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An Assessment of the Impact of a Science Outreach Program, Science in Motion, on Student Achievement, Teacher Efficacy, and Teacher Perception

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The University of Southern Mississippi

AN ASSESSMENT OF THE IMPACT OF A SCIENCE OUTREACH PROGRAM, SCIENCE IN MOTION, ON STUDENT ACHIEVEMENT, TEACHER EFFICACY, AND TEACHER PERCEPTION

by

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Abstract of a Dissertation
Submitted to the Graduate Studies Office
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
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ABSTRACT

AN ASSESSMENT OF THE IMPACT OF A SCIENCE OUTREACH PROGRAM, SCIENCE IN MOTION, ON STUDENT ACHIEVEMENT, TEACHER EFFICACY, AND TEACHER PERCEPTION

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The purpose of the study was to analyze the science outreach program, Science In Motion (SIM), located in Mobile, Alabama. This research investigated what impact the SIM program has on student cognitive functioning and teacher efficacy and also investigated teacher perceptions and attitudes regarding the program.

To investigate student cognitive functioning, data were collected from the Mobile County Public School System based upon student performance on Criterion Referenced Tests (CRT's), consisting of the students' average score, percent of students passing the test (students scoring 60 percent or above), and the percent of students who were considered proficient, (students scoring 70 percent or above). The researcher hypothesized that (1) the students of teachers who participate in the SIM program would have statistically significant higher scores on their science CRT's than students of the same teacher prior to the teacher's participation in the SIM program, (2) students of science teachers who participate in the SIM program would have statistically significant higher scores on their science CRT's than students of science teachers who do not participate in the SIM program, and (3) teachers who participate in the SIM program would have a higher efficacy, as measured on the Teachers' Sense of Efficacy Scale developed by Tschnnen-Moran & Hoy (2001), than science teachers who do not participate in the SIM program. Statistical significant differences at the $p < .05$ level were found for all research hypotheses except for hypothesis 3. No statistical significant differences were found between the efficacy of teachers who participate in the SIM program and those who do not participate.

The researcher also investigated whether or not being involved in the SIM program affected the participating teachers' perspectives towards teaching science, funding of the science laboratory, and high stakes science testing and accountability. A phenomenological qualitative study was performed. The analysis consisted of coding the data and describing the associated themes. The themes were: SIM laboratory exposure Increases student success; SIM reduces teacher stress; SIM provides high quality laboratories for the science classroom; SIM needs to develop and provide more labs for advanced science programs; and, SIM increases teacher effectiveness.

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CHAPTER I

INTRODUCTION

This chapter introduces the study and the underlying rationale for its implementation. The research questions and hypotheses associated with the research are described. Cooperative learning, constructivism, social constructivism, and social cognitive theory have all been found to be effective theoretical frameworks that, when used by teachers, help to increase student learning; the chapter introduces these constructs.

A program in Mobile, Alabama, called Science In Motion (SIM) utilizes such theoretical frameworks. This research investigated what impact, if any, the SIM program has on student cognitive functioning and teacher sense of efficacy and also investigated teacher perceptions and attitudes regarding the program.

Background

Science education in the United States, especially the southern region, has routinely suffered from inadequate funding. Technology has advanced tremendously in the past decade; however, high school science budgets have not. Disciplines such as Biology, Chemistry, and Physics typically receive budgets that are too small for purchasing adequate lab equipment and supplies. Instrumentation for lab use can cost thousands of dollars per instrument, and most school systems simply cannot afford such equipment. Especially hard hit, because of the lack of local funding, are inner-city and rural schools (Lupton, 2005; Tate, 2001). However, research has shown that for adequate student achievement in science, lab instruction is essential (Freedman, 2002). In 1994, Alabama incorporated a program originally developed at Juniata College in Pennsylvania (Helminger, 2007) called Science In Motion (SIM). The SIM program developed by Juniata College was designed to address inadequate science laboratory equipment in rural public schools in Pennsylvania (Juniata College, 2003). Pennsylvania's SIM program provides such schools access to advanced laboratory equipment along with a science specialist to assist in setting up and performing the labs.

Alabama's SIM program emulates that of Pennsylvania in that it provides access to laboratory equipment, along with the help and expertise of a science specialist. The program in Alabama encompasses three science disciplines: Biology, Chemistry, and Physics. Each discipline has a coordinator/specialist that is responsible for stocking supplies, providing workshops, and visiting schools. The SIM program provides all of the supplies needed to perform the labs, along with access to advanced lab equipment. Participating teachers can borrow lab equipment sometimes costing over $20,000 per instrument. This type of expensive lab equipment would not be available to most public schools in Alabama if not for the SIM program. The underlying premise of the SIM program is that having access to proper lab equipment, adequate supplies, and the support that the program provides, allows participating schools to provide more equitable opportunities with respect to lab instruction. In Alabama, the SIM program is enacted through local universities. In the city of Mobile, the University of South Alabama (USA) is the sponsor. USA acts as a facilitator for the program, and the Biology, Chemistry, and Physics departments set aside areas for the SIM coordinators to store equipment and supplies. Along with providing space to store equipment, each of the three science disciplines; Biology, Chemistry, and Physics also give support in the form of scientific expertise through the experience and knowledge of professors and instructors. In Alabama, the program reaches out to schools within 100 miles of the university, and all public schools are invited to participate in the program. The only stipulation for inclusion in the program is that each participating teacher must receive instruction, during a summer training institute held at USA, in order to be trained on the correct use of the instrumentation and labs.

Research has shown that teachers view laboratory instruction as a necessary part of the science experience for students (Ohander & Grelsson, 2006). According to Ohander and Grelsson, teachers believe that the use of laboratory instruction allows students to make the connection between abstract science theories learned in class and concrete hands-on practices learned in the laboratory. Lawrenz, Huffman, and Robey (2003) have performed research that supports the observations of Ohander and Grelsson. Their research indicates that teachers should limit the use of direct, lecture-style instruction, and instead act more as facilitators through the use of inquiry-based instruction. Besides providing students a connection between the abstract and the concrete, science laboratories also teach students about the proper use of instrumentation and technology. In his research, Demeo (2005) stressed the importance of teaching proper laboratory skills to students. He suggests that having exposure to proper laboratory skills in high school will empower students as they transcend into the college science classroom.

Because of the cognitive, cooperative, and social aspects of the science laboratory, the theoretical framework for this research included constructivism, cooperative learning, cognitivism, and situated learning theory. Constructivism is the belief that new knowledge must be connected to existing knowledge; cognitivism studies how the mind processes information; cooperative learning explores interpersonal relationships and how such relationships affect learning; and, situated learning theory examines how interactions between people and their surroundings affect cognitive functioning.

Statement of the Problem

Science education in the United States garnered public attention beginning with the 1957 Russian space launch of Sputnik I, the world's first artificial satellite. The launch of Sputnik caused the American public to focus on science and math education in the United States, and it also caused an influx of federal money into public schools for enhancing science and math curricula (Bybee, 1997).

After the initial fervor created by the launch of Sputnik, the focus on science education lessened. Then, in 1983, a scathing report entitled *A Nation at Risk* once again caused the country to focus upon science education. The report discussed the decline of the American educational system, in part, by comparing test scores in the United States to those of other countries. In the report, emphasis was placed upon increasing the rigor of high school graduation requirements, development of standards for academic performance, and increasing funding to support such changes (National Commission On Excellence In Education, 1983).

In 1995, the National Research Council (NRC) helped develop National Science Education Standards (NSES) partly due to the report *A Nation at Risk*. The standards focused upon: 1) Science Assessment, 2) Science Teaching, 3) Teacher Professional Development, 4) Science Education Programs, 5) Science Education Systems, and 6) Science Content (National Research Council, 1995).

The No Child Left Behind (NCLB) Legislation Act of 2001 has once again focused attention on public science education. While most dedicated educators strive to have all students reach their highest level of achievement, the federal government, through the NCLB Act, expects all schools to obtain student proficiency levels that greatly exceed past expectations. According to NCLB (2001), in the year 2014 all students should reach the proficient level.

While government and public expectations have increased, most public school funding has remained stagnant or is actually projected to decrease (Zehr, 2007). School boards govern public school policy; thus, funding for science education and science programs varies widely across school districts. Poor rural and inner-city schools in particular often have problems funding adequate science programs (Lupton, 2005; Tate, 2001), and they often do not have the funds to purchase equipment and supplies necessary for advanced science courses. Therefore, science outreach programs such as Science In Motion are becoming increasingly important to science education, and they are often described as possible solutions to such funding problems (Helminger, 2007; Juniata College, 2003). However, because funding in public schools is under intense scrutiny, and because school superintendents and school boards are under increasing pressure to spend public monies wisely, it becomes imperative that programs such as Science In Motion be evaluated to determine their effectiveness.

Purpose of the Study

The intent of the research was to study the SIM program in Mobile, Alabama. The Science Supervisor of Mobile County Public Schools asked the researcher to evaluate the program to determine its effectiveness. This research investigated what impact the SIM program has on student cognitive functioning and teacher sense of efficacy and investigated teacher perceptions and attitudes regarding the program. Having information obtained from such a study would either justify the current SIM program, suggest changes that could be beneficial to the program, or provide evidence that the program should be dissolved. From an administrative standpoint, a program such as SIM is a significant investment of both money and human resources. Such a program should be evaluated to determine if the benefits obtained are worth the investment.

Research Questions

This study seeks to answer the following questions:

1. Is there a difference between the science achievement of the students of teachers who participate in the SIM program and the achievement of the students of these teachers before they became participants in the program?

2. Is there a difference between the science achievement of the students of teachers who participate in the SIM program and the achievement of the students of science teachers who do not participate in the program?

3. Is there a difference between the sense of efficacy of teachers who participate in the SIM program and the sense of efficacy of science teachers who do not participate in the program?

4. Has being involved in the SIM program affected the participating teachers' perspectives towards teaching science, funding of the science laboratory, and high-stakes science testing and accountability? If so, in what ways? If not, why?

Hypotheses

The following hypotheses guided the research and analysis associated with this study:

Question 1:

According to theoretical research, science students who participate in hands-on learning activities such as those initiated through SIM, involving cooperative groups, and multi-sensory stimulation, should be able to grasp and comprehend information more quickly and thoroughly (Batchelor, 2007; Doymus, 2007; Freedman, 2002). Mobile County gives a Criterion Referenced Test (CRT) in science each semester. The researcher hypothesized that the students of teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of the same teacher prior to the teacher's participation in the SIM program.

Question 2:

The researcher hypothesized that the students of science teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of science teachers who do not participate in the SIM program.

Question 3:

The researcher hypothesized that teachers who are involved with the SIM program will a have higher sense of efficacy, as measured on the Teachers' Sense of Efficacy Scale (Tschnnen-Moran & Hoy, 2001), than science teachers who do not participate in the program.

Definition of Terms

Accountability: The educational systems responsibility to taxpayers to educate all students.

Coding: The process of taking qualitative data and separating it into topics relating to the research question(s). The coded data is then separated into themes.

Cognition: The information processing of an individual's psychological functions.

Cognitivism: The study of individual cognitive functioning.

Collapsing Data: Taking the themes from the coded qualitative data and combining similar themes.

Constructivism: The learning of new knowledge is connected to existing knowledge structures.

Cooperative Learning: The use of heterogeneous grouping of individuals in the learning process. Each member of the group is responsible for the learning of oneself and others in the same group.

Criterion Referenced Tests (CRTs): Tests given each quarter to public high school science classes to determine the academic progress of students.

Efficacy: The knowledge that one has the power to produce desired outcomes.

Inquiry Laboratories: Instead of following explicit laboratory instructions, students are involved in the development of activities that might influence finding the solution to the proposed problem.

Minority students: Hispanic, African American, Native American and other non-White students.

No-Child Left Behind (NCLB): The 2002 reauthorization of the federal Elementary and Secondary Education Act (ESEA). Contains criteria and penalties for schools that fail to make appropriate academic progress, which is 100% proficient by the year 2014.

Phenomenological Study: The study of some phenomena as experienced from t he first-person point of view.

Program for International Student Assessment (PISA): A system of international assessments that focus on 15-year-olds' capabilities in reading literacy, mathematics literacy, and science literacy.

Science In Motion (SIM): A program used in Alabama that allows advanced lab equipment and support to be furnished to all public schools that choose to participate.

Science Outreach Programs: Institutions of higher learning reaching out to secondary and elementary schools in order to enhance science education.

Situated Learning Theory: Learning is a function of the situation, context, and culture in which it occurs.

Social Cognitive Theory (SCT): The acquisition of new knowledge can be directly related to the interaction and observation of others.

Virtual Laboratories: Laboratories developed by computer programmers that simulate hands-on laboratories.

Delimitations

This study was limited to Biology and Chemistry teachers who had participated in the Science In Motion (SIM) Program in the Mobile County Public School System in Mobile Alabama, along with a sample of non-participating Biology and Chemistry teachers. This sample was further limited to those teachers who had CRT scores for their students. Also, because Physics teachers in Mobile County do not administer a CRT, SIM Physics data was not available for analysis.

The geographical area of the study was limited to a single county. Therefore, there is a possibility that the participants of the study attended the same educational settings and professional functions, thus limiting their responses.

Assumptions

Survey instruments are always subject to the unpredictability of the participant's memory. The utility of this research depended, in significant part, upon whether participants answered survey and interview questions truthfully.

Justification of the Study

This study involved science teachers in the Mobile County Public School System. It proposed to measure the benefits, if any, the SIM program provides to Mobile County Public Schools, and to ascertain if the SIM program has influenced teachers' sense of efficacy. The study also investigated teachers' perceptions and attitudes towards the SIM program.

Funding of educational programs has become an increasing concern for school boards, administrators, and the general public. In the past, Alabama has had lawsuits filed against the state for inadequate K-12 public school funding. In 1993 the courts found Alabama's public school system inequitable and inadequate, giving the state "reasonable time" to bring the school system into compliance with the court orders (American Civil Liberties Union, 2002). In 2001 the case was reopened because the state still had not complied with the courts directions. The Alabama Supreme Court ended the case on May 31, 2002. However, school funding lawsuits continue to be brought against the state of Alabama. On March 14, 2008, Lynch v State of Alabama was filed and once again the state is accused of underfunding K-12 public schools, particularly rural and minority schools. According to court documents, the lawsuit was filed because Alabama's State Constitution limits state and local governments from collecting adequate revenue for the K-12 educational system (Lynch v State of Alabama, 2008).

Science programs are expensive to operate, with equipment and supplies requiring substantial investments from school administrative budgets. This poses a problem for many public schools in Alabama; but, because of the lack of local funds, the problem becomes much greater for some rural and inner-city schools (Lupton, 2005; Tate, 2001). Programs such as SIM have been touted as possible solutions for such funding issues (Helminger, 2007; Juniata College, 2003). This project evaluated the SIM program in order to determine its effectiveness. If the SIM program plays a significant role in increasing student cognition and raising teacher sense of efficacy, school administrators might be interested in learning more about the program. On the other hand, if the evaluation suggests that the program is either ineffective or delivers only trivial benefit, administrators might also consider whether the program needs modification or even whether dissolution of the program is warranted.

Summary

This study investigated a program called Science In Motion with respect to student cognitive functioning, teacher sense of efficacy, and teacher perceptions and attitudes towards the SIM program. The quantitative statistical analysis assisted in determining how well the program meets the goal of increasing student cognition, as well as determining what effects, if any, the program has on teacher sense of efficacy. The qualitative section of the investigation assisted in gaining insight into teacher expectations, perceptions, and attitudes towards the SIM program.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This study examined the relationships between science investigations performed by high school biology and chemistry students using laboratory equipment and/or instruction furnished by the Science In Motion (SIM) program. Chapter two addresses the theoretical framework, which includes the constructs of cooperative learning, constructivism, social constructivism, and social cognitive theory. Research literature that explores the application of these theories in instruction is explored within the context of the explication of the theoretical framework.

The impacts of student and teacher efficacy as they relate to science laboratory investigations are discussed. Standardized testing and its impact on science education are reviewed in this section. Finally, analyses of possible solutions to the high cost of equipping high school laboratories are presented.

Theoretical Framework

The primary theoretical framework of the study includes constructivism, cooperative learning, cognitivism, and situated learning theories. Traditionally, cognitivism has been the study of individual cognitive functioning, or how information is transferred externally to internally (from outside the mind to inside the mind) without focusing on the influences of external stimuli (Kirshner & Whitson, 1997). Situated cognition, or situated learning theory, is cognitivism with the caveat that social interactions of people and their surroundings play an important role in the transference of knowledge (Kirshner & Whitson). Of primary importance for this research project is constructivist theory, developed by Jean Piaget, and social cognitive constructivism, developed by Vygotsky. Piaget's constructivist theory suggests that learning new knowledge must be rooted in existing knowledge (Glasersfeld, 1989). Vygotsky's theory of social cognitive constructivism mirrored Piaget's personal cognitive constructivism, except Vygotsky focused more on the social aspects of Piaget's theory (Kozulin & Presseisen, 1995). According to Glaserfeld (1989), Piaget believed that cognitive change was developed when a student predicts a situation will turn out a certain way; but, instead the situation turns out differently. Such episodes occur frequently in a high school science laboratory because students often have preconceived ideas on scientific principles and natural processes. However, the cognitive change described by Piaget sometimes occurs in small increments because students' preconceived ideas about scientific principles are often wrong. Some of these erroneous ideas have been ingrained from childhood, making it extremely hard for students to dismiss wrong ideas and embrace new ideas grounded in scientific principle (Byrnes, 2001). Laboratory environments help facilitate this process because students, when they have the opportunity to see, touch, and feel why their ideas are wrong are able to let go more easily (Batchelor, 2007; Ohander & Grelsson, 2006).

Cooperative Learning

Vygotsky, a Russian psychologist who lived from 1896 to 1934, made numerous observations of children in educational settings. From these observations he developed a psychological method he called cooperative learning (Henson, 2003). During his observations, Vygotsky observed that if children were placed in cooperative groups, they would work together, helping each other towards finding solutions to the problems they were being presented (Henson).

Cuesco (1992) describes cooperative learning as consisting of small select groups of three to five students working towards a defined objective. The science laboratory provides excellent opportunities for science teachers to use cooperative learning in the classroom (Gupta, 2004), but Doymus (2007) asserts that most teachers in high schools teach their lessons using a lecture based format with infrequent inquiry or cooperative learning experiences being utilized.

According to Kogut (1997), this is unfortunate because laboratory instruction is perhaps one of the easiest places to expose students to cooperative learning. However, Kogut stresses that it does not have to be this way, and he states that he has been very successful using cooperative learning in his college chemistry classes. Initially, he decided to incorporate cooperative learning into his classes with hopes of increasing student retention and reducing student apathy. His research indicates that using cooperative groups in the classroom increased the amount of time students spend studying away from class, thus allowing them to learn chemistry with more depth and understanding. According to Kogut, his students state that their involvement with cooperative learning has enhanced their college chemistry experience.

Cooperative learning has also been used in other college chemistry classes. Doymus (2008) has been teaching chemical bonding with cooperative learning groups. In his research, the experimental group utilized cooperative learning while the control group did not. The results of his study showed a statistically significant increase in student learning from the cooperative learning group when compared to the non-cooperative group.

In a related study, Doymus (2007) investigated whether having students placed into cooperative groups would help them learn chemical phase changes and how to interpret phase diagrams. Once again, he used an experimental and a control group. Instruments for the experiment were the Chemical Achievement Test (CAT) and the Phase Achievement Test (PAT). In order to set a base line, the CAT test was given to both groups as a pretest and again at the end of the experiment as a posttest. His results showed that the cooperative learning groups had a statistically significant increase in their abilities when compared with the control group (Doymus, 2007).

Maloof and White (2005) have used cooperative learning in their biology laboratories with positive results. They spent two years performing research on the use of cooperative learning in their college biology labs using the same students for both years. Their students were assigned to two groups - one a control group and the other an experimental group that incorporated cooperative learning techniques into their biology labs. Maloof and White's findings suggested that with increased use of cooperative learning student test scores also increased. After performing their research they said "We further recommend that in all college science laboratories instructors implement a research-based cooperative learning method" (Maloof and White, p. 123).

