in the four ESLEE labs (two labs per semester, two long semesters for a total of forty-six students) versus the efficacy beliefs and content assessment, pre and post, of the non-SDPEE’s in the four “regular” labs taught by the ESLEE instructors (a total of sixty-two students). A DM MANOVA was used to determine if there was a statistically significant difference between the two groups (Intervention), on the two Occasions, or the Intervention by Occasion interaction.

3. Also, for the Experimental Group, there was a study of the interaction affects among the independent variables of content knowledge and/or efficacy beliefs as a predictor or predictors of lab skills (dependent variable) since it was found that there was a statistically significant difference between the groups. A Multiple Regression model was utilized to determine if there was a correlation between
lab skills (i.e. lab grades) and content knowledge, efficacy beliefs, and/or their interaction.
CHAPTER 2

LITERATURE SURVEY

The survey of related literature focused on the three factors discussed previously, which have been acknowledged in the past as having an influence on elementary educators teaching of science. Although there continues to be overlap, in general, two of the factors appeared fairly discreet – lack of preparation in science and efficacy in science teaching. The third factor, lack of early exposure to science, was often sited as a by-product of either and/or both of these factors as discussed in the “Introduction” to this paper.

Overview of Literature

The research from this study did not directly address the “lack of preparation in science content” factor, but a survey of literature concerning this factor was pertinent since there was a substantial amount of literature that demonstrated crossover effects between this factor and a teachers’ science efficacy as well as lack of early exposure to science. Furthermore, there was a great deal of literature addressing (1) the effects of content and pedagogy and (2) when, where, and how science content can be delivered.

The literature on inservice teaching efficacy, as well as the literature on both inservice and preservice teachers’ attitudes and perceptions, supplied the initial quantitative and qualitative data to support the need for this quantitative study. This study attempted to focus on the affect of in-context, constructivist methods used in an undergraduate environmental science course on preservice teachers’ environmental
science content knowledge achievement and self-efficacy in science teaching. Chapter 2 is divided into two sections, Factor One: Lack of Preparation in Science Content and Factor Two: Attitude, Confidence and Efficacy in Science Teaching.

Factor One: Lack of Preparation in Science Content

“That subject matter is an essential component of teacher knowledge is neither a new nor controversial assertion. After all, if teaching entails helping others learn, then understanding what is to be taught is a central requirement of teaching” (Ball & McDiarmid, 1990, p. 437). The previous quote stated what appears to be obvious in a most eloquent manner. Elementary educators must have some grasp of science concepts and content knowledge in order to be able to teach science to their students. This essential fact did not appear to be in dispute. Instead, debates were usually predicated on questions such as the following: (1) How much content knowledge should teachers be required to have? (2) What kinds of concepts are considered essential or basic? (3) How should the content be taught to the preservice educators? (4) How should the preservice educators teach their own students once in the classroom?

The questions above appeared easier to answer for secondary teachers, as it was obvious that secondary teachers needed more knowledge in the specific area they were to be teaching. But what about elementary teachers, what do they need? As opposed to secondary teachers, elementary teachers continue to be expected to teach all core subjects and thus have been required to take a range of introductory and/or survey type content courses, which have generally included classes in history, English, sociology, biology, psychology and art (Ball & McDiarmid, 1990). From these courses,
Preservice educators have been essentially asked to digest the given content information and then be able to produce a child’s version of each of these subjects later on in their own elementary classrooms (Yager & Penick, 1990).

Because elementary educators cannot be expected to be content experts in every content area, many researchers have concluded that the actual amount of science content need not be as critically important as teaching teachers “how to inquire, how to find answers, how to use material and human resources, and how to model these in a science classroom” (Yager & Penick, 1990 p. 663). This does not mean, however, that content itself was not important in the past or is not important today, but instead that content alone will not be enough. According to Linda Darling-Hammond (2000), research by Druva and Anderson in 1983 demonstrated that the science achievement of students was “positively related to the teachers’ course taking background in both education and in science” (p. 4). In other words, merely knowing a science subject was not sufficient for knowing how to represent the content matter of the subject (Doyle, 1990). Feiman-Nemser (1990) further concurred by stating, “Teachers need more than content knowledge. They need a special blend of content and pedagogy that Schulman (1987) has labeled ‘pedagogical content knowledge’” (p. 221). This pedagogical content knowledge has allowed teachers to transform typical content into representations of the subject matter, making it more easily understood by elementary students (Doyle, 1990). According to Gess-Newsome (1999), in contrast to traditional content delivery, delivery of pedagogical content knowledge has entailed the ability to plan, implement and assess student engagement in meaningful science instruction. This instruction should be active, relevant, developmentally
appropriate, and build on prior knowledge. Activities should be inquiry oriented, support the social construction of accurate science knowledge, and develop classroom community. The range of activities used should promote the science learning of all students and assist in the development of positive attitudes toward science (p. 2).

This kind of teaching requires higher levels of both knowledge and skills. To truly be effective in the environment that Gess-Newsome (1999) has suggested, teachers must have a thorough understanding of both science content and science education (National Commission on Teaching & America’s Future, 1996). Furthermore, they must be able to blend both content and pedagogy for each subject area while also balancing the responsibility of inspiring and managing the day-to-day learning of their students (Moir & Gless, 2001). This has been no easy task for a master level teacher, let alone a novice in the field, yet the United States Department of Education projects the nation will need more than two million new teachers by 2010. So, ready or not, the bulk of teaching responsibility, including science teaching, will fall on these new teachers.

It appears that reformers have heeded the concerns put forth by teachers and supported by researchers, for, according to Roth and Pipho (1990), nearly every state has taken some sort of legislative action to enact education reform. One vehicle for this action has been and continues to be the implementation of “standards.” These “standards” have taken the form of certification standards and/or standards for competency testing for initial teacher certification (Roth & Pipho, 1990) as well as content standards for each core subject area. For science, the National Research Council produced the *National Science Education Standards* in 1996. These standards
were based on the perceived need for science education reform established by both *A Nation At Risk* (National Commission of Excellence in Education, 1983) and *Project 2061, Benchmarks for Science Literacy* (AAAS, 1993). In the *National Science Education Standards* (1996) the National Research Council took a broad sweep concerning science knowledge *and* science education. The document not only set forth a set of K-12 science content and process standards, but it also set forth standards for teaching science, standards for the professional development of teachers of science, standards for assessment in science education, science program standards, and science education system standards (National Research Council, 1996). Based on the *Standards* set forth for the professional development of teachers of science, the Governing Board of the National Research Council (1997) produced a set of seven “Visions” for science teacher preparation. The “Visions” are stated as follows:

**Vision 1:**
All postsecondary science faculty will recognize their role as science teacher educators.

**Vision 2:**
All science faculty members will structure the content, pedagogy, and assessment strategies in science courses, especially in the lower division, to optimize student learning, thereby providing future teachers with the knowledge, understanding, and skills necessary to teach in accordance with the *Standards.*

**Vision 3:**
All science teacher educators will consider issues of teacher preparation program and curriculum design in light of the Standards.

**Vision 4:**
All science teacher educators will have ready access to information about teacher preparation programs, curricula, and courses nationwide.

**Vision 5:**
All postsecondary institutions that prepare teachers will develop and implement mechanisms that encourage collaboration among departments, among postsecondary institutions, and among postsecondary institutions and K-12 schools.

**Vision 6:**
Science teacher preparation programs of high quality will attract and retain students of high quality from diverse backgrounds.

**Vision 7:**

All science teacher educators will have access to a body of research about the effectiveness of various models for teacher preparation, will draw on that research to improve existing science teacher preparation programs, and will contribute to that body of knowledge as part of teacher preparation program design. (pp. 1-3)

Although the *Visions* of the Governing Board of the National Research Council appeared concise, they also have been perceived as nebulous, thereby allowing for wide variation in interpretation and implementation among university-based teacher education programs. As a matter of fact, there has appeared to be as many interpretations and thus permutations in teacher education programs as there are teacher education programs themselves. According to Linda Darling-Hammond (2000),

> In every category of possible investment in teachers’ knowledge and in every area which standards for teaching are set (e.g., licensing, accreditation, advanced certification, on-the-job-evaluation), there are substantial differences in the policies and practices employed by states (pp. 12-13).

Even within states, although licensing may be the same, teacher preparation programs can be considerably different. The state of Texas has provided a good example. The preservice educator who entered the undergraduate elementary education certification program at Sam Houston State University in 2001, majored in academic studies, while at the University of Texas at Austin the student majored in applied learning and development. On the other hand, students at Southwest Texas State, the University of North Texas, and Texas Women’s University in 2001, all received majors in interdisciplinary studies when they entered their respective programs. Further, with regards to science at Sam Houston State University (SHSU),
preservice elementary students were required to take four hours of science as part of their academic foundation courses but were not required to take any more within their interdisciplinary major (SHSU undergraduate catalog, 2001). At the University of Texas at Austin (UT), students were required to take six hours in the sciences as part of their basic education requirements. They were also required to take three hours in a science methods course (UT Undergraduate Catalog, 2001). At Southwest Texas State University (SWT), preservice elementary students were required to take three hours of biology as part of their basic education requirements, then take six hours of general science during their junior year (SWT Undergraduate Catalog, 2001). At Texas Women’s University (TWU), preservice elementary students were required to take six hours of science as part of their basic education requirements (again in the life sciences), but both of the courses were lab sciences. The preservice students could then choose to take three hours in environmental studies as a core elective (TWU Undergraduate Catalog, 2001). At the University of North Texas (UNT), until the 2001-2002 school year, the preservice elementary student was required to take eight hours in the natural sciences to satisfy the core requirement. The eight hours included a biology course for elementary educators and a physics course for elementary educators. Plus, UNT students were and still are required to take a three-hour science methods course (UNT Undergraduate Catalog, 2001). As of the 2001-2002 school year, elementary educators seeking a K-4 certification were required to take a minimum of twelve hours of science to include biology, physics, and environmental science (all lab/lecture based.
courses), and elementary educators seeking 4-8 certification must also take these same courses with the addition of chemistry (UNT Undergraduate Catalog, 2002).

The National Science Teacher’s Association (NSTA) has recommended that elementary teachers take at least twelve hours of science. As evidenced from the brief glimpse at a few of the programs offered within the state of Texas, that recommendation can be as much as four times the current amount of science for some preservice educators. Texas has definitely not been alone. According to Coble and Koballa (1996), there have been several studies, which have assessed the status of elementary science teacher education programs. One such study by Barrow (1991) compared:

the programs offered by 132 institutions in the Midwest states with 87 in New England. All reported that the majority of institutions from which data were collected failed to meet the NSTA’s standards for content preparation. Less than one third of the institutions that graduate at least 75 students per year comply with the standard for 12 semester hours of science courses (p. 470).

As a matter of fact, according to Coble and Koballa (1996), only about 20% of institutions nationwide actually required the twelve hours that the NSTA recommended, thus supporting the factor cited by teachers as “lack of preparation in science content.” To reiterate, however, this is not to say that quantity of content alone will be enough to solve the problem, for research has demonstrated that students achieve greater gains when the background of the teacher is in both educational pedagogy and science content (Druva & Anderson; 1983; Doyle, 1990; Feiman-Nemser, 1990; Yager & Penick, 1990; Darling-Hammond, 2000).
Possibilities continue to abound for changes to be made within these twelve recommended hours. The “standards” do not say that these twelve science content hours should be taken in a “traditional” science class or traditional class format. As a matter of fact, the opposite has appeared to be true. Upon revisiting the first two Visions as set forth by the National Research Council (1997), one sees that the writers explicitly single out postsecondary science faculty to recognize their roles as “science teacher educators” as well as specifically challenging these same science faculty members to structure their science courses, especially in the lower division, in such a way as to provide future teachers with the content, pedagogy, and assessment strategies in science which would provide them with the “knowledge, understanding, and skills necessary to teach in accordance with the Standards” (pp. 1-3). In essence, the first two Visions are looking to Colleges of Arts and Sciences to partner with Colleges of Education in the preparation and co-creation of future science teacher educators (Imig & Switzer, 1996). Despite the university culture which has often appeared to both encourage and reward isolation (Goodlad, 1990; Metcalf-Turner & Fischetti, 1996), there has been evidence that suggests that some professors have been eager and willing to reach across the invisible education versus content boundary and provide interdisciplinary teaching (Anderson & Speck, 1998; Austin & Baldwin, 1992; Cruz & Zaragoza, 1998).

To effectively provide these opportunities, teacher education programs must become campus wide commitments, rather than individual faculty and/or departmental commitments (Imig & Switzer, 1996). Schwartz (1996) stated, “Arts and science
programs need to be more involved in planning and delivering teacher education programs at the undergraduate level and changing teacher education curricula to reflect what is commonly taught in the public schools” (p. 8). Keating and Ihara (1997) believed that for effective change to take place, there must be a greater level of coordination not only among the departments within a University but also between scientists, science teacher educators, classroom teachers, and education faculty. According to Kubota (1997), this can be the only way to ensure that courses are both related to each other and to what the elementary teachers will be required to teach once they enter the profession. The institutions that prepare future elementary teachers “need to consider providing science content courses that allow the students to interact with the environment in much the same way their students do” (Tilgner, 1990, p. 428). Kubota (1997) concurred. He noted that when preservice elementary educators do not observe their university instructors collaborating or team teaching, when they themselves do not participate in hands-on inquiry, and when they are taught courses in a disjointed or non-connected fashion, it should come as no surprise when they, too, go into their own elementary classrooms enacting the same model for the next generation of students. Bryan, Abell, and Anderson (1996) stated, “Learning to teach science can be likened to learning science” (p. 1). If we want elementary educators of science to teach their students in a minds-on, hands-on, inquiry-rich, collaborative environment, then they must be allowed to experience that same model as students themselves, and they must be taught by teacher educators who embody that teaching method (Kubota, 1997).
A variety of innovative, “nontraditional” processes and/or methods have been implemented outside of the college of education and within the colleges of arts and sciences around the country in an attempt to provide the opportunities posited by Kubota (1997). One such offering by Joseph Keating and Jeffrey Ihara at California State University in 1998 was entitled *An Integrated Content/Process Approach to Teaching Science to Elementary Teachers*. This approach utilized a new teaching model, which the authors called Content-Process-Application-Evaluation (CPAE) (Keating & Ihara, 1998). Courses using this model were offered as elective credit to preservice and inservice teachers. The one-credit courses consisted of two eight-hour class periods and enrolled anywhere from ten to twenty-five students (Keating & Ihara, 1998). A variety of science topics were offered but all shared three common components – teaching, curriculum, and outcomes, and most of the courses offered were team taught by a classroom teacher, a university scientist, and a university science educator (Keating & Ihara, 1998). Though positive anecdotal information was obtained from the participants in the form of self-evaluation of lesson effectiveness, no qualitative and/or quantitative data were obtained to determine the overall effectiveness of the model. Another design, created by Stanley Haan and James Jadrich (1999), involved utilizing *A Thematic Integration of Physical and Earth Science for Elementary Education Students*. In this model, the authors concentrated on breadth of science knowledge, rather than depth. The course was developed to replace the survey-type physics/chemistry and/or earth science courses previously taken by elementary education majors. The course was co-taught by the authors, the first of
which is a professor of physics and the second an associate professor of science education and physics. The course was divided into five units, which were developed around what the authors perceived to be five major themes found in science – scientific models, the particulate nature of matter, energy, energy and interactions, and interactions and change. Again, no quantitative data were obtained, though the authors stated “we are in the process of quantitatively evaluating the effectiveness of the course by surveying former students who are now teaching” (Haan & Jadrich, 1999). The qualitative data that the authors did obtain was in the form of a Summary of Student Evaluations, where the authors asked the students to rate the class on a 1 to 5 scale, with one being low and five being high. The seven questions asked by the authors and the percentages by response were as follows:

1. Amount learned, compared with comparable credit courses:

<table>
<thead>
<tr>
<th>Amount Learned</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Little</strong></td>
<td>1</td>
<td>2</td>
<td>Average</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A lot</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

2. Did this course influence your self-confidence with regard to understanding science?

<table>
<thead>
<tr>
<th>Confidence</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destroyed my confidence</td>
<td>1</td>
<td>2</td>
<td>No effect</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

3. Did this course influence your self-confidence with regard to doing science activities?

<table>
<thead>
<tr>
<th>Confidence</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destroyed my confidence</td>
<td>1</td>
<td>2</td>
<td>No effect</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45%</td>
</tr>
</tbody>
</table>
4. How did this course influence your attitude toward science as a discipline?

