AN EVALUATION OF COMMUNITY COLLEGE STUDENT PERCEPTIONS OF THE
SCIENCE LABORATORY AND ATTITUDES TOWARDS SCIENCE IN
AN INTRODUCTORY BIOLOGY COURSE

by

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ABSTRACT

The science laboratory is an integral component of science education. However, the academic value of student participation in the laboratory is not clearly understood. One way to discern student perceptions of the science laboratory is by exploring their views of the classroom environment. The classroom environment is one determinant that can directly influence student learning and affective outcomes. Therefore, this study sought to examine community college students’ perceptions of the laboratory classroom environment and their attitudes toward science.

Quantitative methods using two survey instruments, the Science Laboratory Environment Instrument (SLEI) and the Test of Science Related Attitudes (TORSA) were administered to measure laboratory perceptions and attitudes, respectively. A determination of differences among males and females as well as three academic streams were examined.

Findings indicated that overall community college students had positive views of the laboratory environment regardless of gender of academic major. However, the results indicated that the opportunity to pursue open-ended activities in the laboratory was not prevalent. Additionally, females viewed the laboratory material environment more favorably than their male classmates did. Students’ attitudes toward science ranged from favorable to undecided and no significant gender differences were present. However, there were significantly statistical differences between the attitudes of non-science majors compared to both allied health and STEM majors. Non-science majors had less positive attitudes toward scientific inquiry, adoption of scientific attitudes, and enjoyment of science lessons. Results also indicated that collectively, students’ experiences in the laboratory were positive predicates of their attitudes toward
science. However, no laboratory environment scale was a significant independent predictor of student attitudes. A students’ academic streams was the only significant independent predictor of attitudes toward science, albeit negatively.

The results from this study indicated that there is a need to increase the opportunity for inquiry in the science laboratory. The data also suggest that although all academic streams may have similar views of the laboratory experiences, more needs to be implemented to improve the scientific attitudes of non-science majors enrolled in a course for science majors.
DEDICATION

This work is dedicated to Rodriguez, Coleman Joseph, and Ella Grace. To my husband Rodriguez, thank you for staying close and being supportive throughout this entire process. I appreciate your prayers, hugs, and your ability to stay constant and steady in the midst of my uneasiness. To my children, Coleman and Ella, you are my future and this is for you.
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CHAPTER I:
INTRODUCTION

The current and future global economy requires a workforce that is knowledgeable and educated in the disciplines of science, technology, engineering, and math (STEM) (United States Department of Labor, 2007). These STEM disciplines influence every citizen at various levels from personal day-to-day endeavors and economics to public policies and politics. Although there are clear influences and benefits of the STEM disciplines, the United States (U.S) faces a shortage in the sciences and technologies workforce (National Science Foundation, 2004). As global competition for experts in these fields grows, the decline in workforce numbers is inconsistent with the number of occupational opportunities. In fact, the Bureau of Labor Statistics projects that the workforce in science and engineering related occupations will grow by 21.4% compared to 10.4% of the total workforce between the years 2006 – 2016 (National Science Foundation, 2010). Furthermore, the number of jobs in the U.S. labor force that will require a background in science and engineering grows at a rate of about 5.9 % whereas the rest of the labor workforce is growing by a just over 1.2 % (National Science Board, 2012). Thus, an increase in the number of STEM college graduates is critical to the present and future U. S. workforce and society.

However, the pipeline of college graduates needed to fill this workforce gap has yet to produce adequate numbers to meet the demand. For example, during the 2003 - 2004 academic year although the United States experienced an enrollment increase at the postsecondary level,
only 27% of the degrees awarded were in STEM academic disciplines; 5% less than the number awarded ten years earlier (U. S. Government Accountability Office, 2006). More specifically, in relation to the scientific component of the STEM disciplines, vast majorities of institutions require their students to take an introductory laboratory–based science course; yet, there is a noticeable shortage in the retention rate in the sciences. Factors that can contribute to this deficiency include inadequate preparation in high school, lack of academic support, and poor teaching in the laboratory sciences (Seymour, 2002). In this regard, students often become disengaged with laboratory science courses and the many students earn D’s, F’s, or withdraw entirely from the course (Moore, 2008). Additionally, 50% of students that originally decide to pursue degrees in the sciences change their major to a non-science major (Kardash & Wallace, 2001). Thus, for the purpose of reform and improvement of the science component of STEM, institutions of higher education have to become more pioneering in their methods of teaching, curricula, and technologies. One specific element that has the potential to make strides in this endeavor in all three innovative areas mentioned previously is the laboratory component of the science curriculum.

The science laboratory environment offers experiences that are different from those offered by traditional science classroom lecture. It is within this environment that concepts taught in the lecture are expanded upon through hands on activities. For the teacher, the science laboratory allows the opportunity to provide students with experiences that transform the concepts taught in the lecture into the processes that incorporate the scientific method. Therefore, it is where students should engage in the process of science by learning to identify a problem, investigate, experiment, and analyze results in order to make valid conclusions. Thus, one could surmise that positive experiences in an ideal introductory science laboratory may
increase and cultivate student interests in the sciences; improve the retention of students that initially choose a science major; and increase the number of individuals entering science related careers.

Unfortunately, research in science education literature reveals that the laboratory experience as it relates to student learning outcomes, achievement, and attitudes toward science may not serve its intended purpose (Hofstein & Lunetta, 2004). Recognizing the aforementioned issues, many national organizations, such as the Society of College Science Teachers, issued a position statement that recommends that laboratories should provide students with an inquiry based experience (Halyard, 1993). However, studies indicate that the students do not receive these experiences (Hofstein & Lunetta, 2004; Klopfer, 1990; Toothacker, 1983); and teachers may not be qualified to provide them. Consequently, a break occurs between the acquisition of scientific knowledge, the application of that knowledge in the context of the scientific process, and the relevance of the experience to science education, scientific careers, and society. This notable disconnect has prompted this examination of the perceptions that students have of the science laboratory environment, and how these perceptions are related to students’ attitudes toward science.

**Background**

Most science educators would find it difficult to separate science instruction from the laboratory experience. However, the debate concerning the relevancy and value of the laboratory has existed for several decades. Research by Flansburg (1972) indicated that students who received laboratory instruction performed at the same level on examinations as students who did not have any laboratory exposure. Hodsons’ (1990) research findings concluded that laboratory work is confusing and purposeless for students. An absence of inquiry based
laboratories and clear student-learning outcomes are weaknesses often noted in the student laboratory experience. In a review of 500 college laboratory exercises, Hegarty (1987) demonstrated that laboratory exercises failed to allow students to recognize problems, synthesize experiments, or choose materials needed to conduct an experiment. These unfavorable findings have led to recommendations focused on the improvement of laboratory instruction at all levels of education. More specifically, at the college level, students should be involved in the design of their laboratory experiments and make choices in the protocol (Wilson & Stensvold, 1991). Furthermore, students should learn how to perform literary searches from library databases and be able to communicate effectively the results of investigations (Seago, 1992).

Studies that have investigated inquiry-based laboratories in college courses have produced a number of positive findings. For example, Sunberg (1997) found that students enrolled in an inquiry-based laboratory scored higher on pre and post-tests compared to students enrolled in a traditional laboratory class. A comparison of post-test scores of college students in two different classroom settings, a traditional and an inquiry-based, revealed that students in the inquiry had a better understanding of the processes of osmosis and diffusion (Leonard, 1983). However, according to Hofstein and Lunetta (1982), an extensive review of the research that focused on the laboratory in science education, suggested that laboratory research studies failed to show basic relationships between the laboratory experiences and student learning. In a follow-up to their earlier study, Hofstein and Lunetta (2004) concluded that although some things had changed in twenty years, the following issues remain:

1. The use of cookbook laboratory activities;
2. There is a lack of assessment of laboratory skills, practical knowledge, and inquiry;
3. Teachers’ and administrators’ philosophy about lab and actual practice differ; and
4. The execution of inquiry-based laboratories is slowed down by a lack of funding, time, and other outside variables.

In order to address the concerns about the value of the science laboratory, as well as its function in development of student cognitive and affective outcomes, Fraser, McRobbie, and Giddings (1993) developed the Science Laboratory Environment Instrument (SLEI). The data obtained from the administration of this survey has led to a greater understanding of student perceptions of their laboratory environment. Results have shown that there are positive associations between the science laboratory and student cognitive and affective learning outcomes (Fisher, Henderson, & Fraser, 1997; Fraser, Giddings, & McRobbie, 1995). These studies further indicate that students prefer environments where the following are noted: a connection between the theories taught in class and the activities conducted in lab; adequate materials and equipment; supportive student-student interaction; and clear instructions. Conversely, although these results illustrate that student participation in the laboratory can produce positive outcomes; students report activities and instruction that garner inquiry and higher levels of cognitive thinking are often absent. These latter findings reflect the deficiencies that Hofstein and Lunetta (2004) reported are still prevalent in laboratory instruction.

As noted previously, the laboratory environment can positively influence student cognitive and affective outcomes. One such affective domain, student attitudes, has been of interest to science educators and researchers for many years. Investigations of student attitudes toward the sciences began to appear in the education literature in the late 1960s and early 1970s (Bileh & Zakkariades, 1975; Moore & Sutman, 1970; Schwirian, 1968). These early studies
were prompted by the noticeable decline of students choosing science as a major and career in the field.

A review of the literature that addresses the laboratory environment and student attitudes toward science reveals that the sample student populations are often enrolled in primary and secondary grade level schools. Whereas this student population is of great importance to sciences and the future STEM pipeline, students enrolled in institutions of higher education also provide views that are valuable to learning environment and scientific attitudes research. The publication of national reports such as the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) and *National Education Standards* (National Research Council, 1996) both proposed models and guidelines to improve science teaching and laboratory instruction at the K-12 level. Institutions of higher education have adopted these standards in order improve instruction as well. However, there are challenges that higher education faces when attempting to reform laboratory instruction. These challenges exist because governmental agencies and professional organizations like the American Association of the Academies of Science, initiate reform at the undergraduate level (McCormick, 2004). This is different when compared to the management of K-12 in which policy and recommendations originate at the state level (Shamos, 1995).

Additionally, science education reform at the undergraduate level is not a “one size fits all” solution. Each institution has its’ own unique characteristics which includes, but are not limited to, faculty and student demographics, size, and budgets. Although institutional diversity can affect reform measures, the National Study of Education in Undergraduate Science (NSEUS) has identified certain criteria by which to evaluate the level of implementation of reform in an
introductory undergraduate science course (Sunal, Sunal, Sundberg, Mason, Zollman, Lardy, & Mojgan, 2009). The factors that are most relevant to this study include the following:

1. Emphasis on facilitating all students’ learning of science;
2. Structured inquiry pedagogy with active and extended student participation as a regular part of instruction; and
3. Emphasis on evidence-based learning, using relevant and real data reflecting how science is done.

The criteria above were derived from a review of the literature related to science education reform and a survey of 103 institutions throughout the United States. Of the colleges and universities surveyed, community colleges represented 1% of the sample. This percentage is small when compared to the 44% of undergraduates that begin their matriculation in higher education at the community college level (American Association of Community Colleges, 2011). Additionally, the 1% represented in the study reinforces the need for increased research that focuses on science education at the community college level.

The community college represents a component of higher education that serves an important role in the education of the U.S. populace. These institutions are distinctive in that they are in an intermediate position between the K12 education systems and the four-year institutions. The open-door policy, which is at the core of the accessibility mission of the public community college, enables students that are underprepared academically the opportunity to receive a college education that might otherwise be denied at four-year institutions. The student population that community colleges serve can be diverse in their age, gender, and educational goals when compared to K-12 and four-year universities. According to data from the National Center of Education Statistics (2008), between 2003-2004, the median age of the community
college student was higher when compared to four-year institutions, twenty-four and twenty-one, respectively. Moreover, 59% of the students enrolled at community colleges were females compared to 56% at four-year institutions. Additionally, in a review of over 20 studies, Belfield and Bailey (2011) reported that community college attendance and completion contributes to positive financial earnings and may contribute to gains in health and lower welfare reliance.

The students that enroll at community colleges do so for a number of different reasons. They can be recent high school graduates that enroll with the intent to transfer to a four-year institution, or an older adult that delayed going to college in order to work and raise a family. Community colleges also provide educational opportunities that retrain members of the workforce when continuing education is necessary in a particular industry. The characteristics of these institutions make them an ideal environment for students that enroll in science courses. The average class size of the community college science course is small when compared to four-year institutions (Biermann, 1996) and this allows for greater interactions between teachers and students. Additionally, the community college instructor often has more contact hours with students because they instruct both the lecture and laboratory component of the course. This is different from what occurs at most four-year colleges, where teaching assistants, due to the research obligations of the faculty members, often teach the laboratories. Compared to state-mandated outlines associated with secondary science laboratory classes, the curricula of the community college science laboratory is less standardized (Basey, Mendelow, & Ramos, 2000).

Community college students enroll in introductory biology courses for a myriad of reasons. For instance, biology science major register for the course as a necessary foundation for upper-level science courses, whereas an allied health major enrolls in order to complete a prerequisite to gain entrance into a two-year professional program. Often times, older adults
return to school to seek a new career in the allied health science programs such as nursing, physical therapy assistant, and radiology technician. These students can have a great deal of anxiety about returning to school and taking an IBC. The anxiety coupled with poor-self-images (Biermann, 1996) may directly influence their perceptions of science. In addition, research studies have indicated that nursing students tend to find biology prerequisite courses difficult (Caon & Trexter, 1993). It is because of the diverse student population in an introductory biology course that there exist an opportunity to gain new perspectives about the laboratory environment and attitudes toward science.

**Problem Statement**

The science laboratory is a common element associated with most science courses. The experiences that students encounter in this environment should closely associate with lecture content, allow for critical thinking, and be driven by inquiry processes. However, studies have suggested that students fail to receive the aforementioned experiences; therefore, science educators, researchers, and students question the importance of science laboratory experience.

Determining the cognitive and affective value of the science laboratory is critical. As institutions of higher learning plan to do more with less financial support from state and national levels, accountability for what instructional components are producing positive student learning outcomes has become vitally important. These learning outcomes are the general goals that students should accomplish because of the learning experiences in a course (Seybert, 2002). Recently, there has been a mandate to link learning outcomes to the accreditation process. Therefore, it is important to promote strategies in the laboratory to lead to student success.

Although research studies have demonstrated that positive associations can exist between student perceptions of the science laboratory environment affective outcomes, such as attitude
(Fraser & McRobbie, 1995), other data has suggested otherwise (Hofstein & Lunetta, 2004). The differences in these findings assert that a consensus does not exist about the importance of the laboratory and further studies need to be conducted in order to provide more insight.

**Purpose of the Study**

An immense body of research exists which explores students’ perceptions of the laboratory environment (Fraser, 1998). This area of study has provided important feedback as it pertains to what students deem valuable or lacking in their laboratory experiences. Although, studies have been conducted with students in higher education as the sample population, (Fraser, Giddings, & McRobbie, 1995) the vast majority of the studies are conducted with students from primary and secondary school. Few studies have examined laboratory instruction (Biermann & Sarinsky, 1993; Saunders & Dickinson, 1979) and students’ attitudes toward science on the community college level (Crow & Piper, 1983). Therefore, the purpose of this study was to assess associations between the science laboratory environment and attitudes toward science within a population of community college students enrolled in an introductory biology course. Furthermore, this study examined if differences exist between gender and chosen academic discipline.

**Significance of Study**

The community college student is underrepresented in learning environment research when compared to students enrolled in K-12 and four-year institutions. As a member of the community college workforce, this researcher believes this study was of great value from the perspectives of an administrator, instructor, and researcher. First, administratively, this study serves as a departmental microanalysis of the laboratory environment and students’ attitudes at the community college where the study occurred. Students routinely evaluate their teachers and
the lecture course by means of evaluations administered at the end of the semester. These evaluations are a standard general assessment that all teachers use regardless of academic discipline. However, students enrolled in sciences do not have the opportunity to assess their laboratory experiences, perceptions of the environment, or instruction. Secondly, as an instructor, the results from this study could be significant as they may serve as an impetus that can guide the implementation of new teaching methods and curricula that can cultivate a more positive learning environment for students. Lastly, as a researcher, this study was significant because it examined the community college sector. The data added to a body of literature, that as it currently exist, lacks the views of this student population. The information gathered from this study revealed that community college student views and attitudes toward are similar or uniquely different from those of secondary and university students. As more students begin their higher education at community colleges, it is imperative that students are exposed to quality science education that includes positive laboratory experiences.

Summary

Science education reform is driven by the need for a scientific literate population, inquiry based science curriculum, and a skilled workforce at national and global levels. Reforms in teaching pedagogy and curriculum have led to a desire to foster science education experiences that promote inquiry and higher cognitive learning. The laboratory is a hallmark of science education that allows students to gain hands-on experiences and formulate investigative skills that are a critical part of higher cognitive thinking. However, the vast majority of laboratory experiences that students encounter do not provide opportunities to increase their understanding of the scientific process. The purpose of this study was to assess introductory biology student’s perceptions of the science laboratory environment and determine their effects on students’
attitudes toward science. This study is unique because this investigation takes place at the community college level, which is a division of higher education that has limited representation in laboratory environment research. Moreover, this study seeks to identify if differences persist in students perceptions based on their gender and academic discipline.

This study is presented in five chapters. Chapter II reviews the literature that is pertinent to garner an understanding of the problem and purpose of the research. Chapter III presents the research questions, and outlines the methodology utilized to address the questions. Chapter IV presents the results of the study and Chapter V analyzes the results and makes recommendations for future studies on the topic.
CHAPTER II:

REVIEW OF THE LITERATURE

The review of literature will present bodies of work that are relevant to this study. This chapter will present four major topics that review studies in the following areas: 1) the history and role of teaching science laboratory; 2) the classroom environment; 3) attitudinal research; and 4) the significance of the community college in science education. The first section reviews the emergence and role of the laboratory in the science curriculum in the United States. A review of literature that presents the major educators and scientists that were pivotal to the establishment of the first science laboratories within the American educational systems is presented. Furthermore, the issues and trends that have occurred over the decades as they relate to the purpose and relevancy of the laboratory in science instruction and curriculum are presented. It is necessary to provide to historical perspective of the emergence of the science laboratory in order to provide context for the issues that currently exist in the research surrounding this topic. The second section provides an overview of the historical and theoretical foundations of classroom environment research. This section details the early studies of classroom environment research and highlights the numerous studies that specifically have investigated the laboratory classroom. Additionally, this section details the synthesis of the SLEI survey instrument that is used in this investigation. The third section presents studies that examine the issues that affect the strength and weaknesses of attitudinal research and the instrumental measures that gauge student attitudes. The Test of Science Related Attitudes (TOSRA) is discussed and data from studies that have used the instrument to determine
associations between students’ attitudes toward science, gender, and the laboratory environment are discussed. The fourth and final section provides a brief history of community colleges in America, and their role in college science education. Collectively, this literature of review provides a background for this chosen subject and the rationale of its importance to the researcher.

The Role of the Teaching Laboratory in Science Education

Historical Review

In America, during the early to mid-19\textsuperscript{th} century, the inclusion of laboratory instruction in science education was nearly absent. Students enrolled in the natural and physical sciences obtained instruction through textbooks, lecture, and recitation. The small number of laboratories that existed during the early 19\textsuperscript{th} century were often associated with trade schools and thus thought to be of a substandard level of instruction (Festa, 1980). In 1847, Yale University emerged as one of the earliest institutions of higher education to implement a laboratory in the field of chemistry. However, faculty conducting research and only a select number of students were allowed to utilize the facilities as part of their education in the sciences (Singer, Hilton, & Schweingruber, 2005).

A change in the status of laboratories in the United States first began in higher education as a direct result of the introduction of the German laboratory model championed by the chemist Justus von Liebig (Sheppard & Horowitz, 2006). His investigative approach to teaching and training students consisted of three distinct stages: 1) the learning of essential techniques and practices; 2) qualitative analysis and identification of unknowns; and 3) individual research projects (Sheppard & Horowitz, 2006). Eben Horsford, a student trained under the tutelage of Liebig, is given credit for introducing this laboratory format to the United States at Harvard
University’s Lawrence Scientific School (Williams, 1901). Liebig’s technique began to extend past the walls of Harvard and on to other prominent institutions. These institutions included John Hopkins and Massachusetts Institutes of Technology. Notables involved in the establishment of the German model of laboratory instruction include, Charles W. Eliot and Ira Remsen, who were instrumental in the establishment of chemistry and physics laboratories at Massachusetts Institute of Technology and John Hopkins, correspondingly (Pickering, 1993).

Laboratory work in the high schools began to achieve momentum after universities began to require laboratory experience as a prerequisite for college entrance during the late 19th century. The implementation of this requirement in high school education prompted the publication and distribution of manuals that contained chemistry and physics laboratory activities authored by Harvard professors, Josiah Cook and Edwin Hall, respectively (Singer et al., 2005; Sunal, Sunal, Sunberg, & Wright, 2008). The dissemination of these manuals provided guidance to high school educators and began to serve as the model for the teaching laboratory. Consequently, a metamorphosis began to occur in high school science curriculum at the national level. In 1893, the National Education Association published a report entitled, Report of the Committee of Ten on Secondary School Studies (National Education Association, 1893). The recommendations from the report sought to bring forth the importance of science and laboratory instruction in the high school curriculum. It included details about who should supervise the labs, the proper keeping of record by students, how much the laboratory would count for college admissions, and the number of experiments that should be completed in physics and chemistry (National Education Association, 1899). These recommendations were widely accepted and an increase in the number of high schools adopting the laboratory methodology increased as well.
Hence, there was a co-evolution of the teaching science laboratory at the secondary and higher education level. This co-evolution was motivated by the implementation of laboratory science courses at the high schools that would meet the entrance requirements at colleges and universities across the country. In turn, science educators at colleges and universities would enroll students who were better prepared, compared to their predecessors, to matriculate through college courses in the sciences. In brief, the external factors that shaped the emergence of secondary and higher education laboratories include the following: Liebig’s laboratory methodology, the standardization of course requirements for high school students entering college, and the desire to promote science education in American education.

**Laboratory Reform: 1920s-2005**

As momentum for laboratory instruction continued during the late 19th century and early part of the 20th century the prevailing thought by the majority of scientists and educators was that students would best learn science by an inductive approach. This approach allows students to observe a phenomenon, engage in inductive reasoning, and accurately record their observations (Rudolph, 2005). However, by the end of 1910, declines in secondary laboratory instruction in the high schools began to occur. Sunal et al. (2008) reported that the decrease in laboratory instruction occurred because of increased immigration that led to a larger student population and consequently, a decrease in the available resources to serve the student population. In addition, during this time, firm opposition arose between two major ideologies; the supporters of the laboratory and its value to science education and college preparation and those who believed that the laboratory experiences should provide students with experiences that address social and political concerns of the day (Rudolph, 2005). Science educators began to use efficiency test of the scientific content to determine the effectiveness of laboratory instruction (DeBoer, 1991).
Criticisms abounded from educators that the laboratory exercises promoted by the widely used Harvard experiments, which had been instrumental in the establishment of chemistry and physics laboratories across the nation, needed modification to better meet the needs of the students. The new reformation placed emphasis on presenting more qualitative experiences and less quantitative laboratory exercises in the physics science courses (Mann, Smith, & Adams, 1907). Teachers that were asked to submit recommendations for revisions to the Harvard list were asked to first remove any topics that had the “least bearing on the student’s life and on the problem likely to occur to him spontaneously from his own experiences . . .” (Mann, Smith, & Adams, 1907, p. 290). Thus, a progressive movement away from the utilitarian-inquiry approach of laboratory began and once again, teachers placed more importance on demonstration and examples (Hodson, 1993).

For much of the first half of the twentieth century laboratory instruction oscillated between inquiry-based and traditional cookbook experiments that were textbook and teacher centered. By the 1960s and 70s there was once again a new wave of reformation of science education in the United States that was driven by the launch of the Russian satellite, Sputnik, in 1957. This show of scientific and technological force by the Russians symbolized a threat to American security, superiority in science and technology, and political freedom (Bybee, 2007). This significant event ushered in the “Golden Age” of science education reform in the United States because of increased amounts of governmental support through grant monies that were awarded by the NSF. The slogan that promoted new science curricula during this time was “science as inquiry” (Blosser, 1983). The process of teaching science was no longer the central dogma of this period; teachers were encouraged to allow students to take a more active role in
obtaining inquiry skills and knowledge that would allow them to know how to ask and find the answer to questions (Blosser, 1983).

Consequently, the NSF grants developed new programs and curriculum in K-12 that promoted a hands-on and discovery approach to teaching and learning science (Sunal et al., 2008). Inquiry-based laboratory exercises gained a prominent role in the process of science learning as the new curriculum emphasized higher cognitive skills (Hoftstein & Lunetta, 1982). College and universities also began to reconsider their approach to science and laboratory instruction and took their lead from secondary science education. Pearson and Foster (1967) reported in their case study of Rutgers’ introductory level science college courses that if high schools could organize open-ended experiments that college courses should do the same. This era of reformation in science laboratory instruction that was sparked by the launch of Sputnik lasted until the late 1970s when the United States provided a response to the Russian space endeavors by placing astronauts on the moon (Freidelich, 1998). Afterwards, money that once overflowed from the NSF steadily declined and abruptly stopped. Despite the numerous curriculum changes that elevated the importance of laboratory instruction, the primary goal of increasing students entering the science field decreased as well (Linn, 1997).

During the following decades of the 1980s and 90s, the goals of science education changed in order to address a myriad of national reports that focused on the nature of science education. These reports included but are not limited to the American Association for the Advancement of Science publications, *Science for All Americans* (1989), and *Benchmarks for Science Literacy: Project 2061* (1993). *Science for All Americans* stressed the importance of a having a student population that was scientifically literate and identified ten areas of scientific literacy. *Benchmarks for Science Literacy* outlined expected grade level competencies to address
the ten areas of scientific literacy presented in the earlier report. A subsequent report by The National Research Council (NRC) the *National Science Education Standards* (NRC, 1996), “presented a vision for a scientifically literate population” (p. 2). It further outlined what students needed to know, understand, and be able to do in order to be scientifically literate at different grade levels.

Currently, the ability to offer the laboratory experiences still vacillates periodically in our nation’s schools, colleges, and universities. The reasons for this vary from budget constraints and lack of resources to curriculum changes and teacher preparedness. According to data obtained by the National Association of Scholars (1996) between 1964 and 1993, the percentages of universities and colleges that offered natural science courses with some laboratory work declined from 80% - 30%; additionally, the average credit weight of these same courses dropped by half. Contrary to these earlier findings, more recent data reported by Sunberg, Armstrong, and Wischusen (2005) have indicated increases in laboratory instruction in IBCs at colleges and universities and trends to move away from “cookbook” laboratories and utilize inquiry based and student active investigation.