A similar study was performed in Australia with college students who were majoring in agriculture. They participated in a physical science class that utilized cooperative learning groups. According to the author (Gupta, 2004), the use of cooperative learning allowed for a more comfortable setting for minority, mature, and female students; and, the researcher suggests that, because the students were talking with one another about their projects, communication and conflict resolution skills also improved. Gupta suggests that because students talked about the problems given to them with other group members, discussing and debating alternative solutions, they actually learned more from the lesson than if they had used conventional problem solving techniques.

During the use of cooperative groups the instructors noticed that the students worked together and finished the assigned task; but, if forced to work on their own, they often did not finish the task, or became disenchanted with it and did a poor job (Gupta, 2004). However, Gupta believes that in order for cooperative learning to work, the instructor must constantly monitor the students, providing guidance and communication when needed.

The zealous use of standardized testing by many school systems appears to be one of the most important factors in the failure of teachers to use cooperative learning in their classrooms, especially in the science classroom. Teachers complain that much of the time in the classroom is used to make sure students are ready for the test (Moon, Brighton, & Callahan, 2003). This push towards standardized, high stakes testing has placed severe restrictions on cooperative learning activities, even though research has shown that the use of student centered cooperative learning allows students the ability to fully grasp science concepts (Munk, Bruckert, Call, Stoehrmann, & Radandt, 1998).

This is regrettable because the science laboratory is an excellent place to incorporate cooperative learning into the classroom environment. Research indicates that students undergoing a cooperative learning experience typically grasp material faster, retain it longer, and understand it with more depth than students who have been exposed to the same material in a teacher centered classroom (Munk et al., 1998).

Constructivism

Early research in learning and behavior was developed by pioneer psychologist such as B. F. Skinner. Early behaviorists who researched observable behavior believed that learning came from the environment and was due to either positive or negative incentives and was not mind related (Faryadi, 2007).

Psychologists today have moved away from behaviorism towards constructivism, including social constructivism. Constructivism is using one's own experiences in life to construct one's own internal model of how nature works. New knowledge is built upon previous knowledge; therefore, constructivism teaching methods are student centered (White-Clark, Dicarlo, & Gilchriest, 2008).

Researchers such as Kauffman, Conroy, Gardner, and Oswald (2008), state that the use of constructivist teaching methods can help alleviate some of the inadequacies that face impoverished and immigrant children obtaining an education. Their findings cite that 30 percent of high school students drop out of school before finishing, and Kauffman et al. suggest that the utilization of constructivist teaching methods may be a possible solution to the high dropout rate. They also suggest that constructivist teaching methods could help solve other educational problems, including student apathy and motivation (Kauffman et al.).

The United State's poor performance on the Program for International Student Assessment (PISA) has been seen by some as evidence that teaching methods in the United States need to change (Department of Education, 2006). According to PISA, the United States ranked 22 out of 30 countries in overall scientific literacy of students over 15 years old. The use of constructivist teaching methods in science classes has been suggested as one way to increase test scores on student assessments such as PISA (Widodo & Muller, 2002). Widodo and Muller state that despite the fact prior research has documented the benefits of using constructivist teaching, most teachers are simply not familiar enough with constructivist teaching methods to feel comfortable using them in the classroom. According to Widodo and Muller, this is one of the leading barriers to enhancing science education in the United States.

Constructivist teaching methods revolve around the student and focus on problem solving. Spiridonov (2006) discusses problem solving and how it relates to a person's life experiences. Spiridonov states that problem solving comes from within a person's conceived world, which encompasses past experiences, thought processes, culture, and everything else that makes up a person's being. He believes that because an individual's conceived world plays such an important role in cognition there are many ways to approach finding solutions to problems. This belief, that problems can be approached from many different directions, is part of the core of the constructivist philosophy of education (Batchelor, 2007).

According to Batchelor (2007), the constructivist teaching environment is one where learning is an active experience rather than a passive one, with the teacher acting more as a guide, gently leading students towards finding solutions to problems. Such learning requires intense group interactions, and research indicates that students learn better when they are able to compare their ideas and experiences with those of their classmates (Doymus, 2007; Gupta, 2004; Kogut, 1997; Maloof & White, 2005).

Schools such as the Citadel Military Academy already use learner-centered education as their core educational framework according to Henson (2003). Henson states that at the Citadel consideration is given to the fact that all students view education from different personal perspectives. He says all students are different from one another and have different educational needs. He mentions that most students are, by their nature, curious and want to learn, and research indicates most students learn best when material is presented in such a way as to be relevant to them, and they feel their opinions and viewpoints matter (Henson).

John Dewey was one of the first educators to embrace learner centered or constructivist educational practices. Dewey believed that education was the support for a democratic society, and learning should be instructional, challenging, and fun for the student (Dewey, 1916). Dewey also was one of the first philosophers to formulate ideas on the human thought processes; and, in his book (Dewey, 1910) discusses the evolution of a single thought process. Dewey felt that cognitive processes involved five steps. The steps are: 1) a problem is observed, 2) it is analyzed, 3) a possible solution is developed, 4) the proposed solution is enacted on the problem, and 5) the solution is analyzed for its effectiveness. Close examination of Dewey's problem solving process shows it to be very similar to the steps of the scientific method.

Dewey was also a firm believer in the use of imagination as part of the learning process. He felt that imagination is necessary for a child's cognitive development (Tiles, 2003), and nowhere in school is imagination used more than in a science laboratory. According to Batchelor (2007), being able to observe a phenomenon as it evolves sparks a child's imagination like no other school experience.

Batchelor (2007) describes using learner centered, or constructivist teaching methods in order to help pharmacy students obtain a firmer grasp on performing concentration calculations. According to her, concentration calculations have long been the bane of pharmacy students, but it is essential that they master the process because a calculation error can mean life or death for a patient. Batchelor goes on to explain that thousands of deaths occur each year because of pharmaceutical error. Therefore, every effort should be made to gain mastery of concentration calculations.

In her research, Batchelor (2007) compared the more traditional teaching method to that of a constructivist approach. Some students were placed into constructivist groups, while others followed the traditional teaching method, with both groups learning to perform concentration calculations. Batchelor's findings indicate that by allowing students the ability to work together increases their ability to perform concentration calculations. While working together, the students developed their own problem solving methods. Batchelor felt that the development of their own problem solving methods was one of the key reasons for the increase in student ability because it allowed students to have a process they understood better than the rote method usually presented to them. Batchelor's findings support those espoused by Dewey; namely, students are more effective if allowed to work together towards a common goal, and by working together, they build communication and cognitive skills. Batchelor states that constructivist teaching methods are essential to the science laboratory and a natural part of the scientific process.

Jean Piaget was also an early founder of constructivism. Piaget believed that the learning of new knowledge must be bound to a person's existing knowledge, and he felt problem solving was the force behind cognitive development, with people learning best by being active learners (Gould, Howard, & Cook, 1972). However, Piaget also believed that in order to learn something new, it must be interwoven with existing knowledge, with prior experience helping to drive the acquisition of new knowledge (Glasersfeld, 1989; Henson 2003).

Piaget concentrated his research on the assimilation of knowledge by children, and he investigated how children transition through different stages of development. These stages were described by Piaget as being: Sensorimotor - birth to two years; preoperational - two years to seven years; concrete operational - 7 years to 11 years; and formal operational - 11 years and up. In the Sensorimotor stage the cognitive ability of the child is mainly concerned with the mastery of concrete objects. In the preoperational stage mastery of symbols takes place. In the concrete stage children learn to visualize numerical calculations and relationships between numbers and classes of objects, but they cannot yet visualize abstract concepts. The formal operational stage is when the child begins cognitive operations on abstract thought (Evans, 1973).

The stages described by Piaget progress through all levels of human development, from birth to adulthood. Each stage indicates the level of cognitive development for a given age level; but, of course, the ages are only approximations because people develop at different rates. For example, it would be pointless to expect a child at the concrete operational stage to read a book such as *Lord of the Flies* because at that stage of development they typically are unable to handle abstract thought.

Piaget's stages of development allow educators to structure the school curriculum to accommodate the majority of children. High school students are at the point of their development where they are just starting to visualize abstract thoughts (Evans, 1973). According to Evans, they will not be proficient at abstract thought until they reach adulthood, which is one of the reasons the science laboratory becomes so important in high school. Most people learn better if they are active learners rather than passive learners. For many students, being able to see concrete examples in the lab that represent abstract concepts and ideas learned in class, will help them to form a stronger bond between the abstract and concrete realms of cognition (Byrnes, 2001).

Piaget also advocated that for children new knowledge is not something that can typically be induced by rote methods; instead, acquiring new knowledge is a personal experience, constructed through the child's life experiences and constantly changing shape as the child matures (Ackermann, n.d.). Preconceptions and expectations also play a role in acquiring new knowledge; and, when it comes to science, it appears that female students tend to view science more negatively than their male peers (Weinburgh, 1994), despite the fact that female students typically make higher grades than males do in science classes (Freedman, 2002). Freedman also suggests that research indicates females have been lagging behind males in their appreciation of science and have consistently rated science classes lower than males.

However, Freedman (2002) found in his research that allowing female students exposure to a hands-on science laboratory experience dramatically increased their rating of how well they enjoyed science. It seems that being able to physically handle lab equipment, perform experiments, and work in cooperative groups, increased the comfort level of science classes for them

(Freedman). These findings are supportive of Piaget's research and the constructivist philosophy of education.

Social Constructivism

Piaget focused on the individual nature of constructivism, but Vygotsky and Bruner focused on the social aspects of constructivist learning. Vygotsky was instrumental in the field of educational psychology even though he never had formal training in psychology. Vygotsky felt that one's ability to acquire knowledge was developed as much socially and culturally as it was individually (Edwards, 2005), and he believed that children related to stimuli on two levels - an individual level and a social level (McLnerney, 2005).

Vygotsky developed a theory he called the Zone of Proximal Development (ZPD) which, according to Morris (1998), consists of the amount of learning one can do by one's self and the additional learning that can be added if one is guided by a more capable person. The total amount of learning that has taken place, including both individual and guided, is the Zone of Proximal Development. Morris explains that Vygotsky thought each child has a range of problems that are beyond their capabilities; although, if allowed to work cooperatively with their peers, they are able to solve the problems by working together. But, they are unable to solve the same type of problem independently until the method of problem solving has been internalized.

Vygotsky's ZPD has tremendous implications for a science laboratory setting. First, and foremost, is the ability of the instructor to assign groups in such a way that each group will always have students at different levels of development. Therefore, slower students can be working with the more advanced students (Gabriele, 2007). The slower students should be able to solve problems as part of a team, and hopefully they will then be able to transition their newly acquired problem solving skills into the classroom (Gabriele). This method fits very well in today's educational environment of high stakes testing (Gabriele; Morris, 1998), because teachers can use it as a tool to help lower performing students. Morris states:

> Vygotsky showed those of us in the educational arena that the development of mentally and physically handicapped children follows the same laws as that of normal children. His research demonstrated the possibility of compensating for intellectual and sensory defects by developing higher psychological functions rather than training elementary ones. (p.3)

Renshaw and Brown (2007) extend Vygotsky's ZPD into everyday relationships between speech and scientific principles. They discuss how student interactions through speech helps students establish connections. Depending upon the goals set by the instructor, and by using different formats for discussion in the science classroom or laboratory, the instructor can help students make the transition from common everyday language to the more complex scientific vocabulary (Renshaw & Brown). Just as children need to work with peers in order to make the transition into more complex problem solving, they also need to use everyday familiar language to make the transition into unfamiliar scientific language, and the science lab is a perfect place to make such a transition. Proper science protocol for conducting a lab includes a pre-lab discussion about the procedures involved and a post-lab discussion about the results obtained. Such discussions are excellent places to connect familiar vocabulary with scientific vocabulary (Renshaw & Brown).

Vygotsky (2007) took his work very seriously, and in a letter written to a friend he states that " we are living in an era of geologic cataclysms in psychology - this is my main feeling" (p. 21). One of those cataclysms was the relationship between thought processes and language. Vygotsky understood that mental processing, culture, and speech are all related and work in unison (Renshaw & Brown, 2007). He believed the relationship between cognition and language was extremely important; and, in his book he indicated just how important when he stated that if psychologists cannot understand a relationship as simple as language and cognition, then it would be almost impossible to understand more complex psychological relationships (Vygotsky, 1962).

Bruner (1983), like Vygotsky, thought that people learned through social interaction. But, while Vygotsky believed social interaction provided a platform for learning, and that children can learn simply from their interactions with others, Bruner felt all children are unique individuals, each with different experiences, and each at different levels of development. He thought every child develops a personal scheme which is used to acquire new knowledge. This scheme, or structure, is based upon past experiences. According to Bruner, it is paramount to learning. In fact, he thought that teaching and learning how to develop and use structure was more important than the teaching and learning of facts (Smith, 2002).

Bruner (1983) said that children learn at different rates, and environmental factors experienced by each child play a major role in their cognitive development. In his article Bruner states:

> The first is that mental growth is not a gradual accretion either of associations or of stimulus-response connections or of means-end readiness or of anything else. It appears to be much more like a staircase with rather sharp risers, more of spurts and rests than of anything else. The spurts ahead in growth seem to be triggered off when certain capacities begin to unfold. And certain capacities must be matured and nurtured before others can be stimulated into being. The sequence of their appearance is highly constrained. But these steps or stages or spurts or whatever you may choose to call them are *not* very clearly linked to age; certain environments can slow the sequence down, others move it along faster. (p.133)

Bruner insisted that discovery learning is the most important type of learning because, when a person learns something through investigation, the learning becomes personal and meaningful (Lawton, Saunders, & Muhs, 1980). Bruner's belief that discovery learning is the most important type of learning places the science laboratory as one of the most important components of a school's science curriculum.

Social Cognitive Theory

Social Cognitive Theory (SCT) was developed by Albert Bandura, and is also called Social Learning Theory by some psychologists. In his paper Bandura

(2002) states that social cognitive theory distinguishes between three modes of agency - direct personal agency, proxy agency, and collective agency.

Personal agency is when a person acts by themselves for their own personal interest; proxy agency is when a person asks another person more capable than themselves to act in their best interest; and collective agency is when people group together to accomplish what they cannot do on their own (Bandura, 2002). Similar to Vygotsky, Bandura also believed that people were able to learn simply by the observation of others, and that a person's behavior can change based upon the observations and interactions they have with individuals or groups.

Perhaps one of the most famous experiments performed in psychology is Bandura's "Bobo doll" experiment. In this experiment a group of children watched a film showing an adult being violent towards a Bobo doll. Once the film was over, the children were instructed that they were now allowed to play with the toys in the room, one of which was a Bobo doll. Once play started, the children began to act violently towards the Bobo doll. From this, and other experiments, Bandura surmised that by simply observing another person's actions will sometimes cause people to assume the observed behavioral characteristics (Bandura, 1965).

Experiments such as the Bobo doll demonstrate the reasons educators need to be very careful about what they say and do in the classroom and the image they project. However, as an educator, one can also use the information obtained from psychologist such as Bandura to help children learn. For instance, science labs are a very useful place to utilize Bandura's SCT because students are constantly observing one another (Batchelor, 2007), and the lab is an environment that is perfect for the instructor to utilize behavior modification (Morris, 1998).

According to Morris (1998), if a child has apprehensions about his/her ability to conduct an experiment, the teacher can place the child with a more confident person who will demonstrate appropriate lab techniques. Simply from observing the other person, the low performing student can achieve a higher performance level. Once at the higher level, it will become easier for the student to conduct experiments on their own or to show others how such procedures are performed.

Skills are not static but evolve through time (Bandura, 1989), therefore, students who are proficient at one type of task are not necessarily proficient at another, but they are always able to raise themselves to a higher level (Bandura, 1989). Indeed, one of the tenets of Bandera's SCT states that as old goals are accomplished new goals are set. In his article Bandura says:

> People motivate and guide their actions through proactive control by setting themselves valued goals that create a state of disequilibrium and then mobilizing their abilities and effort on the basis of anticipatory estimations of what is required to reach the goals. Reactive feedback control comes into play in subsequent adjustments of strategies and effort to attain desired results. After people attain the goal they have been pursuing, those with a strong sense of efficacy set higher goals for themselves. (p. 158)

Science laboratory instruction is incremental and follows a path similar to the one suggested by Bandura's SCT. The lab is a place where skills are slowly increased. Usually, the first part of a science course will involve labs of a simple nature. Then, as the course develops, new skills are added to the old ones, and gradually students move to higher levels of laboratory proficiency (Benchmarks for science literacy, 1993; Harris, 2006). The American Association for the Advancement of Science suggests that before a student graduates high school they should have performed at least one in-depth scientific study where they design the experiment, determine how to conduct the experiment, and collect the data (Benchmarks for science literacy). This method of using hands-on instruction and gradually moving from one concept to another is supported by the National Science Teachers Association (NSTA) and allows students the ability to move from the concrete, such as physically performing the lab, to the abstract, such as visualizing how the bonds are being formed or broken (Bruning, Schraw, & Ronning, 1999).

Student Efficacy

The way students "see" themselves determines, to a large extent, what they believe their limitations to be. Bandura (1991) believes that perceived efficacy influences how people think, the course of action they should pursue, and the goals they set for themselves. Students are part of their environment, and the environment helps to shape their thought processes. For this reason, expectation levels they place upon themselves are due in part to environmental conditions.

For instance, research has shown that ethnic minority students typically are less interested in science careers because they perceive greater obstacles to obtaining a career in science than their White peers (Quimby, Seyala, & Wolfson, 2007). In their study, Quimby et al. analyzed 161 undergraduate science majors on their perceptions of science careers, especially environmental science. The researchers utilized instruments measuring self-efficacy, outcome expectations, environmental issues, and interest in environmental science to undergraduates.

The researchers found that minority students in the study were not as interested in science as a career when compared to their White peers. They also found that the minority students felt they had more barriers hindering their pursuit of a career in science than did their White peers. Student self-efficacy had a direct influence on the study conducted by Quimby et al., because if students are not able to see that their efforts in science classes will produce desired outcomes, i.e. a career in science, then they are not apt to pursue such a career (Ornstein, Behar-Horenstein, & Pajak, 2003). The researchers stressed in their book that educators should do all they can to strengthen student self-efficacy.

Bandura (1991) explained that people are driven by their sense of self-efficacy. Here again, the high school science laboratory experience could be used to increase student self-efficacy. Freedman's (2002) research indicated that access to the science laboratory increased female students' self-efficacy. Similarly, once minority students have success in the laboratory, their self-efficacy should also increase. Bandura's research also indicates that increasing a person's level of self-efficacy leads to higher achievement and motivation

(Bandura, 1977). Thus, positive experiences obtained in the science laboratory could have a direct impact on increasing the numbers of minority students pursuing science as a career.

Teacher Efficacy

Just as student efficacy is a hard construct to measure, so too is teacher efficacy. Teacher efficacy is how the teacher views herself, or himself, in terms of teaching capabilities, teacher planning and organization, student capabilities, student outcome, student behavior, and student motivation (Tschnnen-Moran & Hoy, 2001).

Teacher efficacy is also connected to teacher attrition. One of the reasons most often given by teachers when asked why they are leaving the profession is the lack of student motivation (Ingersoll & Smith, 2003). Teacher training appears to be the key to enhancing student motivation because teachers who have adequate training feel more comfortable with their students, and they have a high level of teacher efficacy. They also tend to have higher student achievement (Tschnnen-Moran & Hoy, 2001).

Teachers who are good motivators of students are considered to have high levels of self-efficacy (Enochs, Scharmann, & Riggs, 1995). Teachers' self-efficacy appears to increase as the teacher gains content knowledge in their subject area, develops teaching strategies, and recognizes personality traits that may affect teaching ability (Goddard, Hoy, & Hoy, 2000, 2004). According to Kelly (2006), the difference between an expert and a novice is that the expert can organize and classify problems in a much more efficient and practical manner, and they understand the content knowledge of their subjects with much more depth. Kelly suggests that the transition from novice to expert is expedited if teachers are allowed to work with their peers in content specific subject areas where they can discuss topics and concepts relating to their particular field of study. Goddard, Hoy, and Hoy's research agrees with that of Kelly's, emphasizing that allowing teachers to interact professionally with their peers, either through workshops, discussions, or some other form of professional development will increase teacher efficacy.

The SIM program provides opportunities for the type of professional development described by researchers Kelley (2006), and Goodard, Hoy, and Hoy (2000, 2004). Upon entering the SIM program teachers understand that they will be required to attend workshops for their particular subject in order to learn how to use the laboratory equipment and to become familiar with the laboratories they will be using with their students. During the training sessions teachers interact with their peers, exchange teaching strategies and discuss effective teaching resources. Training from such professional development should help establish a more cohesive cohort group and raise collective teacher efficacy (Gooddard, Hoy, & Hoy, 2000, 2004).

Raising the Bar: Standardized Testing

No Child Left Behind

Since the 1980's the use of standardized testing has increased at an accelerated pace. The most comprehensive legislation enacted so far regarding public schools and accountability is the No Child Left Behind (NCLB) Act that

President George W. Bush signed on January 8, 2002. The law set into effect tremendous changes for the educational system in the United States (NCLB, 2001).

Under NCLB, schools are held accountable for their students' test scores, and states can lose federal funding if their schools do not meet annual yearly progress (AYP) targets. If a school does not meet AYP, the school system must allow parents the ability to transfer their children to a different school (NCLB, 2001; Hursh, 2005). If a school continues to fail to meet AYP they are identified as a school in need of improvement. If a school fails to meet AYP for two consecutive years they are placed on school improvement lists and they must develop and implement an improvement plan (Learning First Alliance, 2003; NCLB, 2001). Sanctions for continued failure to reach AYP targets include the possibilities of: the replacement of school personnel, withdrawal of school funding, restructuring of the school, extension of the school day, and reduction of school administrative authority. If a school continues to fail to meet AYP, state takeover may occur (Learning First Alliance; NCLB).

Not everyone is happy with the NCLB Act. Some say it has reduced the self-efficacy of teachers (Stephens, 2007; Azzam, Perkins-Gough, & Thiers, 2006), lowered teacher morale (Viadero, 2007; Azzam, Perkins-Gough, & Thiers) and has caused some teachers to leave the profession altogether (Ferrell, 2005).

For science classes, the NCLB legislation has changed the way many school districts view their science curriculum. Beginning in the 2007-2008 school year, states were required to administer annual science assessments for at least one of the following grade groupings: third through fifth, sixth through ninth, and ten through twelfth. These assessments must be aligned to the states content science standards and include higher-order thinking skills (Learning First Alliance, 2003). Some researchers claim that whenever high-stakes testing is involved, some schools spend most of their instructional time preparing students for their upcoming assessments, leaving less time for laboratory-based instruction (Moon, Brighton, & Callahan, 2003). Unfortunately, the impact is greatest on urban school districts (Azzam et al., 2006). These schools are already underfunded and usually lack appropriate lab equipment and supplies. They are also schools where research has shown that cooperative learning and constructivist teaching methods, such as those endorsed by Bandura, Bruner, Dewey, Piaget, and Vygotsky are deemed to be very effective (Harcombe, 2005).

In fact, the use of constructivist teaching methods in the science classroom and laboratory are deemed to be so effective that in Houston, Texas, selected teachers from urban schools undergo constructivist training for one year at selected model schools (Harcombe, 2005). The model lab sites are partnered with Rice University, and selected teachers undergo intense constructivist teaching methods training. Results obtained so far from Houston's model lab concept are very encouraging. Teachers participating in the project return to their schools ready to begin constructivist teaching, and results from participating teachers' standardized test scores show that, on average, their students score higher than students from teachers who have not undergone the constructivist training (Harcombe).

Other states also have high schools that are beginning to form partnerships with local universities in order to enhance science education. For instance, Philadelphia Pennsylvania has a program initiated by Thomas Jefferson University (TJU) that seeks to break down the stereotypes students have about science and scientists by assisting educators in running laboratory experiments in their classrooms (Schaefer & Farber, 2004). Teachers undergo training and are provided resources for the laboratory experiments by attending professional development workshops at TJU. The program emphasizes reaching students from ethnic and economic groups that typically come from schools lacking in basic laboratory facilities (Schaefer & Farber).

Kransny (2005) discusses some of the issues involved with science outreach programs. She states that too often educators attend science workshops developed at local universities but never fully implement the programs at their schools. Kransny also notes that if teachers do implement the program, they often modify the specifics in such a way that the results often do not resemble the original program's principles or concepts. However, Kransny suggests that teacher modification of programs is not necessarily detrimental. Such modification is consistent with social learning theory and teachers who make modifications and adjust programs to suite their classrooms feel like active participants (Kransny).

The relationship between higher education and secondary education also has governmental support. Legislation has been introduced in the House of Representatives in the form of 20 million dollars in grants (Hinojosa, 2007) to foster the relationship between higher education and secondary education. Working through the National Science Foundation, the proposed legislation hopes to form partnerships between America's lower performing high schools and local colleges to help upgrade high school labs, increase safety training, and raise science content in the high school classroom (Cavanagh, 2007a).

Funding the Science Classroom

Self-Contained Science Programs

While the legislation being sought offers a possible solution to the science laboratory dilemma, other states are developing their own methods of dealing with the problem. Research indicates that most high school students do not have access to high-quality science labs (Schaefer & Farber, 2004; Kransny, 2005; Cavanagh, 2007b), and that too often there is limited connection between classroom content and science lab. Cavanagh suggests that for some high school science classes such as chemistry, physics, and biology, science labs are very important because most students taking those classes will be transferring to colleges where labs are an integral part of the science curriculum. The question then becomes how to give all students access to high quality science labs without breaking the high school budget. It is not possible for all high schools to build and stock labs equal to those found in most colleges. Modern technology is advancing at a rapid pace, and the stop-watch and meter stick used in old high school science labs are being replaced with the computer timer and computer interface (Trotter, 2008).

Trotter states:

> Turning students into apprentice scientists has long been a goal of K-12 science educators. But it's been many years since real scientists used the paper logs, alcohol thermometers, balances, stopwatches, meter sticks, and other gear that remain staples of many high school science labs. (p.1)

Trotter (2008) goes on to say that the purchase of high-tech lab equipment is not high on the priority list of most schools. This poses a problem for schools. If the goal of a high school laboratory experience is to give students the skills necessary for the transition into college science classes and laboratories, then a disservice is being done to the student if they do not have access to the same type of lab equipment they will be using in college (Trotter). Perkins-Gough (2007) explains that students in college who attended high schools that had proper science labs with advanced equipment will have a distinct advantage over students who attended schools having limited access to science labs. Perkins-Gough expresses that students with negligible high school laboratory experience are going to be especially ill prepared for college.

Having properly funded, well stocked labs is only part of the process. Correlating science labs to state course of studies and learning objectives is also important and is now required by NCLB (Learning First Alliance, 2003). Perkins-Gough (2007) cites a report published by the National Research Council (NRC), which states that some science laboratories need to undergo restructuring because, for some schools, there appeared to be little connection between classroom instruction and lab instruction. According to Perkins-Gough, science laboratories need to be used to support important scientific concepts, and in her paper she reports the goals suggested by the NRC for high school science labs. They are:

* Enhancing mastery of subject matter;
* Developing scientific reasoning;
* Understanding the complexity and ambiguity of work;
* Developing practical skills;
* understanding the nature of science;
* Cultivating interest in science and in learning science;
* Developing teamwork abilities. (Perkins-Gough, p.93)

In order to solve the high school science lab problem, some school systems are moving towards self-contained science laboratories where instead of the students coming to the lab, the lab comes to the students. This system has many distinct advantages. For instance, all of the expensive lab equipment can be carried in a van to the school. All schools visited by the van will be using the same equipment; therefore, no school will have an advantage over another (Helminger, 2007).

Juniata College in Pennsylvania started such a program in 1987 and called it Science In Motion (SIM). The program has grown and now has an annual budget of 2.7 million dollars, with 11 other colleges now being involved with the program. The program in Pennsylvania serves high school chemistry and biology classes (Mulfinger, 2007).

In the southernmost region of Alabama, a similar project began in Mobile County in 1994. It too is called Science In Motion and is patterned after Juniata College's program. The initial program in Alabama serviced high school chemistry and physics teachers. In 1995, the program also began to include biology teachers. Alabama's program has grown and now encompasses 11 sites across the state. The budget for the SIM program in Alabama was 2.47 million dollars in 2007 (USA, 2008).

Virtual Laboratory Instruction

Limited resources in public education have encouraged some educational systems to investigate using virtual laboratory instruction in the science classroom instead of hands-on laboratory instruction (Beaudin, Merritt, & Cornett, 2000). The advantages of using virtual laboratory instruction are that it reduces the expense of acquiring laboratory equipment and supplies, student training takes very little time, and there are virtually no safety concerns.

One of the more popular virtual laboratory programs is a chemistry simulation program, developed at Brigham Young University, called Virtual ChemLab (Carnevale, 2003). The program allows students to mix chemicals and perform experiments by manipulating their computer mouse. However, not everyone is happy with the use of virtual chemistry labs. The American Chemical Society suggests that chemistry students need the hands-on experience only found in a real chemistry laboratory (Carnevale).

While much of the effort by computer programmers in creating educational virtual science programs has focused upon simulating such classroom laboratory activities as chemistry experiments, other researchers have investigated the creation of computer learning companions. Yanghee and Baylor (2006) studied the relationship between people and computer animated digital characters, which they dub as PALS, who serve as virtual classmates for students. Although inconclusive, their research uses the constructivist view of education and learning as its foundation, and it focuses on the social interactions between human subjects and their animated PALs. Yanghee and Baylor state that the reason for the research is because some students do not have a human they can interact with, but social cognitive theory suggests that even interaction with an animated peer, or PAL, should increase student learning (Hoffmann, 2007).

Virtual simulation has evolved at a rapid pace in the last decade. However, more research needs to be performed on the benefits obtained by students using such educational resources. While some educators believe that the virtual laboratory experience is better than no laboratory experience at all, many believe that it can never replace the tactile manipulation of laboratory equipment, the smell of the science lab, or the excitement of a hands-on inquiry based science laboratory (Carnevale, 2003), and according to Beaudin, Merrtt, & Cornett (2000), virtual labs are inappropriate for use with subjects like Physics, Chemistry, and Biology.

Summary

Prior research such as that presented in this chapter illustrates the benefits students receive from teaching methods utilizing cooperative learning, constructivism, social constructivism, and social cognitive theory. Research indicates that science students who have exposure to these instructional methods learn faster, learn with more depth, have greater retention, and they enjoy the learning process more than students learning by methods that fail to address these dimensions of learning. One of the major drawbacks for using teaching methods like those mentioned is time. Research indicates that standardized testing has caused more teachers to spend the majority of their instructional time getting students ready to take the test. This leaves little time that can be devoted to inquiry based science. It takes a great deal of time to prepare labs for biology, chemistry, and physics classes. As indicated in this chapter, different states have taken different approaches to solve this problem. Although the approaches may be different, a common thread of cooperation with local universities can be found in all of them. The research performed for this project investigated such a program.

CHAPTER III

METHODOLOGY

Introduction

Chapter III describes the research outlined in chapter 1, including information about the research questions, research hypotheses, and information about the participants. The survey instrument (The Teachers' Sense of Efficacy Scale), developed by Tschnnen-Moran & Hoy (2001), is also described. The chapter further elaborates the analytical processes to which quantitative and qualitative data were subjected.

Research Questions and Hypotheses

This study investigated what impact, if any, the SIM program has on student cognitive functioning and teacher sense of efficacy and investigated teacher perceptions and attitudes regarding the program. The research questions were:

1. Is there a difference between the science achievement of the students of teachers who participate in the SIM program and the achievement of the students of these teachers before they became participants in the program?

2. Is there a difference between the science achievement of the students of teachers who participate in the SIM program and the achievement of the students of science teachers who do not participate in the program?

3. Is there a difference between the sense of efficacy of teachers who participate in the SIM program and the sense of efficacy of science teachers who do not participate in the program?

4. Has being involved in the SIM program affected the participating teachers' perspectives towards teaching science, funding of the science laboratory, and high- stakes science testing and accountability? If so, in what ways? If not, why?

The research hypotheses are:

Question 1:

The researcher hypothesized that the students of teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of the same teacher prior to the teacher's participation in the SIM program.

Question 2:

The researcher hypothesized that the students of science teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of science teachers who do not participate in the SIM program. The researcher used the number of quarters taught as a covariant in the analysis.

Question 3:

The researcher hypothesized that teachers who are involved with the SIM program will have a higher sense of efficacy, as measured on the Teachers' Sense of Efficacy Scale (Tschnnen-Moran & Hoy, 2001), than science teachers who do not participate in the program.

Research Design

For hypothesis 1, the design of this research was a non-randomized independent samples design. For hypothesis 2, the design of this research was a between subjects independent samples design. For hypothesis 3, the design of this research was a between subjects independent samples design. For research question 4, the researcher conducted a qualitative phenomenological study of teacher perceptions of the SIM program.

For hypothesis 1, the dependent variable was students' CRT scores, with the independent variable being teacher status relative to inclusion in the SIM project; i.e. pre-implementation of the program and post-implementation of the program. The analysis for hypothesis 1 consisted of parametric independent t-tests.

For hypothesis 2, the dependent variable was student CRT scores, with the independent variable being teacher status relative to inclusion in the SIM project; i.e. whether or not teachers participated in the SIM program. The analysis for hypothesis 2 consisted of parametric independent samples t-tests along with MANCOVA analysis. The multivariate analysis of covariance (MANCOVA) for hypothesis 2 also included the number of quarters the teacher has taught as the covariant.

For hypothesis 3, the dependent variable consisted of scores on The Teachers' Sense of Efficacy Scale developed by Tschnnen-Moran & Hoy (2001). The independent variable was teacher status relative to inclusion in the SIM project; i.e. whether or not teachers participated in the program. The analysis for hypothesis 3 consisted of multivariate analysis of variance (MANOVA) utilizing the subscales suggested by the research performed by Tschnnen-Moran & Hoy.

For research question 4, the design of the research was a phenomenological qualitative study. The researcher asked four interviewees 12 semi-structured questions concerning their attitudes and perspectives concerning the SIM program. The analysis for research question 4 consisted of transcribing the interviews, coding the data into themes, and collapsing associated themes.

Participants

The first hypothesis encompassed the study's analysis of the CRT scores of teachers involved in the SIM program; participants for this part of the analysis consisted of the entire population of teachers who had participated in the SIM program from the 2003-2004 school year to the 2008-2009 school year that had pre-implementation and post-implementation CRT scores; this group included 27 participants.

The second hypothesis continues with the study's analysis of teacher CRT scores. Participants for this hypothesis consisted of the entire population of teachers (N=37) who had participated in the SIM program from the 2003-2004 school year to the 2008-2009 school year, along with the entire population of science teachers (N=274) who had not participated in the program during the same time period.

Participants in the study's analysis of hypothesis 3 which addressed teacher sense of efficacy, consisted of the entire population of science teachers employed in the 2008-2009 school year participating in the SIM program, along with the entire population of science teachers employed in the 2008-2009 school year who did not participate in the SIM program. Science teacher populations used for the analysis taught the same subjects. The analysis for hypothesis 3 was conducted utilizing all surveys the researcher received back from the population of responding adult teachers. The letter to participants can be found in Appendix D, and the letter of approval from the Institutional Review Board (IRB) can be found in Appendix E.

The researcher did not perform statistical tests for research question 4; instead, the researcher performed semi-structured interviews with four SIM teachers who had attained level III status (the most experienced) in the program. The teachers were chosen due to their SIM experience. One alternate teacher with level III status was also chosen. All interviews were audio-taped and notes were taken. The interview questions are listed in Appendix C.

Instrumentation

The instrument used in this study was The Teachers' Sense of Efficacy Scale developed at Ohio State University. The instrument has had construct validity and reliability analyses performed on it (Tschnnen-Moran & Hoy, 2001). All of the questions are ranked on a "How Much Can You Do" 1-9 scale, $\alpha = .94$; with 1 being nothing, and 9 being a great deal. Tschnnen-Moran and Hoy's research indicates that the instrument contains three factors: Efficacy in Student Engagement which loads on constructs 1, 2, 4, 6, 9, 12, 14, 22, $\alpha = .87$; Efficacy in Instructional Strategies which loads on constructs 7, 10, 11, 17, 18, 20, 23, 24, $\alpha = .91$; and Efficacy in Classroom Management which loads on constructs 3, 5, 8, 13, 15, 16, 19, 21, $\alpha = .90$. The permission letter to use the Teachers' Sense of Efficacy scale survey instrument can be found in Appendix A, and the survey permission letter can be found in Appendix B.

Procedures

Quantitative Procedure Design

The data used for the CRT analysis was from the inception of the CRT program which began in the 2003-2004 school year, to the present school year of 2008-2009. All data used in the study were obtained from a test coordinator in the school system, and the researcher was limited to CRT data consisting of science teachers' mean class scores, percentage of students meeting proficiency (students who scored higher than or equal to 70 percent), and the percentage of students who passed the test (students who scored greater than or equal to 60 percent). A number replaced teacher name, and all other school identifiers were removed. All school years were divided into two semesters, with each semester consisting of two quarters. Each quarter was divided into four classes, or blocks, and every teacher had scores for all CRT classes taught. For every quarter, three variables were used: average score (AS), percent passed (PP), and percent proficient (PPRO).

The data for the teacher sense of efficacy analysis consisted of inputting responses to the 24 items into SPSS. A variable was used to distinguish between teachers who were part of SIM and those who were not. Demographics for teachers who participated in the efficacy analysis was also obtained and reported.

Qualitative Procedure design

Research question four was applicable to the qualitative research design proposed by this study and yielded information that benefited the overall study. The researcher performed the qualitative portion of this research utilizing purposeful sampling of four Science In Motion (SIM) teacher participants utilizing semi-structured interviews. Semi-structured interviews allow the interviewees the flexibility to give personal reflections of an account or an event (Smith, 1995), while providing the interviewer less opportunity for interjecting bias by maintaining consistency and structure throughout the interview process. The teachers selected for the qualitative section of this research were chosen due to their knowledge of the SIM program and had achieved level III status (the most experienced) in the program.

Key (1997) identifies the characteristics of qualitative research as:

1. Purpose: Understanding – Seeks to understand people's interpretations.
2. Reality: Dynamic – Reality changes with changes in people's perceptions.
3. Viewpoint: Insider – Reality is what people perceive it to be.
4. Values: Value bound – Values will have an impact and should be understood and taken into account when conducting and reporting research.
5. Focus: Holistic – A total or complete picture is sought.
6. Orientation: Discovery – Theories and hypotheses are evolved from data as collected.

7. Data: Subjective – Data are perceptions of the people in the environment.

8. Instrumentation: Human – The human person is the primary collection instrument.

9. Conditions: Naturalistic – Investigations are conducted under natural conditions.

10. Results: Valid – The focus is on design and procedures to gain "real," "rich," and "deep" data. (p.1)

According to Creswell (1988) the goal of qualitative research is to acquire an understanding of the phenomenon being studied, and one of the tools the qualitative researcher uses to reach such understanding is the interview process. All interviewees were asked 12 semi-structured questions pertaining to their involvement in the SIM program. The questions centered on the interviewee's perceptions and attitudes towards the program pertaining to teaching science, funding of the science laboratory, and high-stakes science testing and accountability. Throughout the interview process the interview was recorded.

The data for research question four were transcribed. The transcriptions were then coded as they were analyzed (Charmaz, 2004), and the coded transcriptions developed into themes (Creswell, 1998, 2005; Hara, 1995). Demographics for teachers who participated in the interview analysis were also obtained and reported.

Data Analysis

Because of the limited sample size, the researcher realized that power may be affected. Therefore, because the researcher had a directional hypothesis in hypothesis 1, the researcher used a one-tailed independent sample t-test. The one-tailed t-test allowed for more power and therefore a smaller effect size could be observed. The researcher estimated that for the one-tailed test at a power of .8, the researcher would be able to find up to a medium effect size.

The researcher's hypothesis 2 was directional; therefore, data were analyzed using a series of parametric one-tailed *t*-tests as well as MANCOVA analysis to determine what differences, if any, existed between group responses. The analysis was at the .05 probability level, and the researcher anticipated being able to find medium effect sizes at a power of .8. Utilizing multivariate analysis of covariance (MANCOVA) analysis, the researcher anticipated being able to find only large effect sizes at a power of .8. However, by utilizing the MANCOVA analysis, the researcher factored out the amount of quarters each teacher had taught.

The researcher's hypothesis on teacher sense of efficacy, hypothesis 3, was directional; therefore, data from the Teachers' Sense of Efficacy Scale were analyzed using MANCOVA, to determine what differences, if any, existed between group responses. The analysis was at the .05 probability level, and the researcher anticipated being able to find medium effect sizes at a power of .8.

The researcher did not have a hypothesis for research question 4; therefore, statistical analysis was not performed. Instead, a phenomenological qualitative analysis was performed to ascertain whether being involved in the SIM project had affected the participating teachers' perspectives, attitudes, and goals relative to teaching science, funding the science classroom, and high-stakes science testing and accountability across the time they had been involved with the program. Qualitative analysis for research question 4 consisted of transcribing the interviews, coding the data into themes, and collapsing associated themes.

All quantitative data were entered into the Statistical Package for the Social Sciences (SPSS) 13.0 for analysis. Other statistical tests included frequencies, descriptive means, and standard deviations. The researcher obtained the effect sizes and power estimates by using gpower, a general power analysis program (Erdfelder, Faul, & Buchner, 1996).

Summary

This study investigated what impact, if any, the SIM program has on student cognitive functioning and teacher sense of efficacy and investigated teacher perceptions and attitudes regarding the program. Quantitative statistical analyses were utilized to investigate the relationship between the SIM program and student cognitive functioning, and the relationship between the SIM program and teacher sense of efficacy. The study also performed a qualitative analysis to investigate teacher attitudes and perceptions towards the SIM program. Results from this study will add to the body of knowledge of science outreach programs to the teaching profession.

CHAPTER IV

RESULTS

Discussion of Results

The purpose of this study was to examine the relationship existing between the science outreach program Science In Motion (SIM) and student cognitive functioning and teacher sense of efficacy and to investigate teacher perceptions and attitudes regarding the program. Data analysis consisted of computing descriptive statistics such as means, standard deviations, and frequencies based upon research questions. Research questions 1 and 2 examined the relationship between student cognitive functioning and teacher participation in the SIM program. To address such relationships archival CRT data were collected and analyzed using independent parametric *t*-tests for question 1, and independent parametric t-test along with multivariate analysis of covariance (MANCOVA) for question 2. Research question 3 related to teacher sense of efficacy, and to address this research question teacher sense of efficacy data were collected using the Teachers' Sense of Efficacy Scale survey instrument (Tschnnen-Moran & Hoy, 2001). Multivariate analysis of variance (MANOVA) was used to examine research question 3 using the subscales developed by Tschnnen-Moran & Hoy. Research question 4 examined how the SIM program has affected the participating teacher's perspectives towards teaching science, funding the science laboratory, and high-stakes science testing and accountability. In order to answer research question 4, the researcher conducted a qualitative phenomenological study of teacher perceptions of the SIM program.

Statistical Analysis

Research Question 1 was stated as follows: Is there a difference between the science achievement of the students of teachers who participate in the Science In Motion (SIM) program and the achievement of the students of these teachers before they became participants in the program? The related hypothesis, Hypothesis 1, was: The students of teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of the same teacher prior to the teacher's participation in the SIM program.

Answers to the first research question were derived from the analysis of Criterion Referenced Test (CRT) data obtained from the Science Supervisor of the Mobile County Public School System. The data consisted of the average score, percent passed (students scoring above 60 percent), and the percent of students meeting proficiency (students scoring above 70 percent). The analysis was limited to 27 teachers who had pre-implementation and post-implementation CRT scores. The data used for the CRT analysis was from the inception of the program in the 2003-2004 school year to the 2008-2009 school year. The means for each variable: average score (AS), percent passed (PP), and percent meeting proficiency (PPRO) were used for the analysis. The variables, means, and standard deviations for each variable are shown in Table 1.

Table 1

Means for Variables Used for Research Question 1

Variable	Science IN Motion	Mean	SD
Average Score (AS)	No	66.79	12.34
	Yes	73.32	9.62
Percent Passed (PP)	No	67.24	25.14
	Yes	80.30	17.65
Percent Proficient (PPRO)	No	49.70	28.96
	Yes	63.79	23.04

The analysis for each variable; AS, PP, and PPRO consisted of parametric independent *t*-tests. Levene's test for equality of variances was not significant for variables average score (AS), and percent proficient (PPRO); therefore equal variances were assumed. However, on variable percent passed (PP) Levene's test was significant; therefore equal variances were not assumed. The results indicated that on average, the average score (AS) of teachers who had pre-implementation and post-implementation Science In Motion (SIM) student CRT scores showed a statistically significant increase after their students were exposed to the SIM program (M=73.3, SE=1.85), compared to students of these same teachers who did not participate in the SIM program (M=66.73, SE=2.37). This difference was significant *t* (52) = -2.19, p=.017 (one-tailed). This represents a medium sized effect r=.29.

The results indicated that on average, the percent of students passing (PP) the CRT exams of teachers who had pre-implementation and post-implementation Science In Motion (SIM) student CRT scores showed a statistically significant increase after students of these teachers were exposed to the SIM program (M=80.29, SE=3.40), compared to students of these same teachers who did not participate in the SIM program (M=67.25, SE=4.84). This difference was significant *t* (52) = -2.21, p=.016 (one-tailed). This represents a medium sized effect r=.29.

The results also indicated that on average, the percent of students rated as being proficient (PPRO) of teachers who had pre-implementation and post-implementation Science In Motion (SIM) student CRT scores showed a statistically significant increase after their students were exposed to the SIM program (M=63.79, SE=4.43), compared to students of these same teachers who did not participate in the SIM program (M=49.69, SE=5.57). This difference was significant *t* (52) = -1.98, p=.027 (one-tailed). This represents a medium sized effect r=.26.

The researcher's hypothesis that students of teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of the same teachers prior to the teacher's participation in the SIM program was supported. Results indicated a statistically significant increase in CRT scores after students were exposed to the SIM program.

Research Question 2 was stated as follows: Is there a difference between the science achievement of the students of teachers who participate in the SIM program and the achievement of the students of science teachers who do not participate in the program? The related hypothesis, Hypothesis 2, was: The students of science teachers who participate in the SIM program will have statistically significant higher scores on their science CRT's than students of science teachers who do not participate in the SIM program. The researcher used the number of quarters taught as a covariant in the analysis.

Answers to the second research question were derived from the analysis of Criterion Referenced Test (CRT) data obtained from the Science Supervisor of the Mobile County Public School System. The data consisted of the average score, percent passed (students scoring above 60 percent), and the percent of students meeting proficiency (students scoring above 70 percent). The analysis was limited to 311 teachers. Of these teachers 274 had never participated in the Science in Motion (SIM) program, and 37 had participated in the program. The data used for the analysis was from the inception of the CRT program in the 2003-2004 school year to the 2008-2009 school year. Means for each variable: average score (AS), percent passed (PP), and percent meeting proficiency (PPRO) were used for the analysis. The variables, means, and standard deviations for each variable are shown in Table 2.

Table 2

Means and Standard Deviations for Research Question 2

Variable	Science IN Motion	Mean	SD
Average Score (AS)	No	55.36	18.16
	Yes	72.24	8.917
Percent Passed (PP)	No	46.88	33.20
	Yes	78.70	15.98
Percent Proficient (PPRO)	No	32.30	29.04
	Yes	60.91	21.65

The analysis for each variable: AS, PP, and PPRO consisted of parametric independent *t*-tests. Levene's test for equality of variances was significant for all three variables, therefore equal variances were not assumed. The results indicated that on average, the average score (AS) of teachers who participated in the Science In Motion (SIM) program student's CRT scores showed a statistical significant difference (M=72.24, SE=1.47), compared to students of teachers who did not participate in the SIM program (M=55.36, SE=1.10). This difference was significant t (309) = -9.22, p<.001. This represents a large sized effect r=.46.

The results indicated that on average, the percent of students passing (PP) of teachers who participated in the Science In Motion (SIM) program student's CRT scores were statistically higher (M=78.70, SE=2.62), compared to students of teachers who did not participate in the SIM program (M=46.88, SE=2.00). This difference was significant t (309) = -9.63, p<.001. This represents a large sized effect r=.48.

The results indicated that on average, the percent of students rated as proficient (PPRO) of teachers who participated in the Science In Motion (SIM) program student's CRT scores were statistically higher (M=60.91, SE=3.56), compared to students of teachers who did not participate in the program (M=32.30, SE=1.75). This difference was significant t (309) = -7.21, p<.001. This represents a medium sized effect r=.38.

The researcher also performed the analysis for research question two factoring out the number of quarters taught. The analysis was performed using multivariate analysis of covariance (MANCOVA) statistical procedures. The adjusted means for the covariate are shown in Table 3.

Table 3

Adjusted Means for Covariate - Number of Quarters Taught

Variable	SIM	Mean	Standard Error
Average Score (AS)	Yes	69.6	2.75
	No	55.72	.99
Percent Passed (PP)	Yes	74.48	5.09
	No	47.45	1.85
Percent Proficient (PPRO)	Yes	57.27	4.56
	No	32.79	1.65

The covariate, the number of quarters taught (NQT) was significantly related to the average CRT score (AS), $F(1, 308) = 33.11$, $p < .001$, $r = .31$. There was also significant effect of participation in the SIM program on average CRT scores (AS) after controlling for the number of quarters taught (NQT), $F(1, 308) = 22.37$, $p < .001$.

The covariate, the number of quarters taught (NQT) was significantly related to the percent of students who passed (PP), $F(1, 308) = 24.79$, $p < .001$, $r = .27$. There was a significant effect of participation in the SIM program on the percent of students passing (PP) the CRT exams after controlling for the number of quarters taught (NQT), $F(1, 308) = 22.74$, $p < .001$.

The covariate, the number of quarters taught (NQT) was also significantly related to the percent of students who were rated proficient (PPRO) on their CRT exams, $F(1, 308) = 22.96$, $p < .001$, $r = .26$. There was a significant effect of participation in the SIM program on the percent of students proficient (PPRO) on CRT exams after controlling for the number of quarters taught (NQT), $F(1, 308) = 25.33$, $p < .001$.

Because the groups used in the analysis for research question 2 were so unequal in size, with 274 teachers not utilizing the SIM program and 37 teachers who did, and because Box's test of equality was significant, the researcher decided to repeat the analysis using equal groups. The researcher utilized the statistical analysis program SPSS and randomly selected 37 cases from the 274 in order to make both groups equal. The results from the analysis substantiated the earlier findings. The covariate, the number of quarters taught (NQT) was significantly related to the average CRT score (AS), $F(1, 71) = 7.51$, $p < .001$, $r = .31$. There was also significant effect of participation in the SIM program on average CRT scores (AS) after controlling for the number of quarters taught (NQT), $F(1, 71) = 15.10$, $p < .001$.

The covariate, the number of quarters taught (NQT) was significantly related to the percent of students who passed (PP), $F(1, 71) = 4.81$, $p = .03$, $r = .27$. There was a significant effect of participation in the SIM program on the percent of students passing (PP) the CRT exams after controlling for the number of quarters taught (NQT), $F(1, 71) = 15.12$, $p < .001$.

The covariate, the number of quarters taught (NQT) was also significantly related to the percent of students who were rated proficient (PPRO) on their CRT exams, $F(1, 71) = 5.66$, $p=.001$, $r = .27$. There was a significant effect of participation in the SIM program on the percent of students proficient (PPRO) on CRT exams after controlling for the number of quarters taught (NQT), $F(1, 71) = 12.52$, $p < .001$.

The researcher's hypothesis that students of science teachers who participate in the SIM program will have statistical significant higher scores on their science CRT's than students of science teachers who do not participate in the SIM program was supported. Results indicated a statistical significant increase in CRT scores after students were exposed to the SIM program.

Research Question 3 was stated as follows: Is there a statistical significant difference between the sense of efficacy of teachers who participate in the SIM program and the sense of efficacy of science teachers who do not participate in the program? The related hypothesis, Hypothesis 3, was: Teachers who are involved with the SIM program will have a higher sense of efficacy, as measured on the Teachers' Sense of Efficacy Scale (Tschnnen-Moran & Hoy, 2001), than science teachers who do not participate in the program.

Answers to the third research question were derived from the analysis of Teachers' Sense of Efficacy Scale surveys (Tschnnen-Moran and Hoy, 2001). The surveys were distributed via inter-school mail to the Mobile County Science Department Chairs with the permission of the Science Supervisor of the Mobile County Public School System. A total of 123 questionnaires were distributed. The total number of returns was 43, for a return rate of 35%. Respondent data were entered into SPSS, a statistical package for statistical analysis. SPSS was utilized to produce descriptive analysis, and to perform the statistical analysis necessary to answer the research question. Because of the small sample size, the three subscales identified by Tschnnen-Moran & Hoy's research were used in the data analysis. The questions, means, and standard deviations for the first subscale, Efficacy in Student Engagement are shown in Table 4. The questions, means, and standard deviations for the Second subscale, Efficacy in instructional Strategies are shown in Table 5. The questions, means, and standard deviations for the third subscale, Efficacy in Classroom Management are shown in Table 6. Demographic information from the survey instrument is show in Table 7.

Table 4

Subscale – Efficacy in Student Engagement (α = .83)

Questions 1, 2, 4, 6, 9, 12, 14, 22

Overall Mean for Teachers who Participated in SIM = 5.99; SD = 1.10

Overall Mean for Teachers who do not Participate in SIM = 5.96; SD = .92

Question	SIM	Mean	SD
1. How much can you do to get through to the most difficult students?	Y N	5.48 5.14	1.44 1.73
2. How much can you do to help Your students think critically?	Y N	6.62 6.14	1.75 1.21
4. How much can you do to motivate students who show low interest in school work?	Y N	5.38 5.14	1.40 1.73
6. How much can you do to get students to believe they can do well in school work?	Y N	6.62 6.59	.973 1.33
9. How much can you do to help your students value learning?	Y N	6.43 6.27	1.78 1.49
12. How much can you do to foster student creativity?	Y N	6.29 6.68	1.59 1.43
14. How much can you do to improve the understanding of a student who is failing?	Y N	5.62 5.82	1.28 1.33
22. How much can you assist families in helping their children do well in school?	Y N	5.48 5.86	1.78 1.46

Table 5

Subscale – Efficacy in Instructional Strategies (α=.86)

Questions - 7, 10, 11, 17, 18, 20, 23, 24

Overall Mean for Teachers who Participated in SIM = 7.30; SD = .99

Overall Mean for Teachers who do not Participate in SIM = 6.94; SD = .86

Question	SIM	Mean	SD
7. How well can you respond to difficult questions from your students?	Y N	8.24 7.33	.89 1.32
10. How much can you gage student comprehension of what you have taught?	Y N	6.29 7.00	1.59 1.07
11. To what extent can you craft good questions for your students?	Y N	7.33 7.10	1.32 1.34
17. How much can you do to adjust your lessons to the proper level for individual students?	Y N	6.67 6.36	1.71 1.26
18. How much can you use a variety of assessment strategies?	Y N	7.05 7.14	1.56 1.40
20. To what extent can you provide an alternative explanation or example when students are confused?	Y N	7.90 7.45	1.04 1.37
23. How well can you implement alternative strategies in your classroom?	Y N	6.38 6.50	1.80 1.41
24. How well can you provide appropriate challenges for very capable students?	Y N	7.52 6.59	1.21 1.30

Table 6

Subscale – Efficacy in Classroom Management (α=.91)

Questions - 3, 5, 8, 13, 15, 16, 19, 21

Overall Mean for Teachers who Participated in SIM = 7.20; SD = 1.31

Overall Mean for Teachers who do not Participate in SIM = 7.10; SD = 1.17

Question	SIM	Mean	SD
3. How much can you do to control disruptive behavior in the classroom?	Y N	7.19 7.36	1.50 1.47
5. To what extent can you make your expectations clear about student behavior?	Y N	7.76 7.73	1.61 1.45
8. How well can you establish routines to keep activities running smoothly?	Y N	7.95 7.62	1.32 1.36
13. How much can you do to get children to follow classroom rules	Y N	6.68 7.05	1.56 1.65
15.How much can you do to calm a student who is disruptive or noisy?	Y N	6.80 6.41	1.61 1.76
16. How well can you establish a classroom management system with each group of students?	Y N	7.19 6.68	1.63 1.65
19. How well can you keep a few problem students from ruining an entire lesson?	Y N	6.81 6.48	1.45 2.06
21. How well can you respond to defiant students?	Y N	6.81 6.90	1.45 1.73

Table 7

Demographic Data for Research Question 3

Gender	Male	Female		
	13	30		
Teacher Participation in SIM		Yes	No	
		21	22	
Subscales for Number of Years Teaching	1-3 years	4-10 years	11-15 years	16 or greater
Number of Participants per Subscale	6	13	9	15

Participants SIM Status	Level 1	Level 2	Level 3
Biology Teachers per Level	2	2	6
Chemistry Teachers per Level	1	1	4
Physics Teachers per Level	2	3	1

Note: one teacher participates in both chemistry and physics SIM.

The analysis of the Teachers' Sense of Efficacy scale subscale, Student Engagement, showed no statistical significant differences ($p = .91$) at the $p < .05$ level. The analysis of the Teachers' Sense of Efficacy scale subscale, Instructional Strategies, showed no statistical significant differences ($p = .22$) at the $p < .05$ level. The analysis of the Teachers' Sense of Efficacy scale subscale, Classroom Management, showed no statistical significant difference ($p = .75$) at the $p < .05$ level.

The researcher's hypothesis that teachers who are involved with the SIM program will have a higher sense of efficacy, as measured on the Teachers' Sense of Efficacy Scale (Tschnnen-Moran & Hoy, 2001) was not supported. Results did not indicate a significant increase in teacher sense of efficacy after teachers were exposed to the SIM program.

Research Question 4: Has being involved in the SIM program affected the participating teacher's perspectives towards teaching science, funding of the science laboratory, and high-stakes science testing and accountability? If so, in what ways? If not, why?

In order to answer research question 4, the researcher conducted a qualitative phenomenological study of teacher perceptions of the SIM program. The researcher conducted semi-structured interviews with four level III (the most experienced) Science in Motion (SIM) teachers. The teachers were chosen due to their knowledge of the SIM program. The semi-structured questions sought to find the interviewees' perceptions and attitudes towards the SIM program pertaining to teaching science, funding of the science laboratory, and high-stakes science testing and accountability. The interviewees appeared to be very open with their responses, but some did express they were nervous because the interviews were being recorded. These responses have not been edited or altered. They are written exactly as participants answered each question and the only changes made were to replace information that would identify the interviewee or their school. Also included are the themes obtained from the interviews with the teachers. Participant codes are pseudonyms used to protect the identity of the interviewees. Table 8 provides descriptive information about the interviewees.

Table 8

Descriptive Information for Research Question 4

Participant Code	#of years in SIM	Gender	Courses Taught
Sue	6	Female	AP Chemistry, Chemistry I
John	3	Male	Hr Biology, Biology
Mary	5	Female	AP Chemistry, Chemistry I
David	4	Male	Dual Biology, A&P Biology Hr Biology, Biology

All members of this group of interviewees except for one (John) teach regular and advanced classes. Sue and Mary both teach chemistry, including Honors Chemistry and AP Chemistry. John and David teach biology classes with David also teaching AP (advance placement) and Dual (students obtain college credit for the class) Biology classes.

In this section, the participants' responses to each question are shared.

Responses to Interview Questions

1. If you could pick the one thing the Science In Motion (SIM) program could do, or not do, with respect to your science discipline, what would it be?

> (Sue) It would be more diversity in their labs. Ah, labs that are more applicable to all of the different levels of chemistry education. A lot of the labs are fine, uh; some of the labs come, or arrive at school in unusable conditions. So, that would be an area for improvement, to ensure that all of the labs are such that they could be used by any school at any time; and then, you also have technology that is supposed to work, for example, the CBL's; yea, they don't actually work. That would be an improvement as well.

> (John) One thing that they could do better I think is give us more access to stuff we don't have at the high school level. Some of the equipment, some of the stuff for biology they really don't supply you with, like specimens and stuff for your invertebrates, and stuff that is expensive for you to buy at the high school level. If they could do that it would be better. What it does, is that it cuts down on the expense of labs. You don't have to pay for lab equipment, and a lot of the labs they have are stuff that you pretty much would only have enough lab fees to buy enough stuff for only maybe two semesters, and that's what you get in labs without having to spend any money, so it's nice.

(Mary) I guess the main thing that I would think about with reference to this question would be, uh, I would like to see more AP labs in there. We have a ton of good basic labs for Chem I, and even a lot of labs for Chem II, but AP Chemistry has twenty labs that must be done, and it would be very good and much easier for me if those labs were already prepackaged and could just be dropped off. So, I would say that the one thing the program could do for me would, to be able to pack up some AP labs and have them ready to go for me.

(David) Both could or could not do? *Interviewer- yes*, First I would say that I'm real pleased with what the program is doing for me in terms of providing labs and hands-on activities without being part of my budget; having to pay for it. I have no, no complaints, on how, in terms of administration, how the person responds to us when we need it; in terms of the workshops that she conducts. One thing, there are some items that they could have more of because I find myself needing a certain lab and they only have two in inventory and I have to wait to get it, and it may be that I have already finished that unit before it becomes available. *Interviewer- I know that you teach dual enrollment, do they have enough labs for your dual enrollment classes?* Actually, yea, we've got, I pattern my labs after the AP labs, and the twelve now that we have got that are required for the AP labs, there is only two that the SIM program has the equipment for me to do. So, I guess that a shortfall would be that in the Advanced Program, the Dual Program and the AP Program, is that the equipment that is necessary to do the mandatory labs. In their defense it's, uh, that is some expensive equipment, and the vast majority of teachers would never check it out, so I don't know if they would get their money's worth out of that equipment. Interviewer- *I believe that more schools are going to pick up more AP programs.* Then, in the future they may do that. I have not talked to the specialist in terms of what they are going to do, what she is going to do in terms of adding new labs. I suspect that with our current budget situation there won't be many labs added.

2. How would you describe the science content knowledge of the Science In Motion specialist servicing your school?

(Sue) I have no idea with respect to Science In Motion knowledge at all. *Interviewer-why is that?* Brand new Science In Motion person, ah, new to the SIM program, have no idea as to background knowledge. Not very knowledgeable to the SIM program, which is partially due to her being new at the job and also new to the program? So, specifically, her content knowledge specific to SIM is not very good, content knowledge related to chemistry, I don't know. *Interviewer- what about the previous SIM specialist?* The previous SIM specialist had quite a bit of content knowledge, and was fairly well familiar with all of the labs contained in SIM. Every now and again there was something that he was unfamiliar with. *Interviewer- are you involved with other SIM specialists?* I have been involved with the biology specialist. The biology specialist is very knowledgeable with respect to biology content, and also the labs contained within the biology SIM.

(John) Excellent, excellent, she knows most of the labs and they go right along with the state course objectives, and she knows everything about them. I would grade her as excellent. When you ask for stuff that's there she helps you service wise. If you have any questions about the labs sometimes she will even stay and do the labs with you. I have no complaints about the person running the biology SIM. *Interviewer- so, you're only involved with biology SIM?* Right, so I don't know anything about; that's the reason that with the amount of equipment and stuff, I am sure that it is probably better with chemistry and physics, but on the biology side there is not a lot of equipment except for microscopes and a couple of computer labs we do, but not much.

(Mary) Well since we have a new SIM person I'm not really sure of her science background. I don't know what her degree is in, and I don't know if she has advanced degrees. Uh, she seems to be knowledgeable. I will say as far as her SIM lab experience, uh, I think it may be lacking. She has only been with SIM for basically a summer session, and has now been promoted to a science specialist. So, I'm kinda concerned that the fact that she has not gone through every lab that's in there, but I would hope that is what she is spending her time doing. *Interviewer- let's go back to the previous SIM specialist, how would you rate the previous SIM specialist?* The previous SIM specialist, uh, as far as content knowledge was exceptional. He had a very, uh, amusing way of being able to put very difficult science concepts into very layman terms, and very funny terms.

(David) Oh, she is real good. She is very knowledgeable, she's got several years of experience in the classroom and she has taught all the classes that I have taught in terms of the levels of biology. So, she's very knowledgeable in the content area, she's very knowledgeable in terms of setting up the labs and what's needed to conduct the labs, so I am extremely satisfied with the support she provides us.

3. How would you compare the Science In Motion workshops to other science workshops that you attend throughout the school year?

(Sue) A benefit to the SIM workshops is that they're content driven, and, uh, some of the SIM workshops are focused around labs that can directly be related to the classroom. Most of the science workshops that I attend, or are required to attend, are very little to no value. *Interviewer- so you would rate the SIM workshops higher or lower overall than other workshops?* The SIM workshops would definitely be rated higher.

(John) Uh, I won't say anything bad to make the other workshops look bad, but SIM workshops are better. They are a lot better, they're to the point, you know a lot of the stuff they use is; they don't, a lot of the stuff you use you have to figure out how to implement it in class. With SIM they tell you how to implement it, which helps. They tell you what Course of Study objective that it goes with, and you even test some of the kits out that you can buy from Carolina without having to go buy them yourself and see if you would actually use them in the class; so that's what I like about it. It kinda takes; to me, it kinda takes some of the thinking out of it. You don't have to think how am I going to implement this in my class, how am I going to use this equipment, or how am I going to use that. It just makes it easier. It just makes doing labs so much easier. *Interviewer- so, if I am understanding you correctly, then you're saying that the SIM workshops are more specific towards teaching you how to do the labs?* Yea, it's very streamlined. This is the lab, and this is how you do it. It's what objectives you would use this with, you know it's very straight to the point. No, you really don't have to think at all, it's very, it's easy, and that's what I like about it. *Interviewer- how many workshops do you usually attend for biology?* Uh, we do two. We do one each semester. We did two last year, we haven't done any this year so I don't know, we may only do one this year. I'm a third year now so it's different because I have had to go through two summers of training, and I had to do one day this summer. So, I think that I am pretty much through with the training aspect of it, but usually she tries to do two, but sometimes the budget doesn't allow her to pay for subs for everybody that she services. I think more people than chemistry goes so she has to pay for sixty subs whereas the chemistry people are having to pay for fifteen or twenty subs, so her budget doesn't allow her to do as many during the school year because of that.

(Mary) I have attended the Alabama Science Teachers session of workshops and ASTA and NSTA before. Uh, I guess that ASTA I did not really get a lot out of, uh, there was a lot more life science related stuff. NSTA I absolutely loved. There was a heavy emphasis on technology, very heavy emphasis on AP; uh, SIM is fun and I do learn a lot of new labs, but I will say that, uh, there's not as much inquiry experience there. You don't have how to teach inquiry through labs, uh, how to create your own labs. So, I think that there's lots of ways that SIM could go that I think maybe would put it on par with NSTA that I don't think it's at yet. Uh, I think right now it's more cook book labs. You just kinda read it and follow the directions. I don't think that there's a lot of critical thinking there. Uh, where as in some of the other workshops you learn to take labs and change them and tweak them into being more hands on and more inquiry based or critical thinking based where it's just not a fill in a data table and go. *Interviewer- what about the, uh, you've attended the AP workshops, how would you rate it compared to the AP workshops?* I would say that it's pretty much even. The lab section of the AP workshop that I attended at the University of Alabama, I think it was three years ago, uh, it was pretty much the same set up as SIM workshops, or like the SIM workshops are setup as. They give you a lab and it's a cookbook lab. There wasn't any write-ups that you had to perform; it was just fill in a data table and go. So, I would say that the AP workshop and the SIM workshop were on par with each other.

(David) Oh, hands down a lot better than other science workshops that I've attended. In all honestly, since the SIM program has been kicked off, I have not attended any of the others because they are a waste of time. But, with the SIM program every workshop a new lab is introduced, and you actually participate in the lab and you do the lab yourself. That helps in learning the lab, you feel more comfortable with it, and you will be more likely to use it in your classes because you are comfortable enough that you can perform the procedure. *Interviewer- If I am understanding you correctly the SIM program workshops pretty much focus around the new labs they are developing instead of just a general broad science workshop?* Yea, yea I am level three, and the first year we had to attend two weeks of workshops. We came in and we did all of the basic labs, and then the second year we came in and we did advanced labs. We went back and did a couple of the old labs just to refamiliarize ourselves with it, but each year she's added labs to the ones that we do in our workshops, so it really has not been a repeat of old labs.

4. Do you think that your students require skills when using Science In Motion labs that will transfer to college? If so, which skills, if not, why?

(Sue) Absolutely. They are going to have skills that will transfer to college, specifically skills related to using the equipment; things such as burettes used in titrations, and pH meters; ah, using the mass specs, things like that they are going to be using in the first and second year of college. That would definitely be skills that they will take with them that they would not have been able to acquire without SIM. *Interviewer- so the skills that you are looking at are mainly technical skills verses say increasing science* *content skills or lab skills? I guess that's what I'm getting at.* Yea, I would think definitely lab skills.

(John) Oh yea, the way the labs are written up like you would see in a college lab manual, like if you took 121 or 122. It goes into the same stuff. The breakdowns of the labs are just like you would see in a college lab manual. When you finish your college lab you have the questions you have to answer. The questions are; some of them are just simple one word answers, and then there are others at the end where you have to write a little bit. So, the labs are written like a college lab. It's like a college lab manual. *Interviewer- Can you identify any specific skills?* Uh, right off hand without looking at it and thinking about it there's a lot of graphing in the lab manual. Pretty much every lab we do has a graph or a table they are using. Some of them require you to use the calculator, but really it's mainly graphs and filling out tables and stuff, and drawing conclusions. *Interviewer- when you use the calculators do they hook up to the CBL units?* No, we never use them. The only time we have ever used any calculator stuff is whenever; I don't do it because I don't teach human anatomy, but they have some human anatomy labs where they break out the probes, you know the Vernier probes and stuff like that. We don't get to that in freshman biology. *Interviewer- like temperature probes?* Temperature probes and stuff like that, that's all, I think that there is about five or six human anatomy labs that have temperature labs, they have EKG's and ECG's where they use a heart monitor. They have about five labs where they do, but we never, I never use it with my kids because I don't trust my average ninth grade freshman with it.

(Mary) Uh, yes. I think they do, and then they don't in some areas. I think it's very good that they learn how to use a micropipette, and I think it's very good that they learn how to use an analytical balance. Uh, I think some of the labs are the exact same labs that they are going to see in a college setting. But, when we get on to stuff like the GC's and the Spec 20's and things like that, they're not going to use that in a general chemistry class. They're not going to use them in 131 or 132 or even lower that that, 101. They're never going to lay hands on that unless their majoring in chemistry. So, I think, uh, some of it is very good, again from an AP standpoint. I am going to pose a lot of this from an AP standpoint because, uh, those Spec 20 data are good for the AP test, but as far as to what they're going to use in college, some of it's overkill but some of it's not. *Interviewer- I guess that some of it may benefit them if they enter industry in a work environment as a lab tech maybe?* Absolutely, absolutely, uh, if they go into a lab tech or any kind of industry it's going to be dead-on for them. I'm just thinking about them taking general chemistry in college, it's not goanna do much. I mean, some parts of it will, but other parts as far as the higher end are not going to do anything.

(David) Well, ah the labs, the answer is yes I think that they do acquire some skills. Particularly with, I do some stuff with the Vernier probes and the laptop computers, and that's similar to the labs they will use in college;

and from what I have been told they will use that type of equipment more and more, so I think that my students who participate in those labs are a leg-up on the ones that don't. *Interviewer- so, do you think that they're going to be using the same equipment in college as they are using in the SIM labs to some respect?* To some extent, but I will say this, I adjunct at *college X* and I have adjuncted at *college Y* as well, and to be honest, the labs there don't have the equipment that I have access to through SIM.

5. How would you describe the overall quality of the Science In Motion labs?

(Sue) The overall quality of the SIM labs, in general they are very good labs; they correlate to content, they run well, they are user friendly with respect to write-ups. Most of the labs work very well.

(John) Excellent, I think that with the block schedule it's the time. If you can get enough time to get them in their excellent. The kids tend to score better on those questions if there is a lab related to it. If they can relate it back to the lab they do so much better on it. They score a lot better if I can get a lab in with something that goes along with the CRT or exit exam, they tend to retain it better because they can relate it to something done in class as opposed to books. *Interviewer-You're saying that they are scoring better but how do you know that they are scoring better?* Uh, I just think that when you go back over it in the quarter review unit for the CRT they relate it back to the lab. If you ask them a question about say, uh, the evolution lab, and then you go back and asked which beak is best, they always like that one, and they relate to that because there's a question on the CRT about what type of food would this bird eat, and they relate it back to the lab that we do about which beak is best. That's what I am relating it to; I don't have any numbers as far as; I just notice that they retain the stuff better if I give them a lab that goes with it, instead of just using direct instruction or group learning or something like that. If there is a lab or a project built around it they seem to remember it at the end when you go back over everything.

(Mary) Great quality, uh, very well written, they are very, very, few labs that I've ever done that I have needed to change; uh, very well written procedures, very thoughtful questions at the end of them. Uh, I really like the labs. There's a little something for everybody, and there's something for every single topic you teach. It does not matter if you teach AP, or if you teach Chem I, there's something for everybody. You can make the labs as difficult or as complex as you want if you tweak the questions a little bit.

(David) Good, but again we've got a whole inventory laundry list of labs that we have access to and obviously some are better than others. I pick and choose the labs I am going to use to what I am doing in class, and the ones that I think will support what I am doing in class. Like I say, you pick and choose the ones that you want and they will bring them.

6. How would you improve the laboratory selection and/or laboratory development process in the Science In Motion program?

(Sue) Primarily looking at, or firstly looking at the labs that are used most frequently by various SIM teachers and what content area their supporting. Then, considering what content area is not supported by a lab, why it is not supported by a lab, and what are some labs that could be used to easily be worked into the curriculum so that more than one teacher would use them. *Interviewer- can you think of any, uh, content that you would like to have a lab for, maybe that SIM does not provide?* We really don't have anything with respect to redox; we, uh, do not have anything related to electrochemistry. Our equilibrium lab is coming undone. For gasses we don't have a reliable gasses lab. We have ones with the CBL's, but the CBL's are always touchy, and there are other gas labs that we don't have. We have heats of reaction which works well for Chemistry I, but nothing that is applicable to Chemistry II or AP Chemistry. *Interviewer- I know that you teach AP Chemistry, so for those particular concepts do you usually develop your own labs?* I usually use labs from colleges throughout Alabama, the University of Alabama, or I develop my own. *Interviewer- when you are using a lab say from South Alabama, and you get the chemicals, do you acquire the chemicals from SIM or do you order your own chemicals?* No, usually I order my own chemicals.

(John) Uh, I think that some of the labs as you go through and do them, they are doing a good job of it because they have to constantly keep updating them, because if you do them with the same kids over and over again, sometimes you run the risk of having repeaters who may have seen the lab or have already done it one time already. Sometimes the labs just get outdated because they are constantly changing the Course of Study (COS). The COS used to be where we would spend a lot of time on animals, and now it's shifting more towards ecology and stuff like that. The last meeting I went to they were trying to shift the labs to cover more of the ecology stuff because that's the way that the grad exam and stuff that are being tested on is going to. *Interviewer- when you go to your meetings does your science in motion specialist ask from the teachers their input as far as labs?* Oh yea, she pretty much acts as a facilitator, where you tell me which labs you want, which ones you like, and we will put them into the program and get them out. She doesn't want labs that are not going to be used. She doesn't want to have ten labs that never get used. You know she wants' labs that are going to constantly be getting checked out because it's just a waste of their money if it's not being checked out and being used. She's always, pretty much every meeting I have been to, one of the questions that she asked was, as we were going over a lab was, is this something you are going to use, or is this something you're not going to use? Tell me why you are not going to use it so we can fix it to where you can use it, or is this just something that does not apply to the level of kids your teaching, or just not possibly at the level you're at right now.

(Mary) Again, I'm going to be going back to AP, uh, I would love for them to take a couple of the AP manuals that are out there on the market and go to the college board web site and come up with some, because there's a lot of AP labs that are not anywhere in the curriculum of SIM. I'd love for them to get a couple more of those lab write-ups in there of those labs off hand. Uh, as far as laboratory development, uh I think that they do a fairly good job already of letting us come to the table, saying if you have any labs that you do but not necessarily everybody else does, bring those with you to the workshop. That has always worked really well and I have gotten a lot of labs that weren't SIM labs to begin with from other teachers and then they became SIM. So, I think the process is really good as far as collaboration. Uh, I would just love to see some more AP stuff. *Interviewer-concerning AP labs, where are you getting them from if you're not getting them from SIM?* What I do is the Zimdal textbook that we use came with a laboratory manual, and I just order the chemicals off there and prep my own. The only thing that I may have to do is that if it requires a Spec 20 or an analytical balance or pipettes, instead of ordering a lab I may order a specific piece of equipment (*from SIM*) which does help a lot. I mean I can order chemicals on my own, but it just is easier to have them dropped off in a big box for me. I can do it on my own, but it is nice to be able to get that big ticket equipment because I'm not spending all that money on analytical balances and stuff like that.

(David) Well, from my standpoint, I would have to go back to what I said earlier; I would go back and add the labs that are required for the AP program.

7. What effect, if any, has Science In Motion had on your students' laboratory experiences?

(Sue) Well, the Chemistry I students are going to come into Chemistry II or AP Chemistry with a solid set of laboratory skills, and then the AP students are going to be well prepared for going into their first or second year of college based on the SIM labs and supplemental labs. Uh, so it has done nothing but increase and broaden their laboratory experience. *Interviewer- the equipment they are going to be using in college? In other words, they can make the transition without too much effort from the high school laboratory to the college laboratory?* Yea, they should be able to because SIM has enabled them to use a lot of the equipment they are going to use in college; specifically, in their first year of college chemistry. Those are pieces of equipment that most schools do not have in high school.

(John) I have had kids that have never even went to lab before, so you know, for me it's stuff like microscopes. I have had kids that have never been exposed to microscopes, triple beam balances, just the equipment. They have never seen any of it, and part of that is where they went to middle school at. It's kinda sad that they can get to the 9th grade and never been exposed to any of this equipment. They have never seen a centrifuge, never seen it. I think that if they like going to the lab, and if you can get them to go to lab, and do what they are supposed to, they seem to enjoy it a lot more than being in class. So if you can get enough labs in there where they can go, it just seems like they enjoy the class a lot more. They like to go to lab. *Interviewer- if I'm understanding this correctly, you see it as a positive experience?* A positive experience, yes a positive experience. A lot of them don't get to experience lab in the middle school level. You know what little lab they do is kitchen labs, stuff they would get out of the kitchen.

Some of these labs are a little more involved, they get to go into lab and use equipment that they normally would not get to use. Something they have never seen and operated before. *Interviewer- so, it gives them exposure to equipment and maybe a more positive experience in the classroom?* Yea.

(Mary) It lets me do a lot more labs because I have so much less time prepping because the labs are ready to go. All you have to do is open the box and out the lab comes. It lets me do more labs, for example when I do acids and bases with Chem I, if the lab is already dropped off and ready to go I can do 39 Drops and, uh, Bases and Acids in one day. I can do two labs in one day. There are a number of labs that I can do because I don't have that prep time for the labs. It also gets their hands on high dollar equipment, and they learn to respect this equipment, and not play with it like it's a toy. You tell them that this equipment is not ours, it's on loan from the university from SIM, and they're going to be much more careful with it, especially if you tell them how much some of these things cost. I think it makes them feel very good when they are playing with these really high-tech machines that they have never seen before. They have seen them on CSI before and they actually get to touch one. I think that it gets them excited a bit more, and when the previous SIM specialist would come and do demo shows and things like that, it was just another face in there and another personality. They knew him as the SIM guy. They got really excited when he came because they knew that we were going to be doing a lab.

(David) Ah, it's had a positive effect from the standpoint that they get exposure to the additional equipment that SIM has made available. I mentioned the Vernier probes and the laptops that I use. Obviously, without SIM I would not have been able to do any of those labs.

8. When implementing Science In Motion into your lessons, how does it differ in each content area? For example, Chemistry I verses Chemistry II, or Chemistry II verses AP Chemistry?

(Sue) When you are looking at implementing, uh, SIM labs into Chemistry I, you're looking at, or you're looking for, labs that are going to focus on a specific content area, enabling the students to attach meaning to it from the classroom to the lab. You are also looking at labs that are going to give them basic skills. When your selecting labs for Chemistry II or AP Chemistry, you're trying to go beyond that, and you are looking at things that are going to provide additional skills and to provide an entirely new set of knowledge and information, not just supportive; especially AP. So, as you make the transition between the ranks of Chemistry I, Chemistry II, and AP Chemistry, you're using basically the same equipment, but in Chemistry I students are not going to use the mass-specs and the pH meters, but in Chemistry II or AP those are essential items. You tend not to use the crucibles for Chemistry I but you do with Chemistry II or AP. Uh, everything's kinda deepening if you know what I mean.

(John) I could not answer that because I don't teach chemistry. *Interviewer-can you relate it to biology?* I only teach biology, I have never gotten to teach any other subjects. *Interviewer- what about Honors Biology versus Regular Biology?* Well the difference between the honors and the regular kids would be some of the labs require more time and they require, I won't say more intelligence, but they require you to think before you do stuff instead of just rushing through it and getting an answer. Some of the labs for me it's more of the equipment. I don't want to tear the equipment up and somebody else not get to use it. So, some of the labs I don't use with my regular kids because they just can't handle it. I'm scared they are going to tear something up or beak it; and my honors kids tend to be more relaxed and take their time and read everything thoroughly and go through it and complete it. I have tried to use some of those labs with my regular kids in the past and they ended up getting half way through the lab and mess up on something and have to start back over again and it just doesn't work out. *Interviewer- when your implementing SIM labs into your lessons do you try to match the course of study?* Oh yea, definitely, that's the way to do it. Really it makes your planning easier because you can plan your labs at the beginning and the way she does it you can give her a nine week schedule for the labs you want and she is bringing one a week matched up with whatever you're covering that week. People do different labs. There's some of them that people like and some that people don't like, it's just what you like and what you think your kids will enjoy and get more out of. Some of the labs I've done I have really liked and the kids may hate them. Some of the labs I thought were just silly and stupid I give it to them and they really love it. So you know, it's just different kids. Some years you have kids that like certain things and some years you have kids that like other things. *Interviewer- so do you think that the program has enough labs?* Oh yea, there's a lab for everything. Three or four for every objective, so there's plenty of labs; it's just a matter of picking which ones you want to use. (Mary) I will say that the big difference in Chemistry I verses Chemistry II is that it is really laid out very well for you. You have the introductory manual and then you have the advanced manual for SIM. There are lots of topics in the manuals that you know you are not going to be able to get to in a Chem I class. You are not going to get to buffers and acid base titration, or an acid and a strong base in a Chem I class. In a Chem II class I am. I will say that the major difference is the content that I am going to do. For example, Chem II am going to some basic measurement labs, uh, and when I get to acid base for Chem II would do something like 39 Drop. For AP I would do titration, various titration labs, an indicator with a pH meter, uh, I would do some buffer labs. There is such a wide selection of labs that are available for SIM I could take one topic and branch it off. So, if I am doing thermo chemistry I can do endothermic and exothermic reactions with Chem I; with a thermometer with hydrochloric acid and magnesium. They can graph it and understand what the definitions of endothermic and exothermic are. With chemistry II, or AP chemistry, I would do a totally different level of lab; maybe a Hess's law lab. So, it's really the level, the difficulty level is going to be different for Chem I versus the others.

(David) I teach Biology I, Anatomy and Dual. It goes back to you pick. Our labs are kinda echelon, and what I mean by that is that you have your basic labs, and you have your more advanced labs. You pick. I pick the labs that are appropriate for that particular grade level. I don't go back and do the same labs with my Biology II students even though I am basically covering the same topics, but of course with the Dual I go into a lot more detail. So, I don't use the same labs for those particular topics. We do the more advanced labs. I also require the students to do more writing, and more analysis, and have a much more extensive lab reports for the Dual, Biology II, and the Anatomy.

9. What impact, if any do you think the Science In Motion program has had on your student's use of technology?

(Sue) It's probably given them more confidence because they have been exposed to more pieces of equipment, and they have had to incorporate using a piece of equipment in the lab, and then modeling it or using a computer program such as excel in correlation with it. Probably given them confidence when they see something for the first time that they will be able to successfully use it. *Interviewer- when your students use technology, uh, I know that some teachers already have everything ready for them, do you have them set everything up for themselves or do you set it up for them?* Uh, for Chemistry I I start them off for the semester setting everything up for them, then, after a couple of weeks I set up certain things, and then half way through the course they are setting everything up. By the time they reach Chem II or AP they are setting up everything themselves with a little bit of guidance and instructions.

(John) I would think that it's increased it because they are exposed to technology that they normally don't see. You know the scopes we use to view cells that blows it up on a TV where they can see it. Different types of microscopes we use they have never seen. Most of them have only seen a standard one-eyed microscope. Most of them have never seen a binocular type microscope with all four lenses on it that works. I think that it's had a positive effect of their use of technology. I think they use more technology and that they have used more applications. Most of them have only used a calculator in algebra class. They have never had to use a calculator in a science class up until this point. *Interviewer- I'm not too familiar with the biology stuff but just from your college experience do you think that the equipment that they are using in SIM is similar to what they may use in college?* Some of the stuff I do think is very similar to what they would use in college. Some of the labs obviously for safety reasons and expense are stepped down. Certain chemicals you may not use because you're at the high school level, certain equipment you may not use at the high school level because of the cost of it. It all goes back to the cost of it. But most of the microscope labs I remember doing them in college when I was in college. *Interviewer- so that transition from high school to college is made easier?* A difference in equipment and a difference in technique maybe. Some of the labs I may have prepared the slides for them where they could view them and in college you would probably have to prepare the slides yourself. That would be the only difference. Like with the dyes, like when you dye stuff, you don't want to trust them with the dye because it gets on their hands and clothes. It just gets everywhere. So I would prepare it for them. I put the dye on it and they put the slip on it and go look at it. In college they would actually cut the specimen, put it on a slide and put the dye on it and do it themselves. You're probably cutting out maybe three steps in the lab to change it.

(Mary) Good in some areas, but I don't think it's that much in some areas. If you want to look at technology as far as computers and internet and stuff the research and making presentations, I don't think it has had much. Then we have the CBL system and those tend to not always be in the best functionally. I don't think that the computer, I don't use computers at all with SIM, but what I do use are the higher ticket technology aspects. I use the Spec 20's all the time. I really enjoy using the GC. Uh, I don't use, what else do we have? I use the Spec 20's, I use the GC's. *Interviewer- there's High Pressure Liquid Chromatography* I don't use the HPLC; I can definitely say that I don't use it anymore. I will say again that these kids may not see a GC in their General Chemistry class and they may not see a Spec 20 in their General Chemistry class, but the excitement level of working with something that looks so industrious, it makes them feel really smart to turn all the knobs and it makes them feel like scientists. It may not help them to use it in the future, but they get so excited about the here and now that they are going to focus on whatever it is. So, it may not help them in the long run but its going to help you in the immediate to get their attention; and you know for some it does help in the long run because they tinker with this stuff and they get excited and they may decide that they want to go on and do. *Interviewer- perhaps becomes Chemists?* Exactly, *Interviewer- or Chemical Engineers*, that's right, and then when they get there they use this stuff.

(David) I keep going back to the lap tops and the Vernier probes, and those technology items that we've used. Plus, by being part of that I have learned about some other opportunities, labs, internet virtual labs that I use as well. Not necessarily SIM labs but I learned about them through the SIM program. We end up doing that as a part of my lab program but not necessarily a SIM lab.

10. How has the Science In Motion program impacted you and your methods of teaching science?

(Sue) Uh, ummm... it's forced me to facilitate, what's the word I'm looking for, branching, content to lab? *Interviewer- reaching maybe*? Maybe, I don't know exactly the word I'm looking for; uh, it's made me to ensure that they can see the correlation of what they have in the classroom and what they do in the lab. More, uh, critique and also with more lab opportunities it's strengthening their actual content knowledge. Also, it enables them to see, uh, applications of what they are doing in the classroom. Probably it has broadened my methods of teaching, and it has enabled me to try out different things than perhaps I would have been able to without SIM.

(John) I think that it has made me a better teacher. I don't know of anybody that doesn't feel that way. It makes you a better teacher because it gives you several ways to present it. Also, you know without verbalizing it makes it better. You spend so much time your first couple of years trying to figure out what labs you're going to do for a class. How am I going to present this, and with what, once you have that you already have the labs. Then, it just becomes getting better at knowing the material and presenting the material. I mean, knowing the dumb questions they are going to ask you about stuff, and knowing the answers to the dumb questions. That's really it for the first three years. They are going to ask you all of the questions that you don't know. Also, planning wise, I don't spend so much time planning now because I don't have to worry about buying stuff for a lab and getting stuff to the lab. Also, figuring out what lab I want to do. I have a whole list of labs I can pick from. I just call her up and that's taken care of. It's made teaching science a lot easier. For me the hardest part about teaching science is securing equipment, getting labs and stuff to do labs with. Now that's gone, you don't have to worry about that.

(Mary) Its allowed me to do a lot more labs. When I first started teaching, uh, I started in January second semester, in midyear, and I did not do SIM until that summer. So, from January until May it was a nightmare for me to find labs because I was not well equipped or well versed in how to teach a lab. I came with a chemistry background and a chemistry degree, but I was never taught how to teach kids how to do these labs. I can read it and do it myself, but I was never taught how to get them to do it. It was a very miserable semester in which the kids did very few labs, but once I entered the SIM program that summer, which was really the long time, I think it was three weeks, it was long, but at the end of that three weeks, I felt 100% confident that I could go and teach any lab that was in there. So it really impacted me and the way I taught labs. We had more labs which gives the kids more hands on, which I know increased their knowledge tenfold.

(David) I do more hands-on. *Interviewer- so, you do more hands-on labs with your students?* Yea, and it's because of convenience. They are all packaged and she delivers them. It's just a matter of me opening it up, running off the labs sheets and reports and doing it. Very little prep time.

11. What impact, if any, do you think that the Science In Motion program has had on the funding and/or cost of running your science laboratory?

(Sue) I don't know that it has had any impact at all because anything that's funded in the science lab is funded through lab fees. *Interviewer- can you elaborate on that?* Yea, the students pay ten dollars per science course. It is, uh, just a suggestion and not a requirement because state law states that they are not required to pay the ten dollars, but there is no funding set aside for the science lab. So, if it were not for SIM their laboratory experience would probably be a tenth of what t it actually is. No positive or negative with respect to directly funding the lab, but it certainly increased their laboratory experiences. *Interviewer- so, if you did not have SIM do you think that your labs would be, I don't want to say less or more…* Some of the labs would not be able to run period. The exposure to technology would be, uh, cut down, because we would not be able to afford some of the things that their getting to use now with SIM. *Interviewer- such as*? such as the pH meters; such as the mass specs; such as, uh, CBL's. Those are the two big things because the pH meter's and the mass specs are pretty pricy. We would not be able to afford them, and certainly not a class set. (John) For me, I don't spend hardly any of the money from my labs fees anymore buying supplies for labs. I can actually buy models, equipment, and things that I could not buy before because all of that money was going to labs. If you are going to do a dissection, if you do two dissections, your lab fees are gone. You don't have any money to buy anything else with. With this, I can go now and not have to worry about forking out money to do labs. I can buy more equipment for class. More models, preserved specimens in jars, for stuff that I don't have and stuff that they have never seen before. I have kids that have never seen jelly fish before; you know it's kinda hard to teach them about Cnidarians if they have never seen a jellyfish before. You know things like that. You can go buy stuff that you could not buy before because the money was tied up in labs. *Interviewer- so you feel like SIM has kinda eased the burden?* Yea, it's made the funding not an issue. Before you had to pick the labs, everybody has their standard labs that they do every semester that they know works, and you would spend all of your money on those standard labs, and you would not have any money to go out and buy something new or try something new.

This kind of frees up some money to go and try new things or pick up a kit for a different lab that you haven't tried before just to see if you like it. (Mary) A lot, I don't have to purchase those big ticket items, and I honestly don't have to buy chemicals a lot of the time; uh, its saves a lot. We do collect lab fees, and I have a lot of staple labs that are already set up; in fact, we looked at buying some micropipettes, but they are so expensive, and you need more than one, you really need a class set of them, and there so expensive to purchase a class set. You could purchase one a year but it's not going to do you any good; unless you have a class set it's not going to do any good, and you may only use them once a year. Why would I waste all that money on one lab? That's a lot of bank to put in one lab. Same thing with the Spec 20's, that's an amazing cost there and again that's one lab or one piece of equipment that I always use, but I only use it for maybe two or three labs, so it's not economically feasible for me to purchase them. *Interviewer- even those pH meters are pretty expensive*, even the pH meters, and a thought on the pH meters, because I use ton's of acid based labs. That's a section I really hit heavy. I went through a science catalog and purchased some very inexpensive ones for about seven or eight bucks. When they came in I could not even calibrate them. I mean, it was just, you get what you pay for and I can't pay for a hundred dollar pH meter. But SIM gives me access to it in multiples, it's not just one for my class, they can bring as many as I need.

(David) Oh gosh, it's been, if anything that's probably, the two things, the two real benefits from my standpoint has been having access to the technology; the Vernier probes and the laptops; and the other is that all of the stuff that I use, the consumables that you use in the lab, that doesn't come out of my budget. SIM pays for that, so I have been able to take my lab budget and bring in some other things that I would have had to use for the stuff that SIM provides.

12. Has the Science In Motion program impacted you with respect to science high-stakes student testing and/or accountability?

(Sue) Uh, absolutely, it's enabled the AP students to have the laboratory experiences that they need to perform better on the AP Chemistry Exam which is absolutely high stakes testing, such that one of the free response questions is lab based. Uh, otherwise I don't know that it's had that much of an effect. *Interviewer- so, more so for your advanced AP?* More so for AP than any of the others such as Chemistry I or Chemistry II. I'm certain that it's helped them, uh probably enabled them to see concepts that they might not have otherwise, but a direct correlation to high stakes testing would be iffy.

(John) My kids score, the biology scores are higher than they were before. I don't know if that's because you get better at teaching as you get older or if that's because of SIM. The year I started SIM, using SIM in my classroom, my student's scores went up. *Interviewer- and you know this by what criteria?* Just by the number of B's and the number of C's and the number of

D's I had on the CRT. Before most of them were making just C's and D's and then I had students scoring B's and I even had some make an A last semester. Not without pulling out a percentage, I don't know any percentages but I just know. *Interviewer-but you have no numerical values?* No, their letter grades are up but their class averages are not up, but at the end of the year when they score they tend to score higher.

(Mary) Definitely, I would say uh when it comes to the grad exam, the Alabama High School Graduation Exam is now all biology and it is really not going to affect me as far as the graduation exam, but my high stakes testing is that AP test, and they are not going to pass that AP test unless they have a very thorough lab experience, and a thorough lab experience means that they have got to touch some of these high end things, and I will say I don't know how other schools do it that don't have SIM. I don't know how if you don't use SIM to bring you these high ticket items, how you would be able to afford to run all these labs. So, it comes down to either your at a school where you have tremendous funding, which obviously is going to be a private school because I don't know of many public schools that are able to fund some of these things, or you just don't get that lab experience, which is really going to hurt you on that test. Interviewer- *Do you think that SIM has had* an *impact with regards to CRT results at all?* I do, uh when I just think back to certain questions that I know will be on the CRT, like what are the chemicals that change color in the presence of an acid. I know that my kids are going to be able to answer that better because we did the 39 Drop lab and they loved it and they saw things change colors. I think that we may not think that there is a direct connection, but I really think that there is, because they get so excited about doing labs that, uh, they are going to remember that. I actually did a Chem I survey today, asking what did you like about this class and what did you not like about this class. I would say that 90 percent of the kids put that they liked the labs. The labs were so much fun, we loved the labs, we loved the lab where we did this, or we loved the lab where we did that. Uh, we loved the color change, we loved this, we loved that; they love playing with anything that looks big and scary. So, we may think that there's not an effect but I know that there is. I know that there has to be an effect there. *Interviewer- that's ironic because I gave my survey out yesterday and the same thing, when you ask what do you like about the class almost to a "T" the answer is we loved the labs.* Labs, love, love, love, love labs, and when they get in there you may not think that they love them, they look like they're so intense reading the step-by-step instructions, doing what they are supposed to do while your kinda running around, so it doesn't really look like their having the best time but they are. It makes them think more than they ever thought that they would. More than they would reviewing with a piece of chalk scratching on a chalk board. (David) Say that again. *Interviewer- has the SIM program impacted you with respect to science high stakes student testing and/or accountability, such as let's say the graduation exam or the CRT's.* Ok, well again back to what we were talking about earlier, the CRT's and leveling the playing field. I don't think that it has impacted me that much to be honest. I think that we end up getting ready for the CRT by focusing on that study guide and learning through those things. Now, granted, throughout the year I've selected labs that correlate with those particular objectives, but I think that take away the study guides, and this is the first year that we have not received any study guides, and I think that you will be able to tell a difference between using the SIM labs as far as the achievement of those students that have access to those labs verses a class that doesn't have access to them. Do you know what I'm saying?

Upon completion of the analysis for research question 4 the researcher used systematic grounded theory and coded the data, discovering five themes which are listed in table 9

Table 9

Percentage of Participant Responses Who Supported Themes

Theme	Percentage of Participants Supporting Themes
SIM laboratory exposure Increases student success	100%
SIM reduces teacher stress.	75%
SIM provides high quality laboratories for the science classroom.	100%
SIM needs to develop and provide more labs for advanced science programs	75%
SIM increases teacher effectiveness	75%

SIM Laboratory Exposure Increases Student Success

Self-confidence is enhanced by gaining proficiency (Freedman, 2002). According to Freedman, success in the laboratory increases student self-efficacy, and student self-efficacy is an indicator of student performance (Bandura, 1977). Many of the participants mentioned the relationship between student success in the high-school laboratory and how that success parlays into the college laboratory arena:

> Absolutely, they are going to have skills that will transfer to college. ...That would definitely be skills that they will take with them that they would not have been able to acquire without SIM. (Sue)

> I think that my students who participate in those labs are a leg-up on the ones who don't (David)

> Well the Chemistry I students are going to come into Chemistry II or AP Chemistry with a solid set of laboratory skills, and the AP students are going to be well prepared for going into their first or second year of college based on the SIM labs and supplemental labs. (Sue)

> It's (*SIM*) has probably given them more confidence because they have been exposed to more pieces of equipment, and they have had to incorporate using a piece of equipment in the lab and then modeling it or using a computer program such as excel in correlation with it. Probably given them the confidence when they see something for the first time they will be able to successfully use it. (Sue)

It enables them to see applications of what they are doing in the classroom and what they do in lab. (Sue)

Participants described student perspectives regarding the SIM program and using the equipment. Studies such as those done by Bruner (1983) indicate that discovery learning is one of the most important types of learning and leads to a higher level of personal success.

I think it makes them feel very good when they are playing with these really high-tech machines that they have never seen before. They have seen them on CSI before, now they actually get to touch one. I think that it gets them excited a bit more and when the previous SIM specialist would come and do demo shows and things like that …they got really excited when he came because they knew that we were going to be doing a lab (Mary)

I actually did a Chemistry I survey today, asking what you like about the class, and what did you not like about the class. I would say that 90 % of the kids put that they liked the labs. The labs were so much fun; we loved the labs; we loved the lab where we did this or that. Uh, we loved the color change, we loved this, we loved that. (Mary)

…and when you get in there you may not think that they love them, they look like they are so intense reading the step-by-step instructions, doing what their supposed to do while your kinda running around, so it doesn't really look like their having the best time, but they are. (Mary)

> I think that if they like going to the lab, and if you can get them to go to lab and do what they are supposed to do they seem to enjoy it a lot more than being in class. (John)

SIM Reduces Teacher Stress

Participants indicated that because the SIM labs were pre-packaged and ready to go, they did not have to spend time prepping labs, putting labs together, and correlating the labs to the Alabama Course of Study.

> It lets me do a lot more labs because I have so much less time preparing because the labs are ready to go. All you have to do is open the box and out the lab comes. (Mary)

> Also, planning wise I don't spend so much time planning now because I don't have to worry about buying stuff for a lab and getting stuff for a lab. Also, figuring out what lab I want to do. I have a whole list of labs that I can pick from. I just call her up and that's taken care of. It's made teaching science a lot easier. (John)

Participants also indicated that stress was reduced because they now have more of their science budget to spend on other things besides lab materials for the classroom. Now, many of them are able to purchase auxiliary materials they would not have been able to purchase before participating in the SIM program.

> What it does is that it cuts down on the expense of the labs. You don't have to pay for lab equipment and a lot of the labs they have are stuff for only maybe two semesters and that is what you get in labs without having to spend any money. It's nice. (John)

I can actually buy models, equipment and things that I could not buy before because all of that money was going to labs. ...now I do not have to worry about forking out money to do labs. (John)

First, I would say that I'm real pleased with what the program is doing for me in terms of providing labs and hands-on activities without being part of my budget, having to pay for it. (David)

Research has shown that significant levels of stress in teaching are associated with high-stakes student testing, and many teachers leave the profession because of such testing (Ferrell, 2005). Some participants indicated that the SIM program helps their students perform better on high-stakes student tests.

The biology scores are higher than they were before. I don't know if that's because you get better at teaching as you get older or if that's because of SIM. The year I started SIM, using SIM in my classroom, my student's scores went up. (John)

My high stakes testing is that AP test, and they are not going to pass that AP test unless they have a very thorough lab experience, and a thorough lab experience means they have got to touch some of these high-end things and I will say that I don't know how other schools do it if they don't have SIM. (Mary)

I think that we may not think that there is a direct connection but I really thing that there is because they get so excited about doing labs that they are going to remember that. (Mary)

> The kids tend to score better on those questions if there is a lab related to it. They score a lot better if I can get a lab in with something that goes along with the CRT or exit exam, they tend to retain it better because they can relate it to something in class as opposed to books. (John)

SIM Provides High Quality Laboratories For The Science Classroom

All of the participants expressed the belief that the SIM program provides high-quality labs for their specific courses. In particular, some participants appreciated the fact that the SIM labs were correlated to the Alabama Course of Study and were content-driven. This seemed to be very important to the participants because if they SIM labs were not already correlated to the Alabama Course of Study the participants would have to make the correlations themselves.

> A benefit to the SIM workshops is that they are content driven and some of the SIM workshops are focused around labs that can directly be related to the classroom. (Sue)

> ...they (*the labs*) go right along with the state course objectives and she (*the SIM specialist*) knows everything about them. (John)

> With SIM they tell you how to implement it which helps. They tell you what Course of Study objective that it goes with...this is the lab and this is how you do it. It's what objectives you would use this with, you know it's very straight and to the point. (John)

Three of the participants expressed that the SIM labs were similar to labs that could be found in college freshman science courses. In fact, a couple of the participants said that some of the labs were almost exactly the same labs that the students would see in their college classes.

> Oh yea, the way the labs are written up like you would see in a college lab manual, like if you took 121 or 122. It goes into the same stuff. The break down of the labs are just like you would see in a college lab manual. (John)
>
> I think that some of the labs are the exact same labs that they are going to see in a college setting. (Mary)
>
> I do some stuff with the Vernier probes and the laptop computers that's similar to the labs they will use in college, and from what I have been told they will use that type of equipment more and more, so I think that my students who participate in those labs are a leg-up on the ones who don't. (David)

SIM Needs to Develop and Provide More Labs for Advanced Science Programs

Out of the four participants in the interview, three taught advanced science classes, with two teaching AP Chemistry and Chemistry II, and one teaching Anatomy and Physiology along with Dual Enrollment Biology. These three teachers felt the SIM program needed to develop more upper level science laboratories.

> I would like to see more AP labs in there. We have a ton of good basic labs for Chemistry I and even a lot of labs for Chemistry II, but AP

> Chemistry has twenty labs that must be done and it would be very good and much easier for me if those labs were already prepackaged and could just be dropped off. So, I would say that the one thing the program could do for me, to be able to pack up some AP labs and have them ready to go for me. (Mary)
>
> We have heats of reaction which works well for Chemistry I but nothing that is applicable to Chemistry II or AP Chemistry. I usually use labs from colleges throughout Alabama, the University of Alabama, or I develop my own. (Sue)
>
> So I guess that a shortfall would be that in the Advanced Program, the Dual Program, or the AP Program, is that the equipment that is necessary to do the mandatory labs. (David)
>
> I would love for them to take a couple of the AP manuals that are out there on the market and go to the college board web site and come up with some, because there are a lot of AP labs that are not anywhere in the curriculum of SIM. (Mary)

SIM Increases Teacher Effectiveness

Three of the four participants said the SIM program has enhanced their teaching abilities, increased the numbers of labs they perform with their students, and generally improved their effectiveness as teachers.

> I think that it has made me a better teacher. I don't know of anybody that does not feel that way. It makes you a better teacher because you have several ways to present it. (John)

> Probably it has broadened my methods of teaching and it has enabled me to try out different things than perhaps I would have been able to without SIM. (Sue)
>
> It has allowed me to do a lot more labs. ...so it really impacted me and the way I taught labs. We had more labs which give the kids more hands-on, which I know increased their knowledge tenfold. (Mary)
>
> I came with a chemistry background and a chemistry degree, but I was never taught how to teach kids how to do these labs. I can read and do it myself, but I was never taught how to get them to do it. It was a miserable semester in which the kids did very few labs, but once I entered the SIM program that summer, which was really the long time, I think it was three weeks, it was long, but at the end of the three weeks, I felt 100% confident that I could go and teach any lab that was in there. (Mary)

Summary

In chapter IV, the purpose of the study and the statistical methods of data analysis were discussed. Statistical significant differences was found in research Hypothesis 1, where there was a significant difference between the science achievement of students of teachers who participate in the Science In Motion (SIM) program and the achievement of these same teachers before they became participants in the program. Statistical significant differences was found in research Hypothesis 2 where there was a significant difference between the science achievement of the students of teachers who participate in the SIM program and the achievement of the students of science teachers who do not participate in the program. Statistical significant differences was not found in research Hypothesis 3 where there was not a significant difference between the sense of efficacy of teachers who participate in the SIM program and the sense of efficacy of science teachers who do not participate in the SIM program. Statistical analysis was not performed on research question 4; instead, a phenomenological qualitative study was performed. The analysis for research question 4 consisted of coding the data and describing the associated themes of the study. Chapter V includes conclusions and recommendations based upon the information gathered from the data that were collected.

CHAPTER V

DISCUSSION

Review of Results

The movement towards fiscal accountability in public K-12 education has increased the challenges and responsibilities of school administrators, school superintendents, and state boards of education. These challenges include devising new ways to provide equitable opportunities for all students while holding down financial costs. Science outreach programs such as Science In Motion have been described as being part of the solution for funding science education (Mulfinger, 2007).

This study was conducted to examine the Science In Motion (SIM) program in Mobile, Alabama, and to determine what impact, if any, the SIM program has on student cognitive functioning and teacher sense of efficacy and to investigate teacher perceptions and attitudes regarding the program. The findings of the study are discussed in this chapter.

Four research questions were examined in the study. Research question one, and the related hypothesis, were analyzed using parametric independent multiple *t*-tests. Research question two, and the related hypothesis, were analyzed using parametric independent samples *t*-tests along with multivariate analysis of covariance (MANCOVA). Research question three, and the related hypothesis, were analyzed using multivariate analysis of variance (MANOVA). Research question four was analyzed using phenomenological qualitative research methods.

This chapter reviews and addresses each of the four research questions and their accompanying research hypotheses. The chapter also addresses limitations, implications and recommendations for future study.

Research Question 1

Is there a difference between the science achievement of the students of teachers who participate in the Science In Motion (SIM) program and the achievement of the students of these same teachers before they became participants in the program? The researcher hypothesized that the students of teachers who participate in the SIM program would have statistical significant higher scores on their Science Criterion Referenced Test (CRT's) than students of the same teacher prior to the teacher's participation in the SIM program.

To perform this analysis the researcher obtained archival data from the Science Supervisor of the Mobile County Public School System. The data consisted of the number (N=27) of teachers who had pre and post Science In Motion (SIM) Criterion Referenced Test (CRT) scores. The analysis consisted of independent samples *t*-tests. The independent samples test was chosen instead of a repeated samples test because even though the teachers were the same for the pre-implementation and post-implementation CRT analysis, the students were different.

For the average student CRT score, the results indicated a statistical significant relationship at the $p < .05$ level existing between student means of teachers with pre-implementation and post-implementation CRT exam scores. The mean of the students' CRT scores were 66.79 before the teachers became involved with the SIM program, and the students' had a mean of 73.32 after the teachers entered into the SIM program, a positive difference of 9.8 %. From the analysis it appears that once students are exposed to the SIM program they are able to perform at a statistical higher level on their science CRT's than students who do not participate in the program. School systems are always searching for effective methods of increasing student performance, and a 9.8% increase is a substantial increase.

The analysis continued with the percent of students who passed (students who scored at or above 60%) their CRT exams. The results indicated a statistical significant relationship at the $p < .05$ level existing between student means of teachers with pre-implementation and post-implementation CRT exam scores. The mean of the students' CRT scores was 67.24 before the teachers became involved with the SIM program and the students' had a mean of 80.29 after the teachers entered into the program, a positive difference of 19.4 %. These findings support prior researchers such as Batchelor (2007) who found that the use of constructivist methods of teaching increased student abilities in the science laboratory and classroom. School systems are seeking new methods to increase student success in science, and the study's findings indicate that the SIM program may warrant further investigation.

The analysis continued with the percent of students considered proficient (students who scored at or above 70%) on their CRT exams. The results indicated a statistical significant relationship at the $p < .05$ level existing between student means of teachers with pre-implementation and post-implementation

CRT exam scores. The mean of the students' CRT scores was 49.69 before the teachers became involved with the SIM program and the students' had a mean of 63.79 after the teachers entered into the program, a positive difference of 28.4 %. An increase of almost 30% is very encouraging. These findings are in agreement with prior research performed by Doymus (2007) and Gupta (2004) which indicated that students who are given the opportunity to compare their ideas and experiences with those of their classmates, along with taking an active role instead of a passive one, are able to learn at a higher level.

Of all the research questions in this study, this one was perhaps the most important because the data used in the study were from the same teachers. The most effective data analysis scenario would have been to analyze CRT scores from the same students before and after they became involved in the SIM program; lacking that ability, from a statistical standpoint, the best alternative was to analyze pre-implementation and post-implementation student CRT scores from the same teachers.

The results for research question 1 are supported by the findings of prior researchers such as Kogut (1997) who incorporated the use of cooperative groups into his students Chemistry laboratories and found a significant increase in student learning. Doymus (2007), who also found that the use of cooperative groups such as those utilized in the SIM program, had a statistical significant increase on their Chemical Achievement Test (CAT) scores, and Maloof and White (2005), who found that the use of cooperative groups in their biology laboratories was statistically significant in increasing student test scores.

Research Question 2

Is there a statistical significant difference between the science achievement of students of teachers who participate in the SIM program and the achievement of students of science teachers who do not participate in the program? The researcher hypothesized that the students of science teachers who participate in the SIM program would have statistically significant higher scores on their science CRT's than students of science teachers who do not participate in the SIM program.

To perform this analysis the researcher obtained archival data from the Science Supervisor of the Mobile County Public School System. The data set consisted of all the science teachers in the Mobile County public school system who had never participated in the SIM program (N=274) and the number of teachers who had participated in the program (N=37) who had CRT scores. The data used for the analysis were from the inception of the CRT program in the 2003-2004 school year to the 2008-2009 school year, with the data analysis for each variable; average score (AS), percent passed (PP), and percent proficient (PPRO) consisting of parametric independent sample *t*-tests.

From the analysis, the findings indicated the difference in mean scores for the students' average score (AS) on their CRT exams was statistically significant at the $p < .05$ level. The mean for teachers who participated in the SIM program was 72.24, and the mean for teachers who have never participated in the program was 55.36, a positive difference of 30.5%.

Findings indicated that the mean scores for students passing the CRT exam (PP) were statistically significant at the $p < .05$ level. The mean for teachers participating in the SIM program was 78.70, and the mean for teachers who had never participated in the program was 46.88, a positive difference of 67.9%.

Findings indicated that the mean scores for students rated as being proficient (PPRO) on their science CRT's were statistically significant at the $p < .05$ level. The mean for teachers who participated in the program was 60.91, and the mean for teachers who had never participated in the program was 32.30, a positive difference of 88.6%.

Having such positive increases in student performance is supportive of the SIM program. After exposure to the SIM program the students' average score increased by 30.5 %; the number of students who passed their CRT's increased by 67.9 %; and the number of students who were considered proficient increased by 88.6%. These findings are substantial and illustrate the importance of allowing students who are just beginning to process abstract concepts (Evans, 1973) to have those concepts anchored by concrete physical examples like those found in the science laboratory.

The researcher also performed the analysis using MANCOVA statistical procedures, factoring out the number of quarters taught. The rational for factoring out the number of quarters taught being that it was possible that teachers who had taught longer would have better test scores than teachers who had taught for a shorter period of time.

The results indicated that the SIM program had a statistically significant effect at the $p < .05$ level on the average test score (AS) after controlling for the number of quarters taught. The adjusted mean value for the average score of students of teachers who had participated in the SIM program was 69.60, while the adjusted mean value for students of teachers who had never participated in the program was 55.72, a positive difference of 24.9%.

The results indicated that the SIM program had a statistically significant effect at the $p < .05$ level on the percent of students who passed (PP) their CRT exam after controlling for the number of quarters taught. The adjusted mean value for the percent of students who passed for teachers who had participated in the SIM program was 74.48, while the adjusted mean value for students of teachers who had never participated in the program was 47.45, a positive difference of 57.0%.

The results indicated that the SIM program had a statistically significant effect at the $p < .05$ level on the percent of students who were rated as being proficient (PPRO) on their CRT exam after controlling for the number of quarters taught. The adjusted mean value for the percent of students who were rated as being proficient of teachers who had participated in the SIM program was 57.27, while the adjusted mean value for students of teachers who had never participated in the program was 32.79, a positive difference of 74.7%.

After factoring out the number of quarters taught by each teacher the results of the research were somewhat reduced. The average score dropped from a 30.5 % increase to an increase of 24.9%; the percent of students passing their CRT's dropped from an increase of 67.9 % to an increase of 57%; and the number of students considered proficient dropped from an increase of 88.6 % to an increase of 74.7%. These findings indicate that the number of quarters taught by each teacher does affect their students' CRT scores. However, even after taking the number of quarters taught into consideration in the analysis, the results still show substantial gains from student exposure to the SIM program.

The researcher performed the MANCOVA analysis again for research question 2 because there was such a discrepancy in sample sizes (N=234, N=37). Using SPSS, the researcher randomly picked 37 cases from the 234 cases who had never participated in the SIM program. Once again the researcher factored out the number of quarters each teacher had taught.

Rerunning the analysis, the researcher found that the adjusted mean for the average score (AS) for students of teachers who had participated in the SIM program was 71.32, and the adjusted mean for teachers who had never participated in the program was 58.66, a difference of 21.6%. This value was down from the 24.9% difference from the previous MANCOVA by 15.4%. However, the analysis was statistically significant at the $p < .05$ level.

The results indicated that the SIM program had a statistically significant effect on the percent of students who passed (PP) their CRT exam after controlling for the number of quarters taught. The adjusted mean value for the percent of students who passed for teachers who had participated in the SIM program was 77.29, while the adjusted mean value for students of teachers who had never participated in the program was 53.66. This indicates a positive difference of 44.0%. This value was down from the 57.0% difference obtained by the previous MANCOVA by 29.5%. However, the analysis was statistically significant at the $p < .05$ level.

The results from the study indicated that the SIM program had a statistically significant effect on the percent of students who were rated as being proficient (PPRO) on their CRT exam after controlling for the number of quarters taught. The adjusted mean value for the percent of students who were rated as being proficient of teachers who had participated in the SIM program was 59.39, while the adjusted mean value for students of teachers who had never participated in the program was 37.66. This indicates a positive difference of 57.7%. This value was down from the 74.7% difference obtained by the previous MANOVA by 29.5%. However, the analysis was statistically significant at the $p < .05$ level.

Making the groups equal and factoring out the number of quarters taught by each teacher added additional reductions to the statistical findings of the study. However, all results were still significant at the $p < .05$ level. For schools seeking to improve student cognition and school test scores these results are very encouraging. The research findings indicate that the SIM program may be an effective means of improving student science CRT scores. School administrators may be interested in the results because the SIM program is provided free of charge, and school administrators whose schools are struggling with inadequate test scores may wish to investigate the program further to determine if it would be of benefit to their schools.

The research hypothesis for research question 2, teacher involvement in the Science In Motion (SIM) program leads to increased student CRT scores, was borne out in the statistical analysis. Researchers such as Piaget suggested that the learning of new knowledge cannot be induced only by rote methods but must also be a personal experience (Ackermann, n.d.), and according to Maloof and White (2005), a laboratory setting provides such an experience. In his research Freedman (2002) discovered that giving students the opportunity to handle lab equipment and work in cooperative groups, such as those used by Science In Motion, increased the ratings of how well students enjoy science, and Vygotsky (Edwards, 2005) stated such social interactions increases the ability to acquire knowledge.

Research Question 3

Is there a difference between the sense of efficacy of science teachers who participate in the SIM program and the sense of efficacy of science teachers who do not participate in the program? The researcher hypothesized that teachers who were involved with the SIM program would have a higher sense of efficacy, as measured on the Teachers' Sense of Efficacy Scale (Tschnnen-Moran and Hoy, 2001), than science teachers who do not participate in the SIM program.

To perform the analysis the researcher, with permission from the Mobile County Science Supervisor, distributed the Teachers' Sense of Efficacy Scale (Tschnnen-Moran & Hoy) developed at Ohio State University, to all of the Mobile County science teachers. Out of the 123 surveys sent out, 43 were returned. This represents a 35% return rate. Because of the small sample size (N=43) the researcher decided to utilize the subscales identified by Tschnnen-Moran and Hoy for the data analysis. The data were analyzed using multivariate analysis of variance (MANOVA). The results from the analysis indicated no significant differences in means for all subscales.

The hypothesis that teachers participating in the Science In Motion (SIM) program would have a statistically higher teacher sense of efficacy compared to teachers who did not participate in the program was not supported by the analysis. For the first subscale, Efficacy in Student Engagement, the means for teachers involved with the SIM program were higher on questions 1(How much can you do to get through to the most difficult students?), 2 (How much can you do to help your students think critically?), 4 (How much can you do to motivate students who show low interest in school work?), 6 (How much can you do to get students to believe they can do well in school work?), and 9 (How much can you do to help your students value learning?). However, unexpectedly, the SIM teachers rated themselves lower on questions 12 (How much can you do to foster student creativity?), 14 (How much can you do to improve the understanding of a student who is failing?), and 22 (How much can you assist families in helping their children do well in school?) than nonparticipating SIM teachers. The difference in means was not statistically significant ($p = .91$) at the $p < .05$ level.

The results from this first subscale, while not statistically significant, pose some curious observations. It appears that SIM teachers feel comfortable motivating students but feel less able to assist families in helping their children in school and less able to help students who are failing. It seems that SIM teachers feel in control of student motivation in the classroom, but believe they have less motivational influence on students when factors affecting motivation are outside the school setting.

For the second subscale, Efficacy in Instructional Strategies, the assumption that teachers participating in the Science In Motion (SIM) program would have a statistically higher teacher sense of efficacy compared to teachers who do not participate in the program was not supported by the analysis. Teachers participating in SIM had higher means on questions 7 (How well can you respond to difficult questions from your students), 11 (To what extent can you craft good questions for your students), 17 (How much can you do to adjust your lessons to the proper level for individual students), and 24 (How well can you provide appropriate challenges for very capable students). Teachers who did not participate in the SIM program had higher means on questions 10 (How much can you gage student comprehension of what you have taught), 18 (How much can you use a variety of assessment strategies, and 23 (How well can you implement alternative strategies in your classroom). The difference in means was not statistically significant ($p = .22$) at the $p < .05$ level.

The results from the second subscale, while not significant, are interesting. It appears that teachers who participate in the SIM program feel quite comfortable with the quality of the lessons they provide and with their ability to modify those lessons as needed. However, they are not as confident with their ability to change teaching strategies and/or gauge student learning. From these results it appears that SIM teachers perceived that they had less room for creativity and flexibility in the curriculum. These feelings expressed by SIM teachers could be a result of extensive standardized testing in the classroom and the current educational movement towards standardizing the curriculum, thus allowing less teacher flexibility in the classroom.

For the Third subscale, Efficacy in Classroom Management, the assumption that teachers participating in the Science In Motion (SIM) program would have a statistically higher teacher sense of efficacy compared to teachers who did not participate in the program was not supported by the analysis. Teachers participating in the SIM program had higher means on questions 5 (To what extent can you make your expectations clear about student behavior?), 8 (How well can you establish routines to keep activities running smoothly?), 15 (How much can you do to calm a student who is disruptive or noisy?), 16 (How well can you establish a classroom management system with each group of students?), and 19 (How well can you keep a few problem students from ruining an entire lesson?). Teachers who did not participate in SIM had higher means on questions 3 (How much can you do to control disruptive behavior in the classroom?), 13 (How much can you do to get children to follow classroom rules?), and 21 (How well can you respond to defiant students?). The difference in means was not statistically significant ($p = .75$) at the $p < .05$ level.

The findings related to the third subscale, while not significant, are puzzling. It appears that SIM teachers feel very comfortable in their ability to run an effective classroom and they feel comfortable dealing with classroom distractions. However, they do not feel as comfortable as non-SIM teachers dealing with disruptive and/or defiant students. This is interesting because 45.5% of the survey respondents who participate in the SIM program had 11 years or greater teaching experience. The use of a larger sample size may show the research findings to be an anomaly.

Results from the three subscales pose interesting differences between SIM and non-SIM teachers. While not significant in aggregate, these ratings do suggest the possibility of the need for further research and study.

The findings of the study for research question 3, teacher sense of efficacy, were contrary to the findings of researchers Tschnnen-Moran & Hoy (2001), who found that teachers who have adequate training feel more comfortable with their students and have a higher sense of teacher efficacy. Teachers who participate in the SIM program undergo extensive training as part of the requirements for being accepting into the program (Helminger, 2007). Thus, according to the model developed by Tschnnen-Moran & Hoy, SIM teachers should have a higher sense of efficacy compared to non SIM teachers. One possible explanation for the unexpected findings in this study is that teachers who are involved in the SIM program are more self-reflective than non SIM teachers, therefore rating themselves lower than non SIM teachers on some survey questions. Of course, another possibility would be that some of the respondents did not answer the questions truthfully.

Research Question 4

Has being involved in the Science In Motion (SIM) program affected the participating teachers' perspectives towards teaching science, funding the science laboratory, and high-stakes science testing and accountability? If so, in what ways? If not, why?

Conducting the qualitative portion of the study was exciting, and in the researcher's opinion, beneficial to the study. Having the ability to ask questions and listen to different perspectives about Science In Motion (SIM) from participants of the program, together with the quantitative aspect of the study, gave a more comprehensive and complete analysis of the SIM program.

In performing the interviews, the researcher met with three participants at their schools. The other interview was held at a Barnes and Nobles bookstore in Mobile, Alabama. Two of the participants were male and two were female. From conversations with the participants before the official interviews began, the researcher discovered that all four of the participants had high expectations of their students. Two participants, both female, taught Honors Chemistry and AP Chemistry; the two male participants both taught biology; with one teaching Honors Biology, Dual Enrollment Biology, and Anatomy and Physiology; the other teaching Regular and Honors Biology. All of the participants spoke very highly of the SIM program, and they all felt the program was beneficial. From the interviews five major themes emerged: (1) SIM laboratory exposure increases student success, (2) SIM reduces teacher stress; (3) SIM provides high quality laboratories for the science classroom; (4) SIM needs to develop and provide more labs for advanced science programs; and (5) SIM increases teacher effectiveness. Themes 1, 2, 3, and 5 are incorporated into answering the section of research question 4 pertaining to teachers' perspectives towards teaching science. Themes 3 and 4 are incorporated into answering the section of research question 4 regarding funding the science laboratory; and, themes 1 and 5 are incorporated into answering the section of research question 4 regarding high-stakes science testing and accountability.

Teachers' perspectives towards teaching science. All of the teachers interviewed were very positive about teaching. Even before the interviews were recorded, none of the teachers expressed negative feelings towards teaching, their students, or their schools. The interviewer came away from all of the interviews feeling the participants enjoyed teaching, and they all were probably very capable teachers. All participants felt the SIM program enhanced their ability to teach effectively, and all expressed that the SIM workshops were of a higher caliber compared to the other science workshops they have attended throughout the years. Only Mary felt the SIM workshops should place more emphasis on inquiry based labs. Mary felt the SIM labs read too much like a "cookbook"; however, later on she did state the SIM workshops and the Advanced Placement (AP) workshops she attended were on the same level.

All of the participants felt that part of their jobs as teachers were to prepare students for college, and they all felt their students would acquire laboratory skills through the SIM program that would be beneficial in college, especially Sue, Mary, and David who taught higher level science classes. They all expressed that having exposure to SIM labs would allow their students' access to the same type of lab equipment they would be using in college. However, Mary said some of the lab equipment used in the SIM program was "overkill" because most students would not be using that high a level of equipment in a general college class, but she did state she believed the use of high-tech equipment gets students interested in learning about chemistry. David stated he currently works as an adjunct instructor at a local junior college, and he said the equipment he borrows from the SIM program was actually of a more advanced level than the equipment he uses in his college classes.

The participants expressed to the interviewer how important science labs were to the science curriculum, and they all stated the SIM program furnished high quality laboratories for their students to use. Some, such as John and Mary, suggested that individual teachers using the SIM program could make the labs as difficult or as complex as they wanted simply by tweaking them to their specifications, and they all stated the SIM program had multiple labs for every Alabama Course of Study (ACOS) objective. Sue, Mary, and David expressed that the SIM program should develop more labs suited to the AP and Dual Enrollment programs. They felt the SIM program had a good selection for regular and honors students, but was lacking sufficient laboratories for more advanced students. Mary stated she would appreciate it if the SIM program were to look at the labs required for the AP curriculum and furnish more of those labs to AP teachers in a pre-packaged format.

Funding the science laboratory. All participants indicated that one of the major benefits of being involved with the SIM program was that the program reduced funding costs for their science laboratories. John, Mary, and David stated that because of the SIM program they were now able to purchase equipment and/or supplies for their classrooms that without the program would be impossible to obtain. Sue first said she did not think the SIM program had much of an impact on her funding ability, but she later said there were certain items SIM provided that she simply would not be able to purchase using student lab fee money because of their high price. John stated after he became involved with the SIM program he hardly ever had to use his lab fee money to purchase lab materials for his classroom. Instead, he said he could now purchase items such as models and preserved specimens. Mary explained she did not have to purchase big ticket items anymore because of her participation in the SIM program, and now she hardly ever had to buy chemicals for her laboratories. She also said some of the instrumentation utilized by SIM would be very cost prohibitive for the average public school to purchase. In fact, she went on to say she did not know how teachers of AP classes who were not part of the SIM program could afford to run all of the labs required by AP. David said from his perspective, funding issues for the classroom was one of the strong points of the SIM program, and because of the SIM program, he could now use his lab fee money to purchase others things for his classroom.

From the interviews it became apparent that funding issues were a problem for all of the participants. They all said one of the greatest benefits of being part of the SIM program was that it reduced funding costs for the classroom. The SIM program allows them the flexibility to buy things they normally would not be able to buy, and they all stated they highly valued this aspect of the program.

High-stakes science testing and accountability. This was an interesting section of the interviews because all of the participants except for David said the SIM program enhanced their students' ability to perform at a higher level on high stakes tests such as the graduation exam, AP exam, or Criterion Referenced Test (CRT). However, none of the teachers had quantitative data to backup their rational; they simply had a feeling, or a hunch the program provided such benefits. David said the program really did not affect his student test scores. However, he did state he felt the program would make a difference on CRT scores if the school system did not furnish study guides for the teachers to use. In fact, he stated the SIM program may actually make a difference in test scores this year (2009) because the school system would no longer be providing study guides for CRT's.

Sue, John, and Mary all felt the program made a difference on high-stakes testing. Sue expressed that the SIM program helped her students pass the chemistry AP exam, but she stated she was not sure if it would make a difference on other exams such as the graduation exam or CRT exams. John said his biology scores were higher after his entrance into the SIM program. However, when questioned by the interviewer he admitted he had no quantitative data to corroborate his views. He believed his students now had higher letter grades such as A's and B's from their participation in the SIM program, even though he had not gathered nor analyzed any data relating to his student's grades. The researcher could tell this participant firmly believed the SIM program helped his students on standardized as well as regular tests. Mary stated she believed the SIM program helped with her students AP exams because a large part of the AP exam was laboratory based. She also stated she believed her students scored better on their CRT's because they had access to SIM labs. Again, no quantitative data were exhibited supporting her feelings, she just believed they enjoyed doing the labs so much that it had to have an impact on their ability to answer test questions related to laboratory experiences. For example, she said she felt that her students would be able to answer more acid-base questions correctly because of their exposure to acid-base laboratories via the SIM program.

This part of the study was interesting because of the passion used by the participants when expressing their beliefs that the SIM program enhanced high-stakes test scores for their students, despite the fact that none of the participants had collected any data to substantiate such claims; instead, they simply "knew," or "felt" that it had made a difference.

Limitations

This study was limited by the population of the study. It consisted only of Biology and Chemistry teachers in the Mobile County Public School System. The study was also limited to those teachers who had CRT scores for their students.

The Teachers' Sense of Efficacy Scale suggested running a factor analysis of the subjects in order to obtain independent factors. However, due to the sample size, a factor analysis was not statistically feasible. The researcher therefore used the three factors suggested by prior research from Tschnnen-Moran and Hoy (2001).

An additional possible limitation was that some of the interviewees expressed concern about their interview being recorded. Thus, the candor of their responses may have been jeopardized.

Implications for Policy and Practice

Science education in the United States has many critics who state that as a country we must develop strong science programs or we will fall behind other countries that have (National Research Council, 1995). However, strong, high quality science programs do not come cheaply, and now is a time many school districts are cutting back on programs, not expanding or increasing funding for them (Zehr, 2007). Therefore, it behooves administrators to seek out alternatives to the high cost of funding high quality science curriculums. Science outreach programs such as Science In Motion (SIM) are unique because they bring the laboratory to the students; thus, by having the same equipment distributed among many different schools, the SIM program becomes very cost effective (Juniata College, 2003).

This study was enacted with the intent of determining if the SIM program is an effective means of supplying high quality science laboratories to students of the Mobile County Public School System. Research questions 1 and 2 showed statistical significant differences, and results indicated that teacher participation in the SIM program is effective with regards to enhancing student Criterion

Referenced Test (CRT) scores. Students who were exposed to the SIM program had statistically significantly higher average CRT scores than students not participating in the program. Students who participated in the SIM program had an average score that was 21.6% greater than students not taking part in the program. Students who were exposed to the SIM program had a 44% increase in their ability to pass their CRT exams compared to students who did not participate in the program. Finally, students who were participated in the SIM program had a 57.7 % increase in their CRT proficiency rating compared to students not participating in the program. These findings were substantial, and one might expect that the results could be extrapolated to other criterion referenced tests. Such findings are important because in the past Alabama has had numerous lawsuits filed against the state for inadequate K-12 public school funding (American Civil Liberties Union, 2002; Lynch v State of Alabama, 2008) and in particular funding for rural and inner-city schools because of the lack of local funds (Lupton, 2005; Tate, 2001). The research findings indicate that the SIM program could be used by the State of Alabama to provide equitable laboratory opportunities to all students regardless of location and/or local funding. The state might also consider enhancing the SIM program to include other science courses. The SIM program has many positive attributes. The program is self-contained. The same equipment is shared by all participating schools. The program is very cost effective; and when compared to funding adequate science laboratories for each and every high school in the state the savings are dramatic (Helminger, 2007; Juniata College, 2003).

In addition to funding issues, the SIM program also may help alleviate the pressures experienced by high school teachers with regards to high-stakes testing and accountability. The interviewees in the study indicated that the SIM program is effective in reducing teacher stress. Participating SIM teachers believe that allowing students the ability to physically participate in a science laboratory provides concrete reinforcement to the abstract ideas learned in class, helping them perform at a higher level on both teacher and criterion referenced tests.

One specific recommendation regarding programs such as SIM can be addressed with the conclusions obtained from research question 4 of this study. The recommendation is that science outreach programs, such as Science in Motion, should strive to develop labs for the entire student population they serve, including Advanced Placement (AP) and Dual enrollment classes where applicable.

Suggestions for Future Research

This study was conducted using only science teachers in Mobile County Alabama, but may serve as a starting point for future research in other districts and states with geographical areas that have enacted science outreach programs similar to Science In Motion.

The following recommendations are made based upon the study's findings.

(1) This study should be reexamined to determine which type of student garners the most benefit from such a program (e.g., regular or advanced students).

(2) This study should be conducted to determine if science outreach programs statistically significantly enhance student ACT science scores.

(3) This study should be replicated and studied over a longer period of time. Additional analysis, when feasible, should be enacted with larger teacher and student populations.

(4) Teacher sense of efficacy surveys should be given to new teachers entering into the SIM program. At a later date, these same teachers should be given the same teacher sense of efficacy survey to determine if participating in the SIM program has enhanced their sense of efficacy.

(5) The Teachers' Sense of Efficacy Scale survey sample size should be increased to determine if having a larger sample size will provide similar results to those of prior researchers Tschnnen-Moran & Hoy (2001).

Conclusion

It is becoming more difficult for states to provide equitable and adequate science laboratory experiences for all students. Administrators who are struggling with budget shortfalls may find science outreach programs such as Science In Motion an appealing alternative for providing laboratory experiences for their students. They may wish to have their science departments become involved in such programs and give support to those teachers who choose to participate. While the findings of this study are limited, they do provide useful and practical information for school leaders who are struggling with supplying the funding of high quality science laboratories.

APPENDIX A

Teachers' Sense of Efficacy Scale[1] (long form)

Teacher Beliefs

How much can you do?

Directions: This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for teachers in their school activities. Please indicate your opinion about each of the statements below. Your answers are confidential.

	Item	Nothing		Very Little		Some Influence		Quite A Bit		A Great Deal
1.	How much can you do to get through to the most difficult students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2.	How much can you do to help your students think critically?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3.	How much can you do to control disruptive behavior in the classroom?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4.	How much can you do to motivate students who show low interest in school work?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
5.	To what extent can you make your expectations clear about student behavior?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6.	How much can you do to get students to believe they can do well in school work?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7.	How well can you respond to difficult questions from your students ?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
8.	How well can you establish routines to keep activities running smoothly?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
9.	How much can you do to help your students value learning?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
10.	How much can you gauge student comprehension of what you have taught?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
11.	To what extent can you craft good questions for your students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12.	How much can you do to foster student creativity?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
13.	How much can you do to get children to follow classroom rules?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
14.	How much can you do to improve the understanding of a student who is failing?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
15.	How much can you do to calm a student who is disruptive or noisy?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
16.	How well can you establish a classroom management system with each group of students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
17.	How much can you do to adjust your lessons to the proper level for individual students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
18.	How much can you use a variety of assessment strategies?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
19.	How well can you keep a few problem students form ruining an entire lesson?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
20.	To what extent can you provide an alternative explanation or example when students are confused?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
21.	How well can you respond to defiant students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
22.	How much can you assist families in helping their children do well in school?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
23.	How well can you implement alternative strategies in your classroom?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
24.	How well can you provide appropriate challenges for very capable students?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

APPENDIX B

PERMISSION LETTER

COLLEGE OF EDUCATION AND HUMAN ECOLOGY

ANITA WOOLFOLK HOY, PH.D.

PROFESSOR
PSYCHOLOGICAL STUDIES IN EDUCATION

Dear Phillip Herring

You have my permission to use the *Teachers' Sense of Efficacy Scale* in your research. A copy of both the long and short forms of the instrument as well as scoring instructions can be found at:

http://www.coe.ohio-state.edu/ahoy/researchinstruments.htm

Best wishes in your work,

Anita Woolfolk Hoy

Anita Woolfolk Hoy, Ph.D.
Professor

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APPENDIX C

QUALITATIVE QUESTIONS

1. If you could pick one thing that the Science In Motion (SIM) program could do or not do with respect to your science discipline, what would it be?

2. How would you describe the science content knowledge of the SIM specialist servicing your school?

3. How would you compare SIM workshops to other science workshops that you attend throughout the school year?

4. Do you think that your students acquire skills in using the SIM labs that will transfer to college? If so, which skills; if not, why?

5. How would you describe the overall quality of the SIM labs?

6. How would you improve the laboratory selection and/or laboratory development process in the SIM program?

7. What effect, if any, has SIM had on your student's laboratory experiences?

8. When implementing SIM into your lessons, how does it differ in each content area? Ex: Chemistry I v. Chemistry II or AP Chemistry.

9. What impact, if any, do you think the SIM program has had on your student's use of technology?

10. How has the SIM program impacted you and your methods of teaching science?

11. What impact, if any, do you think the SIM program has had on the funding and/or costs of running your science laboratory?

12. Has the SIM program impacted you with respect to science high-stake student testing and/or accountability?

APPENDIX D

LETTER TO PARTICIPANTS

January 4, 2009

Dear Colleague:

I am a doctoral student at the University of Southern Mississippi working on a research study in the department of Educational Leadership and Research. As part of this research I am interested in what impact, if any, participating in the Science In Motion program has had on teacher sense of efficacy. I have been given permission by the Mobile County Science Supervisor to distribute surveys to Mobile County Science Teachers.

Since the total population of school district science teachers who are qualified to participate in the program is quite small, your involvement is very important to the success of the research project. Your participation is voluntary and all responses to the survey questions are anonymous.

Please complete the Teacher Sense of Efficacy survey and return it to me (Phillip Herring – Satsuma High School) via inter-school mail in the provided self-addressed envelope. This project has been reviewed and approved by the Human Subjects Review Board of the University of Southern Mississippi. Your completion and return of the survey instrument indicates your understanding of the process and your willingness to participate. If you have any questions concerning the study, please contact me at 251-767-0910.

Thank you for your cooperation.

Sincerely,

Phillip Herring
Doctoral Student
The University of Southern Mississippi

APPENDIX E

IRB APPROVAL LETTER

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

118 College Drive #5147
Hattiesburg, MS 39406-0001
Tel: 601.266.6820
Fax: 601.266.5509
www.usm.edu/irb

HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **28102303**
PROJECT TITLE: **An Assessment of the Impact of a Science Outreach Program, Science in Motion, On Student Achievement, Teacher Efficacy, and Teacher Perception**
PROPOSED PROJECT DATES: **10/30/08 to 02/15/09**
PROJECT TYPE: **Dissertation or Thesis**
PRINCIPAL INVESTIGATORS: **Phillip Allen Herring**
COLLEGE/DIVISION: **College of Education & Psychology**
DEPARTMENT: **Educational Leadership and Research**
FUNDING AGENCY: **N/A**
HSPRC COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **11/24/08 to 11/23/09**

Lawrence A. Hosman (signature) — 12-02-08

Lawrence A. Hosman, Ph.D. — Date
HSPRC Chair

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