<table>
<thead>
<tr>
<th>Made me dislike science more</th>
<th>No effect</th>
<th>Made me appreciate science more</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10%</td>
<td>46%</td>
<td>44%</td>
</tr>
</tbody>
</table>

5. How did this course influence your attitude toward teaching science?

<table>
<thead>
<tr>
<th>Made me dread teaching science</th>
<th>No effect</th>
<th>Made me eager to teach science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5%</td>
<td>54%</td>
<td>41%</td>
</tr>
</tbody>
</table>

6. Do you think this course influenced whether or not you will use activities in your own science teaching?

<table>
<thead>
<tr>
<th>Influenced me not to use activities</th>
<th>No effect</th>
<th>Definitely influenced me to use activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>26%</td>
<td>74%</td>
</tr>
</tbody>
</table>

7. Would you recommend this course to your elementary-education friends?

<table>
<thead>
<tr>
<th>Never</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Absolutely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18%</td>
<td>82%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Haan & Jadrich, 1999, p. 335)

From this data, the authors concluded that the outcomes of the course demonstrated increased student confidence and an increase in student understanding of fundamental science concepts as well as providing for an effective modeling of hands-on teaching strategies.

A third study conducted by Ronald Beiswenger, Joseph Stepans, and Patricia McClurg (1998) began as an experimental program at the University of Wyoming. The National Science Foundation (NSF) funded the experimental program for its first four years, though it continues even now, and participation in the program has become a
requirement for all elementary education majors (Beiswenger, Stepans, & McClurg, 1999). The program involved earth, life, and physical science content courses. It also included educational seminars taught in conjunction with each of the science courses, a science methods course, and student teaching led by exemplary elementary educators trained to work with prospective science teachers (Beiswenger et al., 1999). The science content courses were developed and taught by teams of university faculty drawn from both science and science education. “The teams were diverse, representing four colleges and 11 departments” (Beiswenger et al., 1999, p. 253).

There were three courses developed -- an Earth Science Course, a Physical Science Course, and a Life Science Course. All three of the courses utilized methodologies including actively involving the students, making the learning authentic by relating it to students’ personal interests, emphasizing cooperative approaches, and focusing primarily on conceptual understanding rather than discreet information. Each of the science courses featured lab activities, group projects, simulations and field trips, which were considered diametrically opposed to the lecture-type formats which had been utilized prior to the experimental program. Further, Educational Seminars provided the integration of content and pedagogy. The science educators who were directing the experimental project taught the weekly seminars.

The experimental program was first implemented in 1989, and the authors formally evaluated the first two cohort groups. The first cohort consisted of twenty students, who began the program in 1989, and the second cohort consisted of forty-six students who began the program in 1990 (Beiswenger et al., 1999). The comparison of
and posttest scores on the content examinations showed “strong gains” and other tests demonstrated statistically significant increases (with \( p < .001 \)) in positive attitudes toward science and in the level of confidence toward the teaching of science (Beiswenger et al., 1999).

Each of the models described above was unique and demonstrated varying levels of complexity, implementation, and evaluation. However, each shared a common thread – professors in education and in the sciences working collaboratively together in the preparation of future elementary educators.

As was stated earlier, one of the major factors cited as cause for the avoidance of science teaching is lack of content preparation (Bethel, 1984; Heikkinen, 1988). Again, the quickest and cleanest means utilized for attempting to improve the situation has been increasing the credit requirements in science. But, in each of the studies cited above, the courses offered to the students were not additional courses added to their credit requirements. Instead, they were courses implemented to replace courses taught previously. In other words, the studies cited above demonstrated positive affects through change of teaching context and methodology, rather than through additional course offerings. When trying to understand the factor of “lack of content preparation,” one should possibly consider the “lack” being less about quantity of science content and more about the adequacy of that content.

Factor Two: Attitudes, Confidence and Efficacy in Science Teaching

One might envision how teacher preparation programs could provide for the cognitive aspects of the preservice teacher, but what about the affective aspects? In
his social learning theory, Bandura (1981, 1982, 1993) demonstrated that people’s beliefs (i.e. self-efficacy) about their abilities had an effect on their performance. In the realm of teaching, according to Tschannen-Moran & Hoy (2001), “teaching efficacy” is a teacher’s judgment of his or her capabilities to bring about desired outcomes of student engagement and learning (p. 1). Teachers’ attitudes and beliefs (i.e. self-efficacy) have been found to contribute to their effectiveness as educators (Shrigley, 1983; Ashton & Webb, 1986; Tracz & Gibson, 1986), and their beliefs about their personal efficacy have appeared to discriminate between more and less effective teachers (Brophy & Evertson, 1976; Volkman, Scheffier & Dana, 1992). A teachers’ sense of efficacy has also been related to student outcomes such as achievement (Ashton & Webb, 1986; Moore & Esselman, 1992; Ross, 1992), motivation (Gerges, 2001), and a students’ own sense of efficacy (Anderson, Greene, & Loewen, 1988; Gibson & Dembo, 1984). Also, research has shown that a teacher’s perceptions and attitudes (positive and negative) have had a strong influence on time spent learning and teaching science (Schoon & Boone, 1998).

Research has demonstrated that elementary teachers often feel anxious about and overwhelmed by the fact that they have to teach all core subjects to all students (Talsma, 1996). Because of these feelings, many teachers have tended to lean more heavily toward the subjects in which they have felt the most comfortable. As one elementary educator noted, “Like most elementary teachers, I had virtually no content background in the sciences. I scheduled textbook science at the end of the day but rarely taught it” (National Research Council, 1997). According to Schoon and Boone
research has continued to show that teachers tend to spend more time performing those tasks that they feel the most competent in performing (Gerges, 2001; Cunningham & Blankenship, 1979; Hone, 1970). Tilgner (1990) noted that science has not been one of those tasks. To further complicate the matter, Feistritzer and Boyer (1983) pointed out that many elementary teachers state that they neither like nor understand science. According to Tilgner (1990), there has been evidence that has suggested that if the teachers themselves do not like science, then their students tend not to like science.

One might ask, “Where do the negative attitudes toward science come from?” According to Tilgner (1990), much of the negativity elementary teachers have concerning science may come from anxiety, and the anxiety may stem from a perception of lack of ability and inadequate preservice content preparation (Anderson & Smith, 1987). These concerns connect back to Bandura (1981, 1982, 1993), who stated that behaviors occur when people believe in their own ability to perform the behavior. This was evidenced in Pajares’ (1993) work with preservice teachers’ beliefs and in Talsma’s (1996) collection of preservice elementary teachers’ science autobiographies at the University of Michigan. Talsma (1996) studied the effects of formative experiences on the attitudes of preservice elementary teachers towards science and science teaching. The students that participated in her study were required to take four courses (twelve semester hours) in science that integrated both science content and methods for teaching elementary science. Unlike various other institutions, where elementary education majors were required to take general science courses, the
courses at the University of Michigan were specifically designed and tailored for preservice elementary educators. Talsma collected her data via an analysis of student writing assignments of fifty-six participating preservice students who were in the fourth class (Biology for Elementary Educators) in the sequence of semester-long courses for the group science minor that also included introductory courses in physics, chemistry and earth science. In her results, Talsma reported that five themes emerged. These themes helped to reveal why the preservice education students in this study hold particular attitudes toward science. One theme concerned the quality of science education the students themselves received as elementary students. Most of the preservice elementary teachers had difficulty in recalling any school science experiences. Of those who did recall science experiences at the elementary level, “eleven of the essays (20%) related mostly negative experiences of science” (p. 3). Of the positive experiences, thirty-two of the preservice elementary students (57%) recalled some hands-on experience in science which involved activities such as planting seeds, making collections, studying organisms, making circuits, observing chemical reactions, etc. However, after having participated in the specially designed preservice education program at the University of Michigan, which emphasized hands-on learning and which placed the content in the context of teaching science in the elementary school, the students reflected “basically positive experiences, some to the extent of reversing prior negative attitudes toward science” (Talsma, 1996, p. 12).

These same responses appeared congruent with the results from two of the studies discussed in Factor One of this study. Furthermore, in the study conducted by
Haan and Jadrich (1999), the researchers found that while only 10% of their study
group’s attitude toward science was unaffected after taking their “Thematic Integration”
course, another 46% stated that their attitude toward science as a discipline was
positively effected. Forty-four percent stated that the new course “made me appreciate
science more.” (p. 335). Furthermore, in relation to influencing the preservice students
attitudes toward teaching science, only 5% stated that they were unaffected by the
course, while 54% stated that their attitude toward teaching science was positively
effected. Forty-one percent stated that the new course “made me eager to teach
science” (p. 335). Also, 3% of the students stated that the “Thematic Integration”
course had no effect on their self-confidence with regard to understanding science,
while 51% stated that their self-confidence with regards to understanding science was
positively affected. Forty-four percent stated that the course “gave me much greater
confidence” (p. 335) with regards to understanding science.

Beiswenger, Stepans, and McClurg (1998) also evaluated their course in terms of
attitude and confidence levels. They utilized an attitudinal scale developed by
Cummings in 1969 and a self-confidence scale developed by McCormack in 1969.
Based on these instruments, the authors stated that the attitudes of their cohort groups
collectively resulted in a mean difference of 45.3, which resulted in a \( t \) score of 7.49
that was statistically significant at the \( p < .001 \) significance level. In addition, they
stated that the confidence scores resulted in a mean difference of 35.5, which resulted
in a \( t \) score of 9.67 that was statistically significant at the \( p < .001 \) significance level.
A third study by Keating and Ihara (1998) utilized the concept of self-efficacy beliefs rather than ratings of attitude toward or self-confidence concerning science. Researchers such as Judith Mulholland and John Wallace (2001) have argued that the “self-efficacy belief is a concept that has more power to explain willingness to teach science than general terms such as ‘positive attitude toward’ or ‘strong beliefs and commitment to’ science teaching” (p. 245). They have proposed that the concept of self-efficacy incorporates perceptions, attitudes, and confidence and forms the basis of the belief system that the teacher holds about their own abilities learn and teach science (Mulholland & Wallace, 2001). This belief system or sense of self-efficacy has appeared to have a large impact on the amount of time spent teaching science as well as having strong predictive value for academic attainment. “Teachers’ beliefs in their instructional efficacy is a very strong predictor of academic attainment in young children” (Mulholland & Wallace, 2001, p. 244). Thus in their research on the concept of self-efficacy beliefs, Keating and Ihara (1998) utilized the Science Teaching Efficacy Belief Instrument (STEBI) (© 1990 Wiley Periodicals, Inc., www.interscience.wiley.com) to measure students’ perceptions of the effectiveness of the CPAE model as compared to prior courses taken in either content or pedagogy. “The questions on the survey are related to comfort with and appropriateness of materials and content, probability of incorporation of the coursework into one’s own classroom, and personal impact on attitudes towards science” (p. 185). The results from their study indicated that 86% of their 88 participants agreed or strongly agreed that the CPAE approach was more effective than previous courses taken by the participants; 14% were undecided.
In an attempt to break the negative perceptions and attitude portion of the science teaching avoidance cycle, elementary science teacher educators must find ways to influence self-efficacy and thus teacher attitudes (Tschannen-Moran & Hoy, 2001). They must provide new models of instruction to replace the ones held by student recollections of their own elementary science experiences (Gerges, 2001). Finally, they must provide a core of science knowledge, foster conceptual understandings about the nature of science, and highlight the valuable roles of investigation and inquiry in order to bring excitement and adventure to elementary science programs (Steussy & Thomas, 1998).

Summary

As noted in the “Introduction” and the “Survey of literature” above, the need for research concerning factors influencing teachers and the teaching of elementary science continues to be apparent. As cited earlier, a variety of research has been conducted. The studies have shared a number of common factors, (1) they all utilized “hands-on” techniques with their students (2) three of the studies focused on science concepts to teach science content (which is an underpinning of the constructivist approach) and, (3) all of the authors noted the importance of attitudes, perceptions, and/or efficacy of their preservice students. Each of these pieces has been shown to have importance and impact on the preservice elementary teacher. Because so few changes have been evidenced within the elementary schools, it appears that more research is still needed.