**Teaching Inquiry-Based Laboratories**

As mentioned previously, science laboratory instruction has fluctuated between traditional cookbook laboratories to inquiry-based labs. Traditional labs experiments typically do not require students to think critically about the experiments they are conducting. Students may follow procedures from a laboratory manual that lead to a known result with the purpose of learning more about a scientific concept. Similarly, a teacher may present a question(s) that focus on a specific scientific principle and students follow instructions that lead to a known result. These two examples of traditional laboratory exercises represent low levels of inquiry
known as confirmation and structured, respectively (Rezba, Auldridge, & Rhea, 1999).

However, there are higher levels of inquiry-based instruction that can occur in laboratory and Rezba et al. (1999) have referred to these as guided and open inquiry. Guided inquiry is similar to structured inquiry in that it requires that instructors present investigative questions; however, students have to determine the methods and procedures by which to conduct the experiment. The highest level of inquiry, open, calls for students to design the entire experiment, from the formulation of the initial questions to the methodology.

Open inquiry exercises are the type of laboratory activities that are recommended by national science organizations and researchers. For example, the National Research Council (NRC, 2000) outlines five components that are necessary for inquiry education. These components include: 1) students must be engaged in scientific orientated questions; 2) the evidence must have priority when responding to questions; 3) the student must be able to formulate explanations from the results; 4) the student must be able to make connections from the explanation to scientific knowledge; and 5) students must be able to convey and justify the results. Although open inquiry is the ideal method of teaching laboratory sciences it is not necessary to eliminate the lower levels of inquiry from the laboratory experience. This is especially important when introducing students to inquiry–based instruction for the first time. Bell, Smetanta, and Binns, (2005) have contended that only if students have had experiences at the lower levels of inquiry that they should be expected to perform open inquiry investigations. Furthermore, introducing students to inquire is a gradual process that may require a combination of different types of inquiry. For example, Howard and Miskowski (2005) introduced college students to the laboratory through guided inquiry with the aim of familiarizing them with techniques and protocol utilized throughout the semester. As the semester progressed, students
were asked to design their own experiments to answer questions that they proposed using the techniques, they had previously learned. This type of introduction to inquiry-based laboratory allows students the opportunity to experience situations that are more like a real research laboratory experiences. It is these types of experiences that are recommended over the traditional way laboratories are instructed.

Science Laboratory Objectives

The integration of the teaching laboratory into the science curriculum during the late 19th century was a necessary step to validate the importance of the sciences in an educational curriculum dominated by the classical subjects. Over one hundred years later, the presence of the laboratory continues to be perceived as a viable and necessary component for science instruction by many educators. However, the role of the laboratory continues to spark debate in the literature and it is evident that a consensus about its value does not exist among researchers, scientists, and students (Hofstein & Lunetta, 2004; Sunberg et al., 2005). In order to gain a greater understanding of the prominent issues that have been in the forefront of laboratory instruction as it relates to its role in science education, a review of workable definitions of laboratory work is necessary. Hegarty-Hazel (1990) defined laboratory work as “a form of practical work taking place in a purposely assigned environment where students engage in planed learning experiences . . . interact with materials to observe and understand phenomena” (p. 4).

The National Science Teachers Association (National Research Council, 1996) defined laboratory work as “an experience in the laboratory, classroom, or the field that provides students with opportunities to interact directly with natural phenomena or with data collected by others using tools, materials, data collection techniques, and models” (p. 3). Similarly, Singer, Hilton,
and Schwiengruber (2005) reported that the definition of laboratory experiences includes the integration of instruction, discussion, reading, and lecture.

Collectively, these three definitions all reiterate a central view that the laboratory work should provide students with a greater understanding of scientific concepts through exposure to an array of various techniques and experiences. However, the NSTA definition provides a comprehensive description of what the laboratory is and is the definition that the researcher utilizes throughout this review.

In any course, it is necessary that the objectives be clearly stated in terms of who is being taught, how they are to be taught, and what the desired outputs are (Boud, 1986). This has proven to be a difficult task to accomplish for laboratory instruction. Toothhacker (1983) concluded that the difficulties in identifying specific objectives for the laboratory often arise because 1) most faculty believe that laboratory is necessary and will always produce reasons for this need; and 2) there is no universal accord to what the objectives of introductory laboratory work are. However, many researchers and educators have attempted to identify objectives that directly relate to the overall importance of laboratory work in science education.

Wellington (2003) suggested that by having a plethora of objectives one can easily present arguments in support of the validity and importance of the laboratory in science education. He defined these arguments in the context of affective, cognitive, or skills arguments. The cognitive argument suggests that the laboratory improves a student’s understanding of science and promote conceptual development by allowing the student to visualize the theories and laws. The ability to visualize the theories and laws occurs because of conducting experiments from conception to the end. After a review of more than 120 laboratory objectives, Kirshner and Meester (1988) identified specific student centered objectives, which would allow
this to occur in the laboratory setting. These objectives include formulating hypothesis; designing experiments to test hypothesis; interpreting data; solving problems; clearly describing the experiment. It is by having the opportunity to conduct experimentation that students may also develop cognitive skills that further develop logical skills in thinking and organization (Lazorawitz & Tamir, 1994).

Students can often began a science course underprepared and with some degree of trepidation. However, the affective argument implies that student who participates in the laboratory has more motivation and genuine interest in the sciences (Wellington, 2003). The laboratory addresses this affective argument, as noted by Lazorawitz and Tamir (1994), to challenge students’ misconception about the scientific process and provide an opportunity for building community values concerning the nature of science. Furthermore, the central concept of many laboratory experiments is applicable to everyday life. Therefore, the central idea of an experiment can be applied over an extended period of time (Kirschner & Meester, 1988), which could enable a student to have a greater understanding of many scientific processes.

Finally, the skills argument suggests that students that participate in laboratory develop manipulative and manual dexterity skills (Wellington, 2003). Within a laboratory course students are exposed to several biological instruments and be expected to interpret data. Thus, the knowledge and skills gained from the use of these instruments in the laboratory should be able utilized in unfamiliar situations Kirshner and Meester (1988). Additionally, with the current use of computers in the laboratory setting another objective includes having the ability to manipulate data via computer use (Lazorawitz & Tamir, 1994).

Research studies that support these arguments indicate that students that have laboratory instruction show increased problem solving skills (Godomsky, 1971; Gould, 1978; Woolnough,
1994) and higher levels of science achievement (Comber & Keeves, 1973). In one of the limited studies that specifically investigated community college students, Saunders and Dickinson (1979) compared three groups of community college biology students, lecture-lab, lecture-recitation, and lecture only students and found that students that received lecture and lab performed better on posttest and had better attitudes toward science when compared to students that had alternative forms of instruction. Results from a study conducted by Freedman (2002) found that high school students who obtained a year of laboratory instruction scored higher on test of physical science when compared to a control group of students who took a similar course but had no laboratory instruction. Others conclude that laboratory instruction can strengthen lecture content (Kreitler & Kreitler, 1974) and further develop personal and communication skills (Gibbs, Gregory, & Moore, 1997). While these studies present positive findings among students who do have the laboratory as an integral part of their science education, other studies have opposing results.

Data has suggested that students can be turned away from science due to their laboratory experiences (Holden, 1990; Shepardson & Pizzini, 1993) thus countering the affective argument that laboratory can make students more motivated toward science. The development of practical skills and the familiarity with equipment is one of the strongest arguments for lab. However, data implies that students who receive computer simulated instruction performed just as well than students that performed the experiment in the classroom (Toothmaker, 1983). Additionally, research suggests that the laboratory has little effect on more complex aspects of scientific reasoning (Klopfer, 1990). Dubravcic (1979) discovered that there was no significant difference found between final exam scores of community college chemistry students that had lecture and laboratory versus another group that had lecture and discussion only.
The research literature has addressed the discrepancies that focus on the identification of the role(s) and/or effectiveness of the science laboratory (Blosser, 1983; Hofstein & Lunetta, 1982, 2004). Blosser (1983) contributed that opinion based research instead of research based on data was responsible for the differences in the literature that sought to identify the role of the laboratory. In Hofstein and Lunetta’s (1982) review of the literature, they concluded that many past studies examined narrow band of laboratory skills, made conclusions based upon narrow teaching techniques, teacher student characteristics, and learning outcomes. The authors also suggested that earlier studies were also weak in selection and control variable, group size, and choice of instrumentation used to measure the outcomes of the studies. Collectively, the studies Hofstein and Lunetta (1982) reviewed, failed to show a simplistic and meaningful relationship between students learning the student experiences in the laboratory. In their 2004 update, Hofstein and Lunetta concluded that many of their previous assertions were still pertinent and relevant although some strides had been made in 20 years.

**Inequalities in Laboratory Experiences**

Although the debate continues concerning the importance of the science laboratory, studies also reveal that students’ experiences in the laboratory differ based upon gender. Historically, women represent a minority in science related fields of study and careers. High levels of anxiety towards science and math (Hill, Pettus, & Hedin, 1990) and growing sense of loss of abilities in science (Orenstein, 1994) are contributing factors to disparity between women and men in the sciences. Kahle and Meece (1994) summarized additional variables believed to contribute to this discrepancy: 1) cognitive ability, 2) attitude, 3) sociocultural, 4) home and family, and 5) education. For example, sociocultural stereotypes perpetuate that men are naturally more talented in math and science influence the STEM aspirations of males and females.
(Furnham, Reeves, & Budhani, 2002; Kiefer & Sekaquaptewa, 2007). The disparity between males and females choosing to study and subsequently enter STEM fields affects the future pipeline of scientist and engineers. This leads to what is often referred to as a “leaky” pipeline that is less diverse and hinders women from pursuing well-paying jobs within STEM fields (Blikenstaff, 2006). Therefore, it is important to examine the experiences of students in the laboratory environment in order to document what environments promote positive or negative learning experiences for not only women, but men as well.

Comparisons between different types of laboratory settings, inquiry-based versus traditional, have been shown to contribute to differences reported between males and females behaviors. For example, Burkam, Lee, and Smerdon (1997) used a two-wave sample population ($n = 12,120$) of $10^{th}$ grader from the National Education Longitudinal Study of 1998 to determine if hands-on laboratory experiences in secondary physical science courses have a more positive effect on girls learning when compared with boys. The results from the study specify that reasonable levels of laboratory work in the physical science course were associated with a 20% reduction in gender differences. The authors concluded whereas hand-on laboratory experiences are beneficial to all students, these types of activities are of greater importance to girls. Conversely, Javanovic and King (1998) found that girls’ perceptions in grades 5-8 of their science ability decreased after conducting hands-on laboratory experiences for an academic year; however, the girls’ academic performance was comparable to their male classmates. The authors proposed that these results suggest that while the hands-on activities may enhance girls overall experience and interest in science, the activities may not be enough to change girls’ beliefs that science is for males.
In a mixed methods study, Russell and French (2002) compared gender differences in college level introductory biology courses that either a traditional or inquiry based laboratory component. In the traditional laboratory setting students followed instructions from a laboratory manual to reinforce content covered in lecture. Students enrolled in the inquiry based laboratory sections collaborated on a weekly question, performed pre lab exercises, prepared hypothesis, experimental designs, and experimental outcomes. During the laboratory session, students conducted their planned experiments and wrote up reports detailing their data. Quantitative results indicate that women enrolled in both courses participated less when compared to males. However, in the traditional laboratory course women were less likely to manipulate equipment compared to their male counterparts. Similar results were not present in the inquiry-based laboratory and gender participation differences, although present, were less. Qualitative results from interviews conducted by the researcher disclosed that whereas most women did not have an issue with working with male students, those that preferred to work with all females did so because they felt less intimidated and more comfortable with female classmates.

Although once reserved for the academic endeavors of professional scientists and their students at colleges and universities, the laboratory gained prominence in the classrooms of local high schools around the country. Throughout the many years, since its inclusion in the science curriculum the role the laboratory plays in science education still has some educators and researchers questioning its importance. Tobin (1990) suggested that students can learn science if given the opportunity to interact with engage with the materials and equipment in the science laboratory. However, others argue that students’ participating in laboratory work is insufficient to result in the learning of science (Bennett, 2001). In order provide a better understanding of
students perceptions of the laboratory experience it is necessary to view the laboratory through their experiences.

**The Classroom Environment**

The measure of a student’s success in the classroom is often determined by how he or she performs on assessments that evaluate their knowledge of the content covered in the course. Although academic achievement within a specific subject area is of significant value to educators, administrators, policy makers and students, it does not represent the totality of the educational process (Fraser, 1998). One determinant that can directly influence student learning and behavior is the classroom environment. The classroom environment is more than just a physical space; it is entire setting of learning where relationships take place between students and teachers as well as expectations and norms for learning and behavior (Northwest Regional Educational Laboratory, 2002). Additionally, students spend the majority of their time in the classroom (Fraser & Wong, 1996) and thus, “have a large stake in what happens to them at school and their reaction to and perceptions of their school experiences are significant” (Fraser, 1996, p. 527).

The classroom environment has been an area of research interest since the early twentieth century. In the educational arena, the term environment refers to the atmosphere, ambience, and tone of climate that pervades the particular setting (Dorman, 2002). The origin of classroom environment research began in the United States and it is greatly influenced by social psychology and classroom behavior. The earliest studies, conducted in the late 1920s by Dorothy Thomas, focused on interactions between nursery school students and their teachers (Chavez, 1984). The research that followed Thomas’ studies examined patterns of aggressive behavior by observing effects of leadership roles and group climates by conducting observations of 10 -11 year old boys.
(Lewin, Lipitt, & White, 1939). Other investigations determined the influence of teachers’ classroom personality on student behavior and the effects of students’ classroom behavior on each other (Chavez, 1984).

Studies that have investigated the science classroom environment specifically have utilized the Individualized Classroom Environment Questionnaire (ICEQ), or a variation of it called the Science Classroom Environment Questionnaire (SCEQ). Fraser and Fisher (1982) researched students’ perceptions of the classroom psychological environment and relationships between students’ affective and cognitive outcomes. The ICEQ as well as a Classroom Environment Scale were used to assess a sample of 1,083 eighth and ninth grade science classes. The results from the study revealed that scales on both instruments demonstrated satisfactory internal consistency and discriminant validity. The effectiveness of laptop use and student perceptions eighth and ninth grade the science classroom was explored by Fisher and Stolarchuk (1998). The results confirmed that laptop use by students had a positive effect on students and allowed for emphasis on the inquiry skills and processes.

**Classroom Environment Theory**

A shift toward more theoretically and empirically based research led to new approaches of studying the classroom environment (Chavez, 1984). Two noteworthy theories expanded the manner in which classroom environment studies were conducted. The first theory was Lewin’s (1936) field theory which is based upon the determinants of human behavior and expressed in the formula, \( B = f(P, E) \). \( B \) represents the behavior as defined as a function of the person \( (P) \) and the environment \( (E) \). The second theory, Murray’s (1938) need-press model, expanded on Lewin’s theory and represented the person and the environment in terms of psychogenic needs and press. The psychogenic needs are the determinants of the behavior within the individual.
person (Genn, 1984) that will cause an individual to move toward certain goals (Fraser, 1998). The press refers to those environmental factors that can put pressure on an individual and cause the expression of the psychogenic need. Murray further explained that a difference exist between the environmental factors that which are actually present and observed by an external observer, alpha press, and that which is perceived by the individual, beta press. Advancements in learning environment research were accomplished when studies conducted by Stern, Stein, and Bloom (1956) and Pace and Stern (1958) further expanded Murray’s theory.

The studies referenced above served as the gateway for learning environment research conducted over the past forty years. However, differences are apparent between studies conducted during the first half of the twentieth century and those that took place after the 1950s. For instance, studies prior to the mid-twentieth century tended to utilize low-inference measures. Rosenshine and Furst (1971) defined low-inference measures as rating systems that classify specific, denotable, relatively objective behavior recorded by an observer. In contrast, after the mid 1950s, high-inference measures, which require an observer to make inference from classroom events using specific constructs systems, began to appear in the literature and over time began to be employed more frequently to assess learning environments (Rosenshine & Furst, 1971). Increased momentum for the high-inference measure research began in the 1960s as a result of the work of Herbert Walberg and Rudolph Moos. Although Walberg and Moos worked independently of one another, their establishment of assessment instruments that focused on the psychosocial environments significantly contributed to the study of classroom environment. Walberg was involved in the Harvard Project Physics (HPP), which was an innovative physics course that was implemented for high school students in the United States. The new course implemented a number of new instructional media that emphasized the
humanistic, historical, and philosophical view of physics (Chavez, 1984). The effectiveness of the HPP was measured using the Learning Environment Inventory (LEI) that was designed and developed by Walberg (Walberg & Anderson, 1968). Unlike earlier studies where the external observer assessed the classroom environment (alpha press), the students were allowed to evaluate their personal perceptions and observations (beta press) of their experiences in the classroom environment.

Similarly, Moos (1974) conducted a number of studies that used his Social Climate Scales to evaluate psychiatric, prison environments, hospitals, school residency halls, workplace, and more pertinent to this study, the classroom. This research led to development of the Classroom Environment Scale (CES) (Moos & Trickett, 1974), which has served as the impetus for the development of numerous evaluation instruments that focus on social environments. Furthermore, Moos identified three general dimensions of the human environment that have served as keystones for learning environment research. These dimensions include 1) relationship (the nature and intensity of personal relationships); 2) personal development (basic directions along which personal growth and self-enhancement tend to occur); and 3) system maintenance and system change (the extent to which the environment is orderly, clear in expectation, maintains control, and is responsive to change (Moos & Trickett, 1974).

Learning Environment Instruments

The work of Walberg and Moos served as catalysts that expanded learning environment research in a number of different areas. As a result, several classroom environment instruments have been developed and employed internationally at various grade levels. Dorman (2002) identified ten classroom environment research domains that have emerged throughout the past thirty years:
1. associations between classroom environment and outcomes;
2. evaluation of educational innovations;
3. differences between students’ and teachers’ perceptions of classrooms;
4. comparisons of actual and preferred environments;
5. effect on classroom environment of antecedent variables (for example, gender, subject, year level);
6. transitions from primary to secondary school, school psychology;
7. teacher education, educational productivity research; and
8. using environment instruments to facilitate changes in the classroom.

The instruments that were used in the assessment of these domains include, but are not limited to the following: Learning Environment Scale (Fraser, Anderson, & Walberg, 1982); College and University Classroom Environment Inventory (Fraser & Treagust, 1986); Individualized Classroom Environment Questionnaire (Fraser, 1990); Questionnaire of Teacher Interaction (QTI) (Wubbels & Levy, 1993); Science Laboratory Environment Instrument (SLEI) (Fraser, Giddings, & McRobbie, 1995); and, Constructivist Learning Environment Survey (Taylor, Fraser, & Fisher, 1997). The instruments listed all share similar characteristics that include 1) internally consistent scales each of which is assessed a set of 6 to 10 items; 2) a five-point Likert scale for each scale; and 3) a direct association with Moo’s three human domains.

Although the instruments referenced above are widely used, it is notable to point out that alternative instrument designs, actual and preferred forms, were developed in order to address concerns about individual and classroom perception, the length of the surveys, and the inability to identify various subgroups (gender, age, and race) within a population of students. The actual form provides respondents with the opportunity to assess the environment as they experience it.
day to day. Conversely, the *preferred forms* are concerned with the values and goals that represent the ideal learning environment. The content of the two forms is very similar except variations are present in the wording. In order to meet the recommendations of researchers that reported a need for instruments that were shorter in length and easier to score variations of the long form, a short form, was developed (Fraser, 1998). Modifications to the long form included a reduction in the total number of items, easy hand scoring, and the averaging of the perception of students within a class was used to obtain class means (Fraser, 1982; Fraser & Fisher, 1988). Thirdly, Tobin (1987) noted that results from analysis of studies that utilize classroom learning environment instruments, observations, and interviews indicated that distinct groups of students have more favorable perceptions of their classroom when compared to other classmates. This issue exists because the survey items on the conventional class forms are presented in a manner that obtains a student’s perception of the whole class and not that of his or her individual role of the classroom. Tobin and Fraser (1991) addressed the shortcoming of the survey instruments by developing an alternative personal form that changes the wording of an item to reflect personal perceptions to identify differences between subgroups within a classroom population. These three modifications to learning environment instruments enable studies to present opposing perceptions of the classroom in an economical manner.

The classroom environment instrument that is essential to the present study is the *SLEI*. This instrument has been utilized extensively in classroom environmental research at various grade levels and different countries. The remainder of this section of the review will focus on studies that speak to the origins, validation, and use of this survey instrument.
Science Laboratory Environment Instrument

The SLEI is an example of a classroom instrument that has all three modifications discussed in the previous section. It also represents the first survey instrument that specifically assesses the laboratory component of the science classroom. The questionnaire is comprised of thirty-five items that are divided among five different subscales: 1) student cohesiveness; 2) open-endedness; 3) integration; 4) rule clarity; and 5) material environment. Student cohesiveness assesses the extent to which students know, help, and are supportive of one another. Open-endedness evaluates the extent to which the laboratory activities emphasize an open-ended, divergent approach to experimentation. Integration measures the extent to which the laboratory activities are integrated with non-laboratory and theory classes. Rule clarity assesses the extent to which behavior in the laboratory is guided by formal rules. Material environment evaluates the extent to which the equipment and materials are adequate (Fraser, Giddings, & McRobbie, 1995). The SLEI, exist in two alternative forms, class and personal, and the wording of the items is what differentiates one from the other. For example, a student responding to a class form item would encounter a statement such as, “The laboratory equipment students use is in poor working order.” Whereas the personal form statement would appear as follows: “The laboratory equipment I use is in poor working order.” Additionally, there are actual and preferred versions of the questionnaire. Although the actual form measures perceptions of the actual laboratory environment, the preferred form focuses on the goals and value orientations as it measure the perceptions of the environment ideally liked by students. The wording of both forms is similar however, the instructions are clearly distinct and students are directed to answer the items based upon what the laboratory environment is actually like or how they would prefer it to be (Fraser, Giddings, & McRobbie, 1995).
Students enrolled internationally in six countries (Australia, United States, Canada, England, Israel, and Nigeria) at various high school and universities served as a sample population for cross-national field-testing and validation of the SLEI (Fraser, McRobbie, & Giddings, 1993). Results from the study indicate that each scale of the SLEI demonstrates factorial validity, discriminate validity, internal consistency reliability, and differences in the perceptions of students enrolled in different classes was determined. Furthermore, the results demonstrate that close-ended laboratory activities dominate classes and scores on the class form were more favorable than scores on the personal form.

The Attitude Construct

A successful science education is composed of principle components that include the teachers, students, the subject matter, and society. In the classroom, it is the teacher’s responsibility to integrate the latter three components in order to make the content relevant and purposeful, scholarly, and enjoyable if possible. More specifically, it is desired that students grow in the cognitive, psychomotor, and affective educational domains (Simpson, Koballa, Oliver, & Crawley, 1994). The cognitive domain includes the acquiring of facts and information from the text, teacher, or other resources. The psychomotor domain involves the development of dexterity and feelings. The affective domain includes the opinions, beliefs, values, and attitudes. Whereas both the cognitive and psychomotor domains are equally as important as the affective, the following discussion will focus on one particular affective domain that is pertinent to this study, attitude.

Historical Review

The historical origins of the attitude concept can be traced to early animal research conducted by Charles Darwin during the late 1800s to describe the posture of animals trying to
defend themselves Fleming (1967). DeFleur and Westie (1963) suggested that the inclusion of the term attitude as a descriptor of the scientific study of a man’s social and psychological character occurred in four distinct stages. The first two psychological stages focused on the behavioral aspects of the mental processes of man and the measure of bodily reflexes. During the third stage, a merger of the sociological and psychological sciences occurred, and the attitude concept moved away from its earlier association with motor and mental processes to more cognitive and evaluative research. For example, Thomas and Znaniecki’s (1918) study on the Polish immigrant lifestyles represented the first study to use an attitudinal scale to assess individuals’ feelings toward a socially significant object. Subsequent to the preceding study, the fourth stage quickly developed during the 1920s and the major focus was the creation of quantitative instruments to measure attitude. Thurstone’s (1928) research on attitudinal scales represented one of the most significant contributions to this stage and guided a new era of research on the attitude concept.

Thurstone’s (1928) publication of *Attitudes Can Be Measured* introduced a novel scoring methodology to measure attitudes. The scale consists of an 11-point continuum that contains a neutral point and five steps to either side. The scale assessed peoples’ attitudes toward, pacifism-militarism, prohibition, church, and other social issues that were prevalent during the 1920s. This work differed from other attitudinal scales because it safeguarded emotional intensity, which is the quality central to the attitude concept (Shirgley & Koballa, 1984) and was psychometrically sound. Thurstone’s survey instrument served as the benchmark for future attitude research. For example, shortly after the development of Thurstone’s scale, Likert (1932) modified it to include five-point scale that ranged from strongly agrees to strongly disagree. Many survey instruments utilized today follow this Likert-style format. Semantic differential
scales are another style of attitudinal scale that emerged. This category of scale allows students to rate a particular object based upon adjectives that are opposite of one another (example, interesting/dull).

**Attitude and Science Education**

The integration of science education and attitude research began in the 1960s and 1970s as educational researchers attempted to ascertain student’s attitudes toward science and feelings toward learning science (Reid, 2006). Educators and researchers of science education sought to identify and garner a greater understanding of the factors associated with a noticeable decline in the number of students pursuing science courses and as a consequence, science-related careers. Simpson et al. (1994) noted that research interests tended to focus on three main areas: 1) the magnitude of science related affect in school students; 2) measurable changes in attitude as a result of research treatments or innovative practices; and 3) relationships between school-related behaviors and attitudes. During the 1960s - 1980s, there was a proliferation of studies that addressed these issues. However extensive reviews of the literature by Gardner (1975), Haladyna and Shaughnessy (1982), Schibeci (1984), and, Osborne, Simon, and Collins (2003) reveal that collectively this research area is inconsistent and confusing. The authors all identified the following issues: 1) a lack of understanding of the meaning of attitude as a concept in sciences; 2) a lack of valid instruments; and 3) failures to identify the factors that contribute specific attitudinal outcomes.

