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An Interdisciplinary Course for Non-Science Majors:
Students' Views on Science Attitudes, Beliefs, and the Nature of Science

by

Gary Eugene Brannan

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Education
Department of Adult, Career, and Higher Education
College of Education
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methods

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Dedication

I dedicate this dissertation to the memory of mother and father, the late Mona and Gene Brannan. My mother stressed strength and perseverance while my father was a true inspiration, both instilled in me a love for learning. To my wife Jeanne, and children Travis, Trevor, Taylor, and Tatum for providing unwavering support. Without their understanding and confidence in me this dissertation would not have been possible.

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ABSTRACT

This study's purpose was to investigate the differences in the attitudes towards science, belief in science, and the understanding of the nature of science between pre-service elementary education majors who took a two-semester interdisciplinary course called "Science That Matters" (ISC 1004 & ISC 1005) with those pre-service elementary education majors who took two undergraduate science courses other than the two-semester interdisciplinary science course.

The research method employed a 30-item survey (Moore & Foy, 1997) entitled Scientific Attitude Inventory II. The survey's participants were two classes who had taken both semesters of the interdisciplinary course ($n = 23$) compared with six classes of elementary education majors who had taken two other undergraduate science courses other than the two-semester interdisciplinary course ($n = 46$).

A two-tailed t-test was used to examine the differences in the means between the two groups as to their attitudes towards science, belief in science and their understanding of the nature of science. The study concluded that among the survey participants, there was no statistical difference as to the three dependent variables (attitudes

towards science, belief in science, and the understanding of the nature of science) when testing for the independent variable (participants who had taken the two-semester interdisciplinary course and those who took two different science courses).

The author suggests the results provide evidence that the two-semester interdisciplinary course holds its own when compared to other elective science courses, based on this evaluation of the students' attitudes toward science, belief in science and the understanding of the nature of science. Continuing research concerning this interdisciplinary course is needed to accumulate data which may show an advantage for students who take this course in learning and appreciating science for future elementary education teachers.

Chapter 1

Introduction

Science education in America has gone through many changes over the course of American history. These changes were influenced by political, academic, economic, and societal pressures. Each period brings with it a renewed interest and desire to improve what takes place in the classroom. In the past 100 years, science has been viewed as a fundamental aspect of our culture and is, therefore, an essential part of the curriculum.

Historically, subjects have been retained in the curriculum because they were thought to function in some way to produce socially or personally significant outcomes. The purpose of schools in early America was for the instruction of basic literacy. Most schoolhouses were small and ill-kept structures with single classes comprised of students from as young as 5 or 6 years to those in their later teens. Enrollment or attendance was not required; students went when they were not needed in the fields, stores, or at home. Learning involved rote memorization and recitation by the whole class. The names of many natural phenomena, such as the planets, trees, flowers, various animals and so forth were included in the teaching process. Science was not a distinct field of knowledge, but instead invisible, as part of the larger catalogue of words and objects that had to be absorbed.

During the early part of the 1800s very little took place regarding science education. The nation was primarily an agricultural society and the cities were just

beginning to take form. Children spent more time working on the farm than attending school. “The origins of an elementary-school science program may be found in the didactic writings of the early eighteenth hundreds. A number of the most influential writers of such materials placed much emphasis on science as a first-hand study of things and phenomena” (Underhill, 1941, p. 16).

Between 1860 and 1880, there was a movement to promote “object teaching.” Object teaching was an attempt to make instruction more concrete and student centered. “As opposed to lecturing to children, the intent was to give them real objects with which to experiment and make observations. The object teaching movement was sought to develop student thinking and to de-emphasize the memorization of facts” (Chiappetta, 1991, p. 76).

In most homes of the period, a kind of domestic curriculum was set up. Astronomy tended to be a “male” subject, taught by fathers to sons. Natural history, on the other hand, a far larger realm for potential seeing and learning, was handled mostly by mothers, who often took profound interest in the study of plants, flowers, animals, insects, local geography, and geology. According to Cremin (1980, p. 65), “From an earlier role as aid and adjunct, she became the dominant figure of the family, creating with her strength, devotion, piety, and knowledge the ambience within which proper nurture could proceed.”

When not required to work in the fields, the store or elsewhere, women took responsibility for the home during the day and therefore tended to do the flower gardening, vegetable gardening, and other kinds of outdoor tasks that enabled them to

develop an intimate familiarity with the natural environment around the house. Fathers were being drawn from the natural history of the fields to work in other ways. For the fathers, this was limiting their view of the natural world.

In the late 1800s, the combination of industrial expansion and migrations from rural areas to urban centers led to two models of science teaching at the elementary level. One was a knowledge-oriented model referred to as “elementary science”; the other was nature study and had personal development as its primary aim.

Changes in society resulting from a developing technology created a popular interest in science and gave impetus to elementary science. “The chief emphasis during this period [about 1880] was in terms of giving a wider knowledge and understanding of the rapidly increasing science and technology” (Underhill, 1941, p. 111).

The elementary science model seemed to be focused on moving the country from an agrarian to an industrial-technological society whereas the nature study model was designed to slow or stop the exodus of people from rural agricultural communities to urban industrial centers. Nature study was supported as a way of interesting children in farming, thereby slowing emigration to cities. “Nature study was the great remedy for the alienation of man from the land and from his neighbor” (Cremin, 1964, p. 77).

During the first quarter of the 20th century, the population and industrialization continued to grow rapidly. The United States emerged the victors in World War I and fully conscious of the fact. Early postwar trends of economic advancement and wealth expanded. Technological development flourished in the wake of the automobile, oil, rubber, steel, chemicals, and electronics. Technologies also advanced mass

communication, with the publishing business and radio being two examples. The ability to communicate the new technologies fueled the public's desire and curiosity in science and technology. This technological and industrial growth was associated with the advancement of science. This gave the impression that the study of science could promote discipline and patience, a sense of both reverence and understanding toward the natural world. The structure of public schooling was in place at this time with those in higher education speaking highly of science yet treating it with relative disinterest. However, with a new focus on technology, schools were urged to offer a large array of new subjects, all of them in professional areas such as business and engineering. Industry and government both provided funds for setting up new programs. "The lion's share of this new support went to the sciences. Engineering enrollment alone grew from roughly 30,000 to 50,000 in the first few years after the war ended" (Levine, 1988, p. 38).

Public schools continued with teaching the sciences. "The elementary curriculum centered on generalizations and concepts from the various science disciplines. This influence resulted in readers that taught children science content but was lacking in inquiry and hands-on activities" (Chiappetta, 1991, p. 78).

At the end of World War II, with the use of the atomic bomb, it was evident that science was playing a major role in the security and welfare of the American people. After the war, the United States retooled to rebuild the post-war economy, offering soldiers the spoils of war with free education and no-money-down loans for homes. Along with this came families that increased the number of students in elementary and secondary schools as well as soldiers matriculating into classes at the universities.

Chiappetta (1991) noted, “At the same time, it was realized that few people were going into science and mathematics. This caused scientists and mathematicians to examine secondary school science courses even before Sputnik was launched in 1957” (p. 79). The debate reached the public consciousness linking it with the failure in the schools. “The courses, they claimed, lack rigor, were dogmatically taught, were content-oriented, lacked conceptual unity, were outdated, and had little bearing on what was really happening in the scientific disciplines” (Colette & Chiappetta, 1989, pp. 11-12).

This general tendency was bolstered by widespread public concern about the nation’s schools in the wake of the Soviet Union’s successful launch of the Sputnik spacecraft in 1957. The first man-made satellite, and the opening event of the much-anticipated “space age,” Sputnik’s success was a major source of embarrassment for American national pride. The seeming superiority of Russian scientists focused attention on the need for higher standards of academic achievement, especially in mathematics and the sciences.

With the advent of the “cold war” and “space age,” the concerns of scientists and mathematicians were amplified. Millions of dollars were spent on the development of curriculum projects that were unique to education at all levels from elementary school through senior high school. Some were programs to train teachers to familiarize them with the new curriculum projects, while other programs were offered specifically to train teachers to implement a given curriculum project. In an unprecedented move, the scientists developed the programs and curriculum for the teachers, ostensibly to recreate the scientific method that was employed in the laboratory of research scientists. With

this reform, the outcome would be children who would have the fundamental framework to think like scientists.

This type of curriculum reform in the early 1960s was adopted from a model of science education described by Jerome Bruner (1960) in *The Process of Education*. Scientific knowledge was the dominant aim, and the scientific method was the means to achieve this aim. In Bruner's model, knowledge consisted of science concepts forming the structure of a discipline. Bruner states his aim: "The curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to that subject" (p. 31).

With the reform came money to make the change, but dissonance occurred in allocating money for elementary education. The staff at the National Science Foundation (NSF) wanted money to move into elementary school science with programs analogous to those it had initiated at the high school level. Unfortunately, the Chairman of the National Science Board, James Connant, felt the money would be better spent at the secondary level. "For Connant, it was a matter of scale, not fundamental principle. He reasoned that NSF's programs had a realistic chance of reaching a large percentage of the 30,000 to 40,000 teachers of mathematics and science in the country in 1958 in a reasonable number of years" (Atkin & Black, 2003, p. 11). The elementary teachers at the time numbered around a million and Connant was concerned not only with reaching this large cohort but also with the fluid nature of the elementary school teacher. Connant noted, "That this largely female group had a half-life of about three years" (p. 11). Connant also brought up another point that is still salient today, "The clinching argument

for caution, was that elementary school teachers, unlike those in secondary school, not only had responsibility for teaching science but all other subjects as well” (p. 12).

Connant may have felt that these points were making the case to keep money out of the elementary schools, but to the contrary, it could be argued that providing money to elementary teachers could bolster their ability to teach science and contribute to science reform.

However, money did trickle down to the elementary schools for science reform and have stood the test of time.

“Of the many elementary science programs developed during the 1960s, three received considerable attention then and continue to be used today, though not as widely. They are the Elementary School Study (ESS), Science – A Process Approach (SAPA), and the Science Curriculum Improvement Study (SCIS).

These programs all stress hands-on activities and discovery learning. They had no textbook for students to read and placed the teacher in the role of guiding student learning. The influence of these programs can be observed in commercial textbook programs available today” (Chiappetta, 1991, p. 80).

George DeBoer (1991) elaborates on these three courses, “what made the science curriculum projects unusual as an education reform effort was the scale of the endeavor and the extent to which the projects were actually completed and used in the schools” (p. 166). He cites percentages to make his point, “The three most popular new elementary science programs were used in 32% of the surveyed school districts –Elementary Science

Study (15%, Science –A Process Approach (9%), and Science Curriculum Improvement Study (8%)” (p. 167).

By the late 1960s and early 1970s, attention in education had moved from concerns about keeping pace with the Soviet Union to concerns about providing an equitable and humane educational environment for all American youth. An unpopular war in Vietnam served as a catalyst to arouse feelings of discontent and even anger with many facets of American life.

Given the social atmosphere of the late 1960s and early 1970s, the calls for intellectual rigor, for excellence, and for disciplinary study that had been made little more than a decade earlier sounded anachronistic. Many educators who had been skeptical of the curriculum reformers’ emphasis on the structure of the disciplines were quick to point to the failure of these courses to meet the new challenges of education. The new need was for an enlightened citizenry, not an educational elite.

Chiappetta (1991) writes, “During the 1970s educators had an enormous array of curriculum materials and ideas to choose from to teach science. Hundreds of programs were available, many of which were the result of national curriculum project writing teams” (p. 85). Teachers had available a plethora of materials but limited training on theory and concept orientation. In addition, teachers found it difficult to teach these courses that put high conceptual demands on the average student. “The nation’s youths were not turning toward science and engineering nor were they performing well on national assessments to determine knowledge and understanding of these fields,” Chiappetta concludes, adding that “disillusionment with science and technology, focus on

the Vietnam War, and an increased awareness of environmental issues appear to be factors that detracted from science education” (p. 85).

The lessons learned from previous attempts to reform school science are that two kinds of adaptations must occur: (1) Programs must be adaptable to the teachers’ knowledge, skills, and approaches; and (2) teachers must be provided with opportunities to accommodate new programs by developing new knowledge, skills, and approaches.

The science class of today is a joining of three subject areas – Science, Technology, and Society (STS) – combined with a philosophy of “less is more.” In the 1980s what American needed was not so much a better science, but a more efficient and productive one – a science able to yield more inventions, more patents, more kinds of new technology, more new industries, all in a shorter time frame. By the mid-1980s, many sectors of the scientific community, speaking in the name of economic competitiveness, began to proclaim a “crisis” in the supply of new scientists and engineers. It was at this time that the National Commission on Excellence in Education (1983) released *A Nation at Risk* which states that “our educational system has fallen behind and this is reflected in our leadership in commerce, industry, science and technological innovations which is being taken over by competitors throughout the world” (p. 5).

The emphasis on the integration and interaction of science, technology and society still plays a pivotal role in curriculum development. Roger Bybee (1993) reflects on this period in time (1980s) by saying, “Even though the term ‘scientific literacy’ had been around for about 30 years, ‘scientific literacy for all students’ was replacing the

theme of science manpower and emerging as the major goal” (p. 55). He adds, “The science – technology – society (STS) theme was replacing that of inquiry teaching as a way of summarizing a new emphasis for science curricula” (p. 56). To support the point, Chiappetta (1991) states, “several recognized projects and programs appeared that reflect the STS movement. Project 2061 is a long-range undertaking designed to completely revamp science education by the year 2061 when Haley’s comet returns” (p. 89). Additionally he states, “Sponsored by the American Association for the Advancement of Science, the intent of the project is to design programs of science that teach less but develop more understanding for what is taught (American Association for the Advancement of Science 1989)” (p. 87).

In the future greater attention will be paid to elementary teacher preparation in science, since these teachers have been identified as a key factor for improving the success of science education. This scrutiny has come from numerous governmental agencies and science education organizations have coordinated efforts toward the goals of reforming science education. Among the active leadership in this arena have been the National Science Foundation (NSF) (1996a, 1996b, 1997, 2000), National Research Council (NRC) (1996a, 1996b, 1999) and American Association for the Advancement of Science (AAAS) (1989, 1993, 1997, 2001). The standards presented by these three groups are cited throughout the literature by many organizations and individuals who have taken active roles in promoting the science education reform standards and goals. Throughout this paper, special attention will be given to the AAAS, NSF, and NRC because of their leadership role in science education reform. The reader should keep in

mind that the actions of the AAAS, NSF, and NRC have widespread support throughout the scientific community.

Statement of Problem

Improving elementary teacher science competency has been a primary goal of these science education reform efforts (NSF, 1996a, 1996b, 1997, 2000; NRC, 1996a, 1996b, 1999). The relationship between students' early exposure to science and elementary teachers' competence in teaching science has become a major concern for the science community. The concern is that science is not an integral part of the educational experience at the elementary school level, and this will impair the chances of the student appreciating and being competent in science later in the student's education. It is felt by the science community that elementary teachers play a key role in promoting persistence in science (NSB, 2000, pp. 5-12). The National Commission on Mathematics and Science Teaching for the 21st Century states "we are failing to capture the interest of our youth for scientific and mathematical ideas. We are not instructing them to the level of competence they will need to live their lives and work at their jobs productively" (US Department of Education, 2000, p 4).

This concern has been amplified by the results of the Third International Math and Science Survey (TIMSS). In this survey, the data have shown that the science performance level of fourth grade students in the United States is second only to Korea in the percentage of students at the top 10% level. Unfortunately when observing the data of fourth grade students making up the top half, this percentage (63%) drops the United States again below Korea and also Japan (Mullis, Martin, Beaton, Gonzalez, Kelly,

Smith, 1998, p.39). This implies that the United States is not doing as good a job at teaching science to the larger group of students that will make up our community.