Much of the research that has been done has centered on content knowledge and efficacy. Little has been studied in the way of the interaction effects between
efficacy and content achievement. All of the studies cited were conducted within a college of education, though in collaboration with a college of arts and sciences, under the auspices of science methods courses. They were conducted exclusively with education majors within their last two years of their program. Little has been studied concerning students who were within the first two years of their undergraduate program - students who were still taking their core curriculum classes and who were not yet accepted into a program. In addition, little has been studied concerning courses offered within a college of arts and sciences integrating science and pedagogy, as opposed to a college of education integrating pedagogy and science. Also, classes that were taught to and for education majors were taught within the context of their future teaching career. Classes that were taught in the core curriculum were considered general and/or introductory and were often not taught within any context at all. Little research has been evidenced on utilizing context within these introductory courses. Each of the studies utilized methodologies within their studies, which they found to be effective. Hann and Jadrich (1999) used breadth of content versus depth of content; Beiswenger et al., (1998) used three courses to spiral science content, and integrated content, methodology, and student teaching experiences; and Keating & Ihara (1998) used gap bridging elective courses to fill in the perceived science content deficiencies of the preservice and/or inservice teachers. Each of these methodologies touched on aspects of the constructivist approach, yet little has been studied concerning the use of a true constructivist approach to learning science content within a science laboratory course. Thus, a need for more research has become evident. This
study attempted to further the research concerning science content knowledge and efficacy by utilizing a constructivist approach within an environmental science lab, offered in a college of arts and sciences, to teach science content within the context of elementary education to self-described preservice educators regardless of their undergraduate status.
CHAPTER 3

METHODOLOGY

The literature reviewed indicated the need for further research concerning science content knowledge and efficacy beliefs. The purpose of this study was to determine whether learning environmental science content in context, using a constructivist approach would positively affect preservice educators’ ability to retain science content knowledge, and their belief in themselves as science teachers. Chapter 3 provided an explanation of the study methodology. The chapter was divided into five sections: Rationale, Research Hypotheses, Design, Population, Instruments, Procedures, and Analysis of Data.

Rationale

As was discussed in the literature review, some in-context and constructivist techniques have been employed in science methods courses taught to preservice educators. Also, as was detailed, these techniques and methodologies have been employed in a variety of settings. In the research conducted by Keating and Ihara (1998), the authors’ course was offered as a one-credit elective to inservice and preservice teachers. In the studies by Haan and Jadrich (1999) and Beiswenger et al. (1998), the authors worked with elementary education majors who were in their final two years of their preservice teaching programs. Both studies utilized the teaching of science content within science methods courses, where the courses were co-taught by science educators and scientists. In Talsma (1996), the participants again were
elementary education majors who were beginning their student teaching experience. In each of these studies, then, students were either at or near the end of their undergraduate program. A problem was that many students had already taken their science content courses within their first two years of their undergraduate program. Although the authors demonstrated success with their integrated science methods courses, one wonders what would happen if content and pedagogy were integrated into the science courses taken by the students earlier in their undergraduate experience - before they have declared a major or have even been accepted into a program. Could offering such courses to students who think they may want to be elementary educators influence their self-efficacy in science? Could such courses improve their knowledge in science content, increase their lab skills, and/or provide them with an even deeper and broader sense of science and pedagogy to take into their science methods course?

In an attempt to answer these questions, this study was conducted in a laboratory section of an undergraduate environmental science course. Many of the students who took this course were in their first two years of their undergraduate program and were seeking to meet their university core curriculum requirements.

A laboratory setting was chosen for implementation of this study for a number of reasons as follows: (1) according to the National Academy of Sciences (1997), the science lab provides the critical elements of the scientific process, thus integrating content within process; (2) the least common topics for professional development are those dealing with laboratory skills (Wenglinsky, 2000); (3) students whose teachers
have received professional development in laboratory skills outperform their peers by more than 40% (Wenglinsky, 2000).

Research Hypotheses

The following hypotheses were tested in the study:

1. Are science content knowledge and self-efficacy functions of the type of lab intervention? Will using an in-context, constructivist approach in an environmental science lab to teach environmental science knowledge and skills to self-identified preservice educators make a positive difference in their content knowledge achievement and/or their self-efficacy scores?

   \[ H_1 \] Science content knowledge and efficacy beliefs are a function of the type of lab intervention completed by students.

   \[ H_0 \] Science content knowledge and efficacy beliefs are not a function of the type of lab intervention completed by students.

2. If content knowledge and efficacy beliefs are a function of the type of lab intervention, then is content knowledge, and/or self-efficacy significantly related to the student’s lab grade? If content knowledge and efficacy beliefs are a function of the lab intervention, then can one predict a student’s lab score based on their content knowledge achievement or their self-efficacy?

   \[ H_2 \] Content knowledge, and/or efficacy beliefs are significantly related to lab grades.

   \[ H_0 \] Content knowledge, and/or efficacy beliefs are not significantly related to lab grades.
Design

The research utilized a quasi-experimental design, the pretest and posttest control group design. Two pretests and two posttests were given to all of the approximately 1,100 environmental science lab students at the participating institution over two long semesters. One of the tests was the *Science Teaching Efficacy Belief Instrument* (STEBI) developed by Riggs and Enochs (© 1990 Wiley Periodicals, Inc., www.interscience.wiley.com) and the other was a content knowledge assessment (CAT) derived from the lecture text entitled *Environmental Science, A Study of Interrelationships* by Enger and Smith (Copyright © 2000 by The McGraw-Hill Companies, Inc.).

There were three treatment/comparison groups in the study:

*The Experimental Group:* This treatment/experimental group was comprised of the SDPEE’s in the four ESLEE labs (two labs per semester over two long semesters for a total of four labs).

*Control Group 1:* This contrast/control group was comprised of the SDPEE’s in the forty-nine “regular” environmental science labs (twenty-six labs in the first long semester and twenty-three labs in the second long semester).

*Control Group 2:* This contrast/control group was comprised of the non-science majors (minus any SDPEE’s) in the two “regular” labs taught by the two ESLEE instructors (two labs per semester over two long semesters for a total of four labs).
### Table 2
Testing design for Intervention and Occasion

<table>
<thead>
<tr>
<th>Intervention</th>
<th># of Participants</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Group</strong></td>
<td>46</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td><strong>Control Group 1</strong></td>
<td>232</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td><strong>Control Group 2</strong></td>
<td>62</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td><strong>Group 4 – remaining</strong></td>
<td>399</td>
<td>Self-efficacy</td>
<td>Self-efficacy</td>
</tr>
<tr>
<td><strong>students (not used in</strong></td>
<td></td>
<td>Content Knowledge</td>
<td>Content Knowledge</td>
</tr>
<tr>
<td><strong>study)</strong></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The data from these tests were analyzed in three ways:

1. For the Experimental Group by Control Group 1, a 2X2 (Intervention by Occasion) design was used since there were two dependent variables and two occasions: Pre and post efficacy beliefs and content assessments of the SDPEE's in the four ESLEE labs (two labs per semester, two long semesters for a total of forty-six students) versus the efficacy beliefs and content assessment, pre and post of the SDPEE's in the forty-nine "regular" environmental science labs (a total of two hundred and thirty-two students). A DM MANOVA was used to determine if there is a statistically significant difference between the two groups (Intervention), on the two Occasions, or the Intervention by Occasion interaction.

2. For the Experimental Group by Control Group 2, a 2X2 (Intervention by Occasion) design was used since there were two dependent variables and two
occasions: Pre and post efficacy beliefs and content assessments of the SDPEE’s in the four ESLEE labs (two labs per semester, two long semesters for a total of forty-six students) versus the efficacy beliefs and content assessment, pre and post, of the non-SDPEE’s in the four “regular” labs taught by the ESLEE instructors (a total of sixty-two students). A DM MANOVA was used to determine if there is a statistically significant difference between the two groups (Intervention), on the two Occasions, or the Intervention by Occasion interaction.

3. Also, for the Experimental Group, there was a study of the interaction affects among the independent variables of content knowledge and/or efficacy beliefs as a predictor or predictors of lab skills (dependent variable) since it was found that there was a statistically significant difference between the groups. A Multiple Regression model was utilized to determine if there was a correlation between lab skills (i.e. lab grades) and content knowledge, efficacy beliefs, and/or their interaction.

Population Sample

There were no pre-requisites for the Environmental Science course at the participating university. It was open to all non-science majors and fulfills one of the core science requirements for graduation. Thus, the students taking the lab portion of the environmental science course were freshman, sophomores, juniors, or seniors, though most were in the first two years of their undergraduate program. Combining the two long semesters, there were approximately 1,100 students enrolled in the
environmental science labs. Of those 1,100 students, forty-four signed up for an
ESLEE. This population served as the Experimental Group, for this study. Since only
two ESLEEs were offered each semester, many students who may have intended to go
into education in the future were not able to get into an ESLEE. In order to determine
how many other SDPEEs there were in the other forty-nine environmental science labs,
the researcher wrote the following question “ Future plans – a) I intend to make
teaching my career in the future; b) I am considering teaching as a career in the future;
c) I do not intend to make teaching my future career; d) I would not consider teaching
as my future career.” This question was added to the bottom of the Science Teaching
Efficacy Belief Instrument and was used to determine which “group” or Intervention the
student would be placed. The Experimental Group was comprised of the forty-four
students in the ESLEEs. Control Group 1 was comprised of the 232 students who
selected either answer “a) I intend to make teaching my career in the future” or “b) I
am considering teaching as a career in the future,” within the “regular” labs, thus
identifying themselves, for the purposes of this study, as SDPEEs. If a student selected
either “c” or “d” on the question, they were considered a non-SDPEE. The sixty-two
non-SDPEE students in the “regular” labs taught by the ESLEE instructors comprised
Control Group 2. Group Four was comprised of all of the students who marked “c” or
“d” (or failed to answer the question at all) in the remaining forty-nine “regular” lab
sections. The data from these students were not used as a part of this study.

For comparison, the SDPEEs from all four of the ESLEE lab sections were
combined (two sections per semester, two long semesters) to create the population
sample for the experimental/treatment group. All of the SDPEEs from the forty-nine “regular” lab sections were combined to create the population sample for Control Group 1. All of the non-SDPEEs from all four of the “regular” lab sections taught by the ESLEE instructors were combined to create the population sample for Control Group 2.

Demographic data was not obtained or utilized for this study. The only descriptive information obtained from the student was the last four digits of their social security number in order to compare pretest data with posttest data.

Table 3

<table>
<thead>
<tr>
<th>Intervention</th>
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</tr>
<tr>
<td>Control Group 2</td>
<td>62</td>
</tr>
<tr>
<td>Group 4 – remaining students (not used in study)</td>
<td>399</td>
</tr>
</tbody>
</table>

Instruments

Two instruments were utilized for this study: the *Science Teaching Efficacy Belief Instrument* and a content assessment test derived from the lecture text entitled *Environmental Science, A Study of Interrelationships*. The *Science Teaching Efficacy Belief Instrument* (STEBI) was a Likert type scale, which was originally designed to be utilized with in-service educators. However, as was stated in the literature review, other researchers have effectively utilized the STEBI for evaluation of their preservice
programs. The STEBI has received criticism from Roberts and Henson (2000), who cautioned researchers against utilizing the STEBI for determining outcome expectancy. This study, however, was not looking at outcome expectancy, but rather at the amount of efficacious change over a one-semester environmental lab course. Furthermore, Chronbach’s alpha was used to determine the reliability of the efficacy test scores.

The content assessment test (CAT) was a systematically selected sample of fifty-two content knowledge questions obtained from a test-bank of questions provided on CD-Rom as support materials for the text. The authors of the text wrote the test questions. The researcher used the same exact test as pretest and posttest. Data was collected to determine the difference between the pretest and posttest scores. Internal consistency reliability (KR21) was determined for the pre and post administrations of the CAT.

Procedures

Special labs were offered for self-described elementary educators (SDPEEs). These labs were entitled Environmental Science Labs for Elementary Educators (ESLEEs). The students who enrolled in these labs may or may not have been accepted into the participating higher education institution’s College of Education but did identify themselves as potential elementary teachers. Only SDPEE’s were allowed in the two special labs offered over two long semesters. In order to get into an ESLEE the students had to contact the Biology department and obtain a restriction code. There were a maximum of twenty-five students and a minimum of ten students per lab. There were two ESLEEs offered each long semester. For each of the labs, there were
two different instructors. Each of the ESLEE lab Instructors had at least one year of
government high-school teaching experience. One of the ESLEE instructors was the
investigator for this study. The two instructors per semester also taught one “regular”
lab each semester. Thus, the students in the “regular” labs taught by the ESLEE
instructors also served as one of the contrast groups (Control Group 2). The other
forty-nine labs at the institution were considered “regular” non-major labs and were
taught by teaching assistants who did not have any public school teaching experience.
The ESLEEs had the same environmental science content as taught in the “regular”
non-major environmental science labs. The major differences were as follows:

1. The ESLEEs were taught in-context with the context being elementary teaching.
The Texas Essential Knowledge and Skills (TEKS) were utilized to provide this
context and direct relevance between what the SDPEE’s were learning and what
they in turn would be teaching their own students as elementary educators.
Based on the premise that “Non-science majors are more motivated to learn
science when it is placed within a context or issue that is relevant and
interesting” (Adams, 1998, p. 105), and based on the fact that the students
taking the ESLEE were self-described preservice elementary educators, it was
proposed that utilizing the context of elementary teaching (the student’s future
career) would increase the amount of participant motivation and interest in
learning the science content.

2. The ESLEE utilized a loose-leaf notebook (See Appendix B for example pages
from the ESLEE manual) format as a lab manual instead of a traditional bound lab
manual. This change from a traditional lab manual allowed the instructor to provide relevant supplementary material and/or content readings, which were incorporated at appropriate times. This change also allowed for the use of both traditional “cook-book” style labs and non-traditional “inquiry-based” labs.

Further additions and/or changes in the ESLEE manual that were not present in the “regular” manual were as follows:

- An Introduction that provided background concerning the essence of environmental science and environmental education, and statistics concerning the amount of time elementary teachers spend teaching science.

- An added component to the Critical Thinking Question, which was a part of the homework assignment each week. For example, “Which soil type makes the best mud pie? Why? Can young students relate to this? Why?” This question, and others like it, was a part of the ESLEE manual but was not present in the “regular” manual.

- Extra credit opportunities each week which entailed seeking on the Internet, through books, educational magazines, etc., for lesson plans which coincided with the lab of the week: for instance, the study of the Scientific Method. At the conclusion of this lab, on their own time, students sought out lessons that would be useful for teaching the Scientific Method. Then, the students were to look at the TEKS listed on the Texas Education Agency (TEA) website and provide the appropriate TEK for the lesson. All of the lessons were copied each week and given to every student. In this manner, the students, at the
end of the semester, could have as many as fifteen labs for each of the studied topics to place in their loose-leaf notebook. The ESLEE instructor provided a cover page for the notebook. Discussion took place throughout the semester concerning the future use of the notebook.

3. The lab supported the lecture in the provision of core environmental science knowledge and conceptual understandings about the nature of science by utilizing constructivist approaches to enhance students’ learning (Lord, 1994). This was done utilizing the “5E” model developed by Bybee (1993). The Instructor first engaged the students at the onset of class with quotes, anecdotes, slides, short video clips, etc. in order to introduce the topic and initiate interest and excitement about the science to be learned. Second they encouraged the students to explore the topic by creating an atmosphere of cooperative and interactive inquiry, which generated questions, and led to investigations. Third, they provided an opportunity for the students to explain and describe to other students in the class what their group/team had discovered. Fourth, they provided time for the students to elaborate and investigate further on the topic. Finally, there was an evaluation done by both the teacher and the students to assess what they had learned.