One of the most critical issues found in the attitudinal research literature is the lack of a consensus among researchers to reach a definitive definition the term attitude. This problem has been apparent since the 1920s when Bain (1928) concluded that attitude is an ill-defined concept that has as many definitions as there are writers on the topic. More recently, a common
definition has evolved that incorporates three main components consisting of affection (like-dislike), cognition (belief-unbelief), and conation (behavior) (Rajecki, 1990; Shrigley & Koballa, 1988). Reid’s (2006) definition provides a summation of all three parts and suggests that attitude is a positive or negative sentiment, or mental state, that is learned and organized through experiences and that exercises a discrete influence on the affective and cognitive responses of an individual toward some other individual object. However, other schools of thoughts suggest that attitudinal studies should only be focused on the affective domain and the cognition and conation components should be studied independently (Ajzen, 2001; Crano, & Prislin, 2006).

The diversity and overlap in the definitions of attitude leads to a great deal of vagueness among researchers when attempting to have a concise understanding of attitude as it relates to science education. Conversely, in an earlier review, Gardner (1975) suggested that there is a clear distinction between attitude that relates to science and that, which is associated with a student’s attitude toward science. According to Gardner, scientific attitudes include the characteristics of scientists that science students deem most desirable. In contrast, attitudes toward science encompass an interest in science, attitudes about scientists, and attitudes toward the use of science (Gardner, 1975). Haladyna and Shaughnessy (1982) further proposed that a scientific attitude is a student’s approach to thinking about science. In other words, a student’s attitude toward science can be directly influenced by individual beliefs and values about science.

Research studies that focus on student attitudes often investigate how students’ attitudes relate to the learning of the subject matter. Several studies have focused on how student attitudes influence their ability to learn (Boyes, 2003; Custer & Ten, 2002; Dawson, 2000; Reid & Skryabina, 2002; Spall, Barrett, Stanisstreet, & Dickson, 2003). The outcome of these studies, have led to changes in curricula. For example, Custer and Ten (2002) found that medical
students attitudes were better towards basic science courses when enrolled in a more innovative curricula compared students enrolled in a more traditional curriculum. Similarly, Reid and Skyrabina (2002) found that students exhibited better attitudes towards learning physics in Scotland when specific factors were present. These factors included having supportive instructors as well as a physics curriculum that the students deemed positive.

**Attitude Instrument Design and Validity**

Several different methods have emerged over the years to measure attitudes. The five major methods include 1) preference ranking; 2) subject enrollment; 3) interest inventories; 4) qualitative methods; and 5) attitudinal scales (Osborne et al., 2003). As mentioned previously, Thurston’s (1928) attitudinal scale served as the impetus for future researchers’ and this scale serves the model that utilized most commonly in attitudinal research. However, there has been an abundance of criticisms that include the following: 1) overall poor design of instruments and individual items within the instrument; 2) problems with validity and reliability; 3) inappropriate analysis and interpretation of data; and 4) lack of standardization among various instruments (Ramsden, 1998). In his review of issues associated with the revised version of the Scientific Attitude Instrument (SAI), Munby (1997) concluded that new quantitative analysis failed to establish validity for two major reasons. First, the one field test of the revised instrument did not adequately identify what was being measured. Secondly, it was not known if each of the scales of the instrument were conceptually-separate contributors of a students’ attitude toward science. Munby (1997) suggested that performing factor analysis or cluster analysis to determine the fit of the conceptually derived scales with derived factors would increase the validity of an instrument.

The psychometric problems and weaknesses associated with attitudinal scales prompted Blalock, Lichtenstein, Owen, Pruski, Marshall, and Toepperwein (2008) to ask the following
question: “Many attitude instruments have been used through the years, but if these instruments have not been well validated, what exactly can be said of the claimed relationships” (p. 962). In their recent investigation, Blalock et al. (2008) provided a comprehensive review of attitude instruments produced between the years 1935 - 2005. The authors collected a wide-ranging list of attitude instruments from peer-reviewed articles obtained from several databases. The identified instruments (n = 66) were segregated into one or more categories based upon four distinct definitions and concepts associated with students science attitudes. These categories include: 1) attitudes toward science; 2) scientific attitudes; 3) understanding of the nature of science; 4) scientific career interest; 5) multiple categories; and 6) other (instruments that did not fit a specific category). A rubric consisting of five sections (theoretical background, reliability, validity, dimensionality, and development/usage) was created to score and rank instruments on a scale from zero to twenty-eight.

Results from the evaluation and scoring revealed a range of rubric scores from zero to twenty-two. The highest scoring instruments in the categories of attitudes toward science, scientific attitudes, nature of science, multiple categories, and other were as follows: Attitude Toward Science in School Assessment (Germann, 1988) with a score of 22, Nolls’ (1935) instrument; the Views of the Nature of Science Questionnaire (Lederman, Abd-El Kahllick, Bell, & Schwartz, 2002), and a questionnaire by Rubba, Horner, and Smith (1981) both received a score of 7; a survey instrument by Rennie (Rennie, 1986; Rennie & Punch, 1991) received a score of 21; and the Inventory of Societal Issues (Steiner, 1973; Steiner & Barnhart, 1972) scored 18. Only one survey instrument was identified that analyzed scientific career interest and it received a score of zero. Although the authors recognized that there were some limitations to their study created by the instruments (missing data, poor quality, lack of validity and reliability)
they asserted that their findings serve as momentum to replicate studies and improve on the instruments that exist instead of creating new ones.

**Test of Science Related Attitudes**

The TOSRA (Fraser 1978) was one of the survey instruments reviewed by Blalock et al. (2008). Although it did not receive the highest score in its area, multiple categories, it received the second highest score of 19. The survey has been used extensively to gather information related to students attitudes toward science, scientific careers, and scientific career interest and has strong and sound theoretical basis and impressive empirical validation (Haldyna & Shaughnessey, 1982). The scales of the TOSRA were developed to directly assess the six categories of attitudinal aims identified by Klopfer (1971). The scales include 1) social implications of science; 2) normality of scientist; 3) attitude to scientific Inquiry; 4) adoption of scientific attitudes; 5) enjoyment of science lessons; 6) leisure interest in science; and 7) career interest in science. The original TOSRA instrument consisted of five scales that were derived from other attitudinal scales which included the *Science Opinion Poll* (scales 5-6) (Laughton & Wilkinson, 1968), *A Test of Interest* (scale 3) (Meyer, 1969), a survey instrument that asse social implications (scale 1) (Ormerod, 1971), and *Test of Perception of Scientist and Self* (scale 4) (White & Macke, 1976). The revised version of the TOSRA was extended and improved by adding two new scales (2 and 7); shortening the instructions; and limiting the number of items per scale to ten.

The final version of the survey instrument was validated using a sample population that consisted of students \( n = 1337 \) enrolled in grades 7-10 in Australia (Fraser, 1981). Subsequent cross-culturally studies validated the TOSRA within populations of American high schools (Joyce & Farenga, 1999; Khalili, 1987) and college students (Jaleel, 1991). A population of 11th
and 12th graders (n=336) enrolled in psychology and sociology classes at three different Chicago high schools served as the sample for Khalilis’ (1987) study. The data from the study found that TOSRA had a high degree of internal consistency. However, the results also led the author to suggest that three of the subscales, enjoyment in science (r = .80), leisure interest in science (r = .84), and career interest in science (r = .82) should be integrated to form one scale due to their high interscale correlations. In order to establish associations between attitudes toward science, future interest in science, and informal science experiences, and gender for 9- to 13-year-old high ability students (n = 111), Joyce and Farenga (1999) administered the TOSRA. The researchers found that the total scores for the TOSRA exhibited a reliability coefficient of .96. Additional data illustrated that the TOSRA subscales of enjoyment of science lessons (r = .28, p < .05) and career interest in science (r = .30, p < .05) were significantly related to the number of physical science courses that high ability boys selected. Conversely, high ability girls demonstrated high correlations between three TOSRA subscales: adoption of scientific attitudes (r = .37, p < .01); career interest in science (r = .45, p < .001); and leisure interest in science (r = .46, p < .001).

Although the TOSRA was developed for intermediate and high school students, it has been used in one dissertation study that focused on college students’ attitudes toward science. A modified version of the instrument that consisted of only of three of the scales, social implications of science, attitude to scientific inquiry, and career interest in science, was used to assess college students’ attitude toward science and achievement in chemistry (Jaleel, 1991). The outcomes from this study revealed weak associations between the subscales of social implications of science, career interest in science, and social implication of science. The correlations ranged from .06 to .22.
The TOSRA has been shown to be a valid and reliable instrument to assess student attitudes in various countries and grade levels. Although it has been used less frequently in higher education, its validity and theoretical soundness make it an ideal assessment instrument in the community college setting. The results obtained from its use can be used to provide valuable information about attitudes toward science from a mixed population of students who have transitioned immediately from high school or chosen to pursue college after a number of years of being in the workforce or raising a family.

**Laboratory Environment and Student Attitudes**

Several decades of classroom environment studies have sought to investigate and predict associations between student perceptions of their classroom environment and specific affective and cognitive outcomes (Fraser & Fisher, 1982). A significant association between students’ attitudinal outcomes and the laboratory environment was established when the SLEI was validated by Fraser et al (1993). Since the initial validation studies, numerous investigations in various countries, grade levels, and science laboratory settings have revealed that students’ perceptions of the laboratory environment can serve as a predictor of their attitudes toward science.

A review of these studies indicates that specific subscales of the SLEI can significantly correlate with students having positive attitudes toward science. For example, in an examination of Singapore students’ perceptions of the chemistry laboratory and attitudes toward chemistry, Wong and Fraser (1994) determined that the laboratory component of the chemistry course was closely associated with the content taught in lecture. Results from simple correlation analysis revealed that the *integration* and *rule clarity* were the greatest predictors of students having a positive attitude toward science. Likewise, Fisher, Henderson, and Fraser (1997) found
Significant correlations between the integration subscale and attitudinal and cognitive achievement outcomes of senior biology high school students in Tasmania, Australia. In subsequent studies of Korean high school students (Lee & Fraser, 2001) and Turkish seventh grade students (Okzan, Cakiroglu, & Tekkaya, 2008) similar results were found and student cohesiveness, rule clarity, and integration were all positively correlating with students’ attitudes. Collectively, these studies also reveal that the Integration subscale is one subscale that is often significantly correlated with positive attitudes toward science. These results suggest that students prefer to have the content of the science course closely related to the laboratory procedures. Additionally, students exhibited better examination scores and attitudes when there was favorable experiences and opinions of student cohesiveness, rule clarity, and the material environment toward their in the laboratory. Conversely, research has indicated the open-endedness subscale can be negatively associated with students’ attitudes toward science (Giddings & Waldrip, 1996; Wong & Fraser, 1994).

Gender and Attitudinal Outcomes

Researchers and educators continue to pursue investigations of variables that have the greatest impact on students’ attitudes toward sciences. As discussed previously, the laboratory environment can affect students’ attitudes. Variables that may influence a student’s attitude include environmental (socioeconomic), science curriculum, and instruction. However, the gender of a student has consistently been implicated to have considerable influence on students’ attitude. In a meta-analysis of eighteen studies that investigated attitudes toward science between the years 1970 and 1991, Weinburgh (1995) indicated that boys show more positive attitudes toward science than girls do. Moreover, correlations between attitude and achievement as they relate to gender indicate that boys’ attitudes toward the physical sciences are more
positive when compared to biological sciences. A comparison of high-achieving students indicated that girls tend to favor biology courses and boys had a greater affinity for chemistry and physics courses (Benbow & Moore, 1986). This course-specific differentiation can be contributed to the masculine perception that girls and boys have toward physical sciences (Ormerod & Duckworth, 1975).

The gap that exists between girls and boys attitudes toward science begins during the elementary school years. According to Nelson, Weiss, and Capper (1990), attitudinal differences between the genders were relatively small in the third grade but as students entered the seventh and eleventh grades boys exhibited a more favorable attitude and enjoyment of science. A survey of students from 10 different countries indicated that the greatest increase in gender differences widens between the ages of 10 to 14 years (Kotte, 1992). Data also suggested that although both genders benefit from hands-on activities, these types of laboratory experiences are more beneficial to females and thus can potentially promote and increase gender equity in the sciences (Burkam, Lee, & Smerdon, 1997).

In their study of sixth-grade students, Jones, Howe, and Rua (2000) examined gender differences in students’ attitudes toward science and their experiences related to science. The results indicated that female students reported that science was more difficult and they had a tendency to be more interested in science aesthetics and biology. On the other hand, males tended to be more interested in the physical sciences. They also enjoyed experiences that were more fundamental to areas of engineering and applied physics (atomic bombs, atoms, and technology). In an analysis of gender differences in the attitudes of fourth and fifth graders toward environmental science, Carrier (2007) illustrated that females had more positive attitudes toward the environmental sciences than their male counterparts. These notable differences
between the genders continue to persist as students leave secondary education and pursue higher education (Weinburch, 1995).

**The American Community College**

The necessity for a college education has become more evident as the United States economy attempts to recover from the greatest economic downturn since the Great Depression. According to Zeidenber (2008), a high school education is not sufficient to support a family in today’s society and a correlation exists between income and education with those individuals with four-year degrees maintaining the highest levels of income. Although the pursuit of an undergraduate education may be the desire of many seeking upward mobility, obstacles such as rising tuition cost and accessibility prevent individuals from obtaining a four-year degree at a university. An alternative for many is the American community college. In order to understand the relevancy of the community college in today’s society and this research, a historical review of its emergence, evolving missions, and contribution to science education is necessary.

**A Historical Review of the American Community College**

There are a plurality of forces that were instrumental to the establishment and expansion of the community college in America. Cohen and Brawer (2009) suggested that these factors include workforce training, social equality, and community prestige. According to Levinson (2005), a complexity of social changes brought the community college into the American educational system. Various frameworks attempt to explain how a range of internal and external social influences was critical to the development of these colleges. For example, an earlier model proposed by James Ratcliff (1994) integrated the development of the community college with seven historical educational schemes: 1) local community boosterism; 2) the rise of the research institution; 3) the restructuring and expansion of the public educational system; 4) the
vocational education movement; 5) the rise in adult, continuing, and community education; and 6) open access to education. Although all of the proposed factors and schemes have merit, it is a combination of all factors that were influential in the development of the community college.

The creation of the community college is deeply rooted in the passing of the Morrill Act of 1862 (Phillippe & Patton, 2000) and the populist context of the Progressive Era (Levinson, 2005; Radcliff, 1987) in the United States. The Morrill Act of 1862 is a statute that allowed states to purchase federal lands to establish universities and colleges for educating students in mechanical arts and agriculture (Witt, Wattendbarger, Gollatscheck, & Suppiger, 1994). A causative effect of the passage of the Morrill Act of 1862, and subsequently the Morrill Act of 1890, was an increase in students pursuing higher education (American Association of Community Colleges, 2006). This was the first time the idea of educational access to all American citizens, regardless of societal standings and race (although separate), was championed via federal decree.

The demand for secondary education increased significantly during the early 1900s and the construction of junior high schools relieved the overcrowding in kindergarten and high school classrooms. The restructuring of the secondary schools increased access and student populations; consequently, the number of individuals wanting to obtain a college education followed suit (Cohen & Brawer, 2009). As student numbers increased at the collegiate level, an elitist movement emerged among the executive administrators at the country’s universities whom wished to restrict university access to only those in the upper class. During the late nineteenth century, a number of university presidents wanted to limit their curricula to include only advanced studies and focus more on research (Drury, 2003). They recommended removing the first two years of undergraduate studies and relinquishing them to new institutions called junior
colleges (Cohen & Brawer, 2009). Such a move would allow the university to preserve the clientele at the university and the scarcity and selectivity of their degrees (Dougherty, 2001). Furthermore, these elitist educators championed the German “gymnasium” model, which incorporated the first two years of college with high schools in order to create university-affiliated high schools and independent two-year colleges (Kane & Rouse, 1999).

William Rainey Harper of the University of Chicago was among the educational elite and was credited with the establishment of first community college in America. In 1892, Harper initially established two divisions at the University of Chicago. The two divisions included a senior and junior college; and individuals that completed the junior division were the first to receive associate degrees (Drury, 2003). Additionally, he recommended that a number of Midwest liberal arts and denominational colleges that were experiencing difficulties merge with high schools, increasing the four-year high school education to six years (Salzman, 1992). It was not until nearly a decade later in 1901 that Rainey, along with J. Stanley Brown, the principal of Joliet High School, established the first community college, Joliet Junior College, in Joliet, Illinois (Cohen & Brawer, 2009).

The early mission of the community college was to provide lower-level liberal art studies in “general and vocational education to students through age nineteen or twenty” (Cohen & Brawer, 2009, p. 7). Conversely, the purpose of the university was to increase a student’s knowledge and scientific inquiry and confer baccalaureate and graduate degrees. It was Rainey’s belief that the highest intellectual activities should occur at the university level and the preparatory first two years of college be relegated to junior colleges (Salzman, 1992). Additionally, Rainey believed that high schools had better educational facilities when compared to smaller colleges in the same area (Salzman, 1992). Therefore, a push for the integration of
high schools and freshmen and sophomore college years also permeated during the early establishment of the community college.

This educational model, known as the 6-4-4 plan, integrated grades one through six in elementary school, seventh through tenth grade in junior high school, and eleventh through the fourteenth year in junior college (Kisker, 2006). This paradigm addressed concerns about the maturity level of students as they transition from adolescence to adulthood. Proponents of the integration of high school and the first two years of college suggested that students that remained in their home communities and completed the first two years of college, would be more mature to continue on to a university located in another area (Cohen & Brawer, 2009). Ultimately, a 6-3-3-2 grade level model, which separated the community college from the high school emerged and placed the college as part of the higher education system (Drury, 2003).

Although the aforementioned elitist movement and the concern for the maturity of adolescents entering college played a role in the early establishment of the community college, a variety of other factors contributed to furthering its expansion. The need for a ready workforce, as well as a push for social equality, contributed to the growth of the community college (Cohen & Brawer, 2009). The emphasis on vocational training strengthened during the era referred to as the Great Society, which advocated equality while enabling young people the opportunity to move into the lower middle class (Salzman, 1992). During the Great Depression of the 1930s, community colleges increased enrollment due to their offering of technical and vocational training to young adults unable to find work (AACC, 2011). This marked the first time students received vocational guidance and colleges began to take steps to form alliances with local businesses to determine the needs for vocational training (Drury, 2003). Providing vocational training continued to be a prominent trend as veterans returned home from World War II; and the
passage of the United States Servicemen Readjustment Act (GI Bill) in 1944 provided financial support to millions of veterans. As a result, between 1944 and 1947, enrollment at community colleges doubled (Kane & Rouse, 1999).

Access to higher education is closely associated with upward mobility and society as a whole benefits from an educated citizenry. Therefore, community colleges serve as a gateway for many individuals who would not otherwise be able to obtain an education beyond high school. Recognizing the necessity for educational opportunities through grade fourteen for a larger populace, President Truman’s Commission on Higher Education (1947) recommended the establishment of more community colleges. These colleges would serve as cultural centers, provide comprehensive curricula, and service their municipalities at a relatively low tuition cost (Drury, 2003). Subsequently, community colleges gained more prominence and were further legitimized as part of the higher education landscape.

A second phase of expansion of the community college began shortly after the end of the Korean War and was followed by a third expansion during the 1960s (Kane & Rouse, 1999). It was during the 1960s that baby boomers began to matriculate through college; Vietnam War vets returned home; and draft dodgers enrolled to avoid enlistment; thus, enrollments soared. The need to provide educational opportunities sparked a building explosion that saw the establishment of community colleges at the rate of one per week (Salzman, 1999). Additionally, three congressional acts during the 1960s bolstered the growth of the community college: the Higher Education Facilities Act of 1963; the Vocational Education Act of 1963; and the Higher Education Act of 1965. These congressional acts earmarked funds specifically for the construction of new community colleges and technical institutes, the operation of programs for students that had left high school, and the strengthening of developing institutions (Dougherty,
2001). The number of colleges doubled and enrollment quadrupled (Witt et al., 1994). A number of states began to pass legislation, commission studies, and write master plans that would create statewide community college systems (Townsend & Twombly, 2000). Moreover, governors and legislators found it beneficial to support the growth of the community college; the colleges offered a means of cost containment and the politicians did not want higher education budgets to expand and potentially damage political careers (Dougherty, 2001).

Throughout the 1960s and into the 1970s, community college became more aligned with the needs of the communities they served. Advocated by Edmond Gleazer, the first president of the American Association of Community and Junior Colleges, community colleges were urged to offer curriculum that addressed the needs for career development and lifelong learning (Bragg, 2001). Thus, the community outreach and noncredit course offerings became dominating features of the curriculum as the colleges continued to expand. By offering both credit and noncredit courses, along with nonacademic educational services, community colleges developed a more comprehensive mission of providing general education courses, academic preparation for transfer, and vocational training.

Enrollment continued to increase in the 1970s and by the end of the decade, enrollment saw a nearly two-fold increase, from 2.2 million to 4.3 million (Kasper, 2003). This rise in the student population was the result of more parents sending their children to college, students fighting draft deferments, and more baby boomers attending college (Kasper, 2003). Changes in technology and in the labor market impelled community colleges to change their focus from baccalaureate training to vocational training and economic development activities. Although always a component of the community college offerings, vocational training became a more dominant feature during the mid-1980s. Brint and Karabel (1989) suggested that this change in
institutional emphasis occurred not because of student demand, but college leadership attempting to secure a niche in the hierarchy of higher education.

As the focus of the community college shifted, its student ethnic demographic continued to shift as well. At their inception, the typical community college student was a college age white male. By the early and mid-1980s, these institutions enrolled between 45% and 55% of all Black, Hispanic, Asian, and American Indian students (Salzman, 1992). Consequently, the community college became an entry point to higher education for underrepresented minorities and those from lower socioeconomic backgrounds. By increasing accessibility to those that may not have pursued an education, enrollment continued to rise. At the end of the decade, the number of colleges had grown to 968, enrolling 4.8 million students, over one third of the college students (Doughtery, 2001).

The 1990s and the new millennium ushered in yet another transformational era for community colleges. Global competitiveness was now the driving force behind public policy directives that moved these institutions towards improving efficiencies, increasing productivity and becoming accountable to government and responsive to business and industry (Levin, 2001). These requests were to be accomplished by modifying institutional practices and increasing the number of students served, graduating more workplace-ready students, and reducing per unit costs (Levin, 2001). This change in mission prompted Ruth Burgos-Sasscer (1997) to redefine the term “community” for community college leaders to include the state, the nation, and the world. As colleges began to respond to this new agenda they began to move away from the social needs of the community and towards national and international agendas of governments and businesses (Levin, 2001).
Furthermore, President Barack Obama’s administration has taken strides to promote the role of the community college in the national and international success of the country’s future workforce. For example, the Health Care and Education and Affordability Act was signed into law by President Barack Obama on March 30, 2010, and provided $2 billion for the Community College and Career Training Grant Program (Boggs, 2010). More recently, as President Obama addressed the Joint Session of Congress and the nation on September 8, 2011 to introduce the American Jobs Act, he spoke of the United States’ effort to strengthen our global competitiveness. As it relates to community colleges, he stated,

Already, we’ve mobilized business leaders to train 10,000 American engineers a year, by providing company internships and training. Other businesses are covering tuition for workers who learn new skills at community colleges. And we’re going to make sure the next generation of manufacturing takes root, not in China or Europe, but right here, in the United States of America. (Retrieved September 10, 2011) from http://www.politico.com/news/stories/0911/63043_Page3.html#ixzz1Xr3VOJ1u)

The U.S. community college network has grown from one college in Joliet, Illinois, to over 1,200 regionally accredited institutions, serving over 6.5 million students a year for credit courses and another 5 million for noncredit (National Commission on Community Colleges, 2008). Throughout their more than one hundred year existence, they have undergone a metamorphosis from providing courses for transfer to providing a widespread curriculum. As these colleges continue to evolve, their missions will undergo changes to meet the current and relevant needs of the populace in which they serve. Although the missions are varied, all share a central responsibility: to provide access to education to the academically weak, the economically disadvantaged (Zeidenbeg, 2008), and those seeking to better their lives by pursuing a higher education.

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Community College and Science Education

Science education has been an important component of liberal arts curriculum at community colleges since their establishment. According to Cohen and Brawer (2009), “Science was seen as contributing to the process; the more people who would learn its principles, the more rapid the development of the society” (p. 1). Considering that over 40% of college students will begin their higher education at a community college, in stands to reason that they may encounter their first college level science course there as well. In fact, because students that enter the community college may never transfer to a four-year institution, if enrolled in a science course it is likely to be their last (Marcus, 1993). Therefore, the experiences that a student has in a community college science course can influence if the student decides to continue down an academic path in the sciences or a related field.

Most community colleges require that their students enroll in a science elective. Generally, the elective is an introductory biology course. According to Cohen and Brawer (2009) in 1998, 7% of community college students chose to enroll in general biology courses compared to the 3.8% collectively enrolled in physics, earth and space science, and chemistry. However, because of the open door policy that exists at the community college, a biology course may have students with varied degrees of academic preparedness. For example, a student in a remedial reading course may be sitting next to a student that reads and comprehends at a college level. Brown and Cranson (1989) suggested that students entering an introductory biology course at a community college need basic entry-level skills. These skills include 1) reading at a tenth grade level; 2) grammar and sentence structure writing abilities; 3) basic mathematics skills; 4) knowledge of how to construct and interpret a graph; 5) knowledge of basic atomic structure; and 6) knowledge of general geographical features as it pertains to earth’s surface.
The authors also reported that science anxiety might play a role in whether or not a student will successfully complete an introductory science course at a community college. Often, students enter a science course with the expectation that it is going to be difficult, thus a mental barrier is in position before the first lecture material is given. Recognizing that some students start the course with academic deficiencies and varied degrees of self-confidence, Cowan and Peipgrass (2003) suggested that community college instructors could change their approach to the first day of the course. The authors (2003) strategized that instructors can do the following:

1. Hand out non intimidating material;
2. Be clear about course expectations while providing flexibility;
3. Keep students the whole period, but do not give them any testable material;
4. Tell your own story of some struggle you had with science sometime in your academic career; and
5. Tell a story of your success.

The atmosphere that an instructor creates in and out of the classroom can have an effect on student progress. Thompson’s (2001) investigation of the informal student-faculty interaction among community college students enrolled in science and math courses, revealed that students exert a higher level of effort in science courses when there are opportunities for students to interact with faculty on various levels. In other words, when instructors can share their personal experiences, time, and ideas with a student outside the classroom they may be deemed as a more effective instructor. Basilit and Zdravkovich (1988) indicated several attributes that community college science instructors possess. These characteristics include 1) a strong desire to communicate; 2) believes in the value of higher education for the attainment of individual potential; 3) has an orientation toward people; 4) has a fascination for the learning process; and
5) finds satisfaction in having a role in student intellectual and personal development. This does not imply that instructors and/or professors at four-year institutions may not possess similar characteristics. However, the main professional function of the community college instructor is to teach, therefore more time can be devoted to developing skills that directly benefit the learning process for students.

The experiences that community college students have in the classroom may directly start or stop career aspirations (Thompson, 2001). For those students that decide to pursue baccalaureate degrees in the sciences or engineering, there is likelihood that they attended a community college during the pursuit of their degree. Data obtained from the National Science Foundation (2012) indicated that 46% of science and engineering graduates in 2006 and 2007 attended community a community college. In 1999-2000, on average 44% of all science and engineering graduates began their college careers at a community college. Additionally, on average, 44% of underrepresented minority science graduates will attend a community college at some point during their college career. Hispanic, American Indian/Alaskan Native, and African American science graduates attend community college at 51%, 45%, and 43%, respectively. These percentage rates signify that these institutions are an ideal source for the cultivation of large numbers of diverse students into professions that require a scientific background. In their analysis of predictors that contribute to the enrollment of Hispanics in STEM related fields at Hispanic serving institutions, Crisp, Nora, and Taggart (2009) reported that students’ gender, ethnicity, SAT score, and high school percentile influenced decisions to pursue STEM degrees. Furthermore, 46% of women graduates in science and engineering attend community college compared to 41% of men (Tsapogas, 2004). Therefore, community colleges provide access to
underrepresented minorities that may never have thought of pursuing degrees in the STEM related fields (Starobin & Laanan, 2008).

In order to garner and retain interest in the sciences, the federal government has implemented programs to increase in the number of students entering the science pipeline at the federal level. For example, the Bridges to Baccalaureate Program sponsored by the National Institutes of Health (NIH) provides opportunities to ethnically underrepresented community college students. This NIH program has an eight million dollar budget that supports partnerships between two-year and four-year institutions, summer research opportunities, seminars and workshops, tutoring, and peer mentoring (Carpenter, 2008). Similarly, the National Science Foundation’s Undergraduate Research Collaborative program provides opportunities for community college students, faculty, and administrators to take a leading role in increasing the number of students who pursue STEM degrees (Brothers & Higgins, 2008).

In summary, the U.S. community college network has grown from one college in Joliet, Illinois, to over 1,200 regionally accredited institutions, serving over 6.5 million students a year for credit courses and another 5 million for noncredit (National Commission on Community Colleges, 2008). Throughout their more than one hundred year existence, they have undergone a metamorphosis from providing courses for transfer to providing a widespread curriculum. As these colleges continue to evolve, their missions will undergo changes to meet the current and relevant needs of the populace in which they serve. Although the missions may be varied, all share a central responsibility: to provide access to education to the academically weak, the economically disadvantaged (Zeidenbeg, 2008), and those seeking to better their lives by pursuing a higher education.
Summary

This review of literature revealed that the science laboratory has been a fundamental part of the science curriculum for many years and will continue to be considered, by many, necessary to teach a comprehensive science course. However, its importance in the obtainment of science education goals has been deliberated equally as long as it has been a component of the science classroom. The lack of consensus about the value of the laboratory among researchers and educators led to the development of the SLEI, which provides an opportunity to assess student’s perceptions of the laboratory. Studies have shown that students prefer laboratory environments that are well equipped, integrate lecture material with the laboratory, and have clear instructions.

The SLEI can be useful in predicting students’ attitudes toward science. Although discrepancies exist in regards to the actual definition of the attitude construct and the instrumentation used to measure it, it is clear that a student’s attitude can directly affect desired learning outcomes. The TOSRA survey instrument provides an opportunity to assess students’ attitudes toward science. It has been broadly used internationally and across different grade levels. This literature review points toward a need for further exploration of the effect of the laboratory learning environment on student’s attitude towards science; more specifically, the lack of literature on the community college suggests that this area that is often overlooked.
CHAPTER III:
METHODOLOGY

Introduction

This chapter presents the research questions that serve as the foundation for this study. Additionally, the chapter includes sections that present the population and sample selection, description of the laboratory component, survey instrumentation, and methods of analysis.

The purpose of educational research is to help the general public and education practitioners decide which opinions are correct and provide better ways to think about the field of education (Wallen & Fraenkel, 2000). Traditionally, educational research design is empirical in nature and utilizes two paradigms, qualitative and quantitative (Smeyers, 2008). Qualitative research is interpretative and seeks to understand phenomenon in their natural setting by focusing on the meanings of the actions of the subjects involved in the study (Gall, Borg, & Gall 2007). Conversely, quantitative research is positivist and explains phenomenon by analyzing numerical data through statistical methods (Muijs, 2007). Through quantitative research, the investigator studies the distribution of variables and looks to explain observations through inductive reasoning (Smeyers, 2008). Furthermore, quantitative studies allow researchers to extrapolate data that contributes to known theories, and better predict, explain, and understand phenomenon (Creswell, 2005).

This study seeks to gain a greater understanding of students’ perceptions of the laboratory environment and the affective outcome of scientific attitudes. As discussed in Chapter I,
students’ experiences in science courses are often hindered by poor academic preparedness and difficulties with instruction. As a result, science courses have high drop-out rates and students that initially intend to major in the sciences often change their majors. The science laboratory component of the science course can serve as a vehicle to increase student understanding and interest in the sciences, by providing practical and inquiry based hands-on approaches to scientific processes. However, an examination of the literature reveals that the views of researchers take divergent paths in relation to the value of the laboratory in science education.

In order to gain insight and contribute to the body of literature that focuses on the importance of the science laboratory and environment a quantitative research paradigm was chosen. This research model was chosen for a number of reasons. First, quantitative research allows for the investigator to remain objective and independent of the units of study, the students. This is central because the researcher is an instructor who routinely comes in contact with the student population. Therefore, bias interpretations that may result from a qualitative study are eliminated. Secondly, this study used established survey instruments in order to extract students’ perceptions about the laboratory environment and scientific attitudes. This allows non-quantitative data (perceptions and attitudes) to be turned into quantitative data by measuring them numerically using rating scales (Muijs, 2007). Lastly, this study represents the first time that the students evaluated the laboratory setting at the study site. Therefore, the data obtained from the study could potentially serve as a benchmark that can help lead to improvements in instruction and curriculum development.
Research Questions

With the overall aim of investigating community college students’ perceptions of the science laboratory in an introductory biology course, the following research questions were examined:

1. What are introductory biology course students’ perceptions of the laboratory classroom environment;
2. What gender differences exist among student’s perceptions of the laboratory classroom environment;
3. What academic discipline differences exist among students’ perceptions of the laboratory classroom environment;
4. Are there significant differences among gender and academic disciplines as it relates to attitudes toward science; and
5. What relationships exist between students’ perceptions of the science laboratory and student attitudes toward science?

Setting

The site for this study took place at Jefferson State Community College located in Birmingham, Alabama. Founded in 1965 in Jefferson County, the college has grown and presently is comprised of two campus and site locations that serve approximately 15,000 students (10,000 credit and 5000 non-credit). The college offers 40 career programs, certificate programs, and over 120 university transfer programs. Classes are presented in a myriad of different formats, which include traditional, internet, and hybrid (traditional and internet), six days a week. The average age of students enrolled at the college is 26, with the majority of students under the age of 23 (56%), followed by a range between the ages of 23-40 years of age.
Males comprise the minority at the college, making up 40% of the population and females are 60%. The faculty population consists of 138 full-time faculty and 318 part-time faculty (retrieved from http://www.jeffstateonline.com/AboutTheCollege/index.aspx on November 2, 2011).

This site was selected for the study for a number of reasons. First, it serves the target population that is of interest to this study. Secondly, Jefferson State Community College is the second largest community college in the state of Alabama, thus allowing access to a large student population. Thirdly, the laboratory setting and exercise schedule is managed by lab coordinators and is the same for all students regardless of the instructor. Therefore, although teaching styles may be different, students were exposed to the same physical environment and resources. Lastly, the laboratory component of biology courses is expensive to maintain. As the college struggles with budgetary cutbacks, it is important to identify what students perceive as beneficial to their learning process. Hence, this knowledge can lead to the identification and elimination of practices and instructional resources that may be costly.

**Study Participants**

Participants in the study included freshmen and sophomore students enrolled in ten sections of Principles of Biology I during the Spring 2012 semester at Jefferson State Community College in Birmingham, Alabama. This sample is accessible and a convenient population because the researcher is a faculty member at the college and includes all of the students who can realistically be can be included in the study (Gall, Borg, & Gall, 2007). However, student participation in the study was voluntary. Students enrolled in the course represent a diverse population that varies in academic preparedness, age, socioeconomic status, and academic majors.
Principles of Biology I is a transferable, four-hour credit course and is the first of a two-course sequence for science majors. The course provides students with an overview of physical, chemical, and biological principles common to all living organisms. In the past, the course served as a requirement for admissions to allied health programs and a prerequisite course for anatomy and physiology and microbiology courses for allied health majors. However, in 2005 the college participated in a pilot study that removed the course as a prerequisite for admissions to the allied health programs and it no longer served as a prerequisite for enrollment in upper level courses. According to enrollment data obtained from the college, the Fall 2011 student population consists largely of students that intend to pursue career programs at the associate level. Students pursuing an associate’s career degree program in the allied health sciences comprise 42% of the students enrolled in the course. Students intending on majoring in nursing comprise the largest number of allied health enrollees at 47% of the student population. It is important to note that students that intend to apply for the nursing program enroll in the course in order to gain additional admission points and not to meet degree requirements.

**Laboratory Setting**

All students enrolled in the course must complete the laboratory component in order to receive a grade. The department of biology at the college has established that the laboratory must account for minimally 20% of the overall grade, but no more that 25% percent. The laboratory comprises two contact hours of the four-hour course and consists of ten laboratory exercises (see Table 1). The majority of the laboratory exercises are taken from a customized version of the ninth edition of *The Biology Manual* (Vodopich & Moore, 2010). Laboratory exercises in the manual are comprised of three types of activities: directed, thematic, and investigative. Directed activities use traditional skills and exercises in order to introduce basic
biological techniques and processes. The thematic activities reinforce biological themes that are directly connected to lecture, textbook, and manual content. The investigative laboratory activities allow students to incorporate skills they have learned to answer their own scientific questions. Additionally, two virtual lab simulations are used as laboratory exercises. The virtual labs allow students to complete activities that would be difficult to complete within the normal length of a laboratory session.

Table 1

*Laboratory Exercise Listing*

<table>
<thead>
<tr>
<th>Title of Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurements in Biology: The Metric System, Data Analysis, and the pH scale</td>
</tr>
<tr>
<td>The Microscope: Basic Skills of Light Microscopy</td>
</tr>
<tr>
<td>Biologically Important Molecules: Carbohydrates, Proteins, Lipids, and Nucleic Acids</td>
</tr>
<tr>
<td>The Cell: Structure and Function</td>
</tr>
<tr>
<td>Enzymes: The process of digestion (computer simulation)</td>
</tr>
<tr>
<td>Spectrophotometer &amp; Photosynthesis</td>
</tr>
<tr>
<td>Mitosis and Meiosis</td>
</tr>
<tr>
<td>Column Chromatography and Gel Electrophoresis</td>
</tr>
<tr>
<td>Survey of Prokaryotes: Kingdom Archae-bacteria and Bacteria</td>
</tr>
<tr>
<td>Survey of Kingdom Fungi: Molds, Sac Fungi, Mushroom, and Lichens</td>
</tr>
</tbody>
</table>

During the fall and spring semesters one lab is completed each week with the exception of weeks in which there is a laboratory practical scheduled or a holiday. All course sections follow the same schedule and a laboratory coordinator does the preliminary set-up for each lab. The same instructor that is assigned to the lecture section of the course teaches each laboratory section.
Data Collection

Approval of the research proposal was granted by the University of Alabama (Tuscaloosa) Institutional Review Board (IRB) (see Appendix A). Afterward, permission was requested from the Associate Dean of Instruction at Jefferson State Community College in order to administer the survey instruments (see Appendix B). After receiving permission, instructors were asked for consent to gain access to their students. Upon receiving their permission, instructors were given a script to read to their students, which informed them of the purpose of the study (see Appendix C). The researcher supervised the administering of the surveys to each class section during one class session.

Survey Instruments

The use of survey instrumentation in quantitative research addresses two fundamental principles: 1) by describing the sample respondents, a description of the target population can be made; and 2) the answers that the sample respondents give can be used to accurately describe the characteristics of the respondents (Fowler, 2009). In choosing this survey process, it allows data to be obtained and analyzed quickly and it requires minimal cost (paper and copy cost). Two surveys were chosen for this study in order to investigate student perceptions of the laboratory environment and attitudes toward science: 1) the Science Environment Laboratory Inventory and 2) the Test of Science Related Attitudes, respectively. These surveys have been used extensively to study the laboratory environment and the affective outcome of scientific attitude (Fraser & Lee, 2009; Fraser & McRobbie, 1995; Henderson, Fisher, & Fraser, 2000; Quek, Wong, & Fraser, 2005; Wolf & Fraser, 2007) and are therefore used as models for this study.
Science Environment Laboratory Instrument

The actual form of the Science Environment Laboratory Inventory (SLEI) (see Appendix D) was used to examine students’ perceptions of the laboratory. This survey instrument was developed by Fraser, Giddings, and McRobbie (1993) and is one of many instruments designed to study the classroom environment. However, it is the only instrument created by the researchers to assess the laboratory environment specifically. This is of great importance because the laboratory environment includes a number of factors that are not present in the traditional classroom. For example, students work with a number of biological instruments and supplies and most often work in groups.

The SLEI is composed of five scales that consist of seven items each: 1) student cohesiveness (1, 6, 11, 16, 21, 26, 31); 2) open endedness (2, 7, 12, 17, 22, 27, 32); 3) rule clarity (4, 9, 14, 19, 24, 29, 34); 4) integration (3, 8, 13, 18, 23, 28, 33); and 5) material environment (5, 10, 15, 20, 25, 30, 35). Each of these scales correspond to one of Moos’ three general dimensions of the human environment. These dimensions include 1) relationship (the nature and intensity of personal relationships); 2) personal development (basic directions along which personal growth and self- enhancement tend to occur); and 3) system maintenance and system change (the extent to which the environment is orderly, clear in expectation, maintains control, and is responsive to change) (Moos & Trickett, 1974). Students are asked to respond to each item with the following responses, from 1 (almost never) to 5 (almost always). There are negative items (3, 5, 6, 8, 9, 15, 20, 23, 24, 25, 26, 27, and 33) on the survey; therefore, the scoring is reversed. The researcher has chosen to use the personal/actual form of the SLEI, which allows assessment of students’ individual or subgroup perceptions of the actual laboratory environment.
Table 2

*Description of Science Laboratory Environment Inventory Scales (SLEI)*

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Description of Scale</th>
<th>Moos’ Category</th>
<th>Sample Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>Degree to which students know, help and are supportive of one another</td>
<td>Relationship</td>
<td>I get along well with students in this science laboratory class</td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>Degree to which the laboratory activities emphasize on open-ended divergent approach to experimentation</td>
<td>Personal Growth</td>
<td>There is opportunity for me to pursue my own science interest in the biology laboratory class</td>
</tr>
<tr>
<td>Integration</td>
<td>Degree to which the laboratory activities are integrated with non-laboratory and theory classes</td>
<td>Personal Growth</td>
<td>What I do in our regular science class is unrelated to my science laboratory work</td>
</tr>
<tr>
<td>Rule Clarity</td>
<td>Degree to which the behavior in the laboratory is guided by formal rules</td>
<td>System Maintenance &amp; Change</td>
<td>My science laboratory class has clear rules to guide my activities</td>
</tr>
<tr>
<td>Material Environment</td>
<td>Degree to which the laboratory equipment and materials are adequate</td>
<td>System Maintenance &amp; Change</td>
<td>I find that the science laboratory is crowded when I am doing experiments</td>
</tr>
</tbody>
</table>


The field testing and validation of the SLEI was conducted across six countries (Australia, United States, Canada, England, Israel, and Nigeria) (Fraser, Giddings, & McRобbie, 1995).

The sample size included 269 senior, secondary and university classrooms with a total of 5,447 students. Results from this study indicated that the SLEI had the ability to differentiate between classrooms and had strong reliability and factor structure.
Fraser suggested (as cited in Fraser, Giddings, & McRobbie, 1992) that teachers improve their laboratory classrooms by using the results from the SLEI to gather information in three distinct ways. Initially, student perceptions from both the preferred and actual surveys could be used to identify differences between what students experience and the environments they actually prefer. Once the differences were identified, tactics could be initiated that would promote a laboratory classroom more suited to students preferred environment. Lastly, the survey instrument could be administered again to evaluate negative or positive impacts of the new tactics.

**Test of Science Related Attitudes**

In order to analyze student attitudes toward science the Test of Science-Related Attitude (TOSRA) (Fraser, 1978) was used (see Appendix E). The term “attitude toward science” was created by Klopfer’s (1971) and derived from six scientific aims. Klopfer’s six aims included 1) acceptance of scientific inquiry as a way of thought; 2) manifestation of favorable attitudes to science and scientists; 3) adoption of scientific attitudes; 4) development of interest in science and science-related activities; 5) enjoyment of science learning experiences; and 6) development of interest in pursuing a career in science. The TOSRA consists of seven scales based on Klopfer’s aims for science education. The scales include social implication of science; normality of scientist; attitude toward scientific inquiry; career interest in science; leisure interest in science; enjoyment of science lesson; and adoption of scientific attitude. The instrument uses a 5-point, Likert-style responses that consists of strongly agree (SA), agree (A), Not sure (N), disagree (D) and strongly disagree (SD). There are both negative and positive items within each scale, therefore positive items are scored 5-1 and negative items 1-5. However, this study utilized only three scales determined most relevant in order to determine students’ attitudes.
toward science: attitude to scientific inquiry, adoption of scientific attitudes, and enjoyment of science lessons (see Table 3).

Table 3

*Description of Test of Science Related Attitudes (TOSRA)*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Klopfer Classification</th>
<th>Sample Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude toward Scientific Inquiry in Science</td>
<td>Acceptance of scientific inquiry as a way of thought</td>
<td>I would prefer to find out why something happens by doing an experiment than by being told</td>
</tr>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>“Adoption of scientific attitudes”</td>
<td>I dislike repeating experiments to check that I get the same results</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>Enjoyment of Science Learning experiences</td>
<td>Science lessons are fun</td>
</tr>
</tbody>
</table>


Validation of the final version of the survey instrument used a sample population that consisted of students (n = 1337) enrolled in grades 7-10 in Australia (Fraser, 1981). Results demonstrated that the mean and standard deviations for each scale tended to be similar and comparable across all four grade levels. Statistical analysis revealed that the Cronbach α coefficient ranged from 0.66 – 0.93 across all grade levels (Fraser, 1981). Although there are several survey instruments that collect data on students’ attitudes toward science, the TOSRA is theoretically sound and has been validated extensively within populations of American high schools (Khalili, 1987; Joyce & Farenga, 1999) and college students (Jaleel, 1991).

This survey instrument can provide useful information that can be used by teachers and researchers. Teachers may use the TOSRA to obtain information about the science-related
attitudes of the entire class or of individual students. Additionally, it can be used to assess changes in attitudes over a period of time (Fraser, 1981). Permission was granted from Barry Fraser in order to use both surveys in this study (see Appendix F).

**Data Analysis**

All data analyses were conducted using IBM SPSS Statistics software package. To address research Question 1 and evaluate students’ perceptions of the laboratory environment, the reliability of the SLEI was established first. Reliability of the SLEI was determined by assessing the internal consistency (Cronbach α reliability) using the student mean as units of analysis. Descriptive statistics (mean and standard deviation) for the total sample population were analyzed to determine community college student perceptions of the laboratory environment based upon responses to each scale of the SLEI.

Research Question 2 investigated if there are any significant differences between male and female perceptions of the laboratory environment. The means and standard deviations from the respondents’ surveys will be determined in order to assess the students’ perceptions of the laboratory. An independent t-test was conducted in order to determine if any significant differences existed (p < .05) between males and females. The independent t-test is appropriate to address this question because it is used to determine if two means of two unrelated populations are significantly different from each other (Lomax, 2001). The independent variable is gender and the dependent variable were the scale mean scores obtained from survey responses.

In order to address Research Question 3 and determine if a student’s choice of academic discipline affects their perception of the laboratory, students were divided into three academic streams: allied health, STEM, and non-science. The allied health stream includes the following: nursing; physical therapy assistant; biomedical equipment technology; clinical laboratory
Another focus of this study was to determine if any differences exist in students’ attitude towards science based on gender and academic disciplines. Reliability of the TOSRA was determined by assessing the internal consistency (Cronbach α reliability) using the student means as units of analysis. Once reliability of the survey instrument was established, independent T-tests was conducted to determine if any differences existed between male and female attitudes toward science. An ANOVA was done to ascertain if significant differences existed between the three academic streams. The two aforementioned analyses were followed by a two-way ANOVA in order to was conducted to demine any significant interactions between gender and academic streams as it relates to attitudes toward science. *Attitudes toward science* was the dependent variable and was measured by mean scores obtained from the respondents. The independent variables were gender and academic disciplines. Any significant results obtained were further analyzed by post-hoc testing (Research Question 4).
Research Question 5 investigated what relationship existed between students’ perceptions of the science laboratory and their attitudes toward sciences. Simple correlation analyses were conducted to determine how each scale of the SLEI is associated with the individual scales of the TOSRA. Simple correlation analysis is appropriate for this study because it will describe the bivariate association between the affective outcome, attitude, and the scales of the SLEI (Gall, Borg, & Gall, 2007). The individual student means was used as the unit of analysis. Simple correlation analysis was followed by multiple regression analysis to determine the common influence of the five scales of the SLEI on the attitudinal scales. The research questions, variables, and statistical test for the study are summarized in Table 4.
Table 4

Research Questions, Variables, and Statistical Tests

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Statistical Test(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are introductory biology students perceptions of the laboratory environment</td>
<td>Perceptions of the laboratory environment/SLEI Scales</td>
<td>Student &amp; Class Mean</td>
<td>Descriptive</td>
</tr>
<tr>
<td>2. What gender differences exist among students perceptions of the laboratory environment?</td>
<td>Perceptions of the laboratory environment/SLEI Scales</td>
<td>Gender: Male &amp; Female</td>
<td>Independent t-test</td>
</tr>
<tr>
<td>3. What academic disciplines differences exist among students perceptions of the laboratory environment?</td>
<td>Perceptions of the laboratory environment/SLEI Scales</td>
<td>Academic Discipline Streams: STEM, Non-science, Allied Health</td>
<td>ANOVA</td>
</tr>
<tr>
<td>4. Are there significant differences among gender and academic disciplines as it relates to attitudes toward science?</td>
<td>Attitudes toward science/TOSRA scales</td>
<td>Gender &amp; Academic Discipline</td>
<td>Independent T-test; ANOVA; Two-way ANOVA</td>
</tr>
<tr>
<td>5. What relationships exist between student perceptions of the science laboratory and student attitudes toward science?</td>
<td>subscales of TOSRA</td>
<td>subscales of SLEI</td>
<td>Simple Correlation (Pearson) &amp; Multiple Regression Analysis</td>
</tr>
</tbody>
</table>

Assumptions

A number of assumptions were considered for this study. First, several different course sections of Principles of Biology I participated in this study. Students enrolled in these course section at various campuses and sites at Jefferson State Community College. It was assumed that students were exposed to comparable physical environments and laboratory materials. Secondly,
it was assumed that at the time of the survey administration students would have had an adequate number of laboratory experiences in order provide responses that accurately reflect their knowledge and opinion. Lastly, it was assumed that students enrolled in the course and thus participated in the study were pursuing degrees and careers that require a science major biology course instead of a non-majors course.

**Limitations**

There were also several limitations to consider during this study. For example, the level of academic preparedness was diverse among the student population in the course. Students that may have recently finished high school potentially had a greater understanding of some of the procedures in the laboratory, therefore making the experience more positive. Conversely, an older student that had been out of school for an extended period may have had more difficulty in the assigned laboratory tasks. Additionally, this study only investigated students enrolled in one science course at the college. This course was chosen because all students are exposed to the same laboratory exercise schedule. This allowed students to the same activities without any variations although instructors were different. Therefore, students’ perceptions of their laboratory experiences were associated with the one specific course, although they may be enrolled in other science courses.

**Summary**

This research study provided an opportunity to conduct analysis about students’ perceptions of the science laboratory and student attitudes toward science. Although numerous studies exist that have investigated the laboratory classroom environment, very little has been done at the community college level. In order to evaluate student perceptions, five research
questions were presented as well as descriptions of methodology, instrumentation, data collection, and analyses.
CHAPTER IV:

RESULTS

The focus of this study was to investigate Principle of Biology I student perceptions of the laboratory environment at Jefferson State Community College in Birmingham, Alabama. This study further sought to examine if differences existed in student perceptions based upon gender and chosen academic discipline. This chapter will present the descriptive and inferential results derived from the two survey instruments used in the study, the Science Laboratory Environment Instrument (SLEI) and Test of Science Related Attitudes (TOSRA).

Response Rate and Demographic Data

Instructors of eleven course sections of Principles of Biology I were asked to allow access to their students to participate in this study. All instructors, with the exception of one, accepted the request to allow their students the opportunity to contribute to this investigation. The total number of potential participants was determined by accessing course enrollment numbers through the college’s enrollment services management system, BANNER. A total of 219 students were actively registered for the ten course sections; therefore, a total of 219 survey packets (SLEI and TOSRA) were distributed to instructors based on their course section enrollment. The number of completed surveys returned for analysis was 145; therefore, the return rate was 66%.

In order to determine demographic characteristics (gender and academic major), students were asked to provide this information before beginning the survey instruments. A summary of
the demographic data can be found in Table 5. As denoted, the majority of the students enrolled in the course were female (62%) and males comprised the remaining 38%. Principles of Biology I is a course for science majors and it is transferable to four-year institutions. Although this course is generally geared for science majors, student’s intent on majoring in a diverse number of academic disciplines enrolled in the course to either meet degree requirements or obtain points toward entrance into allied health programs at the college. It is for this reason that academic majors were divided into three streams that consisted of the following: allied health, science, technology, engineering, and math (STEM), and non-science. During the 2011 - 2012 academic year, students majoring in allied health, STEM, and non-science disciplines comprised 41%, 29%, and 30% of the course enrollees, respectively (Jefferson State Community College, 2012). The demographic results are summarized in Table 5. At the time of the study, students majoring in the area of allied health sciences constituted the largest number of survey participants (55%). The second largest percentage (36%) of survey respondents identified themselves as STEM majors followed by the smallest percentage (15%) represented by non-science majors. Females accounted for the largest percentage of both allied health majors (39%) and non-science majors (10%) in the sample population. However, the male participants constituted the majority (17%) of the STEM majors.
Table 5

Demographic Characteristics of Participants

<table>
<thead>
<tr>
<th>Academic Stream</th>
<th>Male (n = 55)</th>
<th>Female (n = 90)</th>
<th>Total (n=145)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Allied Health</td>
<td>23</td>
<td>16</td>
<td>57</td>
</tr>
<tr>
<td>STEM</td>
<td>24</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Non-Science</td>
<td>8</td>
<td>5</td>
<td>14</td>
</tr>
</tbody>
</table>

Research Question 1

The first research question addressed, “What are introductory biology students’ perceptions of the laboratory environment?” This question was answered using the Science SLEI. In order to address this question, first the internal consistency of the five scales in the SLEI was established. The reliability for the individual scales of the SLEI ranged from .69 to .81 (see Table 6) with the student as the unit of analysis. The analysis indicated that the reliability of two scales, student cohesiveness and rule clarity, would be improved if specific items were removed. If Item 26, “It takes me a long time to get to know everybody by his/her first name in this laboratory class,” was deleted from the student cohesiveness scale, Cronbach’s alpha would improve from .76 to .79. Similarly, if Item 24, “There are few fixed rules for me to follow in the laboratory,” was removed from the rule clarity scale, Cronbach’s alpha would increase from .69 to .72. The researcher decided to keep both items because of the insight into the overall variance they may provide. Furthermore, although reliability values less than .70 are questionable, previous studies have validated the SLEI with values of less than .69 (Waldrip & Wong, 1996; Wong & Fraser, 1995). The three remaining scales, integration (α = .80), open-endedness (α = .81), and material environment (α = .84) all exhibited Cronbach’s alpha that would not have
improved with the deletion of any items. These results indicate satisfactory reliability for the survey instrument.

Table 6

*Internal Consistency Reliability of SLEI*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Items</th>
<th>Cronbach’s alpha (α)</th>
<th>Item</th>
<th>α if item deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>1, 6, 11, 16, 21, 26, 31</td>
<td>.76</td>
<td>26</td>
<td>.79</td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>2, 7, 12, 17, 22, 27, 32</td>
<td>.81</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>3, 8, 13, 18, 23, 28, 33</td>
<td>.79</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Rule Clarity</td>
<td>4, 9, 14, 19, 24, 29, 34</td>
<td>.69</td>
<td>24</td>
<td>.72</td>
</tr>
<tr>
<td>Material Environment</td>
<td>5, 10, 15, 20, 25, 30, 35</td>
<td>.84</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

In order to assess students’ perceptions of the laboratory environment, descriptive statistics analyses were conducted on student responses to the SLEI. Students responded to each item with (5) *almost always*, (4) *often*, (3) *sometimes*, (2) *seldom*, and (1) *almost never*. Overall, students had favorable perceptions of the laboratory environment ($M = 3.76$) as indicated in Table 7. Perceptions of the individual scales of the SLEI ranged from 2.69 – 4.16. The student’s perceptive range was as follows: *student cohesiveness* ($M = 4.16$) the highest; followed by *material environment* ($M = 4.07$); *rule clarity* ($M = 4.01$); and *integration* ($M = 3.8$); and the lowest perceived scale was *open-endedness* ($M = 2.69$).
**Table 7**

*Student Mean and Standard Deviation for SLEI Scales*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>4.16</td>
<td>.65</td>
</tr>
<tr>
<td>Open–Endedness</td>
<td>2.69</td>
<td>.65</td>
</tr>
<tr>
<td>Integration</td>
<td>3.85</td>
<td>.79</td>
</tr>
<tr>
<td>Rule Clarity</td>
<td>4.01</td>
<td>.63</td>
</tr>
<tr>
<td>Material Environment</td>
<td>4.07</td>
<td>.75</td>
</tr>
<tr>
<td>Total Instrument</td>
<td>3.76</td>
<td>.75</td>
</tr>
</tbody>
</table>

Further examination of the individual items within each scale provided a more in depth evaluation of student perceptions of the laboratory environment. For example, within the *student cohesiveness* scale (see Table 8), Item 31, “I work cooperatively in laboratory sessions,” received the highest mean score (M=4.60). This score indicates that students perceive that they worked well with one another to complete the laboratory assignments. Conversely, Item 26, “It takes me a long time to get to know everybody by his/her first name in the laboratory class,” received the lowest mean score of 3.44.
Table 8

*Descriptive Statistics for Student Cohesiveness Scale*

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>M</th>
<th>SD</th>
<th>α if deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I get along well with students in this laboratory class.</td>
<td>4.66</td>
<td>.594</td>
<td>.733</td>
</tr>
<tr>
<td>6</td>
<td>I have little chance to get to know other students in this laboratory class.</td>
<td>3.97</td>
<td>1.14</td>
<td>.758</td>
</tr>
<tr>
<td>11</td>
<td>Members of this laboratory class help me</td>
<td>4.36</td>
<td>.910</td>
<td>.713</td>
</tr>
<tr>
<td>16</td>
<td>I get to know students in this laboratory class well</td>
<td>4.08</td>
<td>1.06</td>
<td>.688</td>
</tr>
<tr>
<td>21</td>
<td>I am able to depend on other students for help during laboratory classes</td>
<td>4.04</td>
<td>1.12</td>
<td>.695</td>
</tr>
<tr>
<td>26</td>
<td>It takes me a long time to get to know everybody by his/her first name in this laboratory class</td>
<td>3.44</td>
<td>1.39</td>
<td>.792</td>
</tr>
<tr>
<td>31</td>
<td>I work cooperatively in laboratory sessions.</td>
<td>4.66</td>
<td>.701</td>
<td>.725</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.

α = .760 for scale.

The *material environment* scale, which measured students views of the equipment and physical appearance of the lab, received the second highest scale score (M = 4.07). The results of the individual item means for this scale are summarized in Table 9. Students had positive perceptions of the physical space, as indicated by Item 35, “My laboratory has enough room for individual or group work,” (M=4.26). However, student (M= 3.89) responses to reverse scored Item 5, “I find that the laboratory is crowded when I am doing experiments,” indicates that there are times when students perceive that the laboratory may be too crowded.
Table 9

*Descriptive Statistics for Material Environment Scale*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statement</th>
<th>M</th>
<th>SD</th>
<th>α if deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>I find that the laboratory is crowded when I am doing experiments. R</td>
<td>3.89</td>
<td>1.23</td>
<td>.717</td>
</tr>
<tr>
<td>10</td>
<td>The equipment and materials that I need for laboratory activities are readily available.</td>
<td>4.17</td>
<td>1.12</td>
<td>.764</td>
</tr>
<tr>
<td>15</td>
<td>I am ashamed of the appearance of this laboratory. R</td>
<td>4.40</td>
<td>1.10</td>
<td>.726</td>
</tr>
<tr>
<td>20</td>
<td>The laboratory equipment which I use is in poor working order.</td>
<td>4.07</td>
<td>1.23</td>
<td>.698</td>
</tr>
<tr>
<td>25</td>
<td>I find that the laboratory is hot and stuffy. R</td>
<td>3.96</td>
<td>1.27</td>
<td>.733</td>
</tr>
<tr>
<td>30</td>
<td>The laboratory is an attractive place for me to work.</td>
<td>3.81</td>
<td>1.13</td>
<td>.760</td>
</tr>
<tr>
<td>35</td>
<td>My laboratory has enough room for individual or group work.</td>
<td>4.26</td>
<td>1.08</td>
<td>.744</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.

α = .765 for scale.

A review of the item means for the *rule clarity* scale revealed that students perceived that events associated with rule formalities occurred sometimes or often (see Table 11). The range of mean scores were 3.46 - 4.47. Students often perceived that they were required to follow rules as determined by Item 14 (M = 4.47), “I am required to follow certain rules in the laboratory.” Additionally, the lowest scored item was Item 34 (M = 3.60), “My laboratory is run under clearer rules that my other classes.”
Table 10
*Descriptive Statistics for Rule Clarity Scale*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>M</th>
<th>D</th>
<th>α if deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>My laboratory class has clear rules to guide my activities.</td>
<td>4.39</td>
<td>.875</td>
<td>.637</td>
</tr>
<tr>
<td>9</td>
<td>My laboratory class is rather informal and few rules are imposed on me.</td>
<td>3.61</td>
<td>1.29</td>
<td>.677</td>
</tr>
<tr>
<td>14</td>
<td>I am required to follow certain rules in the laboratory.</td>
<td>4.47</td>
<td>.773</td>
<td>.625</td>
</tr>
<tr>
<td>19</td>
<td>There is a recognized way for me to do things safely in this laboratory.</td>
<td>4.43</td>
<td>.761</td>
<td>.612</td>
</tr>
<tr>
<td>24</td>
<td>There are few fixed rules for me to follow in laboratory sessions.</td>
<td>3.46</td>
<td>1.41</td>
<td>.725</td>
</tr>
<tr>
<td>29</td>
<td>The teacher outlines safety precautions to me before my laboratory sessions.</td>
<td>4.18</td>
<td>1.09</td>
<td>.625</td>
</tr>
<tr>
<td>34</td>
<td>My laboratory class is run under clearer rules than my other classes.</td>
<td>3.60</td>
<td>1.19</td>
<td>.649</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.
\( \alpha = .690 \) for scale

The *integration* scale measured student perceptions of how well lecture content was associated with laboratory experiments. Students overall responses to six of the seven items indicated that they perceived that integration occurred sometimes within the laboratory. The range of mean scores was between 3.77 - 3.92 for six of the seven items (see Table 11). However, reverse scored scale Item 8, “The laboratory work is unrelated to the topics that I am studying in my science class,” received a slightly higher mean score of 4.01, which indicated that students often perceived laboratory work was related to lecture content.
Table 11

*Descriptive Statistics for Integration Scale*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>M</th>
<th>D</th>
<th>(\alpha) if deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>What I do in our regular science class is unrelated to my laboratory work.</td>
<td>3.73</td>
<td>1.28</td>
<td>.765</td>
</tr>
<tr>
<td>8</td>
<td>The laboratory work is unrelated to the topics that I am studying in my science class.</td>
<td>4.01</td>
<td>1.22</td>
<td>.741</td>
</tr>
<tr>
<td>13</td>
<td>My regular science class work is integrated with laboratory activities</td>
<td>3.88</td>
<td>1.13</td>
<td>.785</td>
</tr>
<tr>
<td>18</td>
<td>I use the content from my regular science class session during laboratory activities</td>
<td>3.83</td>
<td>1.14</td>
<td>.773</td>
</tr>
<tr>
<td>23</td>
<td>The topics covered in regular science class work are quite different from topics with which I deal in laboratory sessions</td>
<td>3.77</td>
<td>1.24</td>
<td>.760</td>
</tr>
<tr>
<td>28</td>
<td>What I do in laboratory sessions helps me to understand the content covered in regular science classes.</td>
<td>3.82</td>
<td>1.17</td>
<td>.779</td>
</tr>
<tr>
<td>33</td>
<td>My laboratory work and regular science class work are unrelated.</td>
<td>3.92</td>
<td>1.28</td>
<td>.747</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.
\(\alpha = .790\) for scale

A review of the lowest rated scale, *open-endedness*, indicated that events associated with five of the seven scale items were perceived as seldom occurring in the laboratory environment (see Table 13). Items 7, 12, 17, 22, and 27 all received mean scores within the range of 2.06 - 2.93. The lowest of these, reverse scored Item 27 (\(M = 2.06\)), addressed how involved the teacher was in determining laboratory procedures. This item stated, “In my laboratory sessions, the teacher decides the best way for me to carry out the laboratory experiment.” Student response to this item indicates that the teacher was very involved in determining the laboratory procedures for the
laboratory exercises. However, Item 32, “I decide the best way to proceed during laboratory experiments,” received the highest score (M=3.69) among the scale items.

Table 12

**Descriptive Statistics of Open-endedness Scale**

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>M</th>
<th>SD</th>
<th>α if deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>There is opportunity for me to pursue my own science interest in this laboratory class.</td>
<td>3.50</td>
<td>1.24</td>
<td>.722</td>
</tr>
<tr>
<td>7</td>
<td>In this laboratory class, I am required to design my own experiments to solve a given problem.</td>
<td>2.33</td>
<td>1.35</td>
<td>.800</td>
</tr>
<tr>
<td>12</td>
<td>In my laboratory sessions, other students collect different data than I do for the same problem.</td>
<td>2.93</td>
<td>1.13</td>
<td>.697</td>
</tr>
<tr>
<td>17</td>
<td>I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own.</td>
<td>2.30</td>
<td>1.33</td>
<td>.713</td>
</tr>
<tr>
<td>22</td>
<td>In my laboratory sessions, I do different experiments that some of the other students.</td>
<td>2.08</td>
<td>1.27</td>
<td>.789</td>
</tr>
<tr>
<td>27</td>
<td>In my laboratory session, the teacher decides the best way for me to carry out the laboratory experiments. ( ^R )</td>
<td>2.06</td>
<td>1.11</td>
<td>.757</td>
</tr>
<tr>
<td>32</td>
<td>I decide the best way to proceed during laboratory experiments.</td>
<td>3.69</td>
<td>1.22</td>
<td>.798</td>
</tr>
</tbody>
</table>

*Note.* \( R \) denotes reverse scored item.

\[ \alpha = .810 \] for scale
Research Question 2

The second question this investigation sought to answer was, “What gender differences exist between student perceptions of the laboratory environment?” An independent samples t-test was conducted in order to differentiate if any statistically significant differences existed between male and female perceptions of the SLEI. All folded F-test results indicated that the homogeneity of variance was not violated. Therefore, all reported values are from the pooled t-test. As indicated by the results presented in Table 13, statistically significant differences were found only between males and females on the material environment scale, \( t(143) = -2.60, p = .010 \). Cohen’s d was used to determine that the effect size was modest \( (d = .44) \).

Table 13

<table>
<thead>
<tr>
<th>Laboratory Environment Scale</th>
<th>Mean</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>4.04</td>
<td>4.23</td>
<td>143</td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>2.75</td>
<td>2.33</td>
<td>143</td>
</tr>
<tr>
<td>Integration</td>
<td>3.72</td>
<td>3.93</td>
<td>143</td>
</tr>
<tr>
<td>Rule Clarity</td>
<td>3.92</td>
<td>4.07</td>
<td>143</td>
</tr>
<tr>
<td>Material Environment</td>
<td>3.87</td>
<td>4.20</td>
<td>143</td>
</tr>
</tbody>
</table>

*Note. \( *p < .05 \)

Female students (\( M = 4.20 \)) had a slightly more positive perception than their male (\( M = 3.87 \)) classmates. Upon additional review of the individual item means (see Table 14), females had more favorable opinions of scale Items 15 and 20. The most positive perceptions were of...
Item 15, “I am ashamed of the appearance of this laboratory.” This reversed scored item indicates that females (M = 4.57) were less ashamed of the laboratory appearance compared to males (M = 4.13). The lowest scored item within this scale for both males (M = 3.58) and females (3.94) was Item 30, “The laboratory is an attractive place for me to work in.” There were no overall statistical significant differences in the perceptions between male and female students on the remaining four scales: student cohesiveness, open-endedness, integration, and rule clarity.

Table 14

Gender Perceptions of Material Environment Scale by Item

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>Males (n=55)</th>
<th>Males (n=55)</th>
<th>Females (n=90)</th>
<th>Females (n=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>I find that the laboratory is crowded when I am doing experiments.</td>
<td>3.64</td>
<td>1.40</td>
<td>4.04</td>
<td>1.14</td>
</tr>
<tr>
<td>10</td>
<td>The equipment and materials that I need for laboratory activities are readily available.</td>
<td>4.05</td>
<td>1.11</td>
<td>4.24</td>
<td>1.12</td>
</tr>
<tr>
<td>15</td>
<td>I am ashamed of the appearance of this laboratory.</td>
<td>4.13</td>
<td>1.33</td>
<td>4.57</td>
<td>0.912</td>
</tr>
<tr>
<td>20</td>
<td>The laboratory equipment which I use is in poor working order.</td>
<td>3.75</td>
<td>1.40</td>
<td>4.27</td>
<td>1.07</td>
</tr>
<tr>
<td>25</td>
<td>I find that the laboratory is hot and stuffy.</td>
<td>3.76</td>
<td>1.44</td>
<td>4.08</td>
<td>1.15</td>
</tr>
<tr>
<td>30</td>
<td>The laboratory is an attractive place for me to work.</td>
<td>3.58</td>
<td>1.24</td>
<td>3.94</td>
<td>1.04</td>
</tr>
<tr>
<td>35</td>
<td>My laboratory has enough room for individual or group work.</td>
<td>4.22</td>
<td>1.04</td>
<td>4.29</td>
<td>1.10</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.

An evaluation of the individual scale items indicated which practices males and females viewed more positively or negatively within the laboratory environment. Tables 16-19
summarize the descriptive results for each of the seven items within each scale. For example, on the Student Cohesiveness scale (see Table 15), Item 31, “I work cooperatively in laboratory sessions,” received the highest mean score for females (M = 4.70) and males (M = 4.44). Conversely, males (M = 3.16) and females (M = 3.61) scored Item 26, “It takes me a long time to get to know everybody by his/her first name in this laboratory class,” the lowest.

Table 15

*Gender Perception of Student Cohesiveness Scale by Item*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>Males (n=55)</th>
<th>Females (n=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>1</td>
<td>I get along well with students in this laboratory class.</td>
<td>4.62</td>
<td>.62</td>
</tr>
<tr>
<td>6</td>
<td>I have little chance to get to know other students in this laboratory class.</td>
<td>3.96</td>
<td>.90</td>
</tr>
<tr>
<td>11</td>
<td>Members of this laboratory class help me.</td>
<td>4.29</td>
<td>.93</td>
</tr>
<tr>
<td>16</td>
<td>I get to know students in this laboratory class well.</td>
<td>3.93</td>
<td>.99</td>
</tr>
<tr>
<td>21</td>
<td>I am able to depend on other students for help during laboratory classes.</td>
<td>3.91</td>
<td>1.10</td>
</tr>
<tr>
<td>26</td>
<td>It takes me a long time to get to know everybody by his/her first name in this laboratory class.</td>
<td>3.16</td>
<td>1.34</td>
</tr>
<tr>
<td>31</td>
<td>I work cooperatively in laboratory sessions.</td>
<td>4.44</td>
<td>.71</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.

The *open-endedness* scale received the lowest mean scores for both males and females. A closer examination of individual items (see Table 16) revealed that males (M = 3.49) and females (3.81) had similar opinions of highest scored Item 32, “I decide the best way to proceed during
laboratory experiments.” This indicates that students can sometimes choose what direction they want to take in completing a series of exercises within a laboratory assignment. However, males and females differed modestly on the practices that they perceived as seldom or almost never occurring. Males (M = 2.20) were of the opinion that seldom do practices associated with Item 7, “In this laboratory class, I am required to design my own experiments to solve a given problem,” occur. However, females (M = 1.90) perceived Item 22, “In my laboratory sessions, I do different experiments than some of the other students,” as seldom occurring.

Table 16

*Gender Perceptions of Open-endedness Scale by Item*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>Males (n=55)</th>
<th>Females (n=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>2</td>
<td>There is opportunity for me to pursue my own science interest in this laboratory class.</td>
<td>3.35</td>
<td>1.32</td>
</tr>
<tr>
<td>7</td>
<td>In this laboratory class, I am required to design my own experiments to solve a given problem.</td>
<td>2.20</td>
<td>1.31</td>
</tr>
<tr>
<td>12</td>
<td>In my laboratory sessions, other students collect different data than I do for the same problem.</td>
<td>3.13</td>
<td>1.01</td>
</tr>
<tr>
<td>17</td>
<td>I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own.</td>
<td>2.47</td>
<td>1.33</td>
</tr>
<tr>
<td>22</td>
<td>In my laboratory sessions, I do different experiments than some of the other students.</td>
<td>2.36</td>
<td>1.26</td>
</tr>
<tr>
<td>27</td>
<td>In my laboratory session, the teacher decides the best way for me to carry out the laboratory experiments. ( R )</td>
<td>2.27</td>
<td>1.16</td>
</tr>
<tr>
<td>32</td>
<td>I decide the best way to proceed during laboratory experiments.</td>
<td>3.49</td>
<td>1.16</td>
</tr>
</tbody>
</table>

*Note.* \( R \) denotes reverse scored item
Both males (M= 3.72) and females (M = 3.93) perceived that practices that integrated lecture and lab sometimes occurred. A review of the mean scores in the integration scale (see Table 17) reveals that males (M= 3.91) and females (M =4.07) scored Item 8 the highest and perceived that laboratory lessons were sometimes or seldom not unrelated to the content taught in lecture. Similarly, both males (M= 3.62) and females (M = 3.8) scored Item 3, “What I do in our regular science class is unrelated to my laboratory work,” the lowest.

Table 17

*Gender Perceptions of Integration Scale by Item*

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>(n = 55)</th>
<th>(n = 90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>What I do in our regular science class is unrelated to my laboratory work.</td>
<td>3.62</td>
<td>3.80</td>
</tr>
<tr>
<td>8</td>
<td>The laboratory work is unrelated to the topics that I am studying in my science class. R</td>
<td>3.91</td>
<td>4.07</td>
</tr>
<tr>
<td>13</td>
<td>My regular science class work is integrated with laboratory activities.</td>
<td>3.63</td>
<td>4.04</td>
</tr>
<tr>
<td>18</td>
<td>I use the content from my regular science class session during laboratory activities.</td>
<td>3.85</td>
<td>3.81</td>
</tr>
<tr>
<td>23</td>
<td>The topics covered in regular science class work are quite different from topics with which I deal in laboratory sessions.</td>
<td>3.67</td>
<td>3.83</td>
</tr>
<tr>
<td>28</td>
<td>What I do in laboratory sessions helps me to understand the content covered in regular science classes.</td>
<td>3.64</td>
<td>3.93</td>
</tr>
<tr>
<td>33</td>
<td>My laboratory work and regular science class work are unrelated.</td>
<td>3.76</td>
<td>4.02</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.
The composite means scores of the *rule clarity* scale demonstrated that males and females had positive perceptions of guidelines established within the laboratory (see Table 18). Both males (M = 3.92) and females (M = 4.07) tended to perceive that the rules of the laboratory were often practiced. Individual scores on items within the scale indicate that both males (M = 4.35) and females (M = 4.41) scored Item 4, “My laboratory class has clear rule to guide my activities,” the highest. Item 24, “I find that the laboratory is hot and stuffy,” received the lowest mean score from males (M = 3.40) and females (M = 3.50).

Table 18

*Gender Perceptions of Rule Clarity Scale by Item*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statements</th>
<th>Males (n=55)</th>
<th>Females (n=90)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>4</td>
<td>My laboratory class has clear rules to guide my activities.</td>
<td>4.35</td>
<td>.75</td>
<td>4.41</td>
</tr>
<tr>
<td>9</td>
<td>My laboratory class is rather informal and few rules are imposed on me. R</td>
<td>3.65</td>
<td>1.25</td>
<td>3.58</td>
</tr>
<tr>
<td>14</td>
<td>I am required to follow certain rules in the laboratory.</td>
<td>4.29</td>
<td>.85</td>
<td>4.58</td>
</tr>
<tr>
<td>19</td>
<td>There is a recognized way for me to do things safely in this laboratory.</td>
<td>4.27</td>
<td>.80</td>
<td>4.52</td>
</tr>
<tr>
<td>24</td>
<td>There are few fixed rules for me to follow in laboratory sessions. R</td>
<td>3.40</td>
<td>1.39</td>
<td>3.50</td>
</tr>
<tr>
<td>29</td>
<td>The teacher outlines safety precautions to me before my laboratory sessions.</td>
<td>4.00</td>
<td>1.17</td>
<td>4.29</td>
</tr>
<tr>
<td>34</td>
<td>My laboratory class is run under clearer rules than my other classes.</td>
<td>3.49</td>
<td>1.17</td>
<td>3.67</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.
Research Question 3

As mentioned previously, the students enrolled in Principles of Biology I represent an array of different academic disciplines. It is for this reason Question 3 asked the following, “What academic discipline differences exist between student perceptions of the laboratory environment?”

In order to determine if differences were present, one-way analyses of variance (ANOVA) were conducted in which the academic disciplines were the independent variable and the scales of the SLEI were the dependent variables. Results from the Levene’s test for equality of variances for each independent variable indicated that homogeneity of variance was not violated. The outcomes of the analyses are summarized in Table 19.

Overall, students intent on majoring in the three academic streams all had similar perceptions of the perceived the laboratory environment and there was no significant statistical differences. A closer examination of the composite mean scores of each academic stream (allied health, STEM, non-science) indicated subtle differences between the academic streams perceptions of the practices in the laboratory setting. For instance, non-science (M = 4.11) stream students had slightly more positive opinions that the integration of lecture and lab materials occurred often in the class compared to the allied health (M = 3.94) and STEM (M = 3.72) stream students.
Table 19

*Academic Stream Perceptions of the Laboratory Environment*

<table>
<thead>
<tr>
<th>SLEI Scale</th>
<th>Allied Health (n = 80)</th>
<th>STEM (n = 43)</th>
<th>Non-science (n=22)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>4.15</td>
<td>4.17</td>
<td>4.16</td>
<td>.02</td>
<td>.98</td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>2.67</td>
<td>2.80</td>
<td>2.57</td>
<td>1.06</td>
<td>.34</td>
</tr>
<tr>
<td>Integration</td>
<td>3.94</td>
<td>3.72</td>
<td>4.11</td>
<td>2.04</td>
<td>.13</td>
</tr>
<tr>
<td>Rules Clarity</td>
<td>4.00</td>
<td>3.95</td>
<td>4.18</td>
<td>1.02</td>
<td>.36</td>
</tr>
<tr>
<td>Material Environment</td>
<td>4.12</td>
<td>4.00</td>
<td>4.07</td>
<td>.38</td>
<td>.68</td>
</tr>
</tbody>
</table>

Additional evaluations of the individual scale item mean scores reflect that whereas some items were viewed similarly across streams others were not. An analysis of the *student cohesiveness* scale (see Table 20) specified that STEM majors scored Item 31, “I work cooperatively in the laboratory sessions,” the highest. However, allied health (M = 4.73) and non-science (M = 4.68) majors scored Item 1, “I get along well with students in this laboratory class,” the highest. All academic streams perceived Item 26, “It takes me a long time to get to know everybody by his/her first name in the laboratory class,” the lowest.
### Table 20

**Perception of Student Cohesiveness by Academic Stream**

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>Allied Health</th>
<th>STEM</th>
<th>Non-science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>1</td>
<td>I get along well with students in this laboratory class.</td>
<td>4.73</td>
<td>.551</td>
<td>4.51</td>
</tr>
<tr>
<td>6</td>
<td>I have little chance to get to know other students in this laboratory class.</td>
<td>3.96</td>
<td>1.20</td>
<td>4.07</td>
</tr>
<tr>
<td>11</td>
<td>Members of this laboratory class help me.</td>
<td>4.34</td>
<td>1.01</td>
<td>4.33</td>
</tr>
<tr>
<td>16</td>
<td>I get to know students in this laboratory class well</td>
<td>4.13</td>
<td>1.08</td>
<td>3.93</td>
</tr>
<tr>
<td>21</td>
<td>I am able to depend on other students for help during laboratory classes.</td>
<td>3.96</td>
<td>1.23</td>
<td>4.21</td>
</tr>
<tr>
<td>26</td>
<td>It takes me a long time to get to know everybody by his/her first name in this laboratory class.</td>
<td>3.37</td>
<td>.43</td>
<td>3.65</td>
</tr>
<tr>
<td>31</td>
<td>I work cooperatively in laboratory sessions.</td>
<td>4.60</td>
<td>.756</td>
<td>4.56</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.

In general, academic stream student perceptions of the *open-endedness* scale were not favorable as indicated in Table 21. The composite mean score for this scale indicated that inquiry seldom takes place in the laboratory. Interestingly, the mean scores for Item 32 indicated that all academic streams believed that sometimes they were allowed to decide the best way to proceed during laboratory exercises. Similarly, the STEM and non-science streams perceived Item 27, “In my laboratory session, the teacher decides the best way for me to carry out the
laboratory experiments” least favorably which indicates that teachers direct the experiments. However, the allied health stream students perceived Item 22, “In my laboratory sessions, I do different experiments than some of the other students,” least favorably.

Table 21

*Perceptions of Open-Endedness by Academic Stream*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statement</th>
<th>Allied Health</th>
<th>STEM</th>
<th>Non-science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>2</td>
<td>There is opportunity for me to pursue my own science interest in this laboratory class.</td>
<td>3.61</td>
<td>1.25</td>
<td>3.37</td>
</tr>
<tr>
<td>7</td>
<td>In this laboratory class, I am required to design my own experiments to solve a given problem.</td>
<td>2.40</td>
<td>1.36</td>
<td>2.37</td>
</tr>
<tr>
<td>12</td>
<td>In my laboratory sessions, other students collect different data than I do for the same problem.</td>
<td>2.88</td>
<td>1.17</td>
<td>2.98</td>
</tr>
<tr>
<td>17</td>
<td>I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own.</td>
<td>2.27</td>
<td>1.31</td>
<td>2.49</td>
</tr>
<tr>
<td>22</td>
<td>In my laboratory sessions, I do different experiments than some of the other students.</td>
<td>1.86</td>
<td>1.21</td>
<td>2.47</td>
</tr>
<tr>
<td>27</td>
<td>In my laboratory session, the teacher decides the best way for me to carry out the laboratory experiments.</td>
<td>1.96</td>
<td>1.01</td>
<td>2.28</td>
</tr>
<tr>
<td>32</td>
<td>I decide the best way to proceed during laboratory experiments.</td>
<td>3.72</td>
<td>1.33</td>
<td>3.70</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.
Responses to the *integration* scale items (Table 22) indicated that allied health (M= 4.05) and non-science (M= 4.27) streams had the highest score for Item 8, “The laboratory work is unrelated to the topics that I am studying in class.” However, STEM (M=3.81) students had perceived Item 28, “What I do in laboratory sessions helps me to understand the content covered in regular science classes,” more favorably. There were differences among the academic streams in regards to which scale items were perceived least favorably. For example, the allied health stream (M = 3.76) perceived Item 3, “What I do in our regular class is unrelated to my laboratory work,” less positively. Whereas STEM majors (M = 3.53) viewed Item 33, “My laboratory work and regular science class work are unrelated,” the least. The non-science stream students (M = 3.59) regarded Item 28, “What I do in the laboratory sessions helps me to understand the content covered in regular science classes,” the least.
### Table 22

*Perceptions of Integration by Academic Stream*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statement</th>
<th>Allied Health</th>
<th>STEM</th>
<th>Non-science</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>What I do in our regular science class is unrelated to my laboratory work. R</td>
<td>3.76 1.27</td>
<td>3.56 1.33</td>
<td>3.95 1.21</td>
</tr>
<tr>
<td>8</td>
<td>The laboratory work is unrelated to the topics that I am studying in my science class. R</td>
<td>4.05 1.20</td>
<td>3.79 1.30</td>
<td>4.27 1.12</td>
</tr>
<tr>
<td>13</td>
<td>My regular science class work is integrated with laboratory activities.</td>
<td>3.88 1.20</td>
<td>3.77 1.13</td>
<td>4.14 .889</td>
</tr>
<tr>
<td>18</td>
<td>I use the content from my regular science class session during laboratory activities.</td>
<td>3.86 1.16</td>
<td>3.77 1.15</td>
<td>3.82 1.10</td>
</tr>
<tr>
<td>23</td>
<td>The topics covered in regular science class work are quite different from topics with which I deal in laboratory sessions.</td>
<td>3.85 1.21</td>
<td>3.56 1.31</td>
<td>3.91 1.20</td>
</tr>
<tr>
<td>28</td>
<td>What I do in laboratory sessions helps me to understand the content covered in regular science classes.</td>
<td>3.89 1.16</td>
<td>3.81 1.18</td>
<td>3.59 1.22</td>
</tr>
<tr>
<td>33</td>
<td>My laboratory work and regular science class work are unrelated. R</td>
<td>4.04 1.23</td>
<td>3.53 1.50</td>
<td>4.26 .767</td>
</tr>
</tbody>
</table>

Note. R denotes reverse scored item.

There were similarities and differences between the academic streams in regards to which *rule clarity* items received the highest and lowest mean scores (see Table 23). The allied health (M = 4.50) and non-science (M = 4.65) majors scored Item 14, “I am required to follow certain rules,” the highest. The STEM academic stream students (M = 4.35) scored Item 19, “There is a
recognized way for me to do things safely in this laboratory,” the highest. The lowest scored item for both the STEM (M = 3.07) and non-majors (M = 3.68) was Item 34, “My laboratory class is run under clearer rules than my other classes.” Whereas, Item 24, “There are few fixed rules for me to follow in laboratory session,” was the lowest for the allied health academic streams (M = 3.46).

Table 23
Perceptions of Rule Clarity by Academic Stream

<table>
<thead>
<tr>
<th>Items</th>
<th>Statement</th>
<th>Allied Health</th>
<th>STEM</th>
<th>Non-science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>4</td>
<td>My laboratory class has clear rules to guide my activities.</td>
<td>4.42</td>
<td>.911</td>
<td>4.26</td>
</tr>
<tr>
<td>9</td>
<td>My laboratory class is rather informal and few rules are imposed on me.</td>
<td>3.50</td>
<td>1.35</td>
<td>3.72</td>
</tr>
<tr>
<td>14</td>
<td>I am required to follow certain rules in the laboratory.</td>
<td>4.50</td>
<td>.779</td>
<td>4.33</td>
</tr>
<tr>
<td>19</td>
<td>There is a recognized way for me to do things safely in this laboratory</td>
<td>4.48</td>
<td>.763</td>
<td>4.35</td>
</tr>
<tr>
<td>24</td>
<td>There are few fixed rules for me to follow in laboratory sessions.</td>
<td>3.46</td>
<td>1.44</td>
<td>3.26</td>
</tr>
<tr>
<td>29</td>
<td>The teacher outlines safety precautions to me before my laboratory sessions.</td>
<td>4.16</td>
<td>1.09</td>
<td>4.07</td>
</tr>
<tr>
<td>34</td>
<td>My laboratory class is run under clearer rules than my other classes.</td>
<td>3.53</td>
<td>1.23</td>
<td>3.07</td>
</tr>
</tbody>
</table>

The physical appearance and quality of the equipment and materials of the laboratory were assessed on the material environment scale. The summary of item mean scores is
summarized on (see Table 24). All academic streams perceived Item 15, “I am ashamed of the appearance of this laboratory,” as seldom true based upon mean scores between 4.26 - 4.50. The results obtained from this item indicate that students were most pleased with the appearance of the laboratory and materials used in the laboratory. The allied health (M = 3.76) and STEM (M = 3.86) students both perceived Item 30, “The laboratory is an attractive place for me to work in,” the lowest. However, the mean item score for Item 5, “I find the laboratory is crowded when I am doing my experiments,” was scored the lowest by non-science majors (M = 3.77).

Table 24

*Perceptions of Material Environment by Academic Stream*

<table>
<thead>
<tr>
<th>Items</th>
<th>Statement</th>
<th>Allied Health</th>
<th>STEM</th>
<th>Non-science</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>I find that the laboratory is crowded when I am doing experiments.</td>
<td>3.93</td>
<td>3.88</td>
<td>3.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.20</td>
<td>1.33</td>
<td>1.23</td>
</tr>
<tr>
<td>10</td>
<td>The equipment and materials that I need for laboratory activities are readily available.</td>
<td>4.21</td>
<td>4.14</td>
<td>4.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.01</td>
<td>1.15</td>
<td>1.15</td>
</tr>
<tr>
<td>15</td>
<td>I am ashamed of the appearance of this laboratory.</td>
<td>4.45</td>
<td>4.26</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0</td>
<td>.964</td>
<td>.964</td>
</tr>
<tr>
<td>20</td>
<td>The laboratory equipment, which I use, is in poor working order.</td>
<td>4.14</td>
<td>3.87</td>
<td>4.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.24</td>
<td>.922</td>
<td>.92</td>
</tr>
<tr>
<td>25</td>
<td>I find that the laboratory is hot and stuffy.</td>
<td>4.04</td>
<td>3.77</td>
<td>4.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.24</td>
<td>1.01</td>
<td>1.10</td>
</tr>
<tr>
<td>30</td>
<td>The laboratory is an attractive place for me to work.</td>
<td>3.76</td>
<td>3.86</td>
<td>3.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.10</td>
<td>1.21</td>
<td>1.2</td>
</tr>
<tr>
<td>35</td>
<td>My laboratory has enough room for individual or group work.</td>
<td>4.35</td>
<td>4.23</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.03</td>
<td>1.20</td>
<td>1.20</td>
</tr>
</tbody>
</table>

*Note.* R denotes reverse scored item.
Research Question 4

In order to assess how the science laboratory environment relates to the scientific attitudes of students, Research Question 4 asked, “Are there significant differences between gender and academic disciplines as it relates to scientific attitude?” Examination of student attitudes toward science was determined by assessing student responses to the Test of Science Related Attitudes (TOSRA). The original survey instrument consisted of seven scales. However, only three were investigated in this study: 1) attitudes to scientific inquiry; 2) adoption of scientific attitudes; and 3) enjoyment of science lessons. The internal consistency of the three scales of the TOSRA was established and the results are presented in Table 25. The Cronbach’s alpha for the individual scales of the survey instrument ranged from .71 to .88. The reliability values obtained for each would not be improved if any items were deleted. Furthermore, these values are consistent with reliability values established by Fraser (1981). According to Fraser (1981), although these reliability coefficients are high for scales that contain 10 items, the values are large enough to indicate that each had adequate reliability.

Table 25

<table>
<thead>
<tr>
<th>Scales</th>
<th>Items (n= 10)</th>
<th>Cronbach’s alpha (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude to Scientific Inquiry in Science</td>
<td>1, 4, 7,10, 13, 16, 19, 22, 25, 28</td>
<td>.84</td>
</tr>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>2, 5, 8, 11, 14, 17, 20, 23, 26, 29</td>
<td>.71</td>
</tr>
<tr>
<td>Enjoyment of Science Lesson</td>
<td>3, 6, 9, 12, 15, 18, 21, 24, 27, 30</td>
<td>.88</td>
</tr>
</tbody>
</table>
The average item means and standard deviations for the TOSRA scales for the both gender and academic stream are presented in Table 26. As confirmed by the results, collectively, males and females exhibited similar mean scores that ranged between 3.52 - 3.98 for all three attitudinal scales. The results indicated that both males and females had moderately positive scientific attitudes. Similarly, the mean scores for STEM and non-science academic streams indicated that students had favorable opinions concerning inquiry, adoption of attitudes toward science, satisfaction of science lessons. However, allied health students (M = 4.0) scored the adoption of scientific attitude and enjoyment of science slightly higher when compared to the other two academic streams.

Table 26

<table>
<thead>
<tr>
<th>TOSRA Scale</th>
<th>Gender</th>
<th></th>
<th>Academic Streams</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Attitude to Scientific Inquiry</td>
<td>3.53</td>
<td>.75</td>
<td>3.54</td>
<td>.64</td>
<td>3.52</td>
</tr>
<tr>
<td>Adoption of Scientific Attitude</td>
<td>3.92</td>
<td>.54</td>
<td>3.88</td>
<td>.57</td>
<td>3.94</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>3.88</td>
<td>.76</td>
<td>3.72</td>
<td>.81</td>
<td>3.98</td>
</tr>
</tbody>
</table>
Further analyses (i.e., t-tests, ANOVAs) were used to discern if any statistical significance existed between the means of the academic streams, and males and females. Levene’s test for equality of variances was not violated in either parametric test. The results from the t-tests, summarized in Table 27, illustrated that there was a significant difference between males (M = 3.72) and females (M = 3.98) in the enjoyment of science lessons scale, $t(143) = -2.03$, $p = .043$. Cohen’s $d$ was used to determine that the effect size was modest ($d = .34$). These results indicate females enjoyed their science lessons more than their male counterparts did.

Table 27

<table>
<thead>
<tr>
<th>Scale</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitudes Toward Scientific Inquiry</td>
<td>3.54</td>
<td>.64</td>
<td>3.52</td>
<td>.82</td>
<td>.86</td>
</tr>
<tr>
<td>Adoption of Scientific Attitude</td>
<td>3.88</td>
<td>.57</td>
<td>3.94</td>
<td>.53</td>
<td>.58</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>3.72</td>
<td>.81</td>
<td>3.98</td>
<td>.71</td>
<td>.04*</td>
</tr>
</tbody>
</table>

*Note. $p < .05$

To determine if any mean differences existed between of the academic streams attitudes toward science, a one-way between groups ANOVA was conducted. The results of the test, found in Table 28, indicate that there was a statistically significant difference between the academic streams on the adoption of scientific attitude ($F(2, 142) = 1.425$, $p = .008$) and enjoyment of science lessons ($F(2, 142) = 4.212$, $p = .001$) scales. Consequently, Tukey’s HSD post-hoc test was used to further differentiate between the academic streams. The test results indicated there was a statistically significant difference between the attitudinal means of non-
science stream students toward *adoption of science attitudes* ($M = 3.60$) and *enjoyment of science lessons* ($M = 3.31$) when compared to allied health ($M = 4.0, M = 4.0$) and STEM ($M = 3.94, M = 3.97$) academic streams, respectively.

Table 28

*Results for ANOVA Test for Attitudes Toward Science Within Academic Streams*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STEM</td>
<td>Allied Health</td>
<td>Non-science</td>
</tr>
<tr>
<td>Attitudes Toward Scientific Inquiry</td>
<td>3.59</td>
<td>3.60</td>
<td>3.18</td>
</tr>
<tr>
<td>Adoption of Scientific Attitude</td>
<td>4.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.60&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>4.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.31&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>*Note. p < .05</sup>

*Note: Means in a row sharing superscripts are significantly different.*

A $3 \times 2$ ANOVA was conducted to determine the effects of academic major and gender on the three TOSRA scales. There was homogeneity of variance between groups as assessed by Levene’s test for equality of variances. The ANOVA results, summarized in Table 29, indicated that there were no significant interactions between gender and academic streams. The results are as follows: *attitude to scientific inquiry*, $F (2, 139) = .641, p = .52$, partial $\eta^2 = .01$; *adoption of scientific attitude*, $F (2, 139) = .262, p = .770$, partial $\eta^2 = .00$; and *enjoyment of science lesson*, $F (2, 139) = .189, p = .82$, partial $\eta^2 = .00$.

However, there were significant main effects for the academic majors on each scale: *attitude to scientific inquiry*, $F (2, 139) = 3.32, p = .039$, partial $\eta^2 = .05$; *adoption of scientific attitude*, $F (2, 139) = 3.84, p = .024$, partial $\eta^2 = .05$; and *enjoyment of science lessons*, $F (2, 139)$
= 7.17, \( p = .00 \), partial \( \eta^2 = .09 \). The statistical significance of the data extracted from the academic majors’ main effect suggests that a student’s major can impact their attitude toward science as it relates to inquiry, adoption of attitude toward science related tasks, and overall enjoyment of science lessons. Follow-up analyses were conducted to determine the cause of the noted effect within the three academic streams on each attitudinal scale.

Table 29

Two-Way ANOVA for Academic Streams and Gender Differences on TOSRA

<table>
<thead>
<tr>
<th>TOSRA Scale</th>
<th>Gender</th>
<th>Academic Stream</th>
<th>Gender X Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude Toward Scientific Inquiry</td>
<td>.128</td>
<td>3.32*</td>
<td>.641</td>
</tr>
<tr>
<td>Adoption of Scientific Attitude</td>
<td>.019</td>
<td>3.83*</td>
<td>2.62</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>3.20</td>
<td>7.17*</td>
<td>.189</td>
</tr>
</tbody>
</table>

Note: *\( p < .05 \)

Pairwise comparisons were conducted and post-hoc test (Tukey HSD) analysis was used to control for Type I error. Results from the analysis, summarized in Table 30, revealed statistical significance exists between the non-science major academic stream and the allied health and STEM majors streams on all three attitudinal scales. The non-science majors (\( M = 3.1 \)) had a less favorable view toward attitude to scientific inquiry when compared to allied health (\( M = 3.9 \)) and STEM majors (\( M = 3.9 \)). Likewise, on the adoption to scientific attitude scale there was a significant difference between non-science majors (\( M = 3.60 \)) when compared to allied health (\( M = 3.9 \)) and STEM majors (\( M = 3.9 \)). This pattern continued and was observable on the last scale, enjoyment of science lessons as indicated by the non-science majors’ mean of 3.3 and allied health and STEM majors both having means of 3.9. These results
suggested that a significant difference in academic streams was primarily due to non-science major students because the means for the allied health and STEM majors were almost identical statistically.

Table 30

*Pairwise Comparison of Academic Major Main Effect*

<table>
<thead>
<tr>
<th>TORSA Scale</th>
<th>Allied Health</th>
<th></th>
<th>STEM</th>
<th></th>
<th>Non-science</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>p</td>
<td>M</td>
<td>p</td>
<td>M</td>
<td>p</td>
</tr>
<tr>
<td>Attitude Toward Scientific Inquiry</td>
<td>3.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.95</td>
<td>3.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.95</td>
<td>3.1&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>.02*</td>
</tr>
<tr>
<td>Adoption of Scientific Attitude</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.74</td>
<td>3.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.74</td>
<td>3.6&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>.01*</td>
</tr>
<tr>
<td>Enjoyment of Science Lessons</td>
<td>3.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.98</td>
<td>3.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.98</td>
<td>3.3&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>.00*</td>
</tr>
</tbody>
</table>

*Note.* p < .05

*Note.* Means in columns sharing superscripts are significantly different.

**Research Question 5**

The last objective of this study was to determine what associations existed between student perceptions of the laboratory environment and their scientific attitudes. The analyses that were used to determine the relationships between the scales of the TORSA (dependent variable) and the SLEI (independent variable) were simple correlation (Pearson) and multiple regressions. Simple correlations were conducted initially to investigate if any associations existed between the scales of the TORSA and the SLEI scales. The simple correlation analysis was followed up with multiple regressions on each attitudinal scale to establish if any of the SLEI scales were significant predictors of students’ attitudes toward science.
The results from the simple correlation (see Table 31) disclose that 12 out of 15 correlations were statistically significant ($p < .05$) between the three scales of the TOSRA and the five SLEI scales. *Attitude to scientific inquiry, adoption of scientific attitude, and enjoyment of science lessons* were all statistically significant to the four SLEI scales of *student cohesiveness, integration, rule clarity, and material environment*. The significant correlations range from .17 to .32. The correlations between *attitude to scientific inquiry* and *student cohesiveness* ($r(143) = .20$), *integration* ($r(143) = .03$), *rule clarity* ($r(143) = .18$), and *material environment* ($r(143) = .24$) were significant. The correlations between *adoption of scientific attitude* and *student cohesiveness* ($r(143) = .32$), *integration* ($r(143) = .29$), *rule clarity* ($r(143) = .27$) and *material environment* ($r(143) = .30$) were also significant. The third attitudinal scale, *enjoyment of science lessons*, demonstrated statistically significant correlations with *student cohesiveness* ($r(143) = .28$, *integration* ($r(143) = .20$), *rule clarity* ($r(143) = .28$) and *material environment* ($r(143) = .26$) as well. However, there were no significant correlations between any of the attitudinal scales and the laboratory environment scale of *open-endedness*. These results indicated that there is a positive, albeit weak, relationship between the scales of the TOSRA and all of the SLEI scales with the exception of *open-endedness*. However, these results did not indicate how the variables influence one another, therefore multiple regression analyses were conducted.

Multiple regression analysis using the enter method was conducted to evaluate how well the events that occur in the laboratory classroom environment predicted student attitudes. Results from the multiple regression analysis revealed that linear combination of the predictor variables (SLEI scales) were significantly related to *attitudes to scientific inquiry* ($R^2 = .078$, $R^2_{adj} = .045$, $F_{5, 139} = 2.366$, $p = .043$). However, the linear strength of the model was poor and the
scales of the SLEI were not significant independent predictors of attitudes toward scientific inquiry. The results from the multiple regression analysis for adoption of scientific attitude indicated that the linear combination of predictor variables were significantly related ($R^2 = .144$, $R^2_{adj} = .113$, $F_{5, 139} = 4.66$, $p = .001$). The linear strength of the relationship was modest; however, the scales of the SLEI were not significant independent predictors of adoption of scientific attitudes. The results from the multiple regression analysis for enjoyment of science lessons revealed that the linear combination of predictor variables were significant ($R^2 = .111$, $R^2_{adj} = .079$, $F_{5, 139} = 3.45$, $p = .001$). However, the strength of the model was poor. The results also indicated, similar to the other multiple regression analysis, none of the SLEI scales were independent predictors of students’ attitudes toward Enjoyment of Science Lessons.

Interestingly, although the models were significant for each attitudinal scale, the data did not support results from previous research studies that served as models for this investigation (Henderson Fisher & Fraser, 2000; Quek, Wong, & Fraser, 2005; Wolf & Fraser, 2007; Fraser & Lee, 2009) in which specific scales of the SELI were independent predictors of attitudinal scales.

Although it was a divergence from Research Question 5, the researcher determined that it was important to identify what variables, if any, were independent predictors of student attitudes toward science. This perceived irregularity, prompted a second regression analysis in which the two remaining independent variables, gender and academic major were used in the analyses. Previous results had revealed that attitudinal means of STEM and Allied Health academic streams were very similar. Therefore, these two groups were combined to create a single academic stream, AlliedSTEM, thus preventing the need to dummy code the three academic streams. The results from multiple regression analysis (see Table 32) specified that the academic streams were the only statistically significant predictors of the TOSRA scales: attitude towards
scientific inquiry ($R^2 = .124$, $R^2_{adj} = .079$, $F_{7, 137} = 2.758$, $p = .010$); adoption of scientific Attitude ($R^2 = .218$, $R^2_{adj} = .178$, $F_{7, 137} = 5.468$, $p = .001$); and enjoyment of scientific lessons ($R^2 = .240$, $R^2_{adj} = .202$, $F_{7, 137} = 5.468$, $p = .001$). The results from this regression model suggest that a student’s chosen major is the most statistically significant predictor of their attitude toward science, although it is a negative relationship.
<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Student Cohesiveness</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Open-Endedness</td>
<td>-.015</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Integration</td>
<td>.389**</td>
<td>-.180*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Rule Clarity</td>
<td>.582**</td>
<td>.019</td>
<td>.580**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Material Environment</td>
<td>.582**</td>
<td>-.159</td>
<td>.564**</td>
<td>.487**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Attitude Toward Scientific Inquiry</td>
<td>.205*</td>
<td>.037</td>
<td>.176*</td>
<td>.183*</td>
<td>.242**</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Adoption of Scientific Attitude</td>
<td>.320**</td>
<td>-.051</td>
<td>.268**</td>
<td>.277**</td>
<td>.305**</td>
<td>.534**</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>8. Enjoyment of Science Lesson</td>
<td>.276**</td>
<td>-.030</td>
<td>.203**</td>
<td>.283**</td>
<td>.259**</td>
<td>.499**</td>
<td>.739**</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: * p < .05, ** p < .01
Table 32

**Simple Correlation and Multiple Regression Analysis for Associations Between Attitudes Laboratory Environment and Academic Streams.**

<table>
<thead>
<tr>
<th>SLEI Scale</th>
<th>Attitude to Scientific Inquiry</th>
<th>Adoption of Scientific Attitudes</th>
<th>Enjoyment of Science Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>β</td>
<td>r</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>.20*</td>
<td>.12</td>
<td>.32*</td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>.03</td>
<td>.09</td>
<td>-.05</td>
</tr>
<tr>
<td>Integration</td>
<td>.20*</td>
<td>.09</td>
<td>.29*</td>
</tr>
<tr>
<td>Rule Clarity</td>
<td>.18*</td>
<td>.13</td>
<td>.27*</td>
</tr>
<tr>
<td>Material Environment</td>
<td>.24*</td>
<td>.11</td>
<td>.30*</td>
</tr>
<tr>
<td>Academic Major</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-.21*</td>
<td></td>
<td>-.27*</td>
</tr>
<tr>
<td>R^2</td>
<td>.12</td>
<td></td>
<td>.22</td>
</tr>
<tr>
<td>R^2 Adjusted</td>
<td>.07</td>
<td></td>
<td>.17</td>
</tr>
</tbody>
</table>

Note: * p< .05

**Summary**

Chapter IV presented a detailed analysis of the research questions that were presented for this investigation. It was determined that the majority of students that enrolled in the Principles of Biology course are allied health majors, followed by STEM and non-science majors. Additionally, women comprise the majority of students taking the course. Overall, students had positive perceptions of the laboratory environment. However, there was no statistically significant difference between males and females with the exception of the Material Environment Scale of the Science Laboratory Environment Instrument. An examination of the
three academic streams perceptions of the laboratory revealed, regardless of a student’s chosen discipline, their perceptions of the laboratory were not statistically significant from one another.

This study also evaluated students’ attitudes toward science and attempted to discern if differences existed between gender and academic streams. In general, student’s scores on the Test of Science Related Attitudes survey instrument indicated that students had positive attitudes toward inquiry, adoption of scientific attitudes, and enjoyment of science lessons. Nevertheless, additional statistical analyses indicated that there was a statistically significant difference in attitudes between allied health and STEM students when compared to non-science majors.

Lastly, the final objective of this investigation was to determine if the science laboratory environment could encourage positive attitudes toward science. The results from the study specified that there were significant correlations between all of the scales of the SLEI and the TORSA with the exception of *open-endedness*. However, results from multiple regression analysis revealed that a single independent predictor of student attitudes was not present. Further analysis of all independent variables, gender and academic stream, revealed that the only statistically significant predictor of students attitudes toward science was their chosen academic stream.

The following chapter will interpret these research findings as discuss what the implications for practice, policy, and future research.
CHAPTER V:
SUMMARY, DISCUSSIONS, AND CONCLUSION

This chapter presents a summary of the results obtained from the five research questions addressed in Chapter IV. Conclusions will be drawn that either support or contradict previous research findings in related literature. The chapter concludes with implications for practice and future research.

Study Summary

The science laboratory has been included as an element of the American science curriculum since the mid 1800s (Singer, Hilton, & Schweingruber, 2005). This component provides opportunities for students to gain knowledge through experimental processes. It is through not only experimentation but also exploration within the laboratory that principles of the scientific method are introduced to students. These principles include making observation, generating hypothesis, conducting experiments, and interpreting data. This type of inquiry and activity-based learning is believed to provide students with greater comprehension of the lecture content, improve attitudes toward subject matter, and lessen forgetting (Aladejana & Aderribigbe, 2007). Furthermore, there is a national and global need to produce individuals who are knowledgeable in the sciences (National Science Foundation, 2004). These individuals are needed to fill future workforce shortages in STEM related fields.

Although the science laboratory position is firmly rooted within the majority of science curriculum its importance is not without critics. Hofstein and Lunetta (2004) have reported that the laboratory does not improve student-learning outcomes, attitudes toward science, or
achievement. National organizations have also recognized these shortcomings as well and recommended that changes be made to improve laboratory instruction K12 and higher education (National Research Council, 1996; American Association for the Advancement of Science, 1993).

In order to learn more about what types of laboratory settings are most conducive to positive student outcomes, studies that focused specifically on the laboratory classroom environment have provided data that suggests that student-learning outcomes can be improved if the environment was supportive and engaging to students (Aladejana & Aderribigbe, 2007). Classroom environment research has produced a number of widely used survey instruments for evaluating students’ perceptions of the classroom environment (Dorman, 2002; Fraser, 1998). More specifically, the Science Laboratory Environment Instrument (SLEI) has been utilized often to assess student perceptions of the laboratory and demonstrate associations with achievement and attitudes toward science. Consequently, the purpose of this study was three-fold. The first objective was to evaluate what student perceptions of their laboratory environment and determine if their views differed based upon gender and academic discipline. Secondly, this investigation wanted to explore students’ attitudes toward science and distinguish if differences existed between academic majors and gender. Assessing students’ attitudes toward science was accomplished by using the Test of Science Related Attitudes Survey Instrument (TOSRA). Lastly, the researcher wanted to discern if student perceptions of the laboratory were related to the affective outcome of attitudes toward science.

Although a number of studies have been conducted, that have evaluated student perceptions of the laboratory and attitudes toward science, the vast majority of sample populations have been K12 students and four-year institutions. However, the literature lacked
data from the community college sector. Therefore, the student population that was the focus of this study consisted of community college students enrolled in ten sections of an introductory biology course, Principles of Biology I, during the spring 2012 semester. The course is the first of a two-semester course sequence that is specifically for science majors. The course provided students with foundational biological principles that include physical, chemical, and biological principles common to all organisms. These principles were taught through the study of cell structure and function, cellular reproduction, basic chemistry, cell energetics, photosynthesis, and Mendelian and molecular genetics. The laboratory exercises, assigned from Vodopich and Moore’s (2010) The Biology Manual, were chosen to reinforce those principles taught in lecture component of the course. During the semester, students were assessed on their understanding of laboratory procedures and exercise content via laboratory practicals. Although study participants may have had different instructors all were exposed to the same thirteen laboratory exercises within the semester. The laboratory exercises consisted of activities that included investigative, directive, and thematic procedures.

Students were divided demographically by gender and intended major. The academic majors were divided into three streams: allied health, STEM, and non-science major. The majority of the students enrolled in the course were females (62%) and males (38%) comprised the minority. These percentages closely resembled the total enrollment of females (60%) and males (40%) at Jefferson State Community College during the Spring 2012 semester. Students that were enrolled in the course were pursuing degrees in a wide variety of academic fields. Students pursuing degrees in allied health (55%) comprised the largest number of students enrolled in the course followed by STEM (36%) and non-science (15%). The majority of the
students in the allied health stream were seeking degrees in the associate nursing program at the college.

Quantitative methods were used to assess student opinions of their laboratory environment and attitudes toward science. Reliability for both survey instruments was established. The reliability of each SLEI scale was within a range of .69 - .79. This range is slightly lower than that obtained in a cross-national survey of universities and schools (.70 - .83) (Fraser & McRobbie, 1995). Additionally, the internal consistency for the three TOSRA scales used in this study was between .71 -.88. Therefore, reliability for these two instruments was confirmed with this community college student population.

**Discussion**

**Student Perceptions of the Laboratory**

The first research question in this investigation sought to determine introduction biology students’ perceptions of the laboratory environment. Collectively, Principle of Biology I students had favorable perceptions of their laboratory environment. The *student cohesiveness* scale received highest mean score (M = 4.16). Students were of the opinion that cohesiveness and camaraderie within the laboratory environment was often present. Researchers have noted that positive interactions among students in the laboratory have the potential to enhance cognitive learning and promote positive attitudes toward science (Hofstein & Lunetta, 1982; Lazarowitz & Tamir, 1994; Lunetta, 1998). Although students are a given the choice to work independently of one another, this seldom does this occur. The atmosphere and physical design of the laboratory classroom encourages cooperative learning.

Students also had favorable perception of the *material environment* (M = 4.07). This scale measured the extent to which the student perceived that the laboratory equipment and
materials were adequate. This result indicated that students found that there was sufficient space in the laboratory, the equipment was readily available, and the classroom were physically appealing. It should be noted that the laboratory classrooms were renovated or newly constructed within the past six years. On the two larger campuses there is one room designated for the teaching of the Principles of Biology I laboratories. The two smaller campus sites must share their laboratory space with four other science courses. These two site laboratories have considerably more equipment and biological specimens within one space are well organized. Nevertheless, students at these sites perceived the materials environment equally as well as the students at the larger campuses did.

The establishment of rules and expectation within the laboratory was perceived positively by students as indicated by mean score on the rule clarity (M = 4.01) scales. At the beginning of each semester students are asked to read and sign a biological sciences laboratory guidelines contract. This contract contains twelve rules that outline what is expected of each student during laboratory sessions. These expectations included laboratory preparedness, proper attire, unauthorized experiments, and sterile techniques. Failure to comply with the guidelines can result in a student being dismissed from the laboratory classroom. Additionally, at the beginning of each lab all instructors review the foundations of the laboratory exercises that will be completed during that session and review any specific rules that are associated with the specific laboratory exercise. Instructors who find that students are rarely prepared to begin laboratory exercises without assistance deem this introduction of procedural content necessary.

The integration of lecture content and laboratory activities is important in science education. However students in this study were of the opinion that this occurred sometimes, often, but not always. Because integration does not occur always, this may lead to a decrease in
students understanding the relevancy of the laboratory exercises and comprehension of the biological principles being studied in lecture. Students may have had this perception because the laboratory schedule is determined at the beginning of the semester. Therefore, all students completed each laboratory exercise during a specific week during the semester. Certain weeks did not include laboratory classes in order to give instructors time to assess students via lab practicals. Furthermore, instructors had autonomy to teach the course content in the order that they desired. Therefore, this may have led to an instructor introducing a specific principle before or after the scheduling of the related laboratory exercise.

The scale that received the lowest level was *open-endedness* (M = 2.69). This scale measured if students perceive that the laboratory exercises emphasize an open-ended approach to experimentation. Students’ reported that designing their own experiments or making decisions about how an experiment should be conducted was seldom allowed. The experiments that the Principle of Biology I students complete are pre-set by a laboratory coordinator that ensures that all materials are ready and available to the students once they begin the lab. Although there are experiments that allow for further experimentation, which is open-ended, these types of activities are only completed in one laboratory exercise, *Biologically Important Molecules*. Additionally, although this rating is low, it does support similar findings from other laboratory environment studies (Fraser & Lee, 2009; Fraser & McRobbie, 1995; Fraser & Wong 1996; Waldrip & Wong, 1996). This data also confirms that there is still is a lack of inquiry based laboratory activities which would allow student to be involved in the planning, designing, and interpretation of experiments which is fundamental to the process of learning science.
Gender Differences in Laboratory Perceptions and Attitudes Toward Science

Gender differences in the STEM academic disciplines and careers have existed for decades. Historically, females have been underrepresented and initiatives have been implemented to increase female retention in these areas (Taylor, Erwin, Ghose, & Thornton, 2001). Many of these initiatives focus on early exposure, especially in K-12, to science related activities in order to increase females interest in the sciences. The experiences that females encounter within the laboratory are important in garnering and sustaining interest. Whereas data also suggests that both genders benefit from hands-on activities, research has shown these types of laboratory experiences are more beneficial to females and thus can potentially promote and increase gender equity in the sciences (Burkam, Lee, & Smerdon, 1997). Therefore, it was important to evaluate if dissimilarities between males and females were present in this investigation. Research Question 2 and a segment of Research Question 4 both sought to analyze if there were statistically significant differences between males and females as it relates to laboratory perceptions and attitudes toward science, respectively. In order to assess Research Question 2, “What gender differences exist between student perceptions of the laboratory environment,” independent t-tests were conducted. The results demonstrated that males and females viewed the laboratory similarly with the exception of the material environment scale. Collectively, these results suggest that males and females equally perceive that there is cohesiveness, integration of classroom content, definitive rules, and lack of open-endedness. However, females (M = 4.20) perceptions of the equipment and materials utilized in the laboratory were more favorable than their male (M= 3.87) classmates.

This significant difference in the material environment scale suggests that males who may have tendencies to fix objects and seek action oriented activities (Ferenga & Joyce, 1997)
were not positively influenced by the usage of biological equipment and materials or the classroom space used during the laboratory sessions. Conversely, females are less likely to be involved in science-orientated activities or participate in action-oriented task. Therefore, the use of the equipment (microscopes, pipettes, and spectroscopes) and the classroom space may have appeared novel and perceived more positively.

Quek, Wong, and Fraser (2002) obtained comparable results on the material environment scale. In an investigation of gender differences within the chemistry laboratory, they found that males viewed that the laboratory was less equipped when compared to females. The authors concluded that males tended to be much less task orientated therefore they paid less attention to their physical environment. Interestingly, the lack of statistical significance of the other SLEI scales did not support other research findings (Henderson, Fisher, & Fisher, 2000; Wong & Fraser, 1994). However, results from a more recent study by Ozkan, Cakiroglu, and Tekkaya (2008) concluded that no gender differences existed between the genders on any SLEI scale. They suggested that further research may be necessary to confirm these finding and this may be true of this study as well.

A segment of Research Question 4, asked if significant differences existed between males and females attitudes toward science. Results obtained from independent t-test analysis disclosed that on two of the three TOSRA scales, attitude toward scientific inquiry and adoption of scientific attitude, males and females had similar attitudes toward science. However, there was a statistically significant difference between males and females on the enjoyment of science lessons scale. These results were interesting considering that males have been found to have scientific attitudes that are more positive when compared to females (Weinbburgh, 1995). However, the significance between males and females on the enjoyment of science lessons
supports research that suggests females tend to have favorable attitudes toward biological science when compared to males who favor physical science (Benbow & Moore, 1986). The lack of significance on the other two scales may imply that community college students enrolled in a major’s course, no longer exhibit substantial differences in attitudes when compared to secondary students used in the aforementioned studies. Results from Kotte (1992) suggested that the greatest increase in gender differences in the science occurs between the ages of 10 -14 years. Therefore, it is conceivable these difference decrease as student’s age and enter college.

**Academic Stream Differences in Laboratory Perceptions and Attitudes toward Science**

A student’s scientific attitude is an affective outcome that is often studied in learning environment research (Fisher, Henderson, & Fraser, 1997; Fraser & Lee, 2009; Wong & Fraser, 1994). Results from these studies have shown that experiences in the laboratory can promote positive attitudes toward science. Both Research Questions 3 and 4 explored differences among the three academic streams within the laboratory environment and attitudes toward science, respectively. Research Question 3 asked, “What academic discipline differences exist between student perceptions of the laboratory environment?” Results obtained from ANOVA analysis indicated that there were no statistically significant differences in perceptions of the laboratory between the different academic streams. The absence of statistical differences most likely can be contributed to fact that the majority of the students, allied health and STEM, are on science related academic tracts. Fraser and Lee (2009) also examined differences between three academic streams, humanities, science-independent, and science-dependent. The researchers found that there was only one SLEI scale that students viewed similarly, Integration. However, there were subtle but significant differences on all the other scales. The authors concluded that the noted differences might be contributed to differences in student abilities or curriculum.
Therefore, the opposite may be true in this investigation, and similarities in foundational academic curriculum may decrease the likelihood of significant differences among the majority of the students enrolled in the course.

A segment of Research Question 4 asked if there were significant differences between academic disciplines as it related to attitudes toward science. The overall mean for each attitudinal scale indicated that students had positive attitudes toward science on all three attitudinal scales. However, unlike the results from Research Question 3, ANOVA results revealed that non-science majors’ attitudes toward science were significantly different from allied health and STEM students. Statistically-significant results were noted on both the adoption of science attitudes and enjoyment of science lessons. In both instances, non-science majors had less favorable attitudes when compared to the other academic streams. Further analysis investigated if there were any significant interactions between gender and academic streams as it related to attitudes toward science. Although the results yielded no significant interactions, there were statistically significant main effects for academic streams on each attitudinal scale. The greatest significance was obtained from the enjoyment of science lessons scale. The results from the remaining two scales, adoption of science attitudes and attitude toward scientific inquiry revealed that non-science majors viewed conducting experiments and inquiry based activities less positively when compared to the other academic streams. This is understandable considering that non-science majors are only taking the course to meet degree requirements and do not need to continue to enroll in upper level science courses. Additionally, non-science majors may have poorer attitudes toward science because they may find themselves worried or anxious about the subject matter (Steiner & Sullivan, 1984). Whereas these students do not intend on gaining more scientific content though additional classes it may be more
important to help cultivate more favorable attitudes toward science (Waggoner, Schaffner, & McArthur, 2004).

Many colleges and universities offer different courses for science and non-science majors. The assumption by most biology instructors is that non-science majors tend to have different knowledge backgrounds, approaches to biology classes, and attitudes towards science (Knight & Smith, 2010). Furthermore, studies have shown that nursing students, who often enroll in foundational science courses, have anxiety (Nicoll & Butler, 1996) and often find these courses difficult (Caon & Treqgust, 1993). The Principles of Biology I course, which is the focus of this study, is a science major’s biology course. As indicated by previous enrollment data and academic stream percentages obtained from this study, the majority of students enrolled in the course are allied health majors. Therefore, it is important that the lecture and laboratory classes are taught in a manner that engages all students and leads to the possibility of improving scientific attitudes. This is of special significance considering that there has been and continues to be a call to decrease the overwhelming scientific literacy that is apparent in the United States (Cook & Mulvihill, 2008).

**Associations between Laboratory Environment and Student Attitudes toward Science**

Previous research has shown a strong association between students’ affective learning outcomes and the characteristics of the classroom environment (Fraser, 1994). Therefore, the final goal of this study was to determine if associations exist between student perceptions of the laboratory environment and students attitudes toward science. Research Question 5 addressed this objective of the study. Simple correlation analysis revealed that the *student cohesiveness*, *integration*, *rule clarity* and *material environment* scales were statistically correlated with all three attitudinal scales resulting in twelve out of fifteen significant positive correlations.
However, the *open-endedness* scale was not statistically correlated with any of the attitudinal scales. In contrast, results reported by Quek, Wong, and Fraser’s (2005) in their investigation of the chemistry laboratory environment in Singapore schools revealed that *open-endedness* was positively correlated with the *attitude to scientific inquiry* scale. The *open-endedness* scale has also been found to be positively correlated *social implications of science* and *attitude to scientific inquiry* in a study of laboratory environment in Korean high schools (Fraser & Lee, 2009).

Therefore, the results from this population of students are to some extent different from those obtained in past studies.

In order to determine which SLEI scales were predictors of student attitudes toward science multiple regression analysis was conducted. Interestingly, none of the SLEI scales were independent predictors of any of the attitudinal scales. In contrast, in their cross-national study of university science laboratory classrooms Fraser et al. (1992) found that with the exception of the *open-endedness* scale significant positive relationships between the SLEI scales and student attitudes toward science were present. Quek et al. (2005) found *student cohesiveness* and *rule clarity* were a statistically independent predictor of *adoption of scientific attitudes* in chemistry and *attitude to scientific inquiry*, respectively.

The lack of the emergence of any independent predictors of scientific attitudes was different from what has been reported previously. Therefore, a second multiple regression analysis was conducted to determine what factors could be predictors of students’ attitudes within this student sample. The independent variables of gender and academic major stream were included in the second analysis. The allied health and STEM majors were combined because their attitudinal means were very close on all of the TOSRA scales. This led to creation of a dichotomous variable and negated the need for dummy coding on the academic streams.
independent variable. The results from this analysis provided a clearer analysis and revealed that academic major was the only statistically significant predictor of student attitudes toward science in this study.

Overall, the linear combinations of scales of the SLEI were found associated with each of the TORSA scales. These results support past research that has shown positive associations between the laboratory environment and students’ attitudes toward science. However, these findings failed to indicate any specific independent predictors of student attitudes. The results suggest that none of the SLEI scales uniquely accounts for student attitudes within this specific student sample. Although Fraser and Lee’s (2009) previous learning environment study examined differences in academic streams, an analysis of the academic stream as a predictor of student attitudes was not conducted. However, this study conducted further analysis in order to determine if academic streams or gender were predictors of students attitudes toward science. The results revealed that academic streams were the only significant predictor of attitudes. These results suggest that major does matter in regards to positive or negative attitudes toward science. Most non-science majors have no personal interest in science (Smith, Gould, & Jones, 2004) and may not achieve a deep understanding of science related content (Cook & Mulvihill, 2008). Furthermore, it could be implied that non-majors attitudes toward science are directly influenced by their belief system and values about science (Halaadyna & Shaughnessey, 1982) which one could easily conceive as different from students that intend on majoring in disciplines that require a number of science courses within the curriculum.

Recommendations for Practice

The results from the study revealed that overall Principle of Biology I students have favorable perceptions of their laboratory environment and that their chosen academic major is a
significant predictor of attitudes toward science. The results also point out that students do not get the experience of open-ended activities in the laboratory. Although integration of laboratory and lecture does occur, it does not happen as frequently as it should. Furthermore, the results from this study indicate an overwhelming difference in the attitudes of non-science majors when compared to the other two academic streams. In order to address these issues at Jefferson State Community College, a prescribed course of action for the implementation of inquiry based laboratory classes, increased integration, and improving non-science major’s attitudes is described.

**Inquiry Centered Laboratory Classes**

Inquiry based activities would allow students to construct learning of scientific concepts through exploration and discussion and increase open-endedness in the laboratory. Students would be responsible for identifying a problem based on a set of parameters, conducting the experiment, and analyzing and presenting the results. This method of instruction would initially require considerably more effort by both the instructor and the student when compared to the traditional laboratory exercises. Therefore, it is recommended that instructors are trained in this method of instruction before implementation of inquiry laboratory exercises. The National Research Council (2000) identified four professional development standard categories for instructors who are interested in acquiring skills in inquiry-based learning:

1. Learn Science through Inquiry;
2. Learn to Teach Science through Inquiry;
3. Become Lifelong “Inquirers”; and
4. Build professional development programs of Inquiry based teaching.
These categories center on professional development, which is the most vital manner to gain knowledge about this type of instruction. However, in lieu of budgetary constraints that may prevent extensive professional development, online resources and publications (Haury & Rillero, 2004) could be utilized to explore various pedagogies to help train instructors.

It is also recommended that a laboratory manual that emphasizes inquiry-based activities be adopted for use in the laboratory classroom. Faculty members and lab coordinators may produce the lab manual internally or a quality manual may be chosen after a committee selection process. This step in the process is important to ensure that there is divergence from laboratory exercises that contain “recipes” that allow students simply to collect and record data without any comprehension of what the exercise was about or its relevancy to the lecture content. It should be emphasized that students effectively learn how to communicate their understanding of the results they obtain from the laboratory activities. Traditionally students write reports that outline the purpose, materials, methods, results and conclusion of the exercise. This method is a standard that enables students to report data like scientist in order to provide the information necessary for others to replicate and validate their results (Cacciatore, 2006). Although this format may help students learn laboratory procedures, they may learn little else (Hofstein & Lunetta, 1982; Lazarowitz & Tamir, 1994). Therefore, another approach that is recommended for practice is the, science heuristic writing approach. This approach includes not only writing, but also combines collaborative work, and inquiry-based labs (Burke & Greenbowe, 2006).

According to Burke and Greenbowe (2008), the science heuristic writing method allows students to ask their own questions that are directly linked to an experiment. After the questions are developed, students work together in small groups (collaboration) to design the experiment and synthesize the data. Once the data is collected groups discuss, argue, or negotiate their
claims and evidence with the entire class (Yoon, Bennett, Mednez, & Hand, 2010). Afterwards, students are allowed to reflect about how their thoughts may have been confirmed or changed as a result of completing the activity. Throughout this process, students are guided by their instructor and have the encouragement and assistance of their peers. This recommendation will further support inquiry in the laboratory and allow the students to have a better understanding of concepts presented in lab.

**Assessment of Laboratory Activities**

Students that do not have experience with inquiry-based methods of instruction will need support through feedback provided by continuous assessment of their progress (Waggoner et al., 2004). Similarly, instructors need the results from assessments in order to evaluate the successes and or failures of the activities conducted in the laboratory. Therefore, accountability through evaluation of student learning outcomes is recommended. In recent months at Jefferson State Community College has been implementing new procedures in order to prepare for reaccreditation by the Southwestern Association of Colleges and Schools. This approaching visit has prompted revisions of all course objectives and competencies in every discipline. Interestingly, whereas competencies and objectives exist for the lecture component of all science courses, none currently exists for the laboratory. Therefore it is recommended that learning outcomes be created that assess students’ knowledge of basic laboratory equipment and procedures as well as inquiry-based skills gained within the laboratory environment.

Laboratory practicals are a traditional method of evaluating what students have retained in the laboratory. Practicals allow instructors to identify and examine their goals for the laboratory course. Additionally, students know what skills and knowledge they have obtained throughout the semester (Silberman, Day, Jeffers, Klanderman, Phillips, & Zipp, 1987).
to assess students’ investigative skills in six areas, Suits (2004) utilized laboratory practicals to compare the differences between traditional and inquiry-based instruction in college chemistry courses. The investigative areas included procedure, observations, data collection, results, and discussion. In the study, students were given a problem in which they had to develop a procedure, identify materials needed, conduct an experiment, and write up a laboratory report. Students that had received inquiry-based instruction outperformed students that had traditional laboratory instruction in all six areas. This example of a laboratory practical could be used in conjunction with assessments that evaluate student’s working knowledge of basic laboratory equipment and techniques.

An alternative method for assessing learning outcomes associated with equipment and procedures in the laboratory include the use of grading rubrics and small-scale projects. For example, a student ability to operate a light compound microscope is a basic but fundamental learning outcome. In order to assess whether or not a student can successfully name the parts of a microscope, know the functions of the parts, and accurately find a specimen can be assessed by using a rubric. Fitch (2007) developed a fifty-point rubric to evaluate students’ technique, knowledge, safety, and maintenance of the microscope. A similar rubric could be developed for the Principles of Biology I course to assess and provide important feedback about the areas students are most deficient.

Integration of Lecture Content and Laboratory Practices

Lecture content and laboratory activities should be closely related in a science course. If students are simultaneously exposed to biological concepts and practice greater understanding of the overarching principles may occur. Although students enrolled in the Principle of Biology I course perceived that integration occurred sometimes, the researcher supports that there should
always be an immediate and direct connection between what students are exposed to in the classroom and what experiments they conduct in the laboratory. The National Science Teachers Association (2007) reiterated the importance of the integration of lecture and laboratory in their position paper, *Integral Role of Laboratory Investigations in Science Instruction*. In this paper, the association insists that laboratory practices should avoid disconnections from proofs of phenomena that are not directly related to the objectives of the science being taught in the science class at a specific time. For instance, DiBiase and Wagner (2002) found when curriculum changes were made to ensure overlap of laboratory exercises with lecture content students perceived the lecture and laboratory and one class. Additionally, students performed better on lecture examinations when compared to students enrolled in sections in which the lecture and laboratory were taught as two independent courses.

Currently, all instructors follow a standard laboratory schedule throughout the semester. Each week a specific laboratory is scheduled with the exception of two weeks in which instructors give laboratory examinations. This type of scheduling allows of asynchronous presentation of lecture and laboratory activities. Therefore, it is recommended that the science department at Jefferson State Community College adopt a floating laboratory schedule, which would allow instructors to align laboratory activities with the lecture content. This format would not be difficult to implement considering that, instructors are responsible for both lecture and laboratory. Additionally, the design of the courses allows students to attend the laboratory class immediately following lecture or no more than two hours after lecture has ended on the designated laboratory day. These two characteristics allow for instructors to immediately present material in the laboratory that was addressed in the lecture course, allowing for continuity between the two classes. An advantage of this format will allow instructors to discuss and
integrate the observations and results obtained in lab directly to the course content. This format would require laboratory coordinators to create activity modules that would include materials and equipment necessary to conduct specific experiments. The modules would be kept in designated areas within the lab, which would allow instructor access at any time. The laboratory coordinators would also be responsible for assisting in the preparation of materials that would need to be produced the day of the laboratory exercises. Although this format lends itself to increased coordination between the instructors and laboratory coordinators, the greatest benefit is that there will be consistency between the classroom lectures and laboratory activities.

In conjunction with the floating laboratory schedule, the laboratory modules could also be designed to incorporate case studies that are directly associated with lecture content. Howard and Miskowski (2005) introduced an inquiry-based lab by first presenting a related case study. These case studies were modeled after relevant and real-life experiences that a student may encounter in a real laboratory setting at a research facility. This allowed students to put their impending inquiry-based activity into context. By implementing introductory case studies in the Principles of Biology I lab students could become more familiar with the aspects of the laboratory exercise as it relates to lecture content.

**Improving Non-science Majors Attitudes Toward Science**

One of the most noted findings from this research study was the significant difference between the non-majors attitudes toward science compared to the other academic streams. As the results clearly demonstrated, this subset of students has less favorable attitudes toward science. It is important to note that the institution that was the focus of the study does offer a non-majors biology course. However, the non-science majors enrolled in the Principles of Biology I course do so because their non-science degree may require an upper level course.
These results highlight an important challenge which instructors have and raises the question, “How do instructors engage this subset of students in order to improve their attitudes toward science?”

Many innovative teaching techniques can be implemented to engage students in the classroom and improve non-science majors’ attitudes as well as science majors. Techniques that involve active learning instruction which focuses on the interaction that take place between instructors and peers and incorporates a cyclic flow of activities and feedback (Armbruster, Patel, Johnson, & Weiss, 2009). Studies have shown that active learning approaches can improve student attitudes in the sciences (Prezler, Dawe, Shuster, & Shuster, 2007; Prince, 2004). An example of active learning previously discussed is inquiry-based labs. Other examples, as highlighted by Joel Michael (2006), that are recommended for practice include but are not limited to peer instruction, collaborative learning, discovery learning, and technological enhanced learning.

A number of the aforementioned techniques could be incorporated into the present Principles of Biology I course curriculum at Jefferson State Community College. However, two that could be incorporated easily with the appropriate faculty training are peer instruction and technological enhanced learning. For example, peer instruction involves allowing students the opportunity to respond to questions, discuss their answers with their peers, and then be retested on the same questions (Mazur, 1997). Research studies have shown that this type of learning can improve student conceptual understanding (Crouch & Mazur, 2001). This type of instruction has also been shown to improve classroom instruction and motivation (Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996). This type of learning activity can be implemented within the classroom and students may gain a better understanding of the material from a peer that has grasped the
concept instead of an explanation from an instructor. Furthermore, to improve non-majors understanding peer groups could be established that ensured that non-majors would have interactions with allied health and science major students. These interactions could potentially improve non-major attitudes.

It is also recommended that technology be incorporated in the classroom as to improve student attitudes as well as performance. An example of technology recommended for practice is the personal response systems or clicker systems. These systems have been shown to improve students’ conceptual understanding and learning (Duncan, 2005; Knight & Wood, 2005). These technology systems can be used in conjunction with peer instruction in order to provide immediate feedback to a question or questions proposed by an instructor. Students are able to see how the entire class responds and if it becomes evident that there is a large amount of dissonance among students, they are allowed to discuss the question with their peers again and retry the question before the instructor reveals and discusses the correct answer (Smith, Wood, Adams, Wieman, Knight, Gould, & Su, 2009). Crossgrove and Curran (2008) conducted a study that compared the retention learning and opinion of non-science majors and science majors when student response systems were used in the two different course offerings. The results from their study demonstrated that non-science majors had increased retention of lecture material covered in an introductory biology course when compared to science majors enrolled in an upper level genetics course. Because Principles of Biology I is an introductory course this type of technology may not only enhance the attitudes and performance of non-majors but science and allied health majors as well.
Recommendations for Future Research

This study sought to add a new finding to the area of learning environment research through the lens of a student population that is sparingly represented, the community college student. While the findings for students overall perceptions of the laboratory supported previous finding, finding related to gender and association between learning environment and attitudinal outcomes varied when compared to previous findings. With these results in mind, the researcher proposes recommendations for future research that would allow further investigation to support or contradict the current findings. These recommendations also highlight some methodology that the researcher could have done if given the opportunity design the current study differently.

Longitudinal Study Design and Sample Size

This was a cross sectional study in which data was collected at one specific time at the end of the Spring 2012 academic semester. This method influenced the sample size because not all students enrolled in the course were present during administration of the surveys. This was compounded by the fact that as the semester comes to a close course section enrollment further decreases due to students withdrawing from the course toward the end of the semester. Future studies should consider minimally a one-year longitudinal study that would encompass three academic semesters. The collection of survey results would occur during the middle of each semester. This would allow for a larger sample size, which would provide a better assessment of student views of laboratory and attitudes. Additionally, a similar study could be conducted across community colleges in Alabama and this would also allow for a larger sample size to be included in the investigation. The researcher suggests that community colleges that are similar in size and demographics be included in the study. By replicating the study over an extended
period of time, the results that are obtained may support or refute the current study’s findings. This would provide more transparency about the perceptions of community college students.

**Examination of Laboratory Environment across Subject Matter**

This study specifically investigated perceptions of the laboratory environment and attitudes of students enrolled in Principles of Biology I. Future studies should seek to determine if differences exist across various science courses. For example, assessments of students enrolled in Microbiology and Introduction to Biology I (non-majors) science course courses could be conducted. The researcher would not recommend including anatomy and physiology course students in this study because currently laboratory exercises do not include experimentation, only observations of structures associated with physiological phenomenon. Conversely, microbiology students would provide an interesting comparison because this course features the greatest number of laboratory contact hours when compared to the other courses taught within the department. The perceptions of students enrolled in the Introduction to Biology I, a non-majors course, could also provide an interesting perspective when compared to students that are taking upper level biology course.

**Investigation of Teacher–Student Interactions**

Another exploration for future studies includes an investigation of teacher–student interactions in the laboratory environment. Although this study did not find significant difference in the association of the SLEI scales and student attitudes, it would be interesting to determine is similar results are obtained with another classroom environment instrument, the *Questionnaire on Teacher Interactions* (Wubbels & Levy, 1993). Previous studies that have specifically examined the interactions between teachers and students suggest that there is a relationship between a teachers’ interpersonal behavior and student outcomes (Quek, Wong, &
Fraser, 2004; Wubbels & Levy, 1993). By assessing these interactions, researchers have gained insight over the years about the impact of teacher-student interactions in the laboratory environment as well (Wong, 1991; Fraser 1994, 1998).

A teacher’s communicative style can lead to the development of different types of relationships in the classroom environment. For example, if a student feels as if they are not receiving the instruction they need in a helpful and friendly manner it may be difficult to complete a laboratory task with a level of comprehension necessary to integrate lecture concepts with laboratory exercises. Conversely, a teacher may find that students may exhibit a communicative style that is counterproductive for a good laboratory experience and therefore behave in a less friendly manner. This type of communication is characterized as complementary (Watslawick, Beavin, & Jackson, 1967) and most times, it is this type of exchange occurs in the classroom (Wubbels & Levy, 1993). A subsequent study that includes an examination of students’ perceptions of instructors’ communicative styles may help to improve laboratory instruction.

**Summary**

The science laboratory is an integral part of science the science curriculum. At various levels of science education it is important that inquiry based activities are introduced into the teaching and learning paradigm. More importantly, in higher education laboratories, students should develop and test experiments and produce quality laboratory reports. These types of activities increase student cognitive skills and promote greater comprehension of subject matter. These skills are necessary in today’s global communities where there is need for these attributes in science related occupations.
The purpose of this study was to examine community college students’ perceptions of the laboratory environment and attitudes toward science in an introductory biology course. First, the results from this study concluded that students had favorable perceptions of the laboratory environment on all scales with the exception of open-endedness. This result suggests that there needs to be a greater effort to include inquiry-based learning in experimental designs. Secondly, findings from this investigation indicated that there is no significant difference between males and females as it relates to their perceptions of the laboratory with the exception of the material environment scale. Significant gender differences were not associated on any of the attitudinal scales either. These findings do not support conclusions made by many studies that have compared males to female within the laboratory environment. However, further studies will have to be conducted in order to determine if these results are common to this specific population of students. The most surprising results from this study were that the SLEI scales were not significant predictors of students’ attitudes. This data contradicts studies that have shown significant associations between student’s attitudes and the laboratory environment. Finally, the findings from this study highlight attitudinal differences toward science in between non-science majors versus students pursuing degrees in science related disciplines.

The noted difference among majors and non-science-major’s attitudes is not a novel research finding. However, this study serves as a reminder that science educators should be cognizant of this difference. It would be beneficial to create classroom environments and curricula that not only engage the students majoring in science related fields but the non-science majors as well. It also important to recognize although there were significant differences between the academic streams, overall this student population was overwhelming uncertain about their attitudes toward scientific inquiry, adoption of scientific attitudes, and enjoyment of
science lessons. The differences could stem from previous science coursework experiences, peer relationships, self-concept, and home environment (Goglolin, 1992).

The current investigation provided a snapshot of the views and attitudes of a student population that is not largely represented in learning environment research. Although some of the findings were not in supportive of similar science laboratory environment research it does provide perspectives of a population that is lacking representation in learning environment research, the community college student. Overall, community college students’ views of the laboratory environment were similar those of K-12 and four-year institution students. This study found, like most, the lack of open-endedness was the greatest deficiency in the science laboratory environment. Instructors may be the most influential in affecting change and implementing inquiry based laboratory activities at this level. The rationale for this is due to the likelihood that most community college instructors are responsible for the teaching of the laboratory component as well.

The noted differences between the academic streams suggests that changes must occur in how science is instructed in order to improve student’s attitudes. Sunberg and Dini (1993) asked the question, “Science majors versus non-majors: Is there a difference?” Their findings suggested that science majors and non-science majors should not be instructed differently, rather they both should be taught differently. Furthermore, the authors proposed that greater achievement and an increase in scientific literacy could be accomplished if instructors adopted a “less is more” philosophy. This philosophy proposes that students should not be overwhelmed with massive amounts of biological details and facts but instead taught concepts that were most relevant. This “less is more” philosophy could be adopted in the laboratory as well. For example, instead of requiring that students complete thirteen laboratories, as is the case at the
college examined in this study, the exercise number could be reduced. Therefore, instead of completing a specific exercise each week, a combination of inquiry-based exercises, case studies, and related projects that span a few weeks could be integrated with lecture. Changes such as these, which move away from traditional laboratory curricula, may have the greatest potential to increase open-endedness within the laboratory and encourage positive attitudes toward science.
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APPENDICES
APPENDIX A

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

April 19, 2012

Nakin Robinson
Department of ELPTS
College of Education
Box 870302

Re: IRB # 12-OR-137-ME: “An Investigation of Community College Students’ Perceptions of the Laboratory Environment and Attitudes toward Science in an Introductory Biology Course”

Dear Ms. Robinson,

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. You have also been granted the requested waiver/alteration of informed consent. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your application will expire on April 18, 2013. If the study continues beyond that date, you must complete the IRB Renewal Application. If you modify the application, please complete the Modification of an Approved Protocol form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, please complete the Request for Study Closure (Investigator) form.

Should you need to submit any further correspondence regarding this application, please include the assigned IRB application number.

Please use reproductions of the IRB-stamped information sheet.

Good luck with your research.

Sincerely,

Stuart Usdan, Ph.D.
Chair, Non-Medical Institutional Review Board
The University of Alabama
UNIVERSITY OF ALABAMA
HUMAN RESEARCH PROTECTION PROGRAM

Participation Information Sheet

Study title: An evaluation of community college student perceptions of the science lab and attitudes toward science.

Investigator's Name, Position, Faculty or Student Status

Nakia R. Robinson – Graduate Student

Institution if other than or collaborating with UA: Jefferson State Community College

You are being asked to take part in a research study.

The study is being done by Nakia R. Robinson, a graduate student at the University of Alabama. Mrs. Robinson is being directed by Professor Nathaniel Bray who is a professor of Education at the University of Alabama.

What is this study about? What is the investigator trying to learn?
The lab is a common part of most biology courses. However, the importance of the lab is not completely understood. This study seeks to understand what students' opinions are of their lab class. Specifically, the investigator would like to know the following: are students supportive in the lab; are the labs materials easy to use; are the rules of the lab clear; do the lab activities require independent thinking; and is the lab content related to the lecture class. The investigator would also like to know if student attitudes about science are related to their opinions about the lab. It is also important to know if a student's major or gender affects their views of the lab class.

Why is this study important or useful?
The number of college students that choose science as major is on the decline. This decrease has the potential to affect the future job market in science related careers.

Positive experiences that students have in the lab class can serve as a chance to expose students to the process of science. As a result, students may have a more positive attitude about science. This potentially can lead to an increase in the number of students that choose and remain science majors. Therefore, the findings in this study will help instructors and researchers in the sciences and laboratory classroom studies understand what parts of the laboratory students find most enjoyable and beneficial to learning science content. This study will also help to identify parts of the lab class that may need to be changed.
Why have I been asked to be in this study at Jefferson State Community College?
You have been asked to be in this study because you are a student in Principles of Biology I.

How many people will be in this study?
The estimated sample size for this study is 250 students.

What will I be asked to do in this study?
If you agree to be in this study, you will be asked to complete two surveys containing 65 items. These surveys look to understand your opinions of the current lab class and your attitude toward science. There is no right or wrong answers. An example of a statement that will address your opinion of the laboratory is as follows: “I choose my partners for lab experiments.” You will need to decide either Almost Never, Seldom, Sometimes, Often, or Very Often. An example of a statement that will address your attitude toward science is as follows: “Doing experiments is not as good as finding out information from teachers.” You will need to decide if your opinion is, strongly Agree, Agree, Uncertain, Disagree, or strongly Disagree.

How much time will I spend being this study?
Each survey takes about twenty-five minutes. The total length of the study will be no more than fifty minutes.

Will being in this study cost me anything?
Your participation in this study will not cost you anything.

Will I be compensated for being in this study?
You will not be compensated for your participation.

What are the risks (dangers or harms) to me if I am in this study?
There are no risks to you due to your participation in this study. There will be no negative affect towards your grade if you choose not to be a part of the study.

What are the benefits (good things) that may happen if I am in this study?
There are no direct benefits to you. However, you may feel good about knowing that you are helping to provide important information about the current lab classes at Jefferson State Community College.

What are the benefits to science or society?
This study can benefit science by adding to the research that focuses on the value of lab classes in science education.

UA IRB Approved Document
Approval date: 4/19/2012
Expiration date: 4/18/2013
How will my privacy be protected?
Your participation in this study is completely anonymous. All data obtained is only for the completion of this research study.

How will my confidentiality be protected?
The surveys are anonymous. Therefore, DO NOT put your name on the survey.

What are the alternatives to being in this study? Do I have other choices?
The alternative to being in this study is to not participate.

What are my rights as a participant in this study?
Taking part in this study is voluntary. It is your free choice. You can refuse to be in it at all. If you start the study, you can stop at any time. There will be no effect on your relations with Jefferson State Community College.

The University of Alabama Institutional Review Board ("the IRB") is the committee that protects the rights of people in research studies being conducted by their personnel and students. The IRB may review study records from time to time to be sure that people in research studies are being treated fairly and that the study is being carried out as planned.

Who do I call if I have questions or problems?
If you have questions, concerns, or complaints about your rights as a participant in this research study, you may contact Ms. Tanta Myles, the Research Compliance Officer at the University of Alabama at 205-348-8481 or toll-free at 1-877-820-3066.

You may also ask questions, make suggestions, or file complaints and concerns through the IRB Outreach website at [http://osp.ua.edu/site/PRCO_Welcome.html](http://osp.ua.edu/site/PRCO_Welcome.html) or email the Research Compliance office at participantoutreach@bama.ua.edu.

After you participate, you are encouraged to complete the survey for research participants that is online at the outreach website or you may ask the investigator for a copy of it and mail it to the University Office for Research Compliance, Box 870127, 358 Rose Administration Building, Tuscaloosa, AL 35487-0127.
APPENDIX B

PERMISSION TO ADMINISTER SURVEY AT JEFFERSON STATE COMMUNITY COLLEGE

From: Nakia Robinson [mailto:nmarshal@jeffstateonline.com]
Sent: Thursday, February 16, 2012 2:08 PM
To: 'Danielle Coburn'
Subject: Request to Conduct Survey for Dissertation

Dear Associate Dean of Instruction:

I am writing you to request your permission to assess students enrolled in Principles of Biology I for my dissertation study at the University of Alabama (Tuscaloosa). The focus of my study is to determine students perceptions of the biology laboratory environment and their attitudes toward science. Furthermore, I would like to discern if any differences exist between gender and students selected academic disciplines. This study would serve as preliminary analysis of the effectiveness laboratories in the Biology department. Additionally, it provides an opportunity to evaluate the laboratory experience of our students and not solely the lecture classroom component of the course.

With permission of the biology instructors, a feasible time (after midterm) will be identified in order to administer the survey instruments during laboratory hours. Although the laboratory component meets for two hours the assessment will not take the entire class period. Student participation in this study is completely voluntary and anonymous Any information gathered from the study will be confidential. The information obtained from this study will be used only for the purpose of completing my dissertation.

Thank you for taking my request to conduct this study into consideration and I look forward to hearing from you.

Best Regards,

Nakia R. Robinson
Graduate Student
University of Alabama - Tuscaloosa
APPENDIX C

SCRIPT FOR INSTRUCTORS ADMINISTERING THE SURVEY INSTRUMENTS

Dear Instructors,

Thank you for granting me permission to conduct my surveys in your class. Below you will find a script for you to read before any survey packets are given to students that choose to participate.

Students,

Nakia R. Robinson, an instructor in the biology department, is conducting a study. Mrs. Robinson is doing this study in order to complete the doctoral program in Higher Education at The University of Alabama. The study examines the importance of the lab class in science education. The study will also investigate your attitude toward science. Currently, there is a debate about the value of lab class in science education. Some research suggests that students benefit from lab class. On the other hand, some research indicates that students can do well in a science course without the lab. The research that explores this debate is often done at the primary and secondary school levels. However, the views of community college students are just as important in this area of research.

You have been asked to take part in this study because you are a student in Principles of Biology I. Your decision about whether or not to participate in this research project will not affect you or your grade in any way. Your responses will be kept anonymous. If you are interested, you will be given a study information form. The form provides information about the background and importance of the study. You will be informed of your rights as a study participant. Please take your time and read the information carefully. If you choose to participate, you will be given two surveys. The first survey will evaluate your opinion of the lab class. The second survey will gather information about your attitude toward science. The estimated time to complete both surveys is fifty minutes.

Mrs. Robinson requests your assistance in order to complete her research project and appreciates your willingness to assist.

Thank You
APPENDIX D

SCIENCE LABORATORY ENVIRONMENT INSTRUMENT (SLEI)

Demographics

Gender: ______ Male

______ Female

Academic Discipline: Check the appropriate column if see your major listed. If your major is not listed please add it in the space provided

<table>
<thead>
<tr>
<th>Allied Health</th>
<th>Science, Technology Engineering &amp; Math (STEM)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing ____</td>
<td>Biology ____</td>
<td></td>
</tr>
<tr>
<td>Practical Nurse ____</td>
<td>Chemistry ____</td>
<td></td>
</tr>
<tr>
<td>Physical Therapy ____</td>
<td>Pre- Medicine ____</td>
<td></td>
</tr>
<tr>
<td>Physical Therapy Assistant ____</td>
<td>Pre-Pharmacy ____</td>
<td></td>
</tr>
<tr>
<td>Radiology ____</td>
<td>Wild-Life Sciences ____</td>
<td></td>
</tr>
<tr>
<td>Biomedical Equipment Technology ____</td>
<td>Biomedical Engineering ____</td>
<td></td>
</tr>
<tr>
<td>Clinical Laboratory Technology ____</td>
<td>Environmental Science ____</td>
<td></td>
</tr>
<tr>
<td>Veterinary Technology ______</td>
<td>Math ____</td>
<td></td>
</tr>
<tr>
<td>Emergency Medical Services ____</td>
<td>Engineering ____</td>
<td></td>
</tr>
<tr>
<td>Respiratory Therapy ____</td>
<td>Computer Science ____</td>
<td></td>
</tr>
<tr>
<td>Radiological Science ____</td>
<td>Pharmacy ____</td>
<td></td>
</tr>
<tr>
<td>Nuclear Medicine Technology ____</td>
<td>Health Science ____</td>
<td></td>
</tr>
<tr>
<td>Occupational Therapy ____</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

ACTUAL FORM

Directions
This questionnaire contains statements about practices which take place in this laboratory class. You will be asked how often each practice actually takes place. There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Think about how well each statement describes what this laboratory class is actually like for you. Draw a circle around

1 if the practice actually takes place ALMOST NEVER
2 if the practice actually takes place SELDOM.
3 if the practice actually takes place SOMETIMES
4 if the practice actually takes place OFTEN
5 if the practice actually takes place VERY OFTEN

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example. Suppose that you were given the statement "I choose my partners for laboratory experiments." You would need to decide whether you thought that you actually choose your partners Almost Never, Seldom, Sometimes, Often or Very Often. For example, if you selected Very Often, you would circle the number 5 on your Answer Sheet.
Remember that you are describing your actual classroom.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I get along well with students in this laboratory class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>There is opportunity for me to pursue my own science interests in this laboratory class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>What I do in our regular science class is unrelated to my laboratory work. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>My laboratory class has clear rules to guide my activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>I find that the laboratory is crowded when I am doing experiments. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>I have little chance to get to know other students in this laboratory class. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>In this laboratory class, I am required to design my own experiments to solve a given problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>The laboratory work is unrelated to the topics that I am studying in my science class. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>My laboratory class is rather informal and few rules are imposed on me. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>The equipment and materials that I need for laboratory activities are readily available.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>Members of this laboratory class help me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>In my laboratory sessions, other students collect different data than I do for the same problem.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>My regular science class work is integrated with laboratory activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>I am required to follow certain rules in the laboratory.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15.</td>
<td>I am ashamed of the appearance of this laboratory. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16.</td>
<td>I get to know students in this laboratory class well.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18.</td>
<td>I use the content from my regular science class sessions during laboratory activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19.</td>
<td>There is a recognized way for me to do things safely in this laboratory.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20.</td>
<td>The laboratory equipment which I use is in poor working order. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>21.</td>
<td>I am able to depend on other students for help during laboratory classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>22.</td>
<td>In my laboratory sessions, I do different experiments than some of the other students.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>23.</td>
<td>The topics covered in regular science class work are quite different from topics with Which I deal with in regular laboratory sessions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>24.</td>
<td>There are few fixed rules for me to follow in laboratory sessions. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>25.</td>
<td>I find that me laboratory is hot and stuffy. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>26.</td>
<td>It takes me a long time to get to know everybody by his/her first name in this laboratory Class.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>27.</td>
<td>In my laboratory sessions, the teacher decides the best way for me to carry out the laboratory experiments.*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>28.</td>
<td>What I do in laboratory sessions helps me to understand the content covered in regular science classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>29.</td>
<td>The teacher outlines safety precautions to me before my laboratory sessions commence.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>30.</td>
<td>The laboratory is an attractive place for me to work in.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>31.</td>
<td>I work cooperatively in laboratory sessions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>32.</td>
<td>I decide the best way to proceed during laboratory experiments.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>33.</td>
<td>My laboratory work and regular science class work are unrelated. *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>34.</td>
<td>My laboratory class is run under clearer rules than my other classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>35.</td>
<td>My laboratory has enough room for individual or group work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX E

TEST OF SCIENCE RELATED ATTITUDES INSTRUMENT (TOSRA)

Test of Science Related Attitudes (TOSRA)

(Fraser, 1981)

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no “right” or “wrong” answers. Your opinion is what is wanted.

2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. **Please circle only ONE value per statement.**

   5 = Strongly Agree (SA)
   4 = Agree (A)
   3 = Uncertain (U)
   2 = Disagree (D)
   1 = Strongly Disagree (SD)
<table>
<thead>
<tr>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I would prefer to find out why something happens by doing an experiment than being told.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. I enjoy reading about things that disagree with my previous ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. Science lessons are fun.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. Doing experiments is not as good as finding out information from teachers. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. I dislike repeating experiments to check that I get the same results. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. I dislike science lessons. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. I would prefer to do experiments rather than to read about them.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. I am curious about the world in which we live.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9. School should have more science lessons each week.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10. I would rather agree with other people than do an experiment to find out for myself. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11. Finding out about new things is unimportant. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12. Science lessons bore me. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Statement</td>
<td>SA</td>
<td>A</td>
<td>U</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>----</td>
</tr>
<tr>
<td>13. I would prefer to do my own experiments than to find out information from a teacher.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14. I like to listen to people whose opinions are different from mine.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15. Science is one of the most interesting school subjects.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>16. I would rather find out things by asking an expert than by doing an experiment. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>17. I find it boring to hear about new ideas. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>18. Science lessons are a waste of time. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>19. I would rather solve a problem by doing an experiment than be told the answer.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20. In science experiments, I like to use new methods which I have not used before.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>21. I really enjoy going to science lessons.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>22. It is better to ask a teacher the answer than to find it out by doing experiments. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>23. I am unwilling to change my ideas when evidence shows that the ideas are poor. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>24. The material covered in science lessons is uninteresting. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>25. I would prefer to do an experiment on a topic than to read about it in science magazines.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Statement</td>
<td>SA</td>
<td>A</td>
<td>U</td>
<td>D</td>
<td>SD</td>
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<tr>
<td>---------------------------------------------------------------------------</td>
<td>----</td>
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<td>---</td>
<td>---</td>
<td>----</td>
</tr>
<tr>
<td>26. In science experiments, I report unexpected results as well as expected ones.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>27. I look forward to science lessons.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>28. It is better to be told scientific facts than to find them out from experiments.*</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>29. I dislike other peoples’ opinions. *</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>30. I would enjoy school more if there were no science lessons.*</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
APPENDIX F

PERMISSION TO USE SLEI AND TOSRA

From: Nakia Robinson  [mailto:nmarshal@jeffstateonline.com]
Sent: Tuesday, 21 July 2009 3:02 AM
To: Barry Fraser
Subject: Request for permission to use survey instruments

Dear Dr. Fraser,

My name is Nakia R. Robinson and I am a graduate student in the Higher Education Administration Program at the University of Alabama in Tuscaloosa, Alabama. Currently, I am in the preliminary stages of my dissertation studies. However, I have established that I would like to pursue an investigation of the laboratory environment and student attitudes towards science at a multi-campus suburban community college in Alabama. I am writing you to request your permission to use the Science Laboratory Environment Inventory (personal form) as well as the Test of Science Related Attitudes survey instrument. Additionally, copies of each of these instruments would be greatly appreciated. I thank you in advance for your assistance.

Best Regards,

Nakia R. Robinson

From: B.Fraswer@curtin.edu.au
Sent: Tuesday, 22 July 2009 9:55 PM
To: Barry Fraser
Subject: Request for permission to use survey instruments

Nakia

TOSRA is quite old (1981) and the published version is out of print. However I have scanned the original questionnaire and comprehensive handbook. This is attached now. I could airmail you the SLEI and a couple of recent papers, but you didn’t give me your postal address. You have my permission to use the TOSRA and SLEI.

Good luck with your research.

Barry Fraser