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Use of Specific Web-Based Simulations to Support Inquiry-Based High School Science Instruction

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USE OF SPECIFIC WEB-BASED SIMULATIONS TO SUPPORT INQUIRY-BASED HIGH SCHOOL SCIENCE INSTRUCTION

by

Arlene H. Korr

A dissertation submitted to the College of Education and Human Services in partial fulfillment of the degree of

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I would like to dedicate this work in memory of my parents, Harry Perkins and Sadie Goldman Perkins. My father encouraged me to believe in myself and to never give up. My mother constantly instilled the value of getting an education and the importance of being a lifelong learner. It is my hope that this work will serve to develop a deeper understanding within the educational community regarding the sustainable integration of simulations to support inquiry-based science instruction. The integration of technology into the science curriculum comes at a high cost. The educational community must hear the voices of the science leaders and teachers and strongly consider the essential components to accomplish this goal. This realization will enable students to develop a greater conceptual understanding of science.
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ABSTRACT

The primary goal of this study was to acquire an understanding of those practices that encourage the sustained use of simulations in support of inquiry-based science instruction. With the rapid distribution of Internet-related technologies in the field of education, it is most important to understand the function of these innovations. Technology, specifically the implementation of simulations to support inquiry-based instruction, provides new educational strategies for science teachers. Technology also influences the field of education by repeatedly making some teachers' best practices obsolete.

The qualitative research design was selected to explore the nature of science leaders' and teachers’ consideration or lack of consideration to incorporate simulations into their inquiry-based instruction. The method for collecting the data for this study included in-depth, semi-structured interviews. The analysis of this interview data was conducted in two phases. Phase I focused on the consensus views of the participants regarding the implementation of simulations. In order to gain a more in-depth understanding of the interview data, Phase II focused on the subtle differences among the participants regarding their execution of this instructional tool.

The overall conclusion of this study was that the use of simulations requires a multi-faceted approach to ensure sustainability. As noted, science leaders must continue to encourage the high, medium and low users of simulations to implement the ongoing use of these instructional tools. Also, science teachers must do their part to ensure the success of these programs. By addressing the primary and secondary research questions, five major conclusions were reached. These conclusions include (a) the use of web-based simulations can have a positive influence on inquiry-based science instruction, (b) technology challenges have
influenced the teachers’ use of simulations, (c) time influences the use of simulations, (d) ongoing professional development strategies support the sustained use of simulations, and (e) student engagement in inquiry-based science instruction is positively influenced by the use of simulations. This study concludes with suggestions for educational leaders and teachers along with further considerations for future research.
CHAPTER 1

INTRODUCTION: FRAMING THE QUESTION

Today’s policy makers, science education researchers, and the education community as a whole are confronted with student performance issues that have a profound impact on today’s science instruction. *The National Education Goals Report: Building a Nation of Learners, 1991* (National Education Goals Panel, 1991) established a goal that by the year 2000, students in the United States should be international leaders in science achievement. Over a decade has elapsed since this goal was declared; unfortunately, U.S. students’ science performance remains below the international norm (Martin, Mullis, Foy, & Stanco, 2012).

The marriage between education and technology has provided one possible strategy to enhance science instruction for the 21st century. The great hope that technology will serve as the panacea for educational revolution has evolved into a much more realistic understanding that technology, in and of itself, is not the universal solution (Salomon, 2002). Turkle (1995), a highly regarded figure in the field of instructional technology, indicated that there is the possibility of misusing technology and educators should plan accordingly. There are many reasons for the successes and failures of this marriage between education and technology. Practical limitations, such as the absence of computers or the inadequacies of teachers’ professional development, are significant components of failure.

The struggle to have policy makers, educational researchers, and the education community as a whole concur on the proper method of integrating technology into science curricula presents a challenge. The use of online simulations became a viable tool as the understanding of the Internet as a means of teaching evolved. A majority of educators were
instructed in their craft using traditional teaching methods, and thus many teachers are learning
to use online simulations along with their students. The requirement for immediate results to
improve science achievement has been unrealistic (Adelman, et al., 2002; Beerer & Bodzin,
2004; Bell & Smetana, 2008; Bybee, 1995; Ronen & Langley, 2005).

A common misconception concerning the use of computers in education is the false
assumption that they will independently revolutionize educational practice. According to
Ringstaff and Kelley (2002), “it is important for members of the education community to keep in
mind that computer-based technology in K-12 education is a means, not an end; it is a tool for
accomplishing instructional goals, not the goal in and of itself” (p. 1). Some members of the
education community do not consider the human element in the integration of these techniques
into instruction; they also ignore the differences between technology’s ability to convey
information and the learner’s role in constructing knowledge (Salomon, 2002). Technology alone
cannot transform information into knowledge. It is therefore important to consider the role of
teachers’ contributions toward this endeavor.