The example provided below is an illustration of how the above stated methodology was used. Also, an example of the general methodology used in the “regular” lab has been provided in order to demonstrate the differences between the two.
ESLEE – First lab - for this lab the “big picture” or main point was the scientific method itself: not what it was used to test, not what the students will be testing, but the scientific method itself. The lab was about how the scientific method is used, why it is used, and when children begin to use it – both informally and formally. The ESLEE instructor began with a quote on the overhead which stated, “There is a story told of Edison, who made, say, 1,000 unsuccessful attempts before arriving at the light bulb. ‘How did it feel to fail 1,000 times?’ a reporter asked. ‘I didn’t fail 1,000 times,’ Edison replied. ‘The light bulb was an invention with 1,001 steps.’” Discussion followed concerning what this quote meant to the SDPEEs. Further discussion followed concerning the elementary science experiences of the SDPEEs. The discussion traveled different paths in the different sections each semester; however, the ESLEE instructor eventually drew the discussion around to the Scientific Method and its use in solving everyday problems. All of this was used in order to engage the students, open the lines of communication, and ground everyone in essence of the content to be learned. The instructor then led with an “I wonder . . .” question and encouraged each of the students to write down as many “I wonder . . .” questions as they could. This was done in order to provide the opportunity for the students to explore the first step (observation) of the scientific method. The students were then encouraged to turn their “I wonder . . .” questions into statements, thus
creating hypotheses, and null hypotheses (second step of the scientific method). Next the instructor again restated the initial “I wonder . . .” question. The instructor and students turned it into a hypothesis and it’s null and then discussion ensued as to how they would go about testing the statement. The students began a discussion on the different methods (third step of the scientific method) that would be necessary to test the stated hypothesis. The instructor then encouraged the students to form teams, used agreed upon methodology formulated by the class and the tools available, and tested the hypothesis. As the students were working, the instructor walked around the classroom and asked pertinent questions of each of the teams as they were gathering their data (fourth step of the scientific method). This technique was used to provide some necessary direction, encourage the students to analyze their listed methods for effectiveness, and to model an interactive communication between instructor and student. When the data was collected, the teams of students shared and explained their results with their classmates (fifth step of the scientific method). As a class, the students were asked to average their results and determine whether they should reject or fail to reject their null hypothesis. The students were then asked to elaborate on their ability to use the scientific method by looking back at the “I wonder . . .” questions they had generated earlier and to take one of those questions and formulate a testable hypothesis and its null, and to
formulate the methods that would be necessary to test their hypothesis. At the conclusion of the lab, for homework, the students were asked to evaluate their use of the scientific method and to critically evaluate the societal implications of the use of the scientific method. They were also asked to determine at which grade level, as listed in the TEKS, the scientific method was first formally introduced to elementary students. The following week, the students turned in both their lab activity worksheet and their critical thinking response. The ESLEE instructor provided written evaluations of both the structure and the content of the lab work and the critical thinking response to each student as well as a percentage grade for both.

"Regular" lab – First lab - for this lab the "big picture" or main point was how scientists use the scientific method to answer questions. The instructor began with a brief lecture, utilizing transparencies on the overhead projector, as to what the scientific method is, how it is used, and its steps. Examples of hypotheses were provided and students were encouraged to either write a hypothesis concerning the relationship between arm span and height or the size of conventional lima beans versus organic lima beans. As a class, a hypothesis was selected. Students were placed into teams, and the teams were encouraged to write the methods they were to use to test their hypothesis. The instructor was available to answer questions. When all of the data was
collected, as a class, the students finished their worksheet and recorded their results. For homework, the students were to draw conclusions from their experiment and to determine whether their results concerning either arm span versus height or conventional lima beans versus organic lima beans, had any implications for human society. The instructor provided written evaluations concerning the structure and content of the critical thinking response for each student as well as a percentage grade.

All of the environmental science lab students took the pretest CAT and pretest STEBI on the first day of class. There were lab sections offered throughout the week beginning at 7:30 a.m. and ending at 6:00 p.m., Monday through Friday, with approximately eighteen to twenty students in each section. The labs were one-hour and fifty minutes in length, and the students attended class one day a week. The only identifying criteria requested on the tests concerning the students themselves was the lab section and last four digits of their social security number. Each lab met fourteen times within a semester (See Appendix C for the Class Syllabus). During the final class, each student again took the CAT and the STEBI. Further, for the two ESLEEs, the lab score obtained by the student for the class, was also obtained and utilized to determine if there was a relationship between lab skill and content achievement, efficacy, and/or their interaction. Neither the CAT nor the STEBI data were used to affect the student’s grade in the lab course.
Analysis of Data

Quantitative research methods were used to analyze the data. The statistical methods used for data analysis were descriptive and inferential statistics. Specifically, a 2X2 factorial design was utilized. According to Gall, Borg, & Gall (1996), the 2X2 design continues to be the simplest type of factorial design and it means “two variations of one factor and two variations of another factor are manipulated at the same time” (p. 508). Further, the DM MANOVA (Doubly Multivariate Multivariate Analysis of Variance) procedure was utilized for hypothesis one. It was used to determine whether the two groups (Experimental Group versus Control Group 1, and Experimental Group versus Control Group 2), differed as a result of the type of lab intervention, in regards to science content knowledge and/or teaching efficacy beliefs.

According to Shutz & Gessaroli (1987), there are a number of different procedures for analyzing repeated measures. Two of the methods, Mixed Model ANOVA and Multivariate Analysis of Variance (MANOVA) continue to be widely used. The MANOVA is a statistical technique used to determine whether groups differ on more than one dependent variable (Gall et al., 1996). “Multivariate analysis of variance is a useful statistical technique because it helps the researcher see the data in a multivariate perspective” (Gall et al., 1996, p. 398). It also helped the researcher conceptualize and analyze the nature of interrelated characteristics since groups that differ from each other on one important characteristic may likely differ from each other on another interrelated characteristic (Gall et al., 1996). Yet, in a typical 1-Way MANOVA, though the researcher is looking at the between group effects on multiple Dependent Variables
they are only looking on a *single occasion*. If the researcher wanted to look at multiple occasions, they could use 2-Way ANOVA with Repeated Measures; here the researcher is interested in both the between group effects and the within groups across occasion effects, but only on a *single Dependent Variable*. If the researcher wanted to look at multiple dependent variables, however, and multiple measures on multiple occasions then the DM MANOVA would be an appropriate choice (Everitt & Dunn, 1991).

The real power of the DM MANOVA is that it allows the researcher to look at the between group effect, the within group on occasion effect, *and* the interaction effect of multiple variables on multiple occasions. Furthermore, since the DM MANOVA is a single test, an added advantage is that it does not increase the chance of a Type I error. Figures 1a-1c graphically demonstrate the differences between a 1-Way MANOVA, a 2-Way ANOVA with Repeated Measures, and the DM MANOVA.

Figure 1a

**1-Way MANOVA**

Between Groups =

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>DV1</th>
<th>DV2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>DV1</td>
<td>DV2</td>
</tr>
</tbody>
</table>

* Multiple Dependent Variables, single factor
Figure 1b
**2-way ANOVA with Repeated Measures**

Between Groups =

Within Groups across Occasions =

Their interaction effects =

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Group</strong></td>
<td><img src="#" alt="DV1" /></td>
<td><img src="#" alt="DV1" /></td>
</tr>
<tr>
<td><strong>Control Group</strong></td>
<td><img src="#" alt="DV1" /></td>
<td><img src="#" alt="DV1" /></td>
</tr>
</tbody>
</table>

* Single Dependent Variable and multiple factors (group and occasion)

Figure 1c
**DM MANOVA**

Between Groups =

Within Groups across Occasions =

Their interaction effects =

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental Group</strong></td>
<td><img src="#" alt="DV1 DV2" /></td>
<td><img src="#" alt="DV1 DV2" /></td>
</tr>
<tr>
<td><strong>Control Group</strong></td>
<td><img src="#" alt="DV1 DV2" /></td>
<td><img src="#" alt="DV1 DV2" /></td>
</tr>
</tbody>
</table>

* Multiple Dependent Variables on multiple factors (group and occasion)
After conducting the multivariate tests using the DM MANOVA, Post hoc procedures were then used to analyze the univariate test results. The alpha level of .05 was used for all statistical tests in this study.

For the second hypothesis a *Multiple Regression* model was used to determine if there was a correlation between lab skill (lab grade) and content knowledge, efficacy beliefs, and/or their interaction. The *Multiple Regression* model was selected because “Multiple regression is used to determine the correlation between a criterion variable and a combination of two or more predictor variables” (Gall et al., 1996, p. 433). It has been a widely used technique in educational research, and this wide usage may be due to the fact that it is considered versatile and that it yields a productive amount of information concerning relationships among variables (Gall et al., 1996). In this particular study, it was utilized to determine if it was possible to predict the dependent variable of student lab grade from the independent variables of knowledge and/or efficacy beliefs.

Though there were approximately 1,100 students who took the environmental science labs over two long semesters, not all of their data could be utilized. The only data that was considered viable for this study were complete data sets. A complete data set consisted of four parts, each with *the* defining characteristic (last four digits of the social security #):

1. pretest CAT
2. pretest STEBI
3. posttest CAT
4. posttest STEBI

Of the approximately 1,100 students who took the environmental science lab course over two long semesters, 739 tests met the above criteria and were considered viable for this study. Approximately 360 tests could not be used due to one or more of the following factors:

1. The student was not in attendance on the first day of class and thus was unable to take the pretest CAT or pretest STEBI.
2. The student was not in attendance on the last day of class and thus was unable to take the posttest CAT or the posttest STEBI.
3. For whatever reason, the student took the pretest of either the CAT or the STEBI but not both.
4. For whatever reason, the student took the posttest of either the CAT or the STEBI but not both.
5. The student failed to write the last four digits of their social security number (the defining characteristic for matching) on one or more of the four tests.

Furthermore, the Science Teaching Efficacy Belief Instrument was designed for in-service elementary teachers, not preservice elementary teachers, and is comprised of twenty-five questions. Since not all of the questions were pertinent to the SDPEEs’ being tested in this study, ten of the test questions were eliminated (see Appendix D for a list of the eliminated questions). Of the remaining fifteen questions (see Appendix E for a list of the utilized questions), nine of the questions were determined to be phrased in a positive direction and six of the questions were determined to be phrased in a
negative direction. Lastly, the efficacy data had to be transformed and recoded into
numerical values prior to importing into SPSS 11 for Windows® for analysis. Since the
efficacy data was Likert-type (Strongly Agree, Agree, etc.), the researcher recoded each
of the Likert-type answers into numerical values. Table 4 shows the transformed,
recoded values.

Table 4
Likert-type efficacy answers transformed and recoded into numerical values

<table>
<thead>
<tr>
<th>Positively directed</th>
<th>Negatively directed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer</td>
<td>Numerical value</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>5</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
</tr>
<tr>
<td>Uncertain</td>
<td>3</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>1</td>
</tr>
</tbody>
</table>

The results of the data analysis for both hypotheses were presented in Chapter 4.
CHAPTER 4

RESULTS AND DISCUSSION

This chapter presented the results and discussed the findings of the research. The findings from the data analysis were grouped by each tested research hypothesis.

Internal Consistency

Prior to conducting any statistical tests in SPSS 11 for Windows® operating system, reliability analyses were conducted on both the efficacy instrument (STEBI) and the content knowledge assessment (CAT). Chronbach’s alpha was used to estimate the reliability of the efficacy test scores. Chronbach’s alpha was selected because it can be used with Likert-type instruments. The efficacy measure was the Likert-type test entitled Science Teaching Efficacy Belief Instrument (STEBI) developed by Riggs and Enochs (© 1990 Wiley Periodicals, Inc., www.interscience.wiley.com). KR21 was used to estimate the reliability of the content knowledge assessment (CAT) (Copyright © 2000 by The McGraw-Hill Companies, Inc., www.mcgraw-hill.com/).

For STEBI, Chronbach’s alpha was obtained on fifteen questions using the 340 test subjects from the Experimental Group, Control Group 1, and Control Group 2. Table 5 provides the reliability coefficients, pre and post, for each group as well as the total group reliability coefficients.
Table 5
Alpha reliability coefficients for the *Science Teaching Efficacy Belief Instrument*

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
</table>
| Experimental  
(n = 46)            | .52     | .51      |
| Control group 1  
(n = 232)          | .63     | .62      |
| Control group 2  
(n = 62)            | .70     | .64      |
| Total  
(n = 340)          | .63     | .62      |

For content knowledge assessment, KR$_{21}$ was calculated for fifty-two questions using the mean scores and standard deviations from each of the three groups. Table 6 provides the pre and post reliability coefficients for each group.

Table 6
Content knowledge assessment reliability coefficients (KR$_{21}$)

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
</table>
| Experimental  
(n = 46)            | .30     | .55      |
| Control group 1  
(n = 232)          | .56     | .73      |
| Control group 2  
(n = 62)            | .44     | .47      |

According to Nunnally (1967), reliabilities of .60 or .50 are sufficient for determining internal consistency of hypothesized measures. Nunnally (1978) revised and increased the measure to .70. While the coefficients in Table 4 fall within the .50 to .60 range, they did not meet with the more rigorous .70 standard. Only three of the coefficients for the content assessment fall in the .50 or better range; however, KR$_{21}$
produces a lower-bound estimate of test reliability. Obviously in both cases, a reliability of >.80 would be the most desirable and, even imperative in applied studies such as special education placement or college admission, etc. (Henson, 2001). However, for the purposes of this study, keeping these small to mid-sized reliability coefficients in mind, the efficacy and content knowledge assessment test scores were considered to be sufficiently internally consistent to proceed with the analysis of the data.

Hypothesis 1 - Lab Intervention

H₁ Science content knowledge and efficacy beliefs are a function of the type of lab intervention completed by students.

H₀ Science content knowledge and efficacy beliefs are not a function of the type of lab intervention completed by students.