The community in which we live is made up of former students who have acquired their knowledge in science by being exposed to science teaching at the elementary, secondary and possibly collegiate levels. These people include future legislators, business and community leaders, newscasters, lawyers, jurors, and elementary school teachers, to name a few. They will be the people who shape attitudes towards science and make decisions that require at least some understanding of science.

A problem central to this study has to do with the downward trend in science scores of our children and surveys illuminating how ill-prepared elementary teachers are in attitude and abilities to teach science. Along with the attitudes toward science that elementary teachers bring to the classroom, another area of concern is their fundamental belief in science.

Belief systems can play an influential role in the ability of people to change their minds on issues. Beliefs are experiences cultivated over many years, which make the capacity to change beliefs on certain topics very difficult to accomplish. Studies have shown that convincing evidence must be provided before individuals will alter their perceptions about science. As individuals grow older, they acquire preconceived notions about science, which could be false. These preconceived notions are difficult to dislodge.

As it now stands, pre-service elementary teachers may take a potpourri of science courses without receiving a cohesive or coherent foundation in the physical or biological sciences. Learning science in this disjointed fashion creates cognitive dissonance,

hindering the ability to shape concepts and pull together aspects of the natural world that would provide interest and learning to the elementary student.

Pre-service elementary teachers would benefit more from sequential science courses that are interdisciplinary; the two courses would blend the physical and biological sciences for maximum effect, providing a focus for preparing the teachers-to-be in their chosen field. The sequential interdisciplinary courses would present science in a relevant, meaningful, and enjoyable manner. This approach would emphasize the major concepts of the sciences and stress development of higher order thinking, at the same time providing to the student the ability to function productively in society. The National Research Council adds “accumulating evidence suggests that non-majors often fare better in smaller courses and inquiry-based laboratory experiences where they become actively engaged with the subject matter” (2003, p.37). Giving pre-service teachers an opportunity to learn science in this manner would provide the future elementary school teachers with a better attitude towards science, dispel wrongfully held beliefs, and give them a better understanding of the nature of science. Having courses as mentioned may provide elementary teachers with a better attitude, correct beliefs, and a grasp of the nature of science, which may be passed on to the students and stop the downward trend in science scores. The Glenn Report (USDE, 2000) believes “that the way to interest children in mathematics and science is through teachers who are not only enthusiastic about their subjects, but who are also steeped in their disciplines”(p. 5). Because the community would benefit from a better-prepared elementary school teacher,

sequential courses that meld the physical and biological sciences are a timely subject for scholarly research.

Purpose of Study

The purpose of this study was to determine the effectiveness in terms of attitude, beliefs and understanding of the nature of science in a two-course sequence that is interdisciplinary and geared to pre-service elementary school teachers.

The study examined whether the two-sequence interdisciplinary course provides a favorable view of science in respect to attitude, beliefs and knowledge of science compared to students who take a set of unsystematic science courses. The two-semester course integrates the biological sciences with the physical sciences. This approach allows students to make connections between the two disciplines that may form deeper meaning. If elementary teachers brought to the classroom a positive attitude about science, this could influence their science teaching strategy and thus affect the performance of students in science.

Research Questions

The study investigated the following questions:

1. At the end of the two-semester interdisciplinary course, are the attitudes towards science significantly different for students who took the two-semester interdisciplinary course compared to those who took two separate and unrelated college level science courses, where one was physical and one was biological?
2. At the end of the two-semester interdisciplinary course, are the beliefs in science significantly different for students who took the two-semester interdisciplinary course

- compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?
3. At the end of the two-semester interdisciplinary course, is the understanding of the nature of science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?

Rationale

In a few years, the elementary pre-service teachers will assume roles as elementary teachers and they will be the ones who will have to supply children with a foundation in science. It is one of the goals of the science community to have science-competent elementary teachers providing the early exposure to the sciences. Without a science-competent elementary teacher, science may not be a part of the educational experience at the elementary school level, which could diminish the chances of the student appreciating and being competent in science later in the student's education.

The heart of the matter is this: improving undergraduate science education has a direct, positive effect on precollege education. An undergraduate science teacher who models real scientific skills of investigation and critical thinking, and applies those skills to new situations, can make an enormous contribution to the education of those students who will not only use the model, but eventually will teach it.

(National Research Council, 1997, p. 7).

Many in the science community feel that proper science teaching at the elementary level is critical to the student's persistence in the sciences later in life.

Enabling teachers to construct scenarios, analogies or hands-on activities with proper explanation provides opportunity to the elementary school students to draw correct conclusions about the world around them.

Attitudes

Pre-service teachers who have a favorable attitude towards science are more apt to teach science lessons in the elementary schools. Teachers who feel uncomfortable with the subject matter are less inclined to spend the time and energy on a subject that makes them feel uneasy. This uneasiness may come from their lack of education in the sciences or unfavorable experiences in science classes they have taken. A favorable attitude can elicit the excitement with how science can be related to the world in which we live, and can foster imagination, motivation and provide an enjoyable outcome to the children.

Beliefs

In order to have a teacher in the classroom who can impart science to the students, the teacher must have beliefs about science that are positive. This belief can be narrow in focus, e.g. the teacher believes that they have the ability to think scientifically. Beliefs can also be on a broader scale such as the belief that most people are able to understand science. It would very difficult for a teacher to teach science if the teacher felt he or she lacked the ability to think scientifically. If the teacher believed most people couldn't grasp science, it wouldn't make any sense to try to teach the subject. If core beliefs about science are not addressed, then the teacher may not be as effective in the classroom.

Nature of Science

One measure of effective science teaching would be an improvement in student understanding of the nature of science as science philosophers and educators see it. The development of an adequate understanding of the nature of science (NOS) or “science as a way of knowing” by pre-service elementary teachers could affect their delivery and possibly pass along the creativity and passion that can be found when learning about the sciences.

By understanding the nature of science (refer to the definition portion of the chapter), a person can appreciate the intent of science inquiry. The more confident pre-service elementary teachers are in their background in science the more likely the pre-service elementary teachers will be in taking chances on new concepts in science as well as questions from the class. A broad conceptual knowledge base with a strong foundation to understanding the nature of science can provide deep learning to the teacher.

When analyzing the literature, (as discussed later in chapter 2), a two-semester interdisciplinary course may not broaden the nature of science unless explicitly taught in the classroom. However, the importance of understanding of the nature of science should not be overlooked. Therefore, it is included in this study for policy implications.

Limitations

The survey instrument used in this study by Moore and Foy (1997) found in Appendix A while adequate, has areas of weakness that are addressed in chapter five of this study. These flaws may influence the validity and reliability of this study.

Definitions

Five definitions are central to this study's purpose: *pre-service elementary teachers*, *two-semester interdisciplinary science course*, *nature of science*, *attitudes*, and *beliefs*.

For this study, *pre-service elementary teachers* is defined as those persons who are declared elementary education majors pursuing teacher certification in the fields of special education, primary education (K-3), and intermediate education (grades 4-7). Because of their similar needs in the area of science background K-3 and grades 4-7 are grouped together.

The *interdisciplinary course* is a sequential two-semester track for non-science majors/future elementary education teachers. The course focuses on 5-6 important topics per semester, each addressed in a 2- to 3- weeklong module. Individual modules deal with complex subjects such as nature of science, global warming, and water management that require specialized knowledge in more than one scientific sub-discipline or with concepts that can be illustrated in several sub-disciplines, such as energy conversion. The modules engage students through subjects and questions relevant to their daily lives. Just as scientists have their curiosity piqued about subjects important to them, this could be used for students as well. "The instructors help the students become active learners by motivating them with open-ended questions, puzzles, and paradoxes" (NRC, 1997, p.24). This approach provides new avenues for learning instead of the old style of classroom science typified by the Glenn Report (USDE, 2000) by saying "much science instruction

parallels what happens in a badly taught history unit on the Civil War, in which students learn nothing but the names of the generals and the dates of the battles”(p. 20). The interdisciplinary course attempts to go beyond memorization and asks the student to “master the ‘big’ concepts that make science so powerful and fascinating” (p. 20). The topics connect scientific knowledge to public decision making, policy development, and establishing scientifically literate and engaged citizens. Goals for the course are to (Potter & Meisels, 1999):

- Improve students’ understanding of the processes of science.
- Stimulate interest in science and promote life long learning.
- Improve students’ understanding of the important role science plays in society.
- Improve students’ critical thinking, analytical ability, and problem solving skills.
- Improve the students’ ability to communicate effectively and argue persuasively using valid evidence.
- Improve students’ understanding of the basic concepts of science and to see their applicability to the natural world. (p. 1)

The course tries to present science in a relevant, meaningful, and enjoyable manner. This approach emphasizes the major concepts of the sciences and stresses development of higher order thinking, providing the students with the ability to function productively in society.

Individual instructors choose the individual modules, the number of modules and the number of class periods devoted to each module. The instructors are also free to sequence the modules and to decide which modules are taught in consecutive class

periods or interspersed with other modules. As long as the National Science Education Standards (NSES) and Sunshine State Standards (SSS), which can be found in the references, are addressed, the faculty member can be autonomous. Module selection could involve students; in some environments it may be possible for the instructor to meet with students before classes start to choose modules cooperatively. An instructor might also choose a number of introductory modules for the first semester, with students selecting the balance. When possible, students are encouraged to participate in selecting modules, giving them greater “ownership” and control over their own learning.

The modular approach adopts a strategy where learning begins with a question that must be answered from a scientific perspective. Science is brought in to solve the problem or answer the question. The relevance of the science learned becomes immediately clear. Students characterized by the Glenn Report (USDE, 2000) are not crippled by content limited to the “What?” They get the “How?” (or “How else?”) and the “Why?” (p. 21). This will give the students no reason to ask, “Why should I care?” The modular approach allows faculty many choices in the selection of subject matter, although faculty must address all of the standards as stated by the NSES and the SSS.

It is understood that different instructors may teach this two-semester interdisciplinary course. The course is designed to allow input from faculty to revise and update modules. The revised and updated modules will then be given to other faculty who teach the course.

Science education scholars such as Lederman, Abd-El-Khalick, Bell, and Schwartz (2002, p. 499) define the *nature of science* as tentative, empirical, theory-

laden, partly the product of human interference, imaginative and creative, socially and culturally embedded. Three additional important aspects of the nature of science are the distinction between observation and inference, lack of universal recipe-like methods for doing science, functions of and relationships between scientific theories and laws.

Attitudes toward science can be defined as “the positive or negative feelings, opinions and appreciation which individuals have formed as a result of interacting directly or indirectly with various aspects of scientific enterprise, and which exert a direct influence on their behavior toward science” (Hanson & Victor, 1975, p. 247).

Researchers have directed increasing attention toward the study of *beliefs*. Beliefs are understood to be a subjective way of knowing. Beliefs are considered to be personal truths rather than truths that might be accepted by the scientific community.

These personal truths are not held to the same epistemic criteria as knowledge; instead, beliefs are understood to be extra-rational, that is, they are not based on evaluation of evidence, they are subjective, and they are often intertwined with affect (Sinatra, Southerland, McConaughy, & Demastes, 2003, pp. 511-512).

Koballa and Crawley (1985) have defined beliefs as information that a person accepts to be true, whereas *attitudes* refer to a general positive or negative feeling toward something. For example, if a college student judges his/her ability to be lacking in science (belief), that lack in confidence may lead to a dislike (attitude) for science education that may lead to not taking science courses (behavior).

Chapter 2

Review of the Literature

In attempting to answer the three questions of this investigation, this section focused on the current state of science education with respect to the role of the elementary science teacher and attitudes, beliefs, and the nature of science.

Increasing attention has been paid to elementary teacher preparation in science, since these teachers have been identified as a key factor for improving the success of science education. This scrutiny has come from numerous governmental agencies and science education organizations have coordinated efforts toward the goals of reforming science education. Among the active leadership in this arena have been the National Science Foundation (NSF) (1996a, 1996b, 1997, 2000), National Research Council (NRC) (1996a, 1996b, 1999) and American Association for the Advancement of Science (AAAS) (1989, 1993, 1997, 2001). The standards presented by these three groups are cited throughout the literature by many organizations and individuals who have taken active roles in promoting the science education reform standards and goals. Throughout this study, special attention has been given to the AAAS, NSF, and NRC because of their leadership role in science education reform. The actions of the AAAS, NSF, and NRC have widespread support throughout the scientific community.

The Current State of Science Education

Improving elementary teacher science competency has been a primary goal of these science education reform efforts (NSF, 1996a, 1996b, 1997, 2000; NRC, 1996a, 1996b, 1999). The relationship between students' early exposure to science and elementary teachers' competence in teaching science has become a major concern for the science community. The concern is that science is not an integral part of the educational experience at the elementary school level, and this will impair the chances of the student appreciating and being competent in science later in the student's education. The science community feels that elementary teachers play a key role in promoting persistence in science (NSB, 2000, pp. 5-12).

Much of the concern about declining performance in science has been reinforced by the results of the 1995 Third International Math and Science Survey (TIMSS) and the repeat of the survey in 1998 (TIMSS-R). In the TIMSS survey, the data showed that the ranking of the United States students drops as grade level increases when compared to the 26 nations surveyed. The performance began to drop each consecutive year after third-grade (Mullis et al., 1998, p. 53). The fourth grade achievement in science of American students was quite high. Our students were near the top in both mathematics and science. In middle school (eighth grade in the United States), the American students were above the international average but were outperformed by nine nations. Cochrane (1999) adds, "American school children were the only students with above average scores in 4th grade to lose ground in the 8th by testing average, and then to do worse again in the 12th (p. 3). Recently, the National Center for Educational Statistics (NCES) has shown fourth and

eighth grade science performance remained relatively unchanged between 1996 and 2000 (NCES, 2002, p. 1).

The more recent TIMSS-R study, completed in 1999, compared eighth-grade students from 38 nations and ranked the United States 19th in mathematics and 18th in science (TIMSS-R, 1999, p. 2).

The governing board of the NSF, the National Science Board, (NSB) states:

All high-performing countries show student gains between grades 3 and 4, and again between grades 7 and 8. The U.S. does not. Even in 4th grade, where U.S. students do well relative to those in other countries, their performance in physical science areas is weak, foreshadowing their average performance at 8th grade and their unacceptably poor showing at 12th grade. When we compare our K-12 schools and curricula in light of the TIMSS results, we find many teachers lacking good content preparation and, in the aggregate, a muddled and superficial curriculum (NSB, 1999, pp. 2-3).

The National Science Foundation (NSF) and National Research Council (NRC) are actively involved in reforms in science education. Much of the organizational effort of this reform movement has been consolidated in similar statements of standards for P-16 science education (National Science Foundation, 1996a, 1996b, 1997, 2000; National Research Council 1996a, 1996b, 1999). In the reform standards, a significant shift in attitude has occurred within the NSF toward paying more attention to science literacy and science competency in the general education of the entire population. As a result of this

shift, particular attention has been focused on improving the science preparation of elementary teachers. The NSB addresses the seriousness of this problem as follows:

What we have learned about mathematics and science teachers already in the classroom is dismaying. While most teachers embrace a vision of high standards for all students, cooperative learning (in small groups), and the use of technology (computers and calculators), their instructional strategies fall short of the vision. Many teachers lack support to plan and deliver quality instruction: 1 in 2 teachers feel inadequately prepared to integrate computers into instruction, and 2 in 5 feel inadequately prepared to use math or science textbooks as resources rather than as the primary instructional tool, or to use performance-based assessments. Fewer than 1 in 3 teachers feel prepared to teach life science, and only 1 in 10 feel prepared for the physical science course they are teaching. In addition, more than a third of elementary teachers, and more than half of high school mathematics and science teachers in 1993, felt unprepared to involve parents in the education of their children! (NSB, 1999, pp. 9-10)

Florida initiated testing of science ability beginning in the 2002 school year.