Hundreds of studies compare one mode of technology use to another (Bayraktar, 2002;
Bybee, 2000; Flick & Bell, 2000; Guzey & Selcen-Roerig, 2009; Means, 1994; Reeves, 1998).
Researchers are hoping to find that “mode A yields better results than mode B” (Salomon, 2002,
p. xvi). Few considerations are given to interactions with student learning styles and teacher
instructional methodology (Cronbach & Snow, 1977), or to subject matter (Cuban, 2001) or
other variables. Therefore, it should not be surprising that the conclusion generally reached is
that there is little difference between the various methods of classroom technology
implementations (Russell & Butcher, 1999).
The accountability policies of No Child Left Behind (NCLB) require programs to provide evidence of scientifically-based research to justify the validity of instructional strategies (Linn, Baker, & Betenbenner, 2002). It is generally assumed by policy makers, for example, that wisely integrating technology into instruction will result in better learning outcomes as assessed by the same benchmarks (Akpan & Andre, 2000; Coleman, 1998). A thicker, richer, and deeper understanding of effective integration of web-based simulations into science instruction is needed to inform these conversations and subsequent decisions.

Research focused on the identification of distinctive pedagogical benefits of technology in education flourished until the mid-1980s, when the methodologies of the studies were questioned by educators (Roblyer & Knezek, 2003). Cuban and colleagues forcefully questioned the benefits derived from learning technologies in schools (Cuban, 2001). Becker and Ravitz’s (2001) study addressed the presumption that there was a difference between the use of computers as tools for teaching and the requirements of teaching; they sought to discover what conditions are essential for frequent, high-quality use of computers to become normal parts of teachers’ instructional practices. Findings from Becker and Ravitz’s study indicated that teachers who were most professionally engaged were more likely to have their students use the software. Teacher professional engagement includes having a reasonable expertise in using the computer and a belief in constructivist pedagogy that attends to making learning activities meaningful to students (rather than just transmitting content).

Becker and Ravitz’s (2001) study highlighted the notion that the use of simulations in the science classroom cannot be evaluated without considering the following: the context of the teacher’s role and influence in the learning situation, the teacher’s own proficiency and content knowledge, and his or her ability to effectively incorporate computer technology in the
classroom. There is a need to examine a wide range of studies, including qualitative studies, that address these and similar issues of teacher professionalism impacting the learning outcomes of computer simulations for science instruction.

Technologies that are content-based, student-centered, and inquiry-based are most likely to make scientific ideas more accessible; they have the possibility of favorably influencing science instruction (Means et al., 1993; Sivin-Kachala & Bialo, 2000). Increased expenditures to maintain technology infrastructures coupled with evidence of teachers’ low technology use have spawned a new research imperative that seeks to understand the rationale for explicit uses of technology that support teaching and learning. The National Education Technology Plan (United States Department of Education, 2010) called for improved instructional performance by promoting increased preparation and professional learning experiences for both pre-service and in-service educators in hopes of “closing the gap” between students’ and educators’ confidence levels with technology.

The ability to incorporate technology into teachers’ daily practices has lagged (Sandholtz, 2001). Many schools and school districts have been focused on acquiring hardware and software rather than on teacher preparation. Strategic planning and organization are important requirements. These considerations are critical in the adoption process of computer-based instructional technology. However, school districts frequently decide not to invest in professional development services due to budget restrictions. According to Education Market Research, spending on technology products for education was anticipated to increase 8% for the 2010-2011 school year, an estimated $8.1 billion (O’Hanlon, 2009). Exact figures on the number of teachers who do not use the technology can only be surmised; however, anecdotal evidence from vendors and school districts alike has indicated that resistance to technology adoption occurs among a
substantial portion of the U. S. teacher population. According to Sandholtz (2001), “various studies have indicated that technology can have little effect on instructional practices unless teachers have been adequately and appropriately trained” (p. 372). The report of the President’s Committee of Advisors on Science and Technology (1997) cautioned that the significant investment in hardware, software, and infrastructure will be wasted if teachers are not prepared and supported to integrate technology into their strategies to help students learn.