Data Analysis – Experimental Group Versus Control Group 1

As presented in Chapter 3, there was one experimental group and two control groups in the study. The Experimental Group was comprised of the forty-six students who participated in the ESLEE (the Intervention). Control Group 1 was comprised of the 232 students who were Self-Described Preservice Elementary Educators (SDPEEs) in the “regular” labs. The analysis in this section involved these two groups and, thus was a 2 X 2 (Intervention by Occasion) MANOVA with efficacy and content knowledge measured on each occasion. Before the Multivariate Tests could be interpreted, the multivariate assumption of homogeneity was tested. Since the multivariate assumption of homogeneity was met (Box’s M = 11.74, F = 1.14, p < .34), the multivariate tests could be interpreted. Though there were a number of statistics calculated by SPSS 11,
(i.e., Pillai’s Trace, Hotelling’s Trace, and Roy’s Largest Root), Wilks’ lambda was selected for reporting in this study since it has been the most widely used. The multivariate result for the Intervention (which group they were in) was not significant (Wilks’ Lambda = .98, $F_{2,275} = 2.68, p < .08$). However, the multivariate test for the Occasion (pre and post) effect was significant (Wilks’ Lambda = .58, $F_{2,275} = 98.02, p < .001$). The partial eta squared was .42 for Occasion. The Intervention by Occasion interaction was also significant (Wilks’ Lambda = .94, $F_{2,275} = 8.52, p < .001$). The partial eta squared was .06 for the Intervention by Occasion interaction. The means were presented in Table 7.

Table 7
Descriptive statistics

<table>
<thead>
<tr>
<th>Intervention/Occasion</th>
<th>Mean</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Pretest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>28.57</td>
<td>4.26</td>
<td>46</td>
</tr>
<tr>
<td>C1</td>
<td>29.56</td>
<td>5.32</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>29.40</td>
<td>5.16</td>
<td>278</td>
</tr>
<tr>
<td><strong>Content Posttest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>34.85</td>
<td>4.98</td>
<td>46</td>
</tr>
<tr>
<td>C1</td>
<td>33.65</td>
<td>6.43</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>33.85</td>
<td>6.22</td>
<td>278</td>
</tr>
<tr>
<td><strong>Efficacy Pretest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>49.65</td>
<td>4.98</td>
<td>46</td>
</tr>
<tr>
<td>C1</td>
<td>49.57</td>
<td>5.48</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>49.58</td>
<td>5.34</td>
<td>278</td>
</tr>
<tr>
<td><strong>Efficacy Posttest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>53.94</td>
<td>4.58</td>
<td>46</td>
</tr>
<tr>
<td>C1</td>
<td>50.74</td>
<td>5.38</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>51.26</td>
<td>5.38</td>
<td>278</td>
</tr>
</tbody>
</table>

Univariate tests. As with multivariate tests, univariate tests must also meet an assumption of homogeneity. Levene’s tests of homogeneity of variance are presented in Table 8. Since this assumption was met, Post-hoc univariate ANOVAs were conducted for the Occasion and the Intervention by Occasion interaction. The results were presented in Table 9.
Table 8  
Levene’s test of equality of error variances for Experimental Group and Control Group 1

<table>
<thead>
<tr>
<th></th>
<th>$F$</th>
<th>$df_1$</th>
<th>$df_2$</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Pretest</td>
<td>1.72</td>
<td>1</td>
<td>276</td>
<td>.19</td>
</tr>
<tr>
<td>Content Posttest</td>
<td>6.49</td>
<td>1</td>
<td>276</td>
<td>.01</td>
</tr>
<tr>
<td>Efficacy Pretest</td>
<td>.05</td>
<td>1</td>
<td>276</td>
<td>.82</td>
</tr>
<tr>
<td>Efficacy Posttest</td>
<td>.83</td>
<td>1</td>
<td>276</td>
<td>.36</td>
</tr>
</tbody>
</table>

Table 9  
Univariate tests for Occasion and Intervention by Occasion

<table>
<thead>
<tr>
<th>Source</th>
<th>Measure</th>
<th>$F$</th>
<th>$df$</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occasion</td>
<td>Content</td>
<td>171.84</td>
<td>1, 276</td>
<td>.001</td>
<td>.384</td>
</tr>
<tr>
<td>Occasion</td>
<td>Efficacy</td>
<td>31.44</td>
<td>1, 276</td>
<td>.001</td>
<td>.102</td>
</tr>
<tr>
<td>Occasion*Intervention</td>
<td>Content</td>
<td>7.67</td>
<td>1, 276</td>
<td>.006</td>
<td>.027</td>
</tr>
<tr>
<td>Occasion*Intervention</td>
<td>Efficacy</td>
<td>10.22</td>
<td>1, 276</td>
<td>.002</td>
<td>.036</td>
</tr>
</tbody>
</table>

Figures 2 and 3 demonstrated the mean difference scores for the Experimental Group and Control Group 1, for pre and post content knowledge and efficacy, respectively. In addition to the graphic representation of the interaction, the standardized mean difference (delta $\Delta$) effect size measure was calculated for Intervention and Occasion and this result was provided below each graph.

Effect size (delta) was provided as a way of mathematically representing how well the average student who received the Intervention performed on each measure relative to the average student who did not receive the Intervention. Delta was determined by subtracting the raw score means and dividing by the grand raw score standard deviation $[\frac{\mu_1 - \mu_2}{\sigma_{GRAND}}]$. This gave the difference in the means in standardized (i.e., standard deviation) units. In both cases (Intervention and Occasion), the posttest mean difference scores were used.
Figure 2
Content knowledge mean difference between the Experimental Group and Control Group 1 on two Occasions

![Content Knowledge Mean Difference Graph]

(delta) Effect Size = .19

Figure 3
Efficacy mean difference between Experimental Group and Control Group 1 on two Occasions

![Efficacy Mean Scores Graph]

(delta) Effect Size = .59
Discussion

There were some interesting results to note concerning the significant interaction for content knowledge and efficacy. First, the mean difference between the Experimental Group and Control Group 1 on the content knowledge assessment (CAT) pretest was essentially 1.00 (.99). This demonstrated that, though the non-ESLEE students had slightly lower scores on the CAT pretest, essentially the knowledge that all 278 of these students had concerning environmental science prior to taking the course was the same. The mean difference between these two groups on the CAT posttest was 1.2. Again, this did not appear to be a very large difference, yet the ESLEE students began lower on the pretest CAT and ended higher on the posttest CAT, thus the mean change for the ESLEE students was 6.28 and the mean change for the non-ESLEEs was 4.09; thus, the ESLEE students’ mean knowledge gain was different than the gain evidenced by the non-ESLEE students. Second, the mean difference between the Experimental Group and Control Group 1 on the efficacy pretest was essentially identical (.08). This demonstrated that the efficacy that all 278 of these students had concerning teaching science prior to taking the course was essentially the same. The mean difference between these two groups on the efficacy posttest was 3.2. This difference was a substantial change for the ESLEEs. It was clear that the non-ESLEEs also gained in efficacy as they achieved a mean difference of 1.17, but it was also clear that the gain for the ESLEEs was much larger (3.2). It was rewarding to see that overall, all 278 of the students, on average, gained in both content knowledge and efficacy whether they participated in the ESLEE or not; however, it was apparent that
the gain for the students who participated in the ESLEEs was higher than for the SDPEEs who did not participate in the ESLEE.

Another way to view these mean differences was by looking at the effect sizes. There are various types of effect size measures used in inferential statistics. According to Gall et al. (1996) “The effect size is a quantitative way of describing how well the average student who received the intervention performed relative to the average student who did not receive the intervention” (p. 6). Positive effect sizes mean that the average student who received the intervention did better than the average student who did not receive the intervention. In contrast, negative effect sizes mean that the average student receiving the intervention did less well than the average student who did not receive the intervention (Gall et al., 1996).

One effect size measure looks at the magnitude (degree) of difference between measures (delta). Figures 2 and 3 demonstrated the magnitude or degree of the difference between posttest measures across the two groups and thus a standardized mean difference (delta) was calculated. Schuyler Huck (2000) citing Jacob Cohen stated, “effect sizes of .20, .50, and .80 should be considered small, medium, and large, respectively” (p. 207). According to Slavin (2003), however, “In education, an effect size of .20 (20% of a standard deviation) is often considered a minimum for significance; effect sizes above .50 would be considered very strong” (p. 14). And, according to Gall et al., (1996), “the larger a positive effect size, the more powerful the intervention” (p. 6). The posttest effect size of .19 for content knowledge between the Experimental Group and Control Group 1 would be considered a small effect. The
posttest effect size of .59 for efficacy between the two groups would be considered a
medium to moderate effect size by Cohen, and a “very strong” effect size by Slavin (p. 14). In both cases, it was evident that there were substantial differences, on Occasions
and in the interaction of the Intervention on Occasion.

Another effect size measure, the partial eta squared, looks at the magnitude
(degree) of relationship between measures. The partial eta squared looks at the
variation accounted for by one of the factors while it is in the presence of the other two
factors. In this study, in the multivariate tests, Occasion was statistically significant at
the p < .05 level. The partial eta squared was .42, which said that while in the
presence of Intervention and the interaction of Occasion and Intervention, 42% of the
variation in content knowledge and efficacy could be accounted for by this factor.
Because this result was statistically significant, the univariate results can be viewed as
well. In the univariate results, 38% of the variation in Occasion was accounted for by
content knowledge, while 10% was accounted for by efficacy. Also, the interaction of
Occasion and Intervention was statistically significant at the p < .05 level, yet the
partial eta squared for the interaction effect was only .06, accounting for only 6% of the
variance while in the presence of the other two factors. The univariate results in the
interaction revealed that 3% of the variation in the interaction could be accounted for
by content knowledge, while 4% could be accounted for by efficacy.

Looking again to Cohen’s and/or Slavin’s range of effect size measures for the
multivariate tests, a .42 (pre and post content knowledge and efficacy) would be near
the medium effect size in the range while .06 (interaction between Intervention and
Occasion) would be considered a very small effect size. Though these eta values were small to medium, the fact remains that this study utilized a fairly large sample size, which may have helped to decrease the standard error as well as increase the power of the test of the null hypothesis (Hinkle, Wiersma, & Jurs, 1998).

Data Analysis – Experimental Group versus Control Group 2

As described in Chapter 3, to protect against the possibility that any change was a result of the ESLEE instructors rather than the intervention itself, the ESLEE instructors also taught one “regular” lab which contained non-SDPEE students. Those labs were not taught in-context, nor in a constructivist manner. There were forty-nine “regular” labs, which were essentially taught in a “traditional” manner as opposed to that used in the Intervention, as described in Chapter 3. Two of these “regular” labs were taught by the ESLEE instructors’ and contained sixty-two non-SDPEE students who comprised the second control group.

Again, SPSS 11 was utilized to analyze the data. The analysis in this section involves the Experimental Group and Control Group 2. This was a 2 X 2 (Intervention by Occasion) MANOVA with efficacy and knowledge measured on each occasion. Before the Multivariate Tests could be interpreted, the multivariate assumption of homogeneity was tested. Since the multivariate assumption of homogeneity was met (Box’s M = 10.65, F = 1.02, p < .43), the multivariate tests could be interpreted. Though there were a number of statistics calculated by SPSS 11 for Windows®, (i.e., Pillai’s Trace, Hotelling’s Trace, and Roy’s Largest Root), Wilks’ Lambda was selected for reporting in this study since it has been the most widely used. In this case, the
multivariate result for the Intervention was significant (Wilks’ Lambda = .92, \( F_{2,105} = 4.43, p < .02 \)). The partial eta squared was .08 for the Intervention. Also, the multivariate result for Occasion effect was significant (Wilks’ Lambda = .45, \( F_{2,105} = 63.05, p < .001 \)). The partial eta squared was .55 for Occasion. The Intervention by Occasion interaction was also significant (Wilks’ Lambda = .87, \( F_{2,105} = 7.95, p < .001 \)). The partial eta squared was .13 for the Intervention by Occasion interaction.

The means were presented in Table 10.

Table 10
Descriptive statistics

<table>
<thead>
<tr>
<th>Intervention/Occasion</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>28.57</td>
<td>4.26</td>
<td>46</td>
</tr>
<tr>
<td>C2</td>
<td>28.82</td>
<td>4.78</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>28.71</td>
<td>4.55</td>
<td>108</td>
</tr>
<tr>
<td>Content Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>34.85</td>
<td>4.98</td>
<td>46</td>
</tr>
<tr>
<td>C2</td>
<td>32.35</td>
<td>4.75</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>33.42</td>
<td>4.99</td>
<td>108</td>
</tr>
<tr>
<td>Efficacy Pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>49.65</td>
<td>4.98</td>
<td>46</td>
</tr>
<tr>
<td>C2</td>
<td>48.74</td>
<td>5.84</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>49.13</td>
<td>5.49</td>
<td>108</td>
</tr>
<tr>
<td>Efficacy Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>53.94</td>
<td>4.58</td>
<td>46</td>
</tr>
<tr>
<td>C2</td>
<td>49.98</td>
<td>5.71</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>51.67</td>
<td>5.59</td>
<td>108</td>
</tr>
</tbody>
</table>

Univariate tests. As with multivariate tests, univariate tests must also meet an assumption of homogeneity. Levene’s tests of homogeneity of variance were presented in Table 11. Since this assumption was met, Post-hoc univariate ANOVAs were conducted for the Intervention, the Occasion, and the Intervention by Occasion interaction. Results were presented in Table 12.
Table 11

Levene’s test of equality of error variances for Experimental Group and Control Group 2

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Pretest</td>
<td>.20</td>
<td>1</td>
<td>106</td>
<td>.65</td>
</tr>
<tr>
<td>Content Posttest</td>
<td>.41</td>
<td>1</td>
<td>106</td>
<td>.52</td>
</tr>
<tr>
<td>Efficacy Pretest</td>
<td>.87</td>
<td>1</td>
<td>106</td>
<td>.35</td>
</tr>
<tr>
<td>Efficacy Posttest</td>
<td>.72</td>
<td>1</td>
<td>106</td>
<td>.40</td>
</tr>
</tbody>
</table>

Table 12

Univariate tests for Occasion and Intervention by Occasion

<table>
<thead>
<tr>
<th>Source</th>
<th>Measure</th>
<th>F</th>
<th>df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Content</td>
<td>2.04</td>
<td>1, 106</td>
<td>.156</td>
<td>.02</td>
</tr>
<tr>
<td>Intervention</td>
<td>Efficacy</td>
<td>7.04</td>
<td>1, 106</td>
<td>.009</td>
<td>.06</td>
</tr>
<tr>
<td>Occasion</td>
<td>Content</td>
<td>105.63</td>
<td>1, 106</td>
<td>.001</td>
<td>.50</td>
</tr>
<tr>
<td>Occasion</td>
<td>Efficacy</td>
<td>29.86</td>
<td>1, 106</td>
<td>.001</td>
<td>.22</td>
</tr>
<tr>
<td>Occasion*Intervention</td>
<td>Content</td>
<td>8.30</td>
<td>1, 106</td>
<td>.005</td>
<td>.07</td>
</tr>
<tr>
<td>Occasion*Intervention</td>
<td>Efficacy</td>
<td>9.05</td>
<td>1, 106</td>
<td>.003</td>
<td>.08</td>
</tr>
</tbody>
</table>

Figures 4 and 5 demonstrated the mean difference scores for the Experimental Group and Control Group 2, for pre and post content knowledge and efficacy, respectively. As stated earlier, the (delta) effect size was also provided below each graph as a means of mathematically representing how well the average student who received the intervention performed on each measure relative to the average student who did not receive the intervention.
Figure 4

Content knowledge mean difference between the Experimental Group and Control Group 2 on two Occasions

![Content Knowledge Mean Score](image)

(delta) Effect Size = .50

Figure 5

Content mean difference between the Experimental Group and Control Group 2 on two Occasions

![Efficacy Mean Score](image)

(delta) Effect Size = .71
Discussion

Once again, there were some interesting results to note concerning the significant interaction of content knowledge and efficacy. First, the mean difference between these two groups on the knowledge pretest was essentially identical (-.25). This demonstrated that, though the ESLEE students had slightly lower content scores on the pretest, the content knowledge that all 108 of these students had concerning environmental science prior to taking the course was essentially the same. The mean difference between these two groups on the CAT posttest was 2.5. This was a considerable difference. Again, as was stated earlier, the mean change for the ESLEE students was 6.28 and yet the mean change for the regular students was only 3.53. Thus, the ESLEE students’ mean knowledge gain was greater than the gain evidenced by the regular students. The efficacy results were even more interesting. In this case, the mean difference between these two groups on the efficacy pretest was essentially 1.00 (.91). This demonstrated that, though the non-SDPEE students had slightly lower scores on the efficacy pretest, the efficacy that all 108 of these students had concerning teaching science prior to taking the course was essentially the same. The mean difference between these two groups on the efficacy posttest was 3.96. This difference was a substantial change for the ESLEEs. It was clear that the non-SDPEEs also gained in efficacy as they achieved a mean difference of 1.24, which was just slightly higher than the difference evidenced by the SDPEEs in the regular labs. It was also evident, however, that the gain for the ESLEEs was larger. The mean difference effect sizes for
these two measures would be considered moderate to large effect sizes, whether utilizing the Cohen range or the one suggested by Slavin.

When comparing the Experimental Group with Control Group 2, there were statistically significant differences in the between-subjects Intervention and the within-subjects Occasion factor as well as with the interaction between the Intervention and Occasions on the multivariate tests. Again, the partial eta squared is an effect size measure that indicates the relationship between the independent variable and the dependent variable. The partial eta squared looks at the variation accounted for by one of the factors while it is in the presence of the other two factors. The multivariate tests, in this study, indicated that Intervention was statistically significant at the $p < .05$ level, and the partial eta squared was .08. This result stated that while in the presence of Occasion and the interaction of Intervention and Occasion, 8% of the variation could be explained by this Intervention factor. The univariate test, on this measure, indicated that 6% of this variation could be accounted for in efficacy. The Occasion factor was also statistically significant at the $p < .05$ level and the partial eta squared for Occasion was .55, which said that while in the presence of Intervention and the interaction of Intervention and Occasion, 55% of the variation can be explained by this factor (pre and post, content knowledge and efficacy). The univariate test, on this measure, indicated that 50% of this variation was associated with content assessment, while 22% was associated with efficacy. Also, the interaction of Intervention and Occasion (pre and post, content knowledge and efficacy) was statistically significant at the $p < .05$ level and the partial eta squared for the interaction effect was .13, explaining about
13% of the variation while in the presence of the other two factors. The univariate tests on the Intervention and Occasion measure indicated content knowledge accounted for 7% of the variation in this factor and efficacy accounted for 8%.

Again, looking at Cohen’s and/or Slavin’s range of effect size measures for the multivariate tests, .08 for Intervention (which group they were in) would be considered a very small effect size, .55 (pre and post content knowledge and efficacy) would be a medium to moderate effect size, and .13 (interaction between group and occasion) would be considered a small effect size. As stated before, though the eta values were small to medium, the fact remains that this study utilized a fairly large sample size, which again helped to decrease the standard error as well as increase the power of the test of the null hypothesis (Hinkle, Wiersma, & Jurs, 1998).

After analysis of the data, the null hypothesis which stated “Science content knowledge and efficacy beliefs are not a function of the type of lab intervention completed by students” for the first hypothesis was rejected; there was a statistically significant difference in Occasion ($p < .001$), and Intervention and Occasion ($p < .001$), in both content knowledge and efficacy, between the SDPEEs in the Experimental Group who participated in the lab intervention (ESLEE) and Control Group 1. Furthermore, there was a statistically significant difference in the Intervention ($p < .02$), on Occasion ($p < .001$), and the interaction of Intervention and Occasion ($p < .001$), between the SDPEEs in the Experimental Group who participated in the lab intervention (ESLEE) and Control Group 2.
Hypothesis 2 - Significance of Relationships

$H_2$ Content knowledge, and/or efficacy beliefs are significantly related to lab grades.

$H_0$ Content knowledge, and/or efficacy beliefs are not significantly related to lab grades.

SPSS 11 was utilized to analyze the data. After the analysis of the data, the researcher failed to reject the null hypothesis. There was not a statistically significant relationship between content knowledge, efficacy beliefs, and lab grade. Table 13 showed the resulting correlations. The multiple regression result for predicting lab grade from efficacy and content was not significant ($F_{2,43} = 2.13, p = .14$).

Table 13
Correlations for Average Content score, Average Efficacy Score, and Average Lab grade

<table>
<thead>
<tr>
<th></th>
<th>AVGCAT</th>
<th>AVGEFF</th>
<th>LABGRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Content Score</td>
<td>Pearson Correlation</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Average Efficacy Score</td>
<td>Pearson Correlation</td>
<td>-.111</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.461</td>
<td>.940</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Average Lab grade</td>
<td>Pearson Correlation</td>
<td>.297*</td>
<td>.011</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.045</td>
<td>.940</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>46</td>
<td>46</td>
</tr>
</tbody>
</table>

* Correlation is significant at the $p < .05$ level (2-tailed)

As evidenced in these results, the multiple regression analysis demonstrated that there was little predictive value in either the content knowledge score and/or the efficacy score. Though it was true that there was a statistically significant relationship between the average content knowledge score (AVGCAT) and the lab grade, it was clear that the practical significance was minimal since the average content score only
accounts for about 9% of the variance in lab grade. The predictive value of the average efficacy score (AVGEFF) was essentially useless in accounting for any of the variance in the lab grade. This may be due to the fact that the scores on all three of the tests illustrated little variation. On the average content knowledge measure (AVGCAT), only three students scored below 27.5, and only one student scored above 37.5, demonstrating that there was not a wide variation of scores on this measure. On the average efficacy measure (AVGEFF), all of the students’ scores fell between 46.0 and 60.0, again showing only a small amount of variation and, on the lab grade, no student scored below a 75.0. All of this spoke well for the students who earned these grades, but little variation in test scores often leads to poor predictive value. Figures 6-8 presented the graphic results of the average scores on all three measures and graphically demonstrated the limited variability, which may have restricted their predictive capabilities.

Figure 6
Average CAT

![Average CAT Scores](image_url)
Figure 7

**Average Efficacy**

Average Efficacy Scores

![Bar chart showing average efficacy scores with frequency distribution]

- Frequency
- AVGEFF
- Std. Dev = 3.62
- Mean = 51.8
- N = 46.00

Figure 8

**Average Lab Grade**

Average LAB GRADE

![Bar chart showing average lab grade scores with frequency distribution]

- Frequency
- LABGRADE
- Std. Dev = 7.39
- Mean = 88.3
- N = 46.00
Chapter 5 presents the final results of the dissertation in the following manner: discussion, research questions and hypotheses, conclusions, implications, and recommendations.

Discussion

This study began with a concern about the fact that elementary teachers, as a whole, avoid teaching science in the elementary classroom (Gess-Newsome, 1999). The three main factors noted as reasons for this avoidance were: (1) minimum science requirements to reach certification, leading to a lack of preparedness; (2) lack of exposure to science in elementary school; and (3) a general dislike for and poor understanding of science leading to a low self-efficacy in science teaching (Anderson & Smith, 1987; Feistritzer & Boyer, 1983). As noted, these factors have evolved into a spiraling cycle of avoidance. The ultimate goal of the ESLEE was to conduct an intervention to break the avoidance cycle. Educational interventions are often created and/or used to bring about improvement in student performance on a variety of academic measures. With this same objective, the ESLEE was implemented in an attempt to improve the preservice students’ academic achievement in science as well as improve their belief in themselves as teachers of science. The ESLEE Intervention was lab-based and utilized in-context, constructivist approaches to positively influence
participants’ abilities to retain science content knowledge and, perhaps more importantly, to positively effect their belief in themselves as teachers. This Intervention was created to directly respond to, at least in part, all three of the main avoidance factors noted above. First, the Intervention focused on an in-context approach to increase students’ content knowledge in an attempt to help them be better prepared for teaching science content as elementary teachers. Second, the Intervention focused on utilizing the constructivist approach to increase students’ self-efficacy in science teaching. It is purported that when teachers feel better prepared to teach science and both understand and like science, they are more likely to teach science to their own students, thus exposing their students to the science that they were deprived of as elementary students themselves.

Research Questions and Hypotheses
This study focused on two main research questions and hypotheses:

1. Are science content knowledge and self-efficacy functions of the type of lab intervention? Will using an in-context, constructivist approach in an environmental science lab to teach environmental science knowledge and skills to self-identified preservice educators have a positive influence on their content knowledge achievement and/or their self-efficacy?

   \( H_1 \) Science content knowledge and efficacy beliefs are a function of the type of lab intervention completed by students.

   \( H_0 \) Science content knowledge and efficacy beliefs are not a function of the type of lab intervention completed by students.
The null hypothesis was rejected; there was a statistically significant difference in Occasion ($p < .001$), and Intervention and Occasion ($p < .001$), in both content knowledge and efficacy, between the SDPEEs in the Experimental Group who participated in the lab Intervention and Control Group 1. Further, there was a statistically significant difference in the Intervention ($p < .02$), on Occasion ($p < .001$), and the interaction of Intervention and Occasion ($p < .001$) between the SDPEEs in the Experimental Group who participated in the lab Intervention and Control Group 2.

2. If content knowledge and efficacy beliefs are a function of the type of lab intervention, then is content knowledge, and/or self-efficacy significantly related to the student’s lab grade? If content knowledge and efficacy beliefs are a function of the lab intervention, then can one predict a student’s lab score based on their content knowledge achievement or on their self-efficacy?

$H_2$ Content knowledge, and/or efficacy beliefs are significantly related to lab grades.

$H_0$ Content knowledge, and/or efficacy beliefs are not significantly related to lab grades.

The researcher failed to reject the null hypothesis; content knowledge, and/or efficacy beliefs were not significantly related to lab grades ($p = .14$).

Conclusions

Statistical Significance

The first research question asked, “Are science content knowledge and efficacy beliefs a function of the type of lab intervention?” From a statistical perspective, using
this population sample and the results of this study, the answer to this question is “yes.” There were larger gain scores in both content knowledge and efficacy in the Experimental Group that participated in the lab Intervention (ESLEE) as compared to either of the control groups. The smaller gain for the Experimental Group was found in content knowledge, while the largest gain was obtained in efficacy. One of the issues that may have affected the content knowledge gains for the Experimental Group was the internal consistency/reliability of the content knowledge assessment test (CAT) (Copyright © 2000 by the McGraw-Hill Companies, Inc., www.mcgraw-hill.com/). KR$_{21}$ for the CAT pretest for the Experimental group was only .30. Though the KR$_{21}$ provides a lower bound estimate, this reliability coefficient is considered small, and thus the CAT pretest may not be a very reliable measure of the Experimental Group’s pretest content knowledge. The same can be said for both the pretest and posttest CAT for Control Group 2. KR$_{21}$ reliability coefficients for these two measures were .44 and .47, respectively. Again, these measures are low and thus suggest some doubt as to the reliability and/or internal consistency of the tests for this group. In contrast, all of the alpha reliability coefficients for the efficacy instrument fell between .51 and .70 and were deemed sufficient for determining the internal consistency of the hypothesized measures.

Another possible issue, which conceivably could have had a confounding effect, is the issue of “teacher effect.” There certainly was a very reasonable possibility that the ESLEE instructors themselves could be a confounding variable. To investigate this possibility, the ESLEE instructors taught both an ESLEE and a “regular” lab. As
described earlier, each of the “regular” labs contained different sample populations and
the instructor used different teaching methodologies in each lab. For the ESLEE lab the
instructor taught only SDPEEs using the in-context, constructivist approach described in
Chapter 3. For the “regular” lab the instructor taught nonSDPEEs using the “traditional”
methodology as described in Chapter 3. The possibility existed that the ESLEE
instructors themselves could bring about greater gains in either content knowledge or
efficacy in both of their labs thus creating a “teacher effect.” To test for a “teacher
effect,” a second control group, Control group 2 (nonSDPEEs taught by the ESLEE
instructors in the “regular” lab) was created. Control Group 2 was comprised of the 62
nonSDPEES taught by the ESLEE instructors in the “regular” labs. Though it is true that
Control Group 2 had a slightly higher mean difference posttest efficacy score than
Control group 1 (Control Group 2 = 1.24, Control Group 1 = 1.17), this difference of .07
was small enough to appear negligible. Since neither control group had a substantial
gain in efficacy, as compared to the Experimental Group, it appears that the ESLEE
instructors did not have any greater efficacious influence on the nonSDPEEs which they
taught in the “regular” labs than did the “regular” instructors who taught the SDPEEs in
the “regular” labs. Also, in considering the mean difference posttest content knowledge
(CAT) scores for Control Group 1 and Control Group 2, the increase in the mean score
was in favor of Control Group 1 by a difference of 1.3. Again, Control Group 1 was
comprised of the SDPEEs taught by “regular” instructors in “regular” labs, whereas
Control Group 2 was comprised of nonSDPEEs taught by the ESLEE instructors in the
“regular” labs. Since Control Group 2 did not have a greater gain in content knowledge
when compared to Control Group 1, it appears that the ESLEE instructors had no greater impact on Control Group 2 than the “regular” instructors on content knowledge. The data also exemplified that the Experimental Group and Control Group 2 (both taught by ESLEE instructors) had essentially the same initial content knowledge (CAT) scores. Yet, the Experimental Group gain was 6.28, while the gain for Control Group 2 was only 3.53. Utilizing posttest scores, this led to an effect size (\(\delta\)) of .50. According to Slavin (2003), in educational settings, this would be considered a large effect size. As would be expected, since this is a comparison of the Experimental Group and Control Group 2, the posttest effect size (\(\delta\)) for efficacy was even more substantial than for content knowledge. The mean score difference for the Experimental Group was 4.29, while the mean score difference for Control Group 2 was only 1.24, a mean difference of 3.96 between the two groups. The posttest effect size (\(\delta\)) for efficacy was .71, which is considered a large effect size. Again, this large effect size is logical considering the efficacy measure is about teaching science, which the students in the Experimental Group plan to do, while the students in Control Group 2 do not. Again, though both of these effect sizes are large, the obtained results are expected if the ESLEE instructors differentiated their instruction for the two different sample populations in the two labs. If the ESLEE instructors had not differentiated their instruction, it would be expected that the results between the two groups would be similar. In this case, the results were not similar, and thus the assumption can be made that the ESLEE instructors were differentiating their instruction, thus the differences noted can be attributed to the lab intervention, not to the ESLEE instructors.
Under the assumption that the ESLEE instructors had differentiated their instruction, the results of the Experimental Group and Control Group 1 became more intriguing. This was the main focus of the study. “Do SDPEE students who participate in a specially designed lab obtain greater gains in content knowledge and efficacy versus their counterparts who participate in ‘regular’ labs?” The test results appear to answer this question affirmatively. The content knowledge mean difference at posttest between the Experimental Group and Control Group 1 was fairly small at only 1.2, but the actual mean change (pretest CAT to posttest CAT) for the Experimental Group was 4.09, since this group started with lower average scores than Control Group 1 and finished with higher average scores than Control Group 1. Again, utilizing the effect size ranges for educational settings offered by Slavin (2003), the (delta) effect size of .19 would be considered small but appreciable. This score may have been adversely affected by the low CAT pretest reliability. The efficacy mean difference scores between the Experimental Group and Control Group 1 were considerably more dramatic. Essentially, as expected since all 232 of these students perceived themselves to be future elementary educators, both groups began with basically identical pretest efficacy mean scores (ESLEE’s were slightly higher with .08). Yet, the resulting Experimental Group mean on the efficacy posttest was an increase of 4.29, while the increase evidenced by Control Group 1 was only 1.17. The difference between the two group mean scores was 3.2. The posttest effect size (delta) for efficacy was .59, which is considered large in educational settings. Again, this result may be even more powerful considering the fact that a quasi-random design and a relatively large sample
population were used for the study, two factors which are often difficult to attain in educational research (Slavin, 2003).

When considering the second research question concerning the prediction of a student’s lab score based on his/her content knowledge achievement and/or his/her self-efficacy, there was not a significant result ($p = .14$). There were a variety of issues that may have contributed to this result. A main contributing factor may have been that the scores on all three of the tests illustrated little variation. The limited variability in the tests may have restricted their predictive capabilities.

Practical Significance

In this study, five of the six tests were statistically significant ($p < .05$), and significant gains were evidenced for the Experimental Group both in content knowledge and efficacy. What does this mean for the practical application of the research? The effect size obtained on each of the measures for the Experimental Group versus Control Group 1 help to provide some insight toward answering this question. As mentioned earlier, effect size measures look at the degree of difference and at the degree of relationship between independent and dependent variables and can aid researchers in evaluating the practical significance of statistically significant results in applied settings such as this one. The effect size measures in this study provide a view of what is happening within the Intervention. This was extremely helpful since the raw data itself provides very little insight, only demonstrating the simple difference between the group means. This simple difference is an unstandardized estimate of the group effect. The simple difference between the groups in this study does not appear very large;
however, by calculating the effect size (delta) the researcher was able to standardize the difference and thus determine if this difference truly was “small,” “medium,” or “large,” in practical terms. For this study, between the Experimental Group and Control Group 1, the partial eta squared for the multivariate tests ranged from .06 to .42, which translated into accounting for 6% to 42% of the variation of each of the factors while in the presence of the other factors. When these strength-of-association indices are combined with the difference posttest effect sizes (delta), which ranged from .19 to .59 (content knowledge and efficacy respectively), it is evident that positive change did take place in the Experimental Group. The effect size for the difference between the groups ranged from appreciable to large (content knowledge and efficacy respectively), and the effect size for the relationship between the groups ranged from small to large (content knowledge and efficacy respectively). This provides meaningful information for considering the practical importance of this Intervention. Unlike statistical significance, practical significance provides information that allows individuals to make informed decisions about whether the effect of an intervention is large enough to warrant application and/or implementation. For instance, if individuals are looking to implement a new program that cost $1,000,000, and their research resulted in an effect size of .05, (5% of the standard deviation) is such a result worth the money they are planning to spend? Conversely, if there were no extra costs associated with implementing a new program, the same effect size of .05 would take on a different meaning.
For this research, both effect size measures provide meaningful information since there are no extra monetary costs associated with the implementation of ESLEE. The cost to conduct all of the labs is identical, from the pay for the teaching assistants, to the lab materials, to the lab manuals themselves. Since there is no cost difference, there can only be value added from any degree of productive change noted in the scores of the ESLEE participants.

Implications

This study demonstrates both the statistical and practical significance of the ESLEE Intervention. SDPEEs do achieve greater gains in both environmental science content knowledge and self-efficacy when taught utilizing inquiry-based labs, which incorporate constructivist techniques within the context of elementary education (TEKS). Also, on the practical side, the cost of the ESLEE Intervention is no different than the established cost of the existing “regular” labs. Because there are no added costs and because the Intervention labs can easily coincide with “regular” science labs, the ESLEE Intervention may be effortlessly integrated into the science department of any institution of higher education.

The broader implication of the ESLEE Intervention is that it directly addresses the noted science teaching avoidance factors. As stated, the first noted factor is that of minimal science requirements leading to a lack of preparedness. At the institution where this study was conducted, the results of this study have led the dean of the College of Arts and Sciences to implement the Intervention in all four of the science courses required of all preservice elementary educators. Thus, at this one institution in
north central Texas, all preservice elementary educators will participate in Intervention labs in environmental science, biology, physics and geology. As a result, the preservice elementary educators at this institution will only participate in inquiry-based labs. They will only see inquiry-based, constructivist techniques being modeled by their lab instructors. They will receive all of their lab-based science content within the context of elementary education (TEKS). Additionally, at this institution, constructivist and inquiry-based teaching methodologies are taught to preservice educators in their senior-level science teaching methods course. It is proposed that since the students will have participated with these techniques as students themselves, they may well be better prepared to incorporate these techniques during their methods course. Through this combination of pedagogy and increased science content, the ESLEE Intervention is addressing the noted avoidance factor of lack of preparedness.

Second, over the course of this one Intervention, preservice educators’ self-efficacy increased. The possibility exists that the efficacy of the preservice elementary educators at this institution may have a cumulative effect and/or may increase exponentially as they progress through each of the four required Intervention science labs. The initial Intervention addressed the noted factor of low self-efficacy in science. It is possible that each of the subsequent labs will further address this factor.

Third, if one accepts as true the apprenticeship of observation proposed by Lorti (1975), it is possible, since inquiry-based, constructivist techniques will be the only manner in which the students will be receiving their instruction, this may be the way they, in turn, deliver their instruction when they transition from preservice to inservice
teaching. If, as inservice teachers, they provide this same instruction to their own elementary students, it may be possible that the ESLEE Intervention is addressing the noted factor of lack of exposure to science in elementary school.

Finally, it is unknown whether the science teaching avoidance cycle can be broken. The ESLEE Intervention was just one attempt to do so. The initial results do hold promise however, and do provide the foundation for further research.

Recommendations

The discussion and conclusions above lead to several recommendations for future studies:

1. Finding a more accurate method of assessing preservice science teaching beliefs is desirable. Though the alpha reliability coefficients of the efficacy instrument were deemed sufficient for determining the internal consistency of the hypothesized measure, they were low. Thus, the development and/or refinement of a more reliable measure (> .70), which specifically aligns itself with preservice teachers, is recommended.

2. Finding a more accurate method of assessing preservice science content knowledge is desirable. Again, some of the KR21 reliability coefficients were low, and thus a more reliable instrument is recommended.

3. Utilizing a more robust numerical scale or asking more questions on a Likert-type instrument is desirable. In this study on the STEBI, the score range is from one to five on fifteen questions, thus the lowest score possible is a 15 and the highest score is a 75. However, in this study, very few students chose either extreme, and the actual
range of scores obtained was from 45 to 65, resulting in relatively little variation. A more dynamic numerical scale and/or more questions may allow for greater variation.

4. Obtaining demographic data such as a) age, b) gender, c) ethnicity, and c) current academic status (freshman, sophomore, etc.) is desirable. These data could be useful in differentiating individual results.

5. Replicating this study in other institutions and in other science disciplines is desirable. The results obtained in this study are intriguing; however, it would be interesting to see if the same results would be obtained in other higher learning institutions and in biology, chemistry and/or physics laboratories.

6. Following the ESLEE participants as they progress through their methods courses, student teaching, and first year teaching experiences is desirable. The purpose of this study was to determine whether learning environmental science content using an in-context, constructivist approach would (1) positively affect preservice educators' content knowledge achievement and, (2) positively affect their belief in themselves as science teachers (i.e., their science teaching efficacy). As the results demonstrated, this purpose was met. However, the ultimate goal of the ESLEE is to provide an intervention for breaking the cycle of avoidance in elementary science teaching. Though the results show statistical and practical significance in (1) positively affecting a preservice educator's content knowledge achievement and (2) increasing their science teaching efficacy, it cannot be determined from these results that the intervention has indeed broken the avoidance cycle for these particular participants. The only way to determine whether the cycle has been broken for these ESLEE
participants is to follow them as they progress through their preservice teacher training and into their inservice teaching careers.
APPENDIX A

COURSE ANNOUNCEMENT FLYER
Attention:

Current and potential Elementary Education Majors

Special Environmental Science Labs are being offered for Pre-Elementary Educators ONLY! The labs will be available for current and/or potential elementary education majors taking the BIOL 1130, Environmental Science Lecture.

The Environmental Science Labs for Elementary Educators will be:

BIOL 1135 - Section 503 - Mondays– 4:00-5:50
BIOL 1135-Section 512-Wednesdays– 2:00-3:50
(Limited to the first 48 students)

To Register for one of these labs, you must obtain a Restriction Code from Ms. Candy King @ 565-3599.

Labs will be held in room 243 in the Environmental Education, Science and Technology (EESAT) facility.
APPENDIX B

EXAMPLE PAGES FROM THE ESLEE MANUAL
INTRODUCTION

If anything is to be regarded as a specific preparation for teaching, priority must be given to a thorough grounding in something to teach!

Peters, 1977, pg. 151

Environmental science is the study of the interrelationships between science, technology, policy, economics, people, and the environment. It is an approach to learning that seeks to find ways to protect, restore, and enhance the environment for both humans and non-humans alike. Environmental issues are, by their very nature, interdisciplinary. Thus, the study of the environment allows individuals to ask questions, and make forays into the ways to solve problems through the use of language, math, science, art, and history. Environmental education, then, is a great vehicle for teachers to use to capture a student’s attention and encourage their learning since science is something that children do naturally, evidenced by all the “whys” that children bring forth, and the environment is central to each child’s very existence and thus a wonderful place for them to investigate and explore. As a matter of fact, research studies have shown that when children are asked what they would prefer to study, more than half of the time, they choose science (Mechling and Kepler, 1991). Yet, further research has shown that 25% of all elementary teachers do not teach science at all and, among those who do, science accounts for less than two hours of the total instructional time each week (Raizen & Michelsohn, 1994; Tilgner, 1990).

The primary way environmental science approaches environmental problem solving is through the use of the scientific method. This class will focus on the use of the scientific method as one approach to problem solving, although you may come to understand over the course of this class that solving environmental problems is as much a social issue as it is a scientific one. Scientific analysis is only one strand in the web of human nature; feelings and facts are both important parts of making essential decisions. The understanding, then a collective human effort and a synthesis of science and the humanities to obtain solutions that are scientifically sound as well as socially acceptable. This holds true whether we are discussing a global issues such as population size or issues in our own backyards, such as solid waste and the quality of the Denton water supply. Environmental issues have presented themselves to the generations that came before us, and the decisions they made have led us to where we are today. The decisions we make in this generation will continue to affect those that come after. This is one of the many reasons why the study of the environment should begin for everyone at the preschool level and continue as a lifelong process in both formal and informal capacities. As R. Muller so eloquently states, “A child born today will be both an actor and a beneficiary or a victim in the total world fabric and he may
rightly ask: why was I not warned? Why was I not better educated? Why did my teachers not tell me about these problems and indicate my behavior as a member of an interdependent human race?"

THE SCIENTIFIC APPROACH

An extremely important skill is the ability to think clearly and critically about any problem with which you are confronted. There are many disciplines that teach critical thinking, and most academic disciplines can impart the ability to dedicated students. In the scientific disciplines, the scientific method is the framework through which critical thinking is structured. This method is not the only way to solve problems, but it does allow you to think of a problem in a different light, expanding options and possibilities for resolution. As a matter of fact, the scientific method is such an integral part in the solving of problems that the Texas Education Agency has placed this method into the Texas Essential Knowledge and Skills (TEKS) for kindergarten science. The TEK states: (K.2) Scientific processes. The student develops abilities necessary to do scientific inquiry in the field and the classroom. The student is expected to:

(A) ask questions about organisms, objects, and events;
(B) plan and conduct simple descriptive investigations;
(C) gather information using simple equipment and tools to extend the senses;
(D) construct reasonable explanations using information; and
(E) communicate findings about simple investigations.

In this section, we will explore the basic fundamentals of scientific analysis using this very same process. In this particular case we will use numbers, the acquisition of information, and the formal use of the scientific method. These activities may seem tedious from time to time, but this section sets the stage for all future problem solving and future lab activities. The scientific method is the process by which environmental science is practiced by scientists of all ages. Without this basic foundation of science you would have difficulty throughout the course of this class. However, the scientific method is very easy to learn (so much so that it is formally introduced in kindergarten) and the use of numbers becomes easier with practice. Pay special attention to the lab on the scientific method, and you should find that by the end of the semester that the application of science is easier than you might have imagined.
The Scientific Method

Science is a major form of educating the eye, of becoming an apprentice to nature, of entering into a well-informed friendship with nature that accepts the other as it is in its own world.  

Sallie McFague

The scientific method is a systematic and usually mathematical way to think critically about problems. The power of this way of thinking lies in its ability to generate accurate and repeatable predictions given good data collection and analysis.

There are two distinct classes of investigation within the scientific method, termed descriptive (or inductive) and experimental (or deductive). The inductive method is used for investigating associations between classes of facts, and infers generalities from a particular collection of observations or facts. For example, a study that attempts to determine what habitats a particular animal prefers would be an inductive study. The deductive method is used to determine cause-and-effect relationships, and involves comparisons of manipulated situations to an undisturbed “control” situation. For example, once you have determined what habitat a particular animal prefers, you could manipulate variables (such as food availability) within the habitat to see specifically how it affects the population of this animal. As you can see, inductive studies often set the stage for deductive studies, which are in turn meant to refine and improve the knowledge acquired from inductive studies.

There are two basic prerequisites to consider a theory, statement, or hypothesis scientific. First, it must be falsifiable; this is you must be able to pose the statement in such a way that it can be disproved by experiment. Second, it must be replicable; that is, the methods used to gather data during the course of the experiment must be explained in enough detail to allow other, independent researchers to duplicate the original experiment. Only after a great deal of replication has occurred can a hypothesis, statement, or theory be considered reliable knowledge.

The steps of the scientific method include:

1. Observation
2. Hypothesis Formulation
3. Methods
4. Data Collection and Analysis
5. Results
6. Conclusions and Implications
Observation

Observation is the first step of the scientific method. Observation can be as simple as seeing some sort of interaction, and deciding to study this interaction scientifically, or can be as complicated as exploring the finer points of an existing scientific theory.

For example, you might observe a correspondence between two events, and wish to see if they are connected. Or you might have already seen some sort of association, but wish to establish whether or not there is a cause-and-effect relationship. Specifically, you might observe that people living in cities with high levels of air pollution seem to have higher rates of cancer. Or you might observe that a particular species of tree grows better in rural areas than it does in the city. Or perhaps you have seen examples in your own work that seem to contradict an existing scientific theory.

Hypothesis Formulation

Once you have determined the specific area of scientific interest you wish to study, you must then form hypotheses about your idea. A hypothesis is a statement about relationships derived from observation or theory that can be falsified by experiment. In order to test an idea using the scientific method, you must form a set of two contradicting hypotheses: the null hypothesis (symbolized by \( H_0 \)) and the research hypothesis (symbolized by \( H_1 \)).

The research hypothesis is a generalized statement about cause-and-effect processes or relationships derived from observation or theory.

The null hypothesis is simply the research hypothesis phrased in the negative, that is, it falsifies the research hypothesis in order to test it.

These hypotheses can be as general or as specific as needed in order to examine accurately the idea under consideration. However, the more specific your hypothesis, the more chances you have to obtain useful information.

General example:
\( H_1 \): Air pollution causes cancer.
\( H_0 \): Air pollution does not cause cancer.

Specific example:
\( H_1 \): The new growth of sweet gum trees which live in an urban environment will be different from the new growth of sweet gum trees which live in a rural environment.
\( H_0 \): The new growth of sweet gum trees which live in an urban environment will not be different from the new growth of sweet gum trees which live in a rural environment.
You might wonder: why bother with the tedium of research and null hypotheses, since they are saying almost the same thing? It is a common misconception that science proves things, particularly cause-and-effect events. However, the human mind, for all its achievements, is finite, and because of the limitations of our understanding and ability to store and process information we cannot know everything about any particular situation. In other words, science can never prove anything. However, we are able to disprove things through the process of replication, which is why we use a null hypothesis to test our ideas. Scientific experiments are set up so that if we can disprove our null hypothesis, we can – by inference – support the research hypothesis (the original idea under consideration). Put into scientific terminology: if we are able to reject the null hypothesis, we can support the research hypothesis. This may seem confusing at first but it does become more clear with practice.

Finally, scientists always speak in terms of probabilities. Since science cannot prove anything and must accept the validity of its research hypotheses by inference, scientists use statistics to give their results a certain level of confidence (which are based upon probabilities associated with the experiment). For example, after rejecting a null hypothesis, a scientist might report the results as follows: there is a 95% probability that cause \( x \) leads to effect \( y \) given situations like \( z \) due to chance alone.

Methods

It is extremely important to understand the necessity for accurate and specific methods and measurements; without such attention to detail there could be little hope of replicating the results of a particular study. Without replication, a scientific study can be discredited easily, resulting in a waste of time, energy, and money, and – in extreme cases – a career.

Methods are simply the means by which scientists of all ages gather and analyze data. This includes such things as how something is measured, what units it was measured in, and what techniques (such as statistics) are used to analyze the data that is gathered. The metric system of measurement is the international standard for scientific work, and will be employed throughout this course (some basic information and common conversion factors between metric and English units are included in the Appendix). Because it is impossible to measure everything, simplifying assumptions are often made, which might include measuring certain attributes of an object while purposefully ignoring other attributes. These assumptions must be made explicit prior to conducting the experiment, and must be made explicit in the methods section of any resulting report. Without such clarity, it could be extremely difficult to replicate the experiment.
Data Collection and Analysis

Data collection is just what it sounds like: the collection of data using predetermined methods. In order to maintain scientific credibility, scientists must stick to rigorously to the methods they have decided to use for data collection. Once again, other scientists who try to replicate the experiment will definitely derive different results if they stick to the methods that the previous study claimed to use but did not.

Analysis of data is done typically through the use of mathematics and statistics, which are often able to reveal patterns in the data that may not be apparent through the study of the data alone. The patterns that statistics reveal may or may not reveal something in nature, so it is up to the scientist to determine whether or not these patterns are natural or an artifact of the mathematical manipulation.

Results

Results are an explanation of what happened during data collection and analysis. Scientists generally emphasize the important results, that is, the results that bear directly on the hypothesis, idea, or question under consideration. They do not say everything about all of the data; at best that would be tedious and unnecessary. These important results are used to explain what the data mean or imply in terms of the scientific topic under consideration.

Graphs realize the adage that a picture is worth a thousand words. A good graph can explain the important results. Graphs are an integrated part of any scientific report so interpreting their meanings is an important and useful skill.

Conclusions and Implications

The conclusions of a scientific study are oriented around relating the results of the particular experiment to the scientific field of interest.

One of the things that distinguish good scientists is how they derive implications from their data. Good scientists are often able to take the results obtained from a specific study and make a convincing argument applying their results to a much broader problem or situation. In environmental science, implications are often used to discuss what the results imply in terms of the human relationship with the rest of the environment. Some scientists also use this section to make policy recommendations or specific suggestions on adjusting human activities to help restore or protect environmental health.
Lab Activity

You will use the scientific method to look at the relationship between different characteristics of the human body. You may have observed that tall people have long arms and shorter people have shorter arms. You will create a hypothesis of the relationship between arm span and height and test it. How can you test your hypothesis? How will you collect the data? What are your methods? Will you measure from the top of the head to the floor for height? Will you measure from the fingertips of each hand for arm span? How will you determine if there is or isn’t a difference between the two measurements? You may average the height of the entire class and the arm span of the entire class and use the difference. Be sure to state in your methods what average difference interval will qualify as equal lengths or different lengths. You may also graph your class data to visually see the association between height and arm span. Record your data on the worksheet.

Lab Assignment

After completing the Lab Activity, your assignment is to answer the critical thinking question. The appendix of this manual provides an overview of how to respond to a critical thinking question.

Critical Thinking Question

What do you conclude from this experiment? Do the results of this experiment (the scientific method itself) have any implications for human society? In your opinion, why is the scientific method formally introduced in Kindergarten?
Lab Activity Worksheet: The Scientific Method

Observation:

Research Hypothesis:

\[ H_1: \]

Null Hypothesis:

\[ H_0: \]

Methods:

Results:

Are height and arm span approximately the same?

Do you reject or fail to reject the null hypothesis?

What does this imply for your research hypothesis?
APPENDIX C

EXAMPLE ESLEE SYLLABUS
Objective:
When working toward solutions to a problem, several things must happen. First, we must agree that there is a problem. Second, we identify the scope of the problem through measurement. Third, we must discuss possible solutions and finally, we must create strategies for reduction or elimination of the problem.

This course is designed to expose students to environmental problems that have been identified and measured. Students will become familiar with some methods of measurement, will discuss case studies, and will discuss current approaches to solving some of these environmental problems.

Grading:
Quizzes: 30%
Critical Thinking Questions: 30%
Attendance/Participation: 20%
Group Project: 20%

Quizzes:
Each lab session requires a five-question quiz covering the previous week’s lab. Quizzes will not be given late.

Critical Thinking Questions:
There will be a critical thinking question or research topic assigned at the end of each class. The response needs to be a typed one-page response that includes an introduction, body, conclusions/implications and references. No late responses will be accepted.

Group Projects:
A team project focusing on our political system and the environment will be assigned in October. Class members will be split into teams and assigned a topic. The team will investigate and research their respective topic throughout the remainder of the semester. A team report, accompanied by a presentation will showcase the results.

Attendance:
Students are required to attend their scheduled lab section unless formally placed through registration into another lab section. If you miss a lab you are responsible for obtaining notes, data, etc. In the event of an extreme emergency, a lab may be made up if a space can be located in another lab and you have the express permission of that lab instructor. Future absences result in a zero and the lab cannot be made up.

Lab Rules:
Students at each lab table are responsible for leaving it clean and orderly for the next lab session. Outdoor labs will be held regardless of the weather, please dress appropriately.

**Policy on Academic Misconduct:**
Academic misconduct will not be tolerated. Students who are found to be cheating will automatically be assigned a grade of “I” (incomplete) until the matter is resolved through proper procedures. Students are expected to know their rights and responsibilities as put forth in the University of North Texas Undergraduate Catalog and the Student Guidebook.

**Policy on Disability Accommodations:**
The Department of Biological Sciences, in cooperation with the Office of Disability Accommodation, complies with the Americans with Disabilities Act in making reasonable accommodations for qualified students with disabilities. Written requests need to be made prior to the 12th class day.

**BIOLOGY 1135**

**Environmental Science Laboratory Schedule** Fall 2002

<table>
<thead>
<tr>
<th>Week of:</th>
<th>Lab Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2</td>
<td>Syllabus/Pretests/Introduction</td>
</tr>
<tr>
<td>September 9</td>
<td>Scientific method/Policy Issues</td>
</tr>
<tr>
<td>September 16</td>
<td>Tree Identification/Taxonomy/EIA</td>
</tr>
<tr>
<td>September 23</td>
<td>Food Webs</td>
</tr>
<tr>
<td>September 30</td>
<td>Dissolved Oxygen</td>
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<tr>
<td>October 7</td>
<td>Soils</td>
</tr>
<tr>
<td>October 14</td>
<td>Air Quality</td>
</tr>
<tr>
<td>October 21</td>
<td>Water Chemistry</td>
</tr>
<tr>
<td>October 28</td>
<td>Ethics/Times Beach</td>
</tr>
<tr>
<td>November 4</td>
<td>Landfill Field Trip</td>
</tr>
<tr>
<td>November 11</td>
<td>Personal Energy Consumption</td>
</tr>
<tr>
<td>November 18</td>
<td>Presentations/Papers Due</td>
</tr>
<tr>
<td>November 25</td>
<td>Thanksgiving Week/Extra Credit Planetarium Show</td>
</tr>
<tr>
<td>December 2</td>
<td>Policy Lab/Wrap Up</td>
</tr>
</tbody>
</table>

*Schedule subject to change.*
APPENDIX D

STEBI QUESTIONS ELIMINATED FROM THE STUDY
STEBI QUESTIONS ELIMINATED FROM THE STUDY:

Question number -

2. I am continually finding better ways to teach science.

3. Even when I try very hard, I don’t teach science as well as I do most subjects.

6. I am not very effective in monitoring science experiments.

8. I generally teach science ineffectively.

16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child’s teacher.

17. I find it difficult to explain to students why science experiments work.

18. I am typically able to answer students’ science questions.

21. Given a choice, I would not invite the principal to evaluate my science teaching.

22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.

23. When teaching science, I usually welcome student questions.
APPENDIX E

STEBI QUESTIONS UTILIZED FOR ANALYSIS IN THE STUDY
STEBI QUESTIONS UTILIZED FOR ANALYSIS IN THE STUDY:

Question number -

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.

4. When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.

5. I know the steps necessary to teach science concepts effectively.

7. If students are underachieving in science, it is most likely due to ineffective science teaching.

9. The inadequacy of a student’s science background can be overcome by good teaching.

10. The low science achievement of some students cannot generally be blamed on their teachers.

11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.

12. I understand science concepts well enough to be effective in teaching elementary science.

13. Increased effort in science teaching produces little change in some students’ science achievement.

14. The teacher is generally responsible for the achievement of students in science.

15. Students’ achievement in science is directly related to their teacher’s effectiveness in science teaching.

19. I wonder if I have the necessary skills to teach science.

20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.

24. I don’t know what to do to turn students on to science.

25. Even teachers with good science teaching abilities cannot help some kids learn science.
APPENDIX F

CONSENT FORM
NOTIFICATION OF USE OF DATA FOR DOCTORAL DISSERTATION RESEARCH

Collection of data on the *Science Teaching Efficacy Belief Instrument* and the Content Assessment will be used in doctoral research being done by Ruthanne Thompson, doctoral candidate in Curriculum and Instruction at the University of North Texas. The research will be used to investigate whether a relationship exists between perceived science teaching efficacy, content knowledge in environmental science, and lab skills.

We know of no risks to subjects involved in this research; this study asks only that you answer the questions on the two assessments. Your answers and the results of the survey will be used only in Ms. Thompson’s doctoral dissertation and will not in any way be reflected on your course grade.

Your answers on the survey will be used in a statistical evaluation performed as a part of Ms. Thompson’s doctoral dissertation research. Results of the research will be included in her dissertation, tentatively titled *The (Science) Teaching Triad: Pedagogical Knowledge, Skills, and Efficacy*.

No additional time or effort is required of subjects other than answering the questions on the survey. It should approximately 15 minutes to complete the Instrument and approximately 20 minutes to complete the Content Assessment. At any time during Ms. Thompson’s collection or analysis of data you may choose to have your results removed from consideration by notifying her of that desire (see contact information below). For any other questions and/or concerns about this or any other research you may contact Dr. James Laney in Curriculum and Instruction at 565-2602 or the Institutional Review Board (IRB) at 565-3940.

You may choose not to participate in this study. In such case, do not fill out the assessments. There will be no adverse consequences to choosing not to participate.

These data will be used only for the purposes of this research, and your responses will be held in confidence. Your individual ratings on the assessments will be available to you at any time, but will not be available to anyone else. Names will not be used to identify instructors and/or participants. Lab section numbers will be utilized to differentiate the labs and the last four-digits of the social security number will be used to differentiate the participants. The last four digits of the social security number provide confidentiality to the participants and yet allows for matching of the pretest scores with posttest scores on the two measures.

For any questions about the doctoral dissertation research being conducted in this study, or to learn your own personal results, please contact Ms. Thompson at her office, EESAT #164, or via phone at 565-2994, or via email at rudi@unt.edu.

I have been two copies of this form, one of which I may keep for my own records. Further, I understand that I do not have to take part in this study, and my refusal to participate or to withdraw will involve no penalty or loss of rights or benefits or legal recourses to which I am entitled.

Last four (4) digits of Student Social Security Number ______________  Date ______________

Investigator’s Signature _________________________________

*This form has been approved by the UNT IRB*
REFERENCES