Science is now added to the Florida Comprehensive Assessment Test (FCAT) for grades 5, 8, and 10 (Science-FCAT). Including science on the FCAT should provide urgency to the public to take science education seriously. Paradoxically, if test scores on the science portion of the FCAT are comparatively low, this could be bad for the image of the state but could be a clarion call to focus on the needs of pre-service teachers or funding for science in general.

The consequence of poor science preparation of elementary teachers has been viewed by the science education community as a major cause for lack of interest in science by students (NSB, 2000, pp. 5-12). When referring to the TIMSS, this lack of interest begins early in elementary school and the gap in science performance between students who pursue the sciences and those who pursue other majors and vocations widens as students become older.

Nature of Science

What is meant by the nature of science? Any teacher would be hard pressed to teach the nature of science if the term was meaningless. In addition, the teacher would find the nature of science hard to measure if there weren't some standard definition or criteria that can be assessed. Even if a teacher understood the meaning of the nature of science, is he or she able to impart this concept to the students? Many attempts have been made to enhance students, and science teachers' "nature of science" views. Unfortunately, the definition of the nature of science is general and common ground needs to be found among the literature. Lederman et al. (2002, p. 499) provide a definition for the nature of science that can be considered a more modern approach and can be used by K-12 students and relevant to their daily lives:

Science knowledge is

- 1) tentative,
- 2) empirical,
- 3) theory-laden,
- 4) partly the product of human interference,

- 5) imaginative and creative, and
- 6) socially and culturally embedded.

Three additional important aspects are the:

- 1) distinction between observation and inference,
- 2) lack of universal recipe-like methods for doing science, and
- 3) functions of and relationships between scientific theories and laws.

Survey of Research on the Nature of Science

An earlier study reinforces the notion that the nature of science should be stressed in the undergraduate years of college. Kimball (1967) used participants from among the science and philosophy majors who graduated from Stanford University and San Jose State College over selected years. Mailings were sent out to 965 science and philosophy majors who graduated in 5 selected years, providing over 500 replies that were used for the study. Statistical analysis produced no significant differences among those students who became scientists and those who become teachers of science as to their knowledge of the nature of science. In addition, there was no significant difference related to the concept of the nature of science over time. When looking at the results, there is an apparent lack of change in understanding of the nature of science with time or experience. Neither scientists nor teachers gave any evidence of significant changes of opinion over a span of 12 years. This indicates that the concept of the nature of science is fairly well established by the time of graduation from college, another argument in favor of influencing students during their undergraduate years. The Kimball (1967) study above

looked at those majoring in science rather than non-majors but inferences can be drawn to the acquisition of science understanding of non-majors.

Another area in the study, which could lead to more attention in enhancing the undergraduate teaching of science, was the finding that philosophy graduates outperformed the science majors in the area of methodology of science. When looking at the subgroups within the nature of science survey it was found that the understanding of the methodology of science was significantly stronger for the philosophy graduates than the science graduates. The author suggested an inclusion of the study of philosophy of science in the undergraduate preparation of science majors in general and prospective teachers in particular would be wise.

Studies comparing pre-service teachers with other non-science majors have shed more light on the nature of science construct. Abd-El-Khalick and Lederman (2000) explored the aspects of a "History of Science" course for effective science outcomes. Participants were 166 undergraduates and graduate students, and 15 pre-service secondary science teachers. Almost all participants held inaccurate views of several nature of science aspects at the outset of the study. For example, as many as 81% did not demonstrate adequate conceptions of the general goal and/or structure of scientific experiments. The study did not find any significant difference between the two groups but the pre-service teachers did do better. An underlying premise in the study was that in classes where the nature of science was explicitly addressed the pre-service teachers improved. Suggestions were made to expose pre-service teachers in science method courses to the explicit nature of science instruction. The direct exposure to the nature of

science instruction may increase the pre-service teachers' likelihood that the nature of science view will be changed or enriched because of their experience in taking the "History of Science" courses. Emphasis on the nature of science in the classroom whether it is in a methods course or a science course may be a way of instilling foundational constructs in science.

The science education community has been addressing the deficiencies by focusing on pre-service and in-service science teachers. One aspect of these educational efforts, which has received attention, has been centered on the nature of science (Bianchini & Colburn, 2000; Bell, Lederman, & Abd-El-Khalick, 2000; Abd-El Khalick, Bell, & Lederman, 1998). Many of these studies have investigated the relationship between a teacher's belief in the concepts of the nature of science and how the teacher actually practices teaching science. Bell et al. (2000) identified mediating factors that constrain the translation of conceptions of the nature of science into classroom practice. In his study the mediating factors were the conflict between teaching the nature of science and teaching more commonly addressed aspects of science. In addition, teaching the nature of science required substantial time, which prevented those instructors who were teaching the nature of science from keeping up with other teachers who were not. Finally, there was a lack of confidence in understanding the nature of science in teachers who were teaching the aforementioned subject and the notion that many were still in the process of developing their conceptions of various aspects of the nature of science. These constraints are comparable to those described in Abd-El Khalick and Lederman (2000) as were the findings that show teachers' conceptions of the nature of science do

not necessarily translate into classroom practice. One of the primary purposes of the Bell et al. (2000) investigation was to pursue ways to facilitate this translation.

In particular, pre-service teachers were asked to learn about the nature of science (a cognitive goal) as well as how to teach the nature of science (a pedagogical goal) simultaneously. This is a typical approach in methods classes, due to time constraints and instructor preferences for emphasizing pedagogy over science content. It seems reasonable that learning about certain aspects of the nature of science should be the focus at the beginning of the program. Delaying attention to nature of science pedagogy until the end of the term provided more time for the pre-service teachers to assimilate their knowledge of the nature of science. This sequential process of learning the material first and then later showing how it can be taught could be used in many areas of science, not just for the learning the concepts behind the nature of science. Providing pre-service elementary teachers with a cognitive goal-oriented two-semester interdisciplinary science course would be an advantage when taking a methods class later in their coursework. In other words, by having the science background in the earlier interdisciplinary science course, it would be easier to assimilate science concepts introduced when learning the basics of science teaching.

Numerous studies have been directed at various areas of improving the competence of the pre-service and in-service teacher training. Often these studies concentrate on describing the perspectives held by elementary teachers about science reform topics, particularly the nature of science and how science should be taught. Bianchini and Colburn (2000) investigated perspectives of the nature of science held by

instructors and pre-service teachers. The work of Bianchini and Colburn (2000) was a study conducted by Alan Colburn, a teacher-researcher, and Julie Bianchini, the head researcher. Alan Colburn is experienced with the nature of science and taught “Science – a Process Approach” to liberal studies majors interested in pursuing teaching credentials at the elementary level. He implemented inquiry-oriented units commonly encountered in K-6 classrooms, units that spanned the disciplines of biology, chemistry, and physics. Ideas related to science education were infused into these units as well, including extended discussions of the nature of science. In presenting each of these units to his students, Colburn used a method of inquiry teaching that is known as the learning cycle. Instead of using surveys or interviews, the researchers videotaped and transcribed the teachers’ and students’ discourse and practices related to the nature of science within the context of an inquiry classroom. Bianchini and Colburn listed specific aspects of the nature of science and some of these were listed as objectives on the syllabus. Both researchers saw the teacher (Alan Colburn) as instrumental in raising, discussing, and demonstrating various aspects of the nature of science in the inquiry classroom, whether it be a part of his lesson plan or responses to issues that were raised from the inquiry process itself.

Since both researchers offered separate analysis of the classroom discourse, they were quick to point out that their differences in finding evidence of the nature of science being discussed or practiced had to do with the perspectives that each brought to the process. A case in point was the disagreement over whether notions of science as fun and students as scientists should count as aspects of the nature of science. Bianchini included

these notions in her analysis because she saw them as intimately tied to Colburn's goal of promoting student understanding of the nature of science; in other words, she saw them as part of the classroom as culture's definition of science. Colburn did not identify these aspects of the nature of science in his own case. Did Bianchini reach too far in her application of nature of science ideas or did Colburn simply miss these aspects of science's nature? If trained science educators had trouble finding a consensus on the concept of the nature of science it is not surprising that students who are preparing to be elementary teachers would have a difficult time grasping the concepts. The concept of the nature of science should be recognized as complex and challenging. The inquiry process can facilitate the concept of the nature of science but the teacher was found to be instrumental in the role to guide and support the students as they attempted to use inquiry to acquire understanding.

Belief in Science

Education is one of the few fields where future teachers have been exposed to the vocation for approximately 16 years. Most children have a nascent desire to become a productive member of society by pursuing some form of employment. This embryonic desire may be lofty goals with no realization of the consequences of choosing a particular profession. When choosing teaching as a profession, a person has already been exposed to the many facets of instruction. These beliefs or attitudes about teaching may be formed at a very early age and difficult to change.

Dewey (1929) described belief as the third meaning of thought, "something beyond itself by which its value is tested; it makes an assertion about some matter of fact

or some principal of law” (p. 6). He added that the importance of belief is crucial, for “it covers all the matter of which we have no sure knowledge and yet which we are sufficiently confident of to act upon and also the matters that we now accept as certainly true, as knowledge, but which nevertheless may be questioned in the future” (p. 6). For purposes of investigation, beliefs must be inferred. These inferences were taken into account with belief statements answered by the pre-service elementary school teachers.

Since beliefs may affect actions, teachers’ beliefs play a critical role in restructuring science education, as evident in the following statement by Tobin, Tippins, and Gallard (1994):

Future research should seek to enhance our understanding of the relationship between teacher beliefs and science reform. Many of the reform attempts of the past have ignored the role of teacher beliefs in sustaining the status quo. Teacher beliefs are a critical ingredient in the factors that determine what happens in classrooms. (p. 64)

Research on Beliefs in Science

In Hammrick’s (1997) work, she proposed that if a learner’s infrastructure contains misconceptions and contradictions, the subsequent knowledge and concepts built upon these faulty beliefs are likely to be both erroneous and fragmented. In order to come to terms with these faulty beliefs with the nature of science she used a method called cooperative controversy strategy. The cooperative controversy strategy is designed to engage students actively in personal knowledge construction.

When any controversial issue in science, including the nature of science, is approached, there is a choosing-of-sides behavior. With Hammrick's study, the goal was to come to consensus on the most accepted conception of the nature of science. When a learner takes a position on the issue, the individual's conceptions are challenged by other conceptions. If an individual's conception is left unchanged, this conception will continue to strengthen and can provide more evidence to the validity of the concept. For individuals with misconceptions, this may cause uncertainty and a desire for more information. The uncertainty resulting from the misconception may lead to a search for more information and a desire to find out where individual conceptions come from.

If a misconception or belief is changed, it is seen as a positive sign, because this change is due to being convinced of a new conception by another rational argument. Promoting dialogue in a science classroom can open up discussions that could reveal misconceptions held by the pre-service teachers. By allowing debate on issues in science, offering alternate viewpoints, and giving evidence for support, the pre-service teacher is provided the opportunity to dislodge firmly held misconceptions or beliefs.

Attitudes Towards Science

Of great concern are the teachers who have a negative attitude toward science, and through their own actions, pass this on to the students in their classes. Positive attitudes by elementary teachers toward science and science teaching increase their commitment to and intensity of science teaching. This intensity is reflected in more time spent teaching science, greater utilization of hands-on materials, and greater teacher

concern toward including science as an essential basic subject in the elementary curriculum.

Survey of Research on Attitudes Towards Science

Shrigley (1983) did a survey of research done on attitudes, in the general sense, and reached the following conclusions:

- 1) Attitudes are learned; cognition is involved.
- 2) Attitudes predict behavior.
- 3) The social influence of others affects attitudes.
- 4) Attitudes are a readiness to respond.
- 5) Attitudes are evaluative; emotion is involved (pp. 438-439).

The attitude inventory used in this study is by Moore and Foy (1997). It is called the Scientific Attitude Inventory II (SAI II), and is a revision of an early survey by Moore (1973). The survey (Scientific Attitude Inventory II) retains the original position statements of attitudes assessed and the original attitudes statements with changes made only to improve readability and to eliminate gender-based language. In addition, in response to critical analysis, the SAI II uses a five-response Likert Scale. The new version is shorter, 40 items instead of 60 in the original.

The Scientific Attitude Inventory II has been used by Boston University to study attitude development within a National Science Foundation (NSF) grant, the University of Southern Mississippi to study attitude development in high school biology classes, and Sheffield Hallam University for a study of attitudes of first-year students of primary education toward science. Several students at Temple University studying attitude

development among high school students have used the survey. The State University of New York at Brockport used the survey for a study of the effect of a business-school partnership on students' attitude toward science.

Field-testing of the Scientific Attitude Survey II involved data collected from 588 students in the 6th, 9th, and 12th grades in a rural/suburban middle school and high school in the same school district to determine how students at the various grade levels would respond to the revised SAI. When looking at the data, the researchers were able to determine by using a t-test that there was a significant difference between those who scored in the top 27% and those who scored in the bottom 27%. The rationale is that if there is a difference between the scores of the top scorers and the bottom scorers in favor of the top scores on the various subscales, those scales contribute to the instrument's ability to distinguish between those with strong attitudes toward science and those with weak attitudes toward science. High and low mean scores and standard deviations were provided for the 6 subscales along with t-test results. A significant t was obtained in each case at the .05 level of significance. The authors felt that the new version (Scientific Attitude Survey II) was a significant improvement over the original. This study acquired the permission of the author (Appendix A) to use this instrument.

When a pre-service elementary teacher has a preconceived dislike for science the confidence in that teacher's ability to teach science may suffer. Cognitively, this can be a challenge. Once attitudes are formed, the ability to modify them with concrete and lasting new concepts in science can prove complex. A qualitative study using interviews (Palmer, 2001) examined four pre-service elementary teachers in order to identify the

participants whose attitudes had changed from negative to positive (i.e., attitude exchange had occurred) after participating in a one-semester elementary school science education course, and to identify the course factors that were responsible. The participants were randomly selected from a class of 30 who were enrolled in a one-semester compulsory content/methods course. Interviews were carried out at the end of the semester, when the science content/methods course had been completed. The research associate asked whether any of the students felt that their attitudes had changed from negative to positive because of doing this course, and if so, whether they would be willing to volunteer for the research project.

A two-phase interview was carried out that lasted 30 minutes. The first phase consisted of questions that were designed to establish whether attitude exchange had occurred. The second phase consisted of questions that were designed to identify the factors that contributed to attitude exchange.

The study tried to provide evidence that attitude change in the pre-service elementary teachers can be brought about by a combination of factors, which can be grouped under the three broad headings of personal attributes of the instructor, specific teaching strategies, and external validation. Expanded work in this area may provide valuable information to pinpoint ways to influence attitude change and misconceptions of pre-service teachers. The sample size was small and included a very select group of students (those students whose were participated were volunteers). It would have been interesting to compare their perceptions with those of negative cases -- students whose attitudes were not positively affected by participation in the class. Another point that the

study failed to mention is the use of a self-selected sample, which could have skewed the results of the analysis.

Problematic beliefs and negative attitudes about science may be fostered within the science curriculum. Pre-service teachers need a positive experience when taking science courses to give them confidence in learning in an area that is foreign. Most science courses have a co-requisite laboratory course that incorporates a “hands-on” approach to the discovery process. These separate laboratory courses can be disconcerting.

Laboratory Courses and Attitude

Anxiety and laboratory courses may go hand-in-hand. Young and Kellogg (1993) found that elementary education majors often take the minimum number of science courses possible. Although many complained about the lack of hands-on methodology, they did not enroll in laboratory courses when not required to do so. This could be because these students saw little relationship between college science laboratories taught in the traditional manner and what they would need to know in order to develop elementary science hands-on-activities.

Incorporating professionally-related activities into the regular laboratory period can successfully increase favorable attitudes toward science among pre-service elementary teachers as shown by Koballa and Coble (1979). Their study looked at forty-one freshman and sophomore students enrolled in the Biological and Environmental Science Laboratory for Elementary Education Majors. Conventional laboratory activities were taught in both treatment and nontreatment groups. The treatment group was

exposed to additional activities, demonstrations and discussions to bridge the gap between college level treatment of these topics and the teaching of the same topics to elementary age children. The activities were chosen by the authors and judged by a faculty panel to be beneficial in helping students relate their laboratory studies to their professional responsibilities to teach science to elementary age students. A pre-test/post-test control design was employed. A drawback to the study was that it was impossible to randomly assign students into treatment and nontreatment groups because of complexities of class scheduling.

The results of the study indicated that the incorporation of “professionally related activities” into the regular laboratory period can successfully increase favorable attitudes toward science among pre-service elementary teachers.

The results of the study hold implications for all areas of teacher preparation. Specifically the study implied the following:

1. It is feasible to teach to develop attitudes toward science among pre-service teachers.
2. Attitude improvement is more likely with directed instruction than if it is left as an assumed result of a student merely being enrolled in a science course.
3. All science educators involved with the preparation of pre-service elementary teachers need to become keenly aware of the role they play in the development of favorable attitudes toward science among their students.

4. More emphasis needs to be placed on future professional needs as a way of fostering favorable attitudes toward science among pre-service elementary teachers. (Koballa & Coble, 1979, p. 416)

The effect of a laboratory class may be the difference between anxiety and a positive attitude as illustrated in a study by Sundberg (1994). Ostensibly, the pre-test/post-test study was to demonstrate how attitudes are different between majors and nonmajors in biology. It was hypothesized that student attitudes towards science will be more positive in a majors' course, and that differences in student attitude towards science, between majors and nonmajors, will be greater following instruction. Two instruments were administered, a comprehensive examination and an attitude-assessment survey, to eleven sections of nonmajors' biology (2257 students) and three sections of majors' biology (708 students). The same two instruments were given on the first day of class and the last day of class. Although the syllabi suggested that the courses duplicate each other, there was, however, a major difference in the detail presented to students. In the nonmajors' course, there were a maximum of four major concepts to be covered on any given topic, whereas the major's course may have included as many as 15 concepts relating to the same topic. A 36-item survey to assess the effect of instruction on student attitudes was administered. Students were to read each statement and score their opinion on a 5-point Likert scale. The results were surprising. By the end of their respective courses, nonmajors demonstrated higher post-test scores than did majors. Furthermore, although initially students in the major course had a significantly more positive attitude towards science, especially in terms of personal comfort with science, by the end of the

course this difference disappears. The course for majors appeared to do a good job of “turning off” potential majors, whereas the course for nonmajors improved the attitude of the students. The authors suggested that the message we are giving our majors is that science is somehow disconnected from society and that we should simply study science for its own sake. The researchers noted that only about one-half of the majors and one-fourth of the nonmajors simultaneously enrolled in lecture and laboratory. But the researchers concluded that the presence or absence of a laboratory experience probably had little impact on the results. If there would be an effect of having a laboratory class, the researchers conclude, it probably minimized the differences observed. Both student evaluations and withdrawal rates suggested that co-requisite laboratory classes provide a more positive experience to the students than lectures. In addition, laboratory courses may reinforce basic concepts from the lecture.

Summary

Greater attention should be paid to elementary teacher preparation in science, since these teachers have been identified as a key factor for improving the success of science education. Improving elementary teacher science competency has been a primary goal of these science education reform efforts (NSF, 1996a, 1996b, 1997, 2000; NRC, 1996a, 1996b, 1999). The relationship between students’ early exposure to science and elementary teachers’ competence in teaching science has become a major concern for the science community. As stated earlier, the concern is that science is not an integral part of the educational experience at the elementary school level, and this will impair the

chances of the student appreciating and being competent in science later in the student's education.

The science community feels that elementary teachers play a key role in promoting persistence in science (NSB, 2000, pp 5-12). Survey results of the Third International Math and Science Survey (TIMSS) showed that there is a downward trend in science scores of our children, which may be linked to how ill-prepared elementary teachers are in attitude and abilities to teach science.

Scholars such as Bianchini and Colburn (2000); Bell et al. (2000); and Abd-El Khalick et al. (1998) have investigated the relationship between a teacher's belief in the concepts of the nature of science and how the teacher actually practices teaching science. Other studies such as Bianchini and Colburn (2000) and Hammrich (1997) have focused on aspects of improving the competence of the pre-service and in-service teacher training. Other areas of research have moved beyond the arena of scrutinizing the pre-service teacher to providing ways to ensure the pre-service teacher's success; this would include (Young and Kellogg (1993), Koballa and Coble (1979), and Sundberg (1994) who investigated curriculum concerns that facilitates the pre-service elementary teachers' ability to teach science.

Research has concentrated on specific areas within the science cognate such as the concept of the nature of science. The work by Lederman et al. (2000) helped define the nature of science. Scholars such as Kimball (1967) have shown that an early exposure to science concepts including the nature of science can provide a foundation to proper

science processes. The study by Abd-El-Khalick and Lederman (2000) emphasized a direct approach to facilitate the learning of the nature of science.

Another area within the framework of teaching science is the beliefs the educator brings to the classroom on science. The belief in science should be consistent with the science community. Bandura (1997) stated that beliefs are thought to be the best indicators of the decisions people make throughout their lives. Koballa and Crawley (1985) differentiated between beliefs and attitudes, saying that beliefs are information that a person accepts to be true, whereas attitudes refer to a general positive or negative feeling toward something. Tobin et al. (1994) felt that beliefs may affect actions and teachers' beliefs play a critical role in restructuring science education.

A third area of concern for pre-service elementary teachers entering the classroom is attitude. Research such as that by Shrigley (1983) and Palmer (2001) has shown that positive attitudes by elementary teachers toward science and science teaching increased their commitment to and intensity of science teaching.

Some of the major goals of science education is to develop positive attitudes toward science, instill the proper beliefs of science, and promote the knowledge of the nature of science to pre-service elementary school teachers. Misconceptions held by school children and adults manifest themselves into a self-perpetuating spiral of negative beliefs and attitudes toward science. In order to be able to teach the sciences, the instructor should be confident and comfortable. By providing pre-service elementary teachers with the proper instructional background, the comfort level and attitude will be transferred to the students.

Chapter 3

Methods

The purpose of this study was to evaluate the effectiveness of a two-semester interdisciplinary science course curriculum that was developed and implemented for pre-service elementary teachers and student who are not science majors. The focus was on the pre-service elementary teachers' attitudes towards science, beliefs in science, and the understanding of the nature of science.

A survey was used to investigate each of the following research questions:

1. At the end of the two-semester interdisciplinary course, are the attitudes towards science significantly different for students who took the two-semester interdisciplinary course compared to those who took two separate and unrelated college level science courses, where one was physical and one was biological?
2. At the end of the two-semester interdisciplinary course, are the beliefs in science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?
3. At the end of the two-semester interdisciplinary course, is the understanding of the nature of science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?

The quasi-experimental study was designed to examine pre-service elementary teachers' and students' who were not majoring in science as to the three dependent variables; attitude towards science, belief in science, and knowledge of the nature of science. The two-course sequence constituted the independent variable.

The research used an existing survey instrument by Moore and Foy (1997) on two groups of students. One group was undergraduate students who were declared elementary education majors and non-science majors who had taken the two-semester interdisciplinary course. The other group was declared elementary education majors who had not taken the interdisciplinary course but who had chosen to take two independent college non-major physical and biological science classes.

The interdisciplinary course was a two-semester series for non-science majors and future elementary education teachers. The course focused on five or six important topics per semester, each addressed in a two- or three-week long module. Individual modules dealt with complex subjects such as nature of science, global warming, and water management that required specialized knowledge in more than one scientific sub-discipline or with concepts that could be illustrated in several sub-disciplines, such as energy conversion. The modules engaged students through subjects and questions relevant to their daily lives. The topics connected scientific knowledge to public decision-making, policy development, and promoting scientifically literate and engaged citizens. Goals and learning objectives stated from the assessment report by Robert Potter (2003) for the course were to:

- create a relevant, interesting interdisciplinary basic science course based on the National Science Education Standards,
- develop students' positive attitude toward science and improve their science literacy,
- emphasize experiential learning, critical thinking/problem solving and application of knowledge,
- encourage faculty to work together to examine and improve their own instructional practices,
- prepare future elementary teachers with the necessary understanding of science to effectively teach science (p. 1).

The two-semester course entitled “Science That Matters” was first piloted in the fall of 1999 at the University of South Florida and either Science That Matters I or II was offered each semester through fall 2004, the time of this study. Section size has ranged from 25 to 38 students each semester. Beginning in fall 2001 multiple sections were added as a part of a new College of Arts and Science linked course with one section set-aside especially for pre-service elementary education majors. In the fall of 2001 and 2002, three sections of Science That Matters I were offered followed in spring by Science That Matters II. This pattern continued through the end of this study. In the fall of 2003 similar courses based on this model were being taught at St. Petersburg College, and at Hillsborough and Manatee Community Colleges.

The concept of a modular approach that integrates the sciences and models good teaching was developed collaboratively by college science faculty in west central Florida

and school district science supervisors in the greater Tampa Bay region. The concept was implemented and coordinated by the Coalition for Science Literacy at the University of South Florida with the aid of the Suncoast Area Center for Educational Enhancement, the Florida Department of Education, the University of South Florida, the National Science Foundation, and the Southwest Florida Water Management District, which supported this effort.

The project was supported in part by The National Science Foundation, The Suncoast Area Center for Educational Enhancement of the Florida Department of Education, The Federal Eisenhower Professional Development Program, Title II, IASA, and The Southwest Florida Water Management District.

Each module is based on an issue that should be interesting and relevant to students, and addresses one or more of the National Science Education Standards (NSES) and Florida's Sunshine State Standards in Science (SSS). In addition, each module develops one or more of the thinking and science process skills enumerated in these standards. Modules address a wide variety of topics that often integrate the sciences inherently, such as those dealing with the environment. Others focus on a major concept, such as energy, primarily within the context of a given discipline. The relevance of the concepts to other fields is incorporated either directly or as part of assignments to students.

Participants

Students who were declared elementary education majors or non-science majors at a major research university and who had received a grade of C or better in their college

course work in the sciences served as the subjects in this study. One-third of the subjects (n =23) had taken the two-semester interdisciplinary course and received a grade of C or better; the other two-thirds (n = 46) had taken at least two non-major science courses at the college level and received a grade of C or better. Students who finished the second semester of the two-semester interdisciplinary course were identified and asked to participate in the survey. Students who had taken a physical science and a biological science course other than the interdisciplinary course were selected for the survey from elementary education classes at the same college. The target audience for both courses was unique, as it may possibly be the last course in science for non-science majors. The two-semester interdisciplinary course was designed to fulfill the mandatory general education requirements for students that may include future leaders and public policy makers who will have critical influence on society's general view toward science. The two-semester interdisciplinary course is also intended for elementary schoolteachers who influence early attitudes toward science and lay the foundations of basic knowledge of science for the children in our society.

Measurement

A comprehensive review of the mathematics and science literature revealed no single instrument that would provide information as to all three facets of the research regarding attitudes, beliefs, and the nature of science. However, existing tools that measure them could provide partial information. The source for the measurement with permission (appendix B) was from Moore and Foy (1997).

The Scientific Attitude Inventory by Moore (1973) was developed and field-tested 25 years ago. It continues to be used extensively throughout the world. The Scientific Attitude Inventory II by Moore and Foy (1997) was a revision in response to critical analysis especially from Munby (1997) who raised doubts about the instrument's validity.

Support for the validity of the Student Attitude Inventory II was enhanced by confirmatory factor analysis of the data from the 557 respondents. Reliability was tested with a split-half reliability coefficient computed for the entire group of 557 respondents. Application of the Spearman Brown correction for split-half reliability to the correlation coefficient yielded a reliability coefficient of .80. Cronbach's alpha reliability was .78 for this group (Moore and Foy, 1997, p 333).

The Scientific Attitude Inventory II by Moore and Foy (1997) used 40 questions rather than the original 60 questions in the first Inventory in 1973. For the purpose of this study, 30 questions from the Scientific Attitude Inventory II were found to correlate with the definitions of attitudes, beliefs and nature of science as stated in chapter 2. In the Scientific Attitude Inventory II 20 questions pertained to areas that would be considered the nature of science; of those 20 questions, 10 were used for the survey in this study. The rationale for eliminating ten nature of science questions was to have equal numbers of questions dealing with attitudes, beliefs, and the nature of science. It would also reduce the time needed to take the survey. The rationale of eliminating questions without compromising the validity of the survey parallels the reasoning that Moore and Foy used in removing 20 questions from the original 60 questions on the Scientific Attitude Inventory I. In addition, conversation with measurement faculty at the University of

South Florida assured validity would be maintained. Ten of the forced choice questions from the Scientific Attitude Inventory II were extracted for attitude and ten were extracted for beliefs. The process involved the author choosing statements that were aligned with either beliefs or attitudes, which were later confirmed by an independent expert, as described later. The forced choice questions on attitudes and beliefs culled from Moore and Foy (1997) were then correlated to the definitions found in the introduction to this study arriving at the ten best to represent statements on beliefs and attitudes towards science.

For the nature of science questions, a questionnaire by Lederman et al. (2002) that assesses the learners' conceptions of nature of science was used as a source for guidance. With Lederman's study, the questions are open ended rather than forced choice. Lederman argues that establishing the validity of an instrument is an ongoing process. At best the measurement can only provide evidence of an instrument's efficacy in measuring what it is designed to measure.

Comparing the open-ended questions by Lederman et al. (2002) on the nature of science to the 40 forced choice questions from the Scientific Attitude Inventory II, 10 questions from the Scientific Attitude Inventory II were found to be compatible. The researcher and an outside expert who individually picked 10 of the survey statements that clearly represented nature of science statements determined this compatibility. After discussing the reasons for their choices, they arrived at an agreement on the 10 nature of science questions to be used in the survey. Armed with this knowledge, there was

confidence for the use of questions from the Scientific Attitude Inventory II by Moore and Foy (1997) for attitude, beliefs and the nature of science for this study.

There were three constructs measured by the Moore and Foy (1997) instrument based on a 5-point Likert scale (5- strongly agree, 4- mildly agree, 3- uncertain or cannot decide, 2- mildly disagree, and 1- strongly disagree). The questions for each chosen for this study are:

1) Attitudes about science

- I would enjoy studying science.
- I may not make great discoveries, but working in science would be fun.
- Working in a science laboratory would be fun.
- Every citizen should understand science.
- I do not want to be a scientist.
- I would like to be a scientist.
- The search for scientific knowledge would be boring.
- I would like to work with other scientists to solve scientific problems.
- People must understand science because it affects their lives.

2) Beliefs about science

- Scientific work is useful only to scientists.
- Most people are unable to understand science.
- Scientists do not have enough time for their families or for fun.

- Most people can understand science.
- Scientists have to study too much.
- Scientific work would be too hard for me.
- When scientists have a good explanation, they do not try to make it better.
- Only highly trained scientists can understand science.

3) The understanding of the nature of science

- Scientific ideas may be changed over time.
- Scientists are always interested in better explanation of things.
- Scientists must report exactly what they observe.
- A major purpose of science is to help people live better.
- A major purpose of science is to produce new drugs and save lives.
- Some questions cannot be answered by science.
- Good scientists are willing to change their ideas.
- Science tries to explain how things happen. (Moore and Foy, 1997, pp. 333-335).

To assess the effect of instruction on students' attitudes, beliefs and the nature of science, the 30-item survey (refer to appendix A for the survey) was constructed by the author from the Scientific Attitude Inventory II by Moore and Foy (1997). For each item, students were asked to read the statement and score their opinion on a 5-point Likert scale (strongly agree, mildly agree, uncertain or cannot decide, mildly disagree, strongly disagree). The order of the survey questions were arranged randomly. Appendix C

shows questions along with the factor analysis performed on the instrument. All items were answered by all the students. Based on the factor analysis, each item was assigned to the specific factor with which the item was most highly correlated. Reliability was computed using Cronbach alpha. These reliabilities are reported in appendix D.

Students who were not in the two-semester interdisciplinary course were chosen randomly. By having the author randomly select students who had taken a physical and biological science course from elementary education classes for the survey, independence can be established for limiting extraneous variables. Those students who are in the two-semester interdisciplinary course were not randomly chosen, which lowers the confidence in the independent observations, because pre-service elementary teachers and non-major science students voluntarily chose the course. A t-test was performed on the survey. This test is appropriate when comparing two groups of subjects (those who took the two-semester interdisciplinary course and those who took both a physical and biological science) on the dependent variables (attitude, belief, and nature of science). For this test the validity of the p-values depends on two assumptions:

1. Independence of observations: the most important of the assumptions, even a small violation of it produces a substantial effect on both the level of significance and the power of the (t) statistic. Although not random, the students signed up for the classes under their own volition without any influence from the researcher. There is concern that the classes may not have complete independency. For the study the assumption was that there is independent observation.

2. Normality: this assumption is concerned with the normal distribution of the subjects in the study. Descriptive statistics can be used to see if the observations were normally distributed. Because the sums of independent observations having any distribution whatsoever approaches a normal distribution as the number of observations increase, the more participants involved the less this assumption is violated. The normality can be observed when looking at the univariate plots related to mean, median, mode, scatter plot, skewness, kurtosis, and so forth.

Variance can also be an assumption when using t-tests. Variance in the population for the groups should be close to equal. This is the so-called homogeneity of variance. If the group sizes are equal or approximately equal (largest/smallest < 1.5), then the t statistic is robust for unequal variances. The study attempted to keep the number of participants in the two groups as equal as possible.

A t-test was performed for each dependent variable: attitude, beliefs, and the understanding of the nature of science. The alpha was set to .05 with consideration of a medium effect size ($d = .6$). With a power of .8, there was a need for approximately 44 subjects per group.

The study used 23 students who finished the two-semester interdisciplinary course at the end of the spring term with a C or better. It is understood that the greater the sample size the greater the statistical power for rejecting the null hypothesis. With an alpha of .05 the likelihood of a type I error is small. The type I error is the probability of rejecting the null hypothesis when it is true, or saying the groups differ when they actually don't. The type I error cannot be eliminated, but can be controlled with an alpha

at .05 which allows the analysis to be 95 percent correct. In essence, if the statistical analysis provides evidence for rejection of the null hypothesis, then there will be a high confidence level that rejection of the null hypothesis was a correct assumption.

A greater concern with this study is a type II error. A type II error is accepting the null hypothesis when it is false. If a type II error is made, the two-semester interdisciplinary course may be fulfilling its objective but it may not be statistically revealed. For this study, the effect size was small ($d = .24$ or less) with at least 23 participants per group, thus the power was smaller than desired. Power (the ability to reject the null hypothesis) can be adequate with small group size, but only if the effect size is large.

The process is as follows:

Attitude

Variable	Method	Variances	df	t value	p value
ISC	Pooled	Equal			
Non-ISC	Satterthwaite	Unequal			

Beliefs

Variable	Method	Variances	df	t value	p value
ISC	Pooled	Equal			
Non-ISC	Satterthwaite	Unequal			

Nature of Science

Variable	Method	Variances	df	t value	p value
ISC	Pooled	Equal			
Non-ISC	Satterthwaite	Unequal			

In conclusion, the data analysis using a t-test consisted of both descriptive and inferential statistics. The instrument used is based upon the Scientific Attitude Inventory II instrument developed by Moore and Foy (1997) which was a modification of an earlier 1973 version called the Scientific Attitude Inventory. The research investigated whether any significant differences in attitudes, beliefs, and the nature of science existed for pre-service elementary education teachers who took the two-semester interdisciplinary course compared to those pre-service elementary education teachers and non-majors who did not.

Chapter 4

Results

In light of this study's purpose, which is to determine the effectiveness in terms of attitudes, belief, and understanding of the nature of science in a two-semester course that is interdisciplinary and geared to pre-service elementary school teachers, this chapter presents the results of the quantitative analysis used to investigate each of the research questions. Specifically, this chapter includes a summary of the data collection process and the analysis of data results.

Survey Distribution

In early April 2004, during the twelfth week of the 15-week semester course, the Scientific Attitude Inventory II by Moore and Foy was given to 94 students. Of the 94 participants, 45 were students in two interdisciplinary courses called Science That Matters I & II, and 49 were students in six elementary education classes specifically designed for students majoring in elementary education. Three sections of the elementary education courses were "Introduction to Elementary Education" and the other three were "Teaching Diverse Populations." Twenty-one students in the two interdisciplinary courses did not take the first sequence of the two-course sequence "Science That Matters I," and were excluded from the study. Additionally, one student received below a C in the first semester of the "Science That Matters" course and also was eliminated from all data calculation. Of the 49 students within the six elementary

education courses, three indicated that they had no plans to become elementary education majors.

Furthermore, there was a big gender difference between the two groups, of the total number of students for whom data was collected (n=93), 23 out of 44 (52%) in the two interdisciplinary courses were female. Forty-six of the 49 (94%) participants who completed the survey in the six elementary education classes were female.

In accordance with the research design outlined in Chapter 3, t-tests were performed on the three research questions using only survey responses from students who took both semesters of the interdisciplinary course “Science That Matters” and earned a C or better. Students that met these criteria were 23 (n=23). Forty-six participants took two science courses, and not the two-semester sequence interdisciplinary science course. Three of the forty-nine participants in the elementary education courses were not or did not desire to become elementary education majors and were not included in any analysis during the study.

For computing all the calculations (t-test for attitudes, beliefs, and nature of science; t-test for the means of the 30 questions; confirmatory factor analysis; and Cronbach’s alpha) the participants are the same (n=69). The participants were students who took the two-semester interdisciplinary course (n=23) compared to elementary education majors who took two regular science courses other than the interdisciplinary course (n=46).

Treatment of Data: Survey

The unit of analysis was the individual student who participated in the survey. Each participant was given an introductory letter (appendix E) and the survey (appendix A). The introductory letter described the author and the intent of the survey. The introductory letter also mentioned this study's Institutional Review Board approval, the research project number and the anonymity of the survey. The anonymous nature of the survey was stressed verbally to the students along with the encouragement to answer every question. Furthermore, the author emphasized being honest and forthright to students in their choice of answers as being helpful as to the intent of the study. To further assist the students, the second page of the survey provided an example of the procedure in answering the statements along with the thought processes that may be involved.

Statistical Analysis Software (SAS) for Windows, Version 8.12 was used to analyze all data. Treatment of the answer "Uncertain or cannot decide" was viewed as neutral and was assigned a value of 3 throughout all aspects of data analysis. Other data remained (as indicated in Chapter 3) with some exception when calculating the t-tests. For the t-test, a correct response as viewed by the researcher, as well as the publisher of the survey, was given a higher value. For example, on the construct of attitude a respondent may circle E "strongly disagree" to the statement number 30: I do not want to be a scientist. Generally circling E would be given a point value of one, but since the statement was a negative the value is reversed and a point value of a 5 is awarded, indicating that this respondent has a favorable view about wanting to be a scientist.

Data Analysis: Attitudes

Results for Research Question 1

The first research question was: “At the end of the two-semester interdisciplinary course, are the attitudes towards science significantly different for students who took the two-semester interdisciplinary course compared to those who took two separate and unrelated college level science courses, where one was physical and one was biological?”

Table 1 presents a comparison of the descriptive statistics for the two levels of the independent variable. In relation to level 1 (students who took the interdisciplinary course, $n=23$) of the independent variable, the analysis of the data revealed a mean of 3.02, median of 3.10 and a mode of 2.20 with a range of 3.60. Additionally, the data cites a standard deviation of 0.88 and a variance of 0.77. Graphically, this distribution has a skewness of -0.08 and a kurtosis of 0.05. This implies a very slight negative skew with slight leptokurtic distribution, indicating that the distribution of the scores were close to a normal distribution.

Table 1 also presents the descriptive statistics for those students who took two science courses other than the interdisciplinary course sequence. In relation to level 2 of the independent variable ($n= 46$), the analysis of the data revealed a mean of 3.23, median of 3.15 and a mode of 2.90 with a range of 3.80. The data cites a standard deviation of 0.88 and a variance of 0.75. Graphically this distribution has a skewness of 0.03 and a kurtosis of -0.38 . This implies a slight positive skew with a platykurtic shape where the distribution of the scores is normal with few or no outliers or extreme scores.

In order to proceed with the two-tailed t-test the author considered some assumptions. There does seem to be independence of observation. Although not random, the students signed up for the classes under their own volition, without any influence from the researcher. It is recognized that there may not be complete independency because some students may study together and exchange information and knowledge; which could be a limitation of the study; however, independence will be assumed.

When considering if the observations were normally distributed between groups, the box plot and stem leaf for both levels of the independent variables were acceptable. These indices will allow for violations if the sample sizes are 20 or more, which both are.

Table 1

Descriptive Statistics for Attitudes

Descriptive Statistics	Interdisciplinary	Other Science
Participants	23	46
Mean	3.02	3.23
Standard Deviation	0.88	0.87
Variance	0.77	0.75
Median	3.10	3.15
Mode	2.20	3.50
Range	3.60	3.80
Skewness	-0.08	0.03
Kurtosis	0.05	-0.38

When looking at the variances listed in Table 2 of equality of variances, it can be determined if the variances are equal. A study of Table 2 indicates the value of the F-test for equal variances was $p = .916$. The ability to reject the assumption that the two levels of the independent variable are equal can occur if the p value of the F-test is higher than 0.05. In order to consider the values different the number had to be smaller than 0.05, which it was not. Therefore, there was no rejection of the assumption that the variances are equal. Since the variances are considered equal, the pooled variance value can be used to find the probability of the mean. Based on the evaluation of the assumptions, it was reasonable to proceed with the two-tailed t-test.

Table 2

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	P > F
Attitude	Folded F	22	45	1.02	0.9164
Belief	Folded F	22	45	1.26	0.4951
NOS	Folded F	22	45	1.90	0.672

To investigate the null hypotheses, a two-tailed t-test was used to examine differences in the means between attitudes of those students who took the two-semester interdisciplinary course ($M = 3.02$, $SD = 0.88$) and those students who took two science courses other than the two-semester interdisciplinary course ($M = 3.23$, $SD = 0.87$). By examining Table 3 the t-test failed to reject the null ($p = 0.3552$) using equal pooled variance. According to the data in Table 3, the obtained t-value (-0.93) was smaller than

the critical t-value (2.00) when identified on a two-tailed t-test chart with the alpha set at 0.05 and 67 degrees of freedom. ($t(67) = -0.93, p = 0.3552$). The rejection of the null hypothesis determined that the differences in the means between the students who took the interdisciplinary course and those students who took two different science courses were not statistically significant. To check the degree of the mean differences, a computed Cohen's d was -.24. This computation determined that the magnitude of differences in the means of those students who took the interdisciplinary course and those students who took two different sciences courses was less than .24 standard deviations apart.

Table 3

Inferential Statistics for Attitudes (Alpha 0.05)

F-test (Equal Pooled Variance)	0.916
t-Test (p)	0.3552
Obtained t-test value	-0.93
Critical t-test value	2.00
Degrees of Freedom	67
Effect Size	-.24
Cronbach alpha	.89

When investigating the first question a computation of a coefficient alpha for internal reliability for specific questions related to attitudes was performed (appendix D). The Cronbach coefficient alpha for these nine items was .89.

Data Analysis: Beliefs

Results of Research Question 2

The second research question was: “At the end of the two-semester interdisciplinary course, are the beliefs in science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?” Table 4 presents a comparison of the descriptive statistics for the two levels of the independent variable. In relation to level 1 (students who took the interdisciplinary course, $n=23$) of the independent variable, the analysis of the data revealed a mean of 3.40, median of 3.40 and a mode of 3.40 with a range of 3.30. Additionally, the data yielded a standard deviation of 0.77 and a variance 0.59. Graphically, this distribution has a skewness of -1.29 and a kurtosis of 2.54. This implies a negative skew with a leptokurtic distribution, meaning the distribution of the scores were many in the middle with some scores creating a heavy tail towards the negative.

Table 4

Descriptive Statistics for Beliefs

Descriptive Statistics	Interdisciplinary	Other Science
Participants	23	46
Mean	3.40	3.53
Standard Deviation	0.77	0.68
Variance	0.59	0.46
Median	3.40	3.60
Mode	3.40	3.00
Range	3.30	3.00
Skewness	-1.29	-0.66
Kurtosis	2.54	0.14

Table 4 also presents the descriptive statistics for those students who took two science courses other than the interdisciplinary course sequence. In relation to level 2 of the independent variable (n= 46), the analysis of the data revealed a mean of 3.53, median of 3.60 and a mode of 3.00 with a range of 3.00. The data indicated a standard deviation of 0.68 and a variance of 0.46. Graphically this distribution has a skewness of -0.66 and a kurtosis of 0.14. This implies a slight negative skew with a slight leptokurtic shape meaning that the scores have a normal distribution with a few scores generating a negative tail.

As with the previous question, the author considered some assumptions. There does seem to be independence of observation as stated earlier in this chapter.

When considering if the observations were normally distributed between groups, the box plot and stem leaf for both levels of the independent variables were acceptable.

From review of the equality of variances listed in Table 2, one can determine if the variances are equal. A study of Table 2 indicates the value of the F-test for equal variances was $p = .495$. The ability to reject the assumption that the two levels of the independent variable are equal can occur if the p value of the F-test is higher than 0.05. In order to consider the values different the number had to be smaller than 0.05, which it was not. Therefore, there was no rejection of the assumption that the variances are equal. Since the variances were considered equal by the researcher at the onset of this study, the pooled variance value was used to find the probability of the mean. Based on the evaluation of the assumptions, it was reasonable to proceed with the two-tailed t-test.

To investigate the null hypotheses for the second question a two-tailed t-test was used. Differences in the means between beliefs of those students who took the two-semester interdisciplinary course ($M = 3.40$, $SD = 0.77$) and those students who took two science courses other than the two-semester interdisciplinary course ($M = 3.53$, $SD = 0.68$) were calculated. By examining Table 5 the t-test failed to reject the null hypothesis ($p = 0.5044$) using equal pooled variance. According to the data in Table 5, the obtained t-value (-0.67) was smaller than the critical t-value (2.00) when identified on a two-tailed t-test chart with the alpha set at 0.05 and 67 degrees of freedom. ($t(67) = -0.67$, $p = 0.5044$). Failing to reject the null hypothesis was a result of the differences in the means

between the students who took the interdisciplinary course and those students who took two different science courses, which were not statistically significant. To check the degree of the mean differences, a computed Cohen's d was $-.18$. This computation determined that the magnitude of differences in the means of those students who took the interdisciplinary course and those students who took two different sciences courses was less than $.18$ standard deviations apart.

When investigating the second question a computation of a coefficient alpha for internal reliability for specific questions related to belief was performed. The Cronbach coefficient alpha for these eight items was $.78$ (appendix D).

Table 5

Inferential Statistics for Beliefs (Alpha 0.05)

F-test (Equal Pooled Variance)	0.495
t-Test (p)	0.5044
Obtained t-test value	-0.67
Critical t-test value	2.00
Degrees of Freedom	67
Effect Size	-.18
Cronbach alpha	.78

Data Analysis: Nature of Science

Results of Research Question 3

The third research question was: “At the end of the two-semester interdisciplinary course, is the understanding of the nature of science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?” A comparison of the descriptive statistics for the two levels of the independent variable is presented in Table 6. In relation to level 1 (students who took the interdisciplinary course, $n=23$) of the independent variable, the analysis of the data revealed a mean of 3.77, median of 3.80 and a mode of 3.50 with a range of 1.50. Based on the data in Table 6 the standard deviation was 0.43 with a variance of 0.19. Graphically, this distribution has a skewness of 0.01 and a kurtosis of -0.93. This implies an extremely slight positive skew with a platykurtic distribution implying many scores toward the middle and no tails influencing the direction of the distribution.

Descriptive statistics for those students who took two science courses other than the interdisciplinary course sequence are shown in Table 6. In relation to level 2 of the independent variable ($n= 46$), the analysis of the data revealed a mean of 3.81, median of 3.85 and a mode of 3.90 with a range of 1.40. According to the findings in Table 6, the standard deviation was 0.31 with a variance of 0.10. Graphically this distribution has a skewness of -0.39 and a kurtosis of 0.83. This implies a slight negative skew with a leptokurtic shape, giving the distribution a greater than normal peak with a heavier tail towards the negative direction.

As with the previous questions, the author considered some assumptions.

Independence of observation was assumed as stated earlier in this chapter.

When considering if the observations were normally distributed between groups, the box plot and stem leaf for both levels of the independent variables were acceptable.

Table 6

Descriptive Statistics for Nature of Science

Descriptive Statistics	Interdisciplinary	Other Science
Participants	23	46
Mean	3.77	3.81
Standard Deviation	0.43	0.31
Variance	0.19	0.10
Median	3.80	3.85
Mode	3.50	3.90
Range	1.50	1.40
Skewness	0.01	-0.39
Kurtosis	-0.93	0.83

According to the findings listed in Table 2 of equality of variances, it can be determined if the variances are equal. A study of Table 2 indicates the value of the F-test for equal variances was $p = .067$. The ability to reject the assumption that the two levels of the independent variable are equal can occur if the p value of the F-test is higher than 0.05. In order to consider the values different, the number had to be smaller than 0.05,

which it is not. Therefore, there was no rejection of the assumption that the variances are equal. Since the variances are considered equal, the pooled variance value can be used to find the probability of the mean. Based on the evaluation of the assumptions, it was reasonable to proceed with the two-tailed t-test.

To investigate the null hypotheses for the third question a two-tailed t-test was used. Differences in the means between the nature of science of those students who took the two-semester interdisciplinary course ($M = 3.77$, $SD = 0.43$) and those students who took two science courses other than the two-semester interdisciplinary course ($M = 3.81$, $SD = 0.31$) were calculated. An inspection of Table 7 indicates a failure to reject the null ($p = 0.6340$) using equal pooled variance. According to the data in Table 7, the obtained t-value (-0.48) was smaller than the critical t-value (2.00) when identified on a two-tail t-test chart with the alpha set at 0.05 and 67 degrees of freedom. ($t(67) = -0.48$, $p = 0.6340$). Failure to reject the null hypothesis was a result of the differences in the means between the students who took the interdisciplinary course and those students who took two different science courses, which were not statistically significant for understanding the nature of science. To check the degree of the mean differences, a computed Cohen's d was $-.11$. This computation determined that the magnitude of differences in the means of those students who took the interdisciplinary course and those students who took two different sciences courses was less than $.11$ standard deviations apart..

When investigating the third question a computation of a coefficient alpha for internal reliability for specific questions related to the nature of science was performed. The Cronbach coefficient alpha for these eight items was $.32$ (appendix D).

Table 7

Inferential Statistics for Nature of Science (Alpha 0.05)

F-test (Equal Pooled Variance)	0.067
t-Test (p)	0.6340
Obtained t-test value	-0.48
Critical t-test value	2.00
Degrees of Freedom	67
Effect Size	-.11
Cronbach alpha	.32

Factorial Validity of Survey

Factor analysis was used to identify faulty statement items on the initial 30-item survey whose removal or repositioning to the appropriate construct improved the internal consistency reliability and factorial validity. A criterion factor loading of 0.35 was used to define a factor. The factors were tested according to the three major hypothesized indices (attitude, belief, and nature of science). A principal components factor analysis set for the three factors with varimax rotation produced 25 statements that loaded at 0.35 or greater (appendix C). Five statements (11, 14, 15, 17, and 24) from the potential survey did not load significantly on any factor and were not used in the calculations. Statement 10 loaded as factor 2 (belief) when the statement was originally under the construct of the nature of science (factor 3). Conversely, statement 16 loaded as factor 3 (nature of science) but was categorized under belief (factor 2). Statements 19, 27, and 29

loaded as factor 2 (belief) but originally were classified as an attitude (factor 1). Question 23 loaded with factor 1 (attitude) but originally was proposed as a belief (factor 2). There was cross-loading on three statements, 1 and 18 and 25. All (1, 18 and 25) were determined to be statements similar in nature to attitude (factor 1) and the nature of science (factor 3). All three statements (1, 18 and 25) correlate with the concept of the nature of science and were left with this construct due to the support in the literature (chapter 2) which addresses the philosophy of the nature of science. Briefly, this philosophy about the nature of science is tentative, which means that scientists may not have all the answers, have doubts about each others research, and must change ideas. Other considerations are that science is empirical and theory-laden, meaning that scientists are concerned with theories or basic research and must report exactly what they observe.

The calculation of reliability and the appropriate t-tests were performed once the statements were aligned with their proper factorial loading, taking care not to undermine the theoretical structure proposed for each of the three constructs – attitude, belief, and the nature of science. Factor 1 (attitude) was internally consistent ($\alpha = .89$) and consisted of nine survey statements. Factor 2 (beliefs) was also internally consistent ($\alpha = .78$) and consisted of eight survey statements. Factor 3 (nature of science) was defined by eight statements and had marginal internal consistency ($\alpha = .32$).

The marginal internal consistency for the nature of science prompted the researcher to reassess the Cronbach's alpha for the nature of science. A new calculation was performed on the nature of science statements after eliminating the three statements

that cross-loaded with attitudes. When this calculation of the Cronbach's alpha was completed the new alpha was .46, not a significant improvement. The researcher decided to retain the eight statements with an alpha of .32 rather than have only five statements reflecting the nature of science.

Based on the analysis of the data generated by this sample, the three-component model of the Scientific Attitude Survey does appear to be applicable to the population tested, although small.

Discussion of Results

This chapter has presented the results of the data analysis (descriptive and inferential) for each research question following the procedure set forth in Chapter 3. Factor loading of the initial 30 statements resulted in 25 statements that were aligned with one of the three a priori constructs. A small number of statements were recombined to conform to the proper construct that was revealed in the factorial analysis. Creating an internal consistency relates to homogeneity or the degree to which the items on a survey jointly measure the same construct. Whenever a survey's statements are linearly combined as the case with this survey (nine statements about attitudes, eight statements about beliefs, and eight statements about the nature of science), the issue of homogeneity will arise. Homogeneity provides the ability of the researcher to interpret the composite score for each construct as reflected by the survey's statements. Reliability of the internal consistency of the scores was calculated using Cronbach's alpha. The reliability is central to understanding the observed relationships between the three dependent variables used in this research. The purpose in the use of factorial analysis, and

Cronbach's alpha for the Scientific Attitude Inventory survey was to enhance the study's finding, conclusions, and implications.

According to the findings in Table 3 referring to question #1 "At the end of the two-semester interdisciplinary course, are the attitudes towards science significantly different for students who took the two-semester interdisciplinary course compared to those who took two separate and unrelated college level science courses, where one was physical and one was biological?" it can be determined that students who took the two-semester interdisciplinary course did not leave the course with a more positive attitude than those students who took two regular undergraduate science courses. When comparing the means of the two groups, those who took the interdisciplinary course (mean =3.02) and those that took two regular science undergraduate courses (mean =3.23) it can be determined that those students who took two semesters of regular science courses had a slightly more positive attitude towards science.

As for question number 2, "At the end of the two-semester interdisciplinary course, are the beliefs in science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?" the results listed in Table 5 indicate the difference in means in the belief in science. Students who took the two-semester interdisciplinary course were compared with students who took two semesters of regular undergraduate science classes, which produced t-test results that were not statistically significant. The mean for the belief in science for students who took the interdisciplinary course was 3.40 whereas the mean of

students who took two semesters of regular science courses had a mean of 3.53. Students who took two semesters of regular undergraduate science courses had a slightly more correct view of the beliefs in science (difference of .13). Having a value of 3 on the scale would be considered neutral compared with values of 4 (agreeable) and 5 (strongly agreeable), values of 4 or 5 can be interpreted as a positive evaluation to the belief statements. Statement number 10 (Table 8) was a belief statement that recorded a difference in mean that was close to significance ($p = 0.062$). Participants in the two-semester interdisciplinary course had a higher agreement (mean 2.30) with the incorrect statement “When scientists have a good explanation, they do not try to make it better,” whereas students who took two semesters of regular undergraduate science courses agreed less to the incorrect statement (mean 1.87).

Table 8

Mean, Standard Deviation, and Comparison of Belief Statement #10

Beliefs	Interdisciplinary	Other Science
Participants	23	46
Mean	3.40	3.53
Standard Deviation	0.40	0.68
When scientists have a good explanation, they do not try to make it better ($p = 0.062$)	2.30	1.87

Lastly, question number 3 states “At the end of the two-semester interdisciplinary course, is the understanding of the nature of science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two

separate and unrelated college level science courses, where one was physical and one was biological?” A comparison of the understanding of the nature of science was presented earlier in Table 7. An inspection of Table 7 reveals a value for the obtained t that does not exceed the critical value of t . This implies that students who take the two-semester interdisciplinary course have a concept of the nature of science that is as accurate as elementary education majors who took two semesters of a regular undergraduate science class. The difference in the means of the two groups is not statistically significant. Both groups have a moderate understanding of the nature of science. The mean for the students who took two semesters of regular science courses is slightly higher (3.81) than those students who took the interdisciplinary course (3.77). Since a value of 3 is considered neutral, with values of 4 and 5 indicating a better understanding of the nature of science, it can be concluded that both groups had a moderate understanding of the nature of science. Among the survey statements related to the understanding of science, the differences in means of the two groups were not statistically significant.

An inspection of the data in Table 9 indicates that statement #9 had a difference of mean that was considered statistically significant and #25 was extremely close to being statistically significant. Statement #9, “Some questions cannot be answered by science,” was agreed to rather strongly (mean 4.37) by those students who have taken two science courses other than the two-semester interdisciplinary course, whereas those who took the two-semester interdisciplinary course had a mean of 3.61.

Additionally, statement #25 declared, “A major purpose of science is to help people live better” which is not considered a nature of science tenet. Those students who

had taken two science courses other than the two-semester interdisciplinary course wrongly agreed with the statement (mean 4.22). On the other hand, those students who took the two-semester interdisciplinary course were less inclined to agree with the incorrect statement (mean = 3.78)

Table 9

Comparison of Statement Means #9 and #25 on the Nature of Science

	Interdisciplinary	Other Science
#9 – Some questions cannot be answered by science. (p = 0.003)	3.61	4.37
#25 – A major purpose of science is to help people live better. (p = 0.052)	3.78	4.22

There are other statements which did not reach the level of statistical significance when comparing their means between the two groups, but which warrant notice. It appears statements concerning beliefs in science were consistently more positively aligned with scientific thinking by participants who had taken two regular undergraduate science classes. Of the eight statements that are “belief in science” related, five were higher in their means for students who took two semesters of a regular undergraduate science course. The other three statements were very close to equal (less than .1 difference). Those statements are listed with their means in Table 10. This implies that the beliefs held by both groups were consistent but beliefs in science were more aligned with the science community with the group that had taken two semesters of regular

science classes. These beliefs may be hard to unseat and may make it difficult to increase a positive attitude toward science.

From the results, it could be concluded that beliefs might not influence the students' effort to understand the nature of science. Overall, the participants who took two courses other than the two-semester interdisciplinary course had higher mean values according to the means in Table 5 that occurs earlier in the study.

Table 10

Comparison of Means Relating to Belief Statements

Statement Means	Interdisciplinary	Other Science
#4 - Scientific work is useful only to scientists.	2.20	1.90
#7 - Most people are unable to understand science.	2.96	2.74
#19 - Scientists have to study too much.	3.64	2.93
#22 - Only highly trained scientists can understand science.	2.35	1.98
#10 - When scientists have a good explanation, they do not try to make it better.	2.30	1.87

Two statements (#16 & #28) out of the eight statements that represented the understanding of the nature of science were answered with a higher correct value by the students who took the two-semester interdisciplinary course. The data in Table 11 indicates that for question #16, the mean for the students in the two-semester interdisciplinary course was 3.43 and those students who took two other science courses other than the interdisciplinary course had a mean of 3.67. In the case of statement #16,

the lower value indicates a more correct response to the statement “A major purpose of science is to produce new drugs and save lives.” Concerning statement #28, “Science tries to explain how things happen,” which is a correct statement, the interdisciplinary science students had a mean of 4.43 whereas the students who took two regular science classes had a mean of 4.17. In the case of the understanding of the nature of science, the students may have learned in the interdisciplinary course in spite of their negative beliefs in science.

Table 11

Statement Means for #16 and #28 Regarding the Nature of Science

	Interdisciplinary	Other Science
#16 – A major purpose of science is to produce new drugs and save lives.	3.43	3.67
#28 – Science tries to explain how things happen.	4.43	4.17

It appears that even though the students who took two regular undergraduate science classes did perform better as to attitudes towards science, belief in science, and the understanding of the nature of science, the difference in the means was not statistically significant and there were statements in relation to the nature of science (#16, #25, and #28) that indicated that the two-semester interdisciplinary class had higher mean values.

Overall, results showed that students who took two separate and unrelated college level science courses had mean values higher than students who took the two-semester

interdisciplinary course. The mean values for the participants who took two unrelated science courses were higher for each of the constructs measured (attitude towards science, beliefs in science, and the understanding of the nature of science). However, the difference in means for the each of the three constructs did not reach the level of significance. The difference in the means for attitudes toward science was the greatest (-0.207), with smaller differences in the means for the beliefs in science (-0.122), and the least amount of difference in the means was for the understanding of the nature of science (-0.043).

Chapter 5

Summary of Findings, Conclusions, Implications and Recommendations

This study's purpose was to investigate the difference in the attitude towards science, belief in science, and the understanding of the nature of science between students who took a two-semester interdisciplinary course called "Science That Matters" (ISC 1004 & ISC 1005) and those pre-service elementary education majors who took two regular undergraduate science courses other than the two-semester interdisciplinary science course.

Method Summary

The researcher distributed a 30-item survey entitled Scientific Attitude Inventory II (Moore & Foy, 1997). The survey included an introduction detailing the purpose of the study, demographic questions, and the 30 statements of the Scientific Attitude Inventory. The participants who took the two-semester interdisciplinary science course had to meet two criteria to be involved in the study: they had to successfully complete the first semester of the two semester course and they must have received a "C" or better in that course. When this was taken into consideration, 23 (n=23) participants were eligible. As for the participants who were pre-service elementary education majors, six classes produced 46 (n=46) students who had successfully completed two undergraduate courses other than the two-semester interdisciplinary course.

Following the administration of the survey, a factorial analysis was performed with the loading to three factors. The three factors were used to maintain the philosophical structure pertaining to attitudes towards science, belief in science and understanding of science. Attention was taken to identify and align the proper theoretical constructs as elaborated in Chapter 2 to maintain the integrity of the statements as to attitudes, belief, and nature of science when factorial loading was assigned. Once assigned, the number value chosen by the participants to a particular set of statements, attitudes towards science for example, were combined to form a point total for that construct. The point values calculated, representing the participants' responses to each of the three constructs, were used in performing a two-tailed t-test. The two-tailed t-test was performed on each dependent variable (attitudes towards science, belief in science, and understanding of the nature of science) comparing the difference in means of those students who took the two-semester interdisciplinary course and those pre-service elementary education students who took two undergraduate science courses other than the two-semester interdisciplinary course.

Summary of Findings

Using quantitative analysis, this study explored three research questions, each of which is presented below with a summary of the findings for each question. It must be noted that the overall sample size is small ($n=69$), as well as the effect sizes for attitudes towards science, belief in science, and understanding of the nature of science (-.24, -.18, and -.11) respectively. This makes it difficult to extract too much information from the

results provided. This study's outcomes, then, were affected by both the small sample size and the small effect size.

1. Research question #1 asked; "At the end of the two-semester interdisciplinary course, are the attitudes towards science significantly different for students who took the two-semester interdisciplinary course compared to those who took two separate and unrelated college level science courses, where one was physical and one was biological?"

The result of the t-test to question number one on attitudes towards science indicate that although there was not a significant difference of the means, students taking two science courses other than the two-semester interdisciplinary course (mean = 3.23) had a more positive attitude towards science than those who had taken the two-semester interdisciplinary course (mean = 3.02). When comparing the data, the two-semester interdisciplinary course participants had attitudes towards science that can be considered neutral, whereas those who took two courses other than the two-semester interdisciplinary course had a moderately positive attitude towards science. When comparing the independent variables as to the difference in the means of the nine individual questions that pertained to attitudes towards science, none of the nine questions reached a level of significance.

When looking at the mode for both groups, those who took the interdisciplinary course (mode =2.20) and those who took two science courses other than the two-semester interdisciplinary course (mode =3.50), the difference is striking. Coincidentally the number of participants who took two courses other than the two-semester

interdisciplinary course is twice the number that took the two-semester interdisciplinary course.

In response to research question #1, those students who took two courses other than the two-semester interdisciplinary course were more likely to have a moderately positive attitude towards science than the students who took the two-semester interdisciplinary course.

2. Research question #2 asked; “At the end of the two-semester interdisciplinary course, are the beliefs in science significantly different for students who took the two-semester interdisciplinary course compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?”

Both groups leaned toward having beliefs that correlated with the scientific community when confronted with statements concerning beliefs in science. Both groups' convictions toward beliefs in science are weakly moderate (interdisciplinary mean = 3.40, other science courses mean = 3.53); the value of 3 would be considered neutral in having the correct beliefs in science. Values exceeding 3 have a more positive (and correct) view of science. Although both means are still in the 3 range the values are trending towards 4 which can be interpreted as not strong in their correct response (value of 4) but weakly moderate.

3. The final research question asked; “At the end of the two-semester interdisciplinary course, is the understanding of the nature of science significantly different for students who took the two-semester interdisciplinary course

compared to those who took the two separate and unrelated college level science courses, where one was physical and one was biological?”

On examining the survey statements related to the understanding of science, the differences in means of the two groups were not statistically significant. Both groups had a higher understanding of the nature of science than they did in their belief in science. The students who took the two-semester interdisciplinary course had a mean of 3.77 whereas those participants who took two regular undergraduate science courses had a mean of 3.81. Both groups had a positive and relatively strong understanding of the nature of science.

Discussions and Conclusions

This study has shown that among the survey participants, there seems to be no statistically significant difference as to the three dependent variables (attitudes towards science, beliefs, and the understanding of the nature of science) when testing the independent variables (participants who have taken the two-semester interdisciplinary course and those who took two different science courses). However, survey participants who took two science courses other than the two-semester interdisciplinary course did have higher scores pertaining to the means on attitude towards science, belief in science, and the understanding of the nature of science when compared to those participants who took both semesters of the interdisciplinary course.

When observing individual statements within the survey (appendix F), the students who took the two-semester interdisciplinary course had lower mean values on all of the statements for attitudes and beliefs. However concerning the understanding of the

nature of science, the interdisciplinary group had mean values on three statements that were higher. First, an explanation in reviewing the statements concerning attitudes towards science and belief in science before discussing results for the nature of science. Students who have taken the two-semester interdisciplinary course have a belief system that is not as positive (lower mean values) compared to those who have taken two semesters of regular undergraduate science classes. Every belief statement by the students who took two semesters of regular undergraduate science courses either had a higher value towards correct scientific beliefs (five statements) or had a mean value close to equaling those students who took the two-semester interdisciplinary course (three statements). Not surprisingly, the results for the number values on “attitudes towards science” were all less positive for those students who took the two-semester interdisciplinary course. Beliefs and attitudes go hand-in-hand; if the students’ belief in science is low, their attitude towards science is apt to be low too. The belief in science by the students in the two-semester interdisciplinary course may be influencing their attitudes towards science but their understanding of the nature of science is heading in a positive direction. Belief systems may be cultivated over many years, which makes the capacity to change beliefs on certain topics very difficult to accomplish. As individuals grow older, they acquire preconceived notions about science, which could be false. As stated in Chapter 2 of this study, researchers have directed increasing attention toward the study of beliefs. Beliefs are considered to be personal truths rather than truths that might be accepted by the scientific community. “Beliefs are understood to be extra-rational, that is, they are not based on evaluation of evidence, they are subjective, and they are

often intertwined with affect” (Sinatra et al., 2003, pp.511-512). Koballa and Crawley (1985) have defined beliefs as information that a person accepts to be true, whereas attitudes refer to a general positive or negative feeling toward something. For example, if a college student judges his/her ability to be lacking in science (belief), that lack in confidence may lead to a dislike (attitude) for science education that may lead to not taking science courses (behavior).

Although the attitudes and belief in science were not favorable for the students who had taken the two-semester interdisciplinary course, the trend in the understanding of the nature of science is positive. Three of the eight statements (#16, #25, & #28) had a higher correct value for the students in the two-semester interdisciplinary course when compared to the students who took two semesters of regular science courses.

Having the instructional time to extricate ill-conceived beliefs in science whether it is in the classroom or laboratory setting is a concern. Hammrick (1997) proposed promoting dialogue in science classrooms, which can open up discussion that could reveal misconceptions held by the pre-service teachers. By allowing debate on issues in science, offering alternative viewpoints, and giving evidence for support, the pre-service teacher is provided the opportunity to dislodge firmly held misconceptions or beliefs. Using inquiry-based teaching to remove misconceptions that may have been held for many years and providing the proper understanding of the nature of science is a daunting task if time is a premium. Having the time for student-teacher interaction is important to the educational process. As has been stated earlier in the study “the instructors help the students become active learners by motivating them with open-ended questions, puzzles,

and paradoxes” (NRC, 1997, p. 24). For most students who have taken two semesters of a regular undergraduate science class, there is a laboratory component. The university where this study was conducted has a requirement for those students seeking a degree in elementary education to have at least one science class that has a laboratory component. Experiencing a laboratory setting can be valuable for processing scientific information. The National Research Council adds “accumulating evidence suggests that non-majors often fare better in smaller courses and inquiry-based laboratory experiences where they become actively engaged with the subject matter” (2003, p.37). Koballa and Coble (1979) studied students involved with a laboratory course for elementary education majors. Conventional laboratory activities were taught in both groups but one group was exposed to additional activities. The results of the study indicates that incorporation of additional activities into the regular laboratory period can successfully increase favorable attitudes toward science among pre-service elementary teachers. A study by Sundberg (1994) mentioned earlier in this study suggested when looking at student evaluations and withdrawal rates that co-requisite laboratory classes provide a more positive experience to the students than lectures.

The positive trend for the understanding of the nature of science, and potential future positive directions towards the attitudes and beliefs in science for the two-semester interdisciplinary science course can be understood when realizing that the course consists of two 75-minute classes a week. When referring to the literature discussed in Chapter 2, it is conceivable that the interdisciplinary course may have had a more positive result if the interdisciplinary course had had a co-requisite lab or additional time within the two

class meetings. In other words, the potential for students who take the two-semester interdisciplinary course to achieve a more positive attitude towards science, a more positive belief in science and a better understanding of the nature of science may be increased if more instructional time were added. Adding additional time or laboratory co-requisite to the two-semester interdisciplinary course may provide an educational boost to a course that has been shown by this study to have lower means as to the constructs measured in this survey compared to courses that already have a laboratory component.

Discussion of Limitations

This study has several limitations. Perhaps the most important limitation of the study is the overall sample size ($n=69$), particularly the interdisciplinary course group with a sample size of 23. This low number raises question about power and type II error. The concern of low participation is addressed in chapter 3 but does confine the ability to draw any conclusions to the results that have been elucidated in chapter 4. It would be unfortunate to interpret nonsignificant results from this study where the independent variables made no difference, if in fact, the independent variables did make a difference but the study had poor power (in this case small sample size) for detecting the difference.

In addition to the sample size the participants in the two-semester interdisciplinary sample numbered 23 when an a priori power analysis suggested at least 44, which was achieved by those participants who took two science courses other than the two-semester interdisciplinary course. Lastly, a small sample size raises the questions as to the

generalizability of the study's findings to the target population of elementary education majors.

Furthermore, those participants who took the two-semester interdisciplinary course were not all elementary education majors whereas all the participants ($n = 46$) who took two unrelated science classes were elementary education majors. Ideally, all the students in the two-semester interdisciplinary course should be elementary education majors; for this study, nine of the twenty-three from the two-semester interdisciplinary course were in that category. A statistical t-test was performed using the nine elementary education students to see if there was any difference in the results, which there was not.

The reliability for the construct of the understanding of the nature of science was marginally internally consistent ($\alpha = .32$) which is a concern. The low reliability was not a result of keeping statements within the theoretical framework of understanding the nature of science rather than replacing the statements that were cross-linked with another construct (attitudes) when factorial loading was analyzed. The flaw may have to do with the validity and reliability of the Scientific Attitude Inventory II survey.

Two factors stand out as problematic with the Scientific Attitude Inventory II in relation to this study. One factor is the alpha value (.781) for the Scientific Attitude Inventory II. The alpha attained by the Scientific Attitude Inventory II used the 40 statements grouped together as a whole rather than separated into constructs. The researchers of the Scientific Attitude Inventory II describe attempts to use confirmatory and exploratory factor analysis to ferret out a scale or grouping of items but their efforts

were not satisfactory. In essence, the 40-item SAI II by Moore and Foy (1997) is presented without the support of factor analysis. However, this study did provide favorable results for constructs that may suggest further review. Another area of concern is that the 557 respondents to the study by Moore and Foy (1997) were students in 6th, 9th, and 12th grades. Comparing outcomes from the SAI II, which uses respondents that may not have the proper foundation of intellect as compared to college students used in this study, could offer different results. Moore and Foy should continue to improve the Scientific Attitude Inventory II survey for validity and reliability.

Implications for Practice

The results of the study show no discernible difference in the two delivery methods of classroom instruction, in regards to influencing the attitude towards science, belief in science, and the understanding of the nature of science. When comparing the means, the interdisciplinary course is close to being equivalent towards the statements related to attitudes towards science, belief in science, and an understanding of science as two semesters of undergraduate courses in science. The two-semester interdisciplinary course comes close to accomplishing the same goals of attitudes in science, belief in science and understanding of science with less instructional time than two semesters of undergraduate science courses. It could be inferred that the interdisciplinary course may be more efficient in its approach to teaching science to non-majors, when comparing attitudes towards science, belief in science, and an understanding of science since less time is spent in the classroom. This is not an endorsement for the two-semester interdisciplinary course to replace science courses that have laboratory courses. On the

contrary, it would be beneficial to add more instructional time or a laboratory component to the interdisciplinary course to continue the positive direction mentioned earlier of enhancing the students' attitude towards science, belief in science and understanding of the nature of science.

To sum up, having two semesters of regular science courses resulted in higher mean values with respect to statements involving attitudes towards science, belief in science, and the understanding of the nature of science but the difference did not come close to being statistically significant. However, students in the interdisciplinary course group did answer three out of eight individual nature of science statements with higher correct values than students who took two regular undergraduate science courses. This could be an indication that even though the beliefs and attitude statement values of the two-semester interdisciplinary students may be lower than their counterparts in this study, the two-semester interdisciplinary course was able to inculcate an understanding of the nature of science. Neither group had statistically significant higher means when comparing the constructs; however, the interdisciplinary course had less instructional time and no prescribed laboratory course. It could benefit the two-semester interdisciplinary course to have additional time to increase favorable attitudes in science, belief in science, and an understanding of science. A continuing effort should be made in developing and refining the two-semester interdisciplinary course.

Implication for Future Methods of Instruction

The results of this study lead to several implications for future methods of instruction for the two-semester science interdisciplinary course:

1. Better student tracking to allow more elementary education majors to take the two-semester interdisciplinary course: This would increase the number of elementary education majors to be participants in studies to determine the effectiveness of interdisciplinary course called “Science That Matters.”
2. Focusing on students’ misconceptions of science through classroom interaction: If an instructor is to dislodge misconceptions or beliefs, the instructor needs to know what the students are thinking throughout the instruction. Driver (1991) argues that teacher preparation programs must not only prepare preservice teachers to help their students overcome alternative conceptions, but they must also address the alternative conceptions of science held by their own teacher candidates. Instructors should help the students confront their own misconceptions by exposing the students to situations that provide an opportunity to challenge their own thinking. This challenge may come from students who possess radically different experiences or beliefs than other students. The results of this study indicate that educators should organize the two-semester interdisciplinary science course to include experiences that make students aware of and adept at confronting their existing beliefs about science. The negative beliefs of the students in the two-semester interdisciplinary course may have been formed before entering that class. The negative beliefs in science that were brought to the class may have made it difficult for the curriculum to alter their attitudes towards science. Science courses that relate concepts, avoid excessive lecturing and memorizing, and build upon students’ experiences by paying particular attention

to science concept development and overcoming alternative conceptions may dispel hard to displace beliefs. Courses that move to more student-centered instruction that include more hands on experiences and opportunities to apply ideas in real world situations and that accommodate individual students' ways of thinking are needed. An example is the curriculum of Alan Colburn (Bianchini & Colburn, 2000) cited earlier in this study; Colburn is a teacher-researcher who is experienced with the nature of science and taught "Science—a Process Approach" to liberal studies majors interested in pursuing teaching credentials at the elementary level. Using instruction time for the history and philosophy of science has been shown useful for understanding the nature of science (Adb-El-Khalick et. al, 2000) as well as long-term retention (Kimball, 1967).

3. Extending contact hours for the two-semester interdisciplinary course: Allowing more time to give students an opportunity to overcome misconceptions, this may create a more positive attitude towards science. The extension of contact hours may come with increasing the time in class from 75 minutes per session to 100 minutes per session, which would provide a greater opportunity to use modules that are laboratory-oriented. Alternatively, creating a separate laboratory class that would meet each week, in addition to the standard 75-minute session twice a week. Focusing on time and the construct of understanding the nature of science, Bell et al. (2000) identified mediating factors that constrain the translation of the concept. In his study, the mediating factors were the conflict between teaching the nature of science and teaching more commonly addressed aspects of science.

In addition, teaching the nature of science required substantial time, which prevented those instructors who were teaching the nature of science from keeping up with other teachers who were not.

4. Provide long-term qualified teachers for the interdisciplinary science courses who would offer stable instruction: This would allow the instructors to focus on the course objectives, which can be centered on active learning rather than muddling through new material by the teachers. Teaching well in any context requires that teachers learn about and teach from their students' strengths. The study revealed that the two-semester interdisciplinary science course had lower mean values for the constructs measured compared to those students who took two separate science courses. It is possible that the lower mean value for the three constructs was a symptom of a problem that occurred within the two-semester interdisciplinary course. Late in the first semester of the two-semester interdisciplinary science course, an instructor was removed for poor instructional skills, which may have influenced the results especially since she was there most of the semester. The poor skills of the instructor in conjunction with the disruption of the educational process that included introducing a new teacher may have influenced the outcomes in the two-semester interdisciplinary course. Being able to know the students during classroom interactions throughout both semesters of the course allows the instructor to perceive distinct strengths that they may bring to elementary science teaching.

Implications for Research

The results of this study suggest future research in comparing students who take two science courses other than the two-semester interdisciplinary science course with those students who do take the two-semester interdisciplinary science course. Results indicated that the two-semester interdisciplinary science course mean values for the three constructs measured were lower than the students who took two unrelated science courses. Part of the cause for lower mean scores could be a problem with competent faculty members. The role of the faculty member as to the success or failure of a course is always important. Without high-quality instruction, a course may be doomed for failure. The faculty member influences the intellectual performance and motivation of their students.

Additionally, the experience of the students in the cohort (two-semester interdisciplinary science course) may have affected the results. The students in the interdisciplinary cohort were freshmen that had just begun their college experience. This could have contributed to the slightly more negative results. In the future, it may be beneficial to have a variety of instructors, maybe through collaboration in the classroom or having a different instructor for each of the two-semester courses.

Supplementing the lack of experience could be maturity level. The interdisciplinary cohort were typically freshmen so experience and age could have contributed to the lower mean values. The students surveyed who had two semesters of an unrelated science course were elementary education majors who were late

sophomores. The one-year difference in college experience may contribute to the difference in means for the two groups. Additionally the entering confidence levels and expectations of the students in the two separate science courses may be different than those students in the interdisciplinary course. The students who took two different science courses may have a higher confidence level considering the science courses they may have taken could have the potential to be difficult. Whereas the students in the interdisciplinary course may have taken the two-semester course because their expectation of the course was that it would be easier than two random courses in the sciences. In other words, there may have been different populations on the characteristics of confidence levels and expectations that could affect the study.

Rewording some of the statements in the Scientific Attitude Inventory may be helpful in creating a more valid instrument. Some of the survey statements concerning attitudes and beliefs were out of the ordinary. The nature of science statement “A major purpose of science is to produce new drugs and save lives” is misleading. Currently students are aware of the value that science has in their lives. It is common for students to think that science is concerned with making our lives better but it is not one of the goals of the nature of science.

It should be noted that the two-semester interdisciplinary course is a three-credit course that meets for 75 minutes twice per week. The two regular science courses taken by the other students probably have a laboratory class that meets for at least two hours per week in addition to the lecture class that meets twice a week for 75 minutes per session. Although the attitudes towards science, belief in science, and the understanding

of the nature of science may not differ between the two groups (those that took the two-semester interdisciplinary course and those that took two semesters of regular undergraduate science) the amount of class time did. Students who were in the two-semester interdisciplinary class met for fewer hours than those students who took two regular undergraduate science classes. In essence, the students who took two semesters of a regular science class had more time in the classroom because of an additional laboratory class per week.

It would be unfortunate to interpret nonsignificant results from this study where the independent variables made no difference, but in fact, the independent variables did make a difference but the study had poor power (in this case small sample size) for detecting the difference. Collecting data at the end of the spring 2005 term would allow for a comparison of the results from this study. Furthermore, providing the students an opportunity to reveal on the survey whether the two semesters of regular science courses that were taken had a separate laboratory component would be enlightening. Additionally the data could be added to this study to generate a larger sample size thus creating more power of analysis. Considered nascent, the two-semester interdisciplinary science course would be better served with a long-term investigative approach compiling data used in this study and those in the future.

In summary, the two-semester interdisciplinary science course generated lower mean scores for the three constructs measured (attitude toward science, belief in science, and understanding of the nature of science) than two separate and unrelated science courses. Implications from this study could be the experience of faculty member,

experience of the college student as well as their age, faulty survey instrument, and most importantly the time on task.

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Appendices

Appendix A: Survey Instrument

INDIVIDUAL STATISTICS

Please circle the appropriate answer to the following questions:

1) Have you taken the first semester of *Science That Matters* (ISC 1004)?

Yes No

2) If “No” to question #1 continue to question #3. If “Yes” to #1, did you earn a “C” or better?

Yes No

3) Are you or do you plan to become an elementary education major?

Yes No

4) Please circle your gender:

Male Female

5) Please circle the age group where your age would be found.

Age Group:

18-24 25-30 31-35 over 35

Thank you,

Please continue with the survey on the next page.

WHAT IS YOUR ATTITUDE TOWARD SCIENCE?
(A Scientific Attitude Inventory)
SAI II

There are some statements about science on the next three pages. Some statements are about the nature of science. Some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with others. That is exactly what you are asked to do. By doing this, you will show your attitudes toward science.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. You may decide that you are uncertain or cannot decide. Then, find the number of that statement on the answer sheet, and **CIRCLE** the:

- A** if you agree strongly
- B** if you agree mildly
- C** if you are uncertain or cannot decide
- D** if you disagree mildly
- E** if you disagree strongly

EXAMPLE:

I would like to have a lot of money.

(A) B C D E

The person who circled this example agrees strongly with the statement, “I would like to have a lot of money.”

Please respond to each statement and circle only ONE letter for each statement.

Appendix A: (continued)

1. Good scientists are willing to change their ideas.
A B C D E
2. I would enjoy studying science.
A B C D E
3. I may not make great discoveries, but working in science would be fun.
A B C D E
4. Scientific work is useful only to scientists.
A B C D E
5. Scientific ideas may be changed over time.
A B C D E
6. Scientists are always interested in better explanation of things.
A B C D E
7. Most people are unable to understand science.
A B C D E
8. Working in a science laboratory would be fun.
A B C D E
9. Some questions cannot be answered by science.
A B C D E
10. When scientists have a good explanation, they do not try to make it better.
A B C D E
11. Scientists should not criticize each other's work.
A B C D E

Appendix A: (continued)

12. Most people can understand science.

A B C D E

13. Every citizen should understand science.

A B C D E

14. Scientific questions are answered by observing things.

A B C D E

15. Anything we need to know can be found out through science.

A B C D E

16. A major purpose of science is to produce new drugs and save lives.

A B C D E

17. If one scientist says an idea is true, all other scientists will believe it.

A B C D E

18. Scientists must report exactly what they observe.

A B C D E

19. Scientists have to study too much.

A B C D E

20. I would like to be a scientist.

A B C D E

21. The search for scientific knowledge would be boring.

A B C D E

22. Only highly trained scientists can understand science.

A B C D E

23. People must understand science because it affects their lives.

A B C D E

Appendix A: (continued)

24. Electronics are examples of the really valuable products of science.

A B C D E

25. A major purpose of science is to help people live better.

A B C D E

26. I would like to work with other scientists to solve scientific problems.

A B C D E

27. Scientists do not have enough time for their families or for fun.

A B C D E

28. Science tries to explain how things happen.

A B C D E

29. Scientific work would be too hard for me.

A B C D E

30. I do not want to be a scientist.

A B C D E

Appendix B: Permission

Gary, permission to use the SAI II for your current work is hereby granted. I have attached a copy of the instrument. I have attached the position statements assessed by the various attitude statements. From the latter, you should be able to determine the scoring design for the SAI II.

Best wishes with your work.

RWM

At 05:01 PM 1/24/2004 -0500, you wrote:

>Dr. Moore;

>

>My name is Gary Brannan, I am a biology professor at Hillsborough
>Community College. I'm a doctoral candidate at the University of
>South

>Florida, both the community college and USF are located in Tampa. I
>would

>like to have permission to use your instrument to evaluate a two-
>semester

>course that is offered at USF for pre-service elementary school
>teachers. The two-semester course was implemented in 1999 with the
>help of a NSF grant. The SAI II would be the instrument used in my
>dissertation. A copy of the instrument would be helpful. My email
>address is gbrannan@hccfl.edu.

>

>Your assistance would be greatly appreciated.

>

>Thank you;

>

>Gary Brannan

>Biology professor

>Hillsborough Community College

>

Appendix C: Factor Loading Analysis

Statement	Factor 1 (Attitude)	Factor 2 (Belief)	Factor 3 (Nature of Science)
1	0.46451		0.39787
2	0.79856		
3	0.79654		
4		0.47844	
5			0.64795
6			0.58297
7		0.57034	
8	0.60138		
9			0.36830
10		0.41771	
12		0.44638	
13	0.62252		
16			0.49990
18	0.33030		0.35644
19		0.64880	
20	0.71148		
21	0.51702		
22		0.69545	
23	0.53735		
25	0.50552		0.47561
26	0.77390		
27		0.71475	
28			0.63995
29		0.71347	
30	0.63579		

Note: Factor loadings less than 0.35 are not included.

Appendix D: Reliability Analysis

Attitudes

Item-total statistics

- E 2 I would enjoy studying science
- E 3 I may not make great discoveries, but working in science would be fun.
- E 8 Working in a science laboratory would be fun.
- E 13 Every citizen should understand science.
- E 20 I would like to be a scientist.
- E 21 The search for scientific knowledge would be boring.
- E 23 People must understand science because it affects their lives.
- E 26 I would like to work with other scientists to solve scientific problems.
- E 30 I do not want to be a scientist.

Reliability coefficient 9 items

Alpha = .89

Appendix D: (continued)

Beliefs

Item-total statistics

- E 4 Scientific work is useful only to scientists.
- E 7 Most people are unable to understand science.
- E 10 When scientists have a good explanation, they do not try to make it better.
- E 12 Most people can understand science.
- E 19 Scientists have to study too much.
- E 22 Only highly trained scientists can understand science.
- E 27 Scientists do not have enough time for their families or for fun.
- E 29 Scientific work would be too hard for me.

Reliability coefficient 8 items

Alpha = .78

Appendix D: (continued)

Nature of Science

Item-total statistics

- E 1 Good scientists are willing to change their ideas.
- E 5 Scientific ideas may be changed over time.
- E 6 Scientists are always interested in better explanation of things.
- E 9 Some questions cannot be answered by science.
- E 16 A major purpose of science is to produce new drugs and save lives.
- E 18 Scientists must report exactly what they observe.
- E 25 A major purpose of science is to help people live better.
- E 28 Science tries to explain how things happen.

Reliability coefficient 8 items

Alpha = .32

Appendix E: Cover Letter

Students' Views on Science Attitudes, Beliefs, and the Nature of
Science Research Project.

I am a professor of biology at Hillsborough Community College who is interested in students who are not majoring in the sciences. I am trying to determine if a particular science course may provide non-science majors with a better attitude toward science, belief in science, and understanding of the nature of science.

This study has been approved for an exemption certification by the University of South Florida's Institutional Review Board (IRB). The IRB number for this research project is: # **102328**

You may be assured that information you provide on the survey will be handled in confidence and will never be associated to you by name.

Thank you,

Gary Brannan
Doctoral Candidate
College of Education
University of South Florida

Appendix F: Frequency and Means for Statements

Statement	Interdisciplinary Group					Mean	Non-Interdisciplinary Group					Mean
	Frequency						Frequency					
	1	2	3	4	5		1	2	3	4	5	
1	1	0	2	11	9	4.17	1	3	2	17	23	4.26
2	2	5	3	9	4	3.35	4	6	9	17	10	3.50
3	1	5	5	10	2	3.30	2	4	13	17	10	3.63
*4	8	7	3	5	0	2.22	26	10	1	5	4	1.93
5	0	1	1	7	14	4.48	0	0	1	16	29	4.61
6	0	0	2	10	11	4.39	0	2	3	13	28	4.46
*7	1	6	8	6	1	2.96	2	19	20	8	2	2.74
8	1	2	10	7	3	3.39	3	10	6	15	12	3.50
9	1	3	6	7	6	3.61	0	3	3	14	26	4.37
*10	4	11	6	1	1	2.30	17	20	8	0	1	1.87
*11	8	10	3	0	2	2.04	16	19	5	3	3	2.09
12	2	6	5	9	1	3.04	5	8	18	13	2	2.98
13	1	1	7	12	2	3.57	2	6	10	24	4	3.48
14	1	2	2	15	3	3.74	1	2	7	26	10	3.91
*15	2	6	8	7	0	2.87	9	14	9	13	1	2.63
*16	2	4	2	12	3	3.43	3	6	6	19	12	3.67
*17	8	13	2	0	0	1.74	28	15	3	0	0	1.46
18	0	2	6	9	6	3.83	1	4	5	15	21	4.11
*19	1	5	12	2	3	3.04	5	15	11	8	7	2.93
20	11	5	3	1	3	2.13	11	17	7	6	5	2.50
*21	3	8	7	4	1	2.65	9	16	12	5	4	2.54
*22	3	13	4	2	1	2.35	13	26	3	3	1	1.98
23	1	3	4	11	4	3.61	1	2	9	22	12	3.91
*24	0	1	6	9	7	3.96	1	4	6	20	15	3.96
*25	1	1	7	7	7	3.78	0	2	2	26	16	4.22
26	6	6	6	2	3	2.57	5	17	10	8	6	2.85
*27	5	9	7	0	2	2.35	15	13	10	6	2	2.28
28	0	0	2	9	12	4.43	1	3	2	21	19	4.17
*29	3	7	5	5	3	2.91	9	11	7	11	8	2.96
*30	4	1	2	5	11	3.78	4	7	7	12	16	3.63

* Indicates negative statements. Lower scores represent a more favorable response for the science survey.

About the Author

An Illinois native, Gary Eugene Brannan attended Lincolnland Community College in Springfield, Illinois and received a bachelor's degree in microbiology and a master's degree in biology education from the University of South Florida. He is entering his twenty-fifth year of teaching with 12 of those years in the community college teaching anatomy and physiology, microbiology, and other related courses. He taught high school classes in biology and chemistry for 13 years in the Hillsborough County school system. He taught five years at Pasco-Hernando Community College and the past six years at Hillsborough Community College, Brandon Campus.