Consideration of the importance of professional development for teachers in the use of technology requires an understanding of the actions that constitute the incorporation of technology into instruction (Sandholtz, 2001). According to the National Center for Education Statistics (NCES), “Teachers who reported feeling prepared to teach using technology used technology more frequently and in a greater variety of ways and were more likely to have their students use technology as a tool in tasks that require higher-order thinking” (as cited in Ringstaff & Kelley, 2002, p. 13). In a report that reviewed the results of over 300 studies of technology use, Sivin-Kachala and Bialo (2000) concluded that the most significant variable in the effective implementation of instructional technology was comprehensive teacher training. Teacher training was the most significant variable influencing the effective use of educational technology to improve student achievement. They found that students in classrooms with teachers who had more than 10 hours of technology-related professional development significantly outperformed students in classrooms with teachers who had 5 or fewer training hours. Continuous teacher support appeared to be essential in order to sustain an effective technology-infused program using the current science curricula (Sivin-Kachala & Bialo, 2000).

The imperative to develop teacher proficiency in the use of technology to support science instruction has been addressed numerous times. For example, at the 2009 Florida Educational
Technology Conference, Mark Benno stated, “If you take the five stages from the evolution of thought and practice, starting with ‘entry’ and moving through ‘adoption’ to ‘adaptation’ to ‘appropriation, and finally ‘innovation,’ research shows it takes seven years on average to go from top of that list to the bottom” (Reidel, 2009, para. 4). Benno indicated that professional development is the key to close this gap in teacher integration of technology into instruction. Effective professional development strategies could reduce the technology integration process from seven years to two years.

Statement of Purpose

The present study investigated how to improve a specific instructional practice (Patton, 2002): high-frequency use of computer simulations in high school science education. This study was used to generate an understanding of a specific strategy to support inquiry-based science instruction. An important component of this method was the use of professional development which incorporated practical applications in the implementation of simulations.

The present study focused on the integration of web-based simulations to support science instruction. Furthermore, it sought to dispel the common assumption that the only effort required to prepare teachers to operate well in a technology environment is to expose them to the new technology and to teach them appropriate pedagogies. Because it is ultimately the responsibility of teachers to enact educational change, it is important to consider their role and their motivation in this transformation.

According to Chen and Howard (2010), “Scientific concepts are complex and highly technical, and science courses are frequently considered among the most challenging subjects to teach K-12 students” (p. 133). Many teachers support an inquiry-based approach to learning science, one in which students are provided opportunities to actively participate in constructing
scientific knowledge through the inquiry process (Linn et al., 2002). This study explored the implementation of simulations to support the inquiry process for science instruction from the perspective of science leaders and teachers. The use of simulations, as defined in the present study, is to imitate real-world scientific endeavors and make the inquiry process relevant and more accessible to the students.

Projects under the purview of the U.S. Department of Education’s (DOE’s) Preparing Tomorrow’s Teachers to Use Technology (PT3; 2002) initiative have demonstrated that the process of integrating technology effectively into education occurs at a high financial cost. The education community overall and policy makers in particular look to educational technology research to provide a strong rationale to support investment in these projects (Ringstaff & Kelley, 2002). It is important to consider the criticisms of these expenditures for technology infrastructure and the uneven impact and low usage by teachers, despite their increased training involvement and access to resources (Cuban, Kirkpatrick, & Peck, 2001). It was therefore imperative for the present study to include teachers who were determined to be proficient and open to the use of technology in their science classrooms in order to gain a thorough understanding of ways that the proper use of simulations can support instruction.

The increase of digital technology has had a profound influence in science education (Flick & Bell, 2000). Advances in personal computing are causing science educators to rethink the traditional teaching methods that have been in place for decades. Specific, ongoing professional development strategies were examined to support this effort.

**Research Design and Methodology**

A qualitative methodology was used in this exploratory study to determine the factors that influence science teachers to consider or reject incorporating computer simulations into their
science instruction. This exploratory study was also used to determine the factors that influence science leaders to consider or reject the support of incorporating computer simulations into science instruction. Qualitative research provides a better opportunity for the researcher to discover people’s feelings, knowledge, and sensory experiences about a unique phenomenon (Patton, 2002). Studies on understanding those factors that positively influence teachers to incorporate computer simulations into their science instruction are limited. The participants for this study were science teachers from a designated district’s Title I high schools and their science leaders at the district level. The opportunity to interview those teachers who have received ongoing professional development services to support this integration provided a deeper understanding of their motivations. The interviews of the district’s science leaders provided additional information regarding their decisions to include and support the use of simulations in their science curriculum.

**Research Questions**

This study investigated and described those factors that positively influence high school science teachers to use computer simulations in their instructional practice. This study also investigated those factors that positively influence science leaders to support the incorporation of simulations into their teachers’ instructional practices. The primary questions that guided this study:

1. **What factors influence teachers to consider or reject incorporating computer simulations into their science instruction?**

2. **What factors influence science leaders to consider or reject the support of incorporating computer simulations into science instruction?**
**Definition of Terms**

The following terms were used in this study.

*Computer simulations* are computer-generated depictions of real-world phenomena or processes (Bell & Smetana, 2008). For the purpose of this study, simulations are constructed with an underlying model that is based on some real-world behavior or natural/scientific phenomena (such as models of the ecosystem or simulated animal dissections). The significant standard is that the simulation include some interactivity on the part of the user, with a focus on “inputs and outputs” of the representation (D’Angelo et al., 2013, para. 4).

*Constructivist learning theory* supports learning as an active process and asserts that for learning to occur students must be mentally involved. According to Proulx (2006), “Constructivists maintain that we have no access to an objective truth and that all knowledge is subjective and dependent on the learner” (p. 76). The incoming sensory input is primarily organized by the person receiving it (Lutz & Huit, 2004).

*Constructivist pedagogy* involves several features: learning should be student-centered and the instructor should facilitate group dialogue that leads to the creation and shared understanding of a topic (Richardson, 2003). Students should participate in active inquiry, problem solving, and decision making set in significant frameworks.

*Gizmos* are interactive, virtual simulations designed to support and deepen student understanding of concepts and principles found in math and science curricula.

*Inquiry-based science instruction* includes opportunities to identify and pose questions, design and conduct investigations, analyze data and evidence, use models and explanations, and convey findings (Keys & Bryan, 2001). The four levels of inquiry and the information given to the student at each level are shown in Table I. For the purpose of this study, I have
elected to use the Open Inquiry definition.

Table I: The Inquiry Continuum

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<th>Question</th>
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<tr>
<td>1-Confirmation Inquiry</td>
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<td>X</td>
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<td><em>Students confirm a principle through an activity when the results are known in advance.</em></td>
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<tr>
<td>2-Structured Inquiry</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td><em>Students investigate a teacher-presented question through a prescribed procedure.</em></td>
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<td></td>
<td></td>
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<tr>
<td>3-Guided Inquiry</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Students investigate a teacher-presented question using student designed/selected procedures.</em></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4-Open Inquiry</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><em>Students investigate questions that are student formulated through student designed/selected procedures.</em></td>
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**Instructional leadership** includes the following responsibilities: Allocating resources, managing the curriculum, monitoring lesson plans and evaluating teachers (Brookover & Lezotte, 1982).

**Knowledge-centered** refers to an effective learning environment that encourages the student to think, reflect, and solve problems. This method of instruction is strengthened by providing the student with access to ideas, assumptions and conceptions of others arranged in meaningful ways (Riel, 2000).

**Science content knowledge** refers to the opportunity for students to develop a deep understanding of the material, ways to internalize it, and ways to understand the nature of
knowledge development (Richardson, 2003).

Science education reform denotes “inquiry” as the essential component of science education (Keys & Bryan, 2001; National Research Council, 1996).

Science leaders recruit and guide the teachers and school administrators in achieving common science educational goals (Stein & Nelson, 2003). The present study will focus on the following science leaders: the district’s Science, Technology, Engineering and Mathematics (STEM) director and the district’s high school science supervisor.

Science process skills denotes a cognitively complex process that requires the student to have background knowledge in the area he or she plans to investigate, formulate appropriate questions, identify hypotheses and design experiment (Germann, Aram & Burke, 1996).

Science teachers inspire their students to seek out the answers for themselves. Providing lab experiments, field trips, mixed media materials and computer research, encourages their students to explore the natural world around them and to learn new scientific theories (Anderson, 2002). The present study will focus on a specific group of high school science teachers who have access to simulations for the development of scientific understanding.

Spiraling of the curriculum is the plan by which the same topics are introduced at increased levels of difficulty, abstractness, and complexity. In this approach, additional concepts are introduced by comparing the previously learned information to the newly presented information (Bruner, 1987, 1990).
Significance of the Research

This study sought to develop an understanding of those innovative practices that encourage the sustained use of simulations in support of inquiry-based science instruction. With the availability of numerous instructional technology resources to support science education, it is important to understand the role of these programs. Studies that endeavor to understand the design of support structures which will make the best use of these technology programs have increased in importance. Technology, specifically when used to implement simulations to support inquiry-based instruction, provides new educational strategies for teachers. Generally, there is a consensus in most current literature regarding the nature of best practices using technology. However, there is limited accord on the significant factors which are applicable to the initiation and success of such novel instruction. Through this qualitative study, I hoped to develop a useful understanding of those practices which encourage the continuous use of simulations in support of inquiry-based science instruction.

The literature has shown that professional development programs that facilitate collaboration between teachers, reflect positive results and receive support and feedback enhance teacher confidence levels. (Grossman, Wineburg, & Woolworth, 2001; Huffman, 2006; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). The literature does not include studies that address ways the initial training and support for use of computer simulations may translate to effective teaching practice. There are, also, limited studies which address the influence of the school leader to support this practice. This study had the potential to develop an understanding of the influence of ongoing collaboration and its role in the teaching of science inquiry skills in a technology-rich environment.
Since the 1980s, researchers have acknowledged the importance of incorporating web-based simulations into the inquiry-based science classroom. Trowbridge, Bybee, and Carlson-Powell’s study (2004) reaffirms the benefits of the use of simulations that engage students in their knowledge search and improve their critical thinking skills. Despite the availability of this technology, teachers are still challenged by the use of simulations. Therefore, it is important to provide teacher training to support the integration of simulations into their science instruction (Chen & Howard, 2010).

Successful technology integration is most often accompanied by professional development opportunities (Guzey & Selcen-Rohrig, 2009). Researchers have emphasized the necessity for participant driven professional development, where teachers engage in inquiry and reflect on their individual practices to improve their understanding of technology (Loucks-Horsley et al., 2003; Zeichner, 2003). These studies, however, rarely describe those opportunities that provide teachers with ongoing support and opportunities, to analyze their learning and to practice the use of computer simulations.

The role of the instructional leader in championing the continued implementation of simulations in the science classroom tends to be ignored by the literature. Reforms such as technology-enhanced instruction require principal leadership. Nevertheless, research has shown that many school administrators need to develop a greater understanding of the current science and technology reforms (Gerard, Bowyer, & Linn, 2008). The research community knows little about the way school leaders enact instructional changes (Fullan, 1993; Heck & Hallinger, 1999). This gap in the knowledge base needs to be filled. One important challenge, therefore, involves making the practice of school-leadership more transparent through in-depth investigation of the ways leaders enact those tasks thought to be essential for instructional
innovation (Spillane, Diamond, & Jita, 2003). Through the interview of district level science leaders, this study sought to develop a deep understanding of their level of influence regarding the use of simulations to support inquiry-based science instruction.

This research sought to enhance the understanding of educational community regarding the significant role of simulations in the construction of knowledge for inquiry-based science instruction. It is my position that the potential instructional gain from the use of simulations depends on the quality of teacher preparation. This study sought to understand the value of one type of an effective teaching practice, the use of simulations in optimizing students’ learning of science.

Finally, it was my goal to develop a common understanding of those conditions necessary for frequent, high quality use of simulations to become a normal part of science teachers’ instructional practices. Despite all of the reforms mandated by policy makers and suggested by educational researchers, the teaching and learning of science in many schools across the U.S. have not incorporated the reforms that have been suggested. The science curriculum continues to be presented in the traditional lecture and discussion method (Weiss, Banilower, McMahon, & Smith, 2001). The National Science Board (2002) found that students may be learning science without actually understanding the subject at a higher application level. Science teachers are relying on traditional methodologies that are ineffective for promoting science understanding. Technology offers tremendous opportunities for students to develop deeper scientific knowledge and reflective thinking patterns (Chen & Howard, 2010). High-quality teachers are fundamental to improving teaching and learning (Darling-Hammond, 1997). Students with positive attitudes toward science are more likely found in classrooms that use innovative teaching strategies (Myers & Fouts, 1992). This research sought to develop an understanding of those ongoing
professional development strategies that are essential to the success of a simulation-infused, inquiry-based science curriculum. Hopefully, this study, through the interview process, gave voice to the teachers and science leaders who must follow the mandates of the policy makers, support and encourage research-based practices, and prepare today’s students to become tomorrow’s scientists.

Chapter Summary

In the first chapter of this report, I established the framework for my inquiry and the rationale for this study. I also provided the research questions that guided this study. In addition, I introduced the definition of terms that are pertinent to this study. I ended this chapter with a discussion of the significance of this research for policy makers, educational researchers, and the education community.

In Chapter 2 of this study, I review the related literature; it is organized around five themes:

- Importance of inquiry-based science instruction;
- Challenges of inquiry-based teaching in the science classroom;
- Computer simulations support inquiry-based science instruction;
- Professional development supports and sustains implementation; and
- Leader support is essential to teachers’ sustained and effective use of simulations.

Chapter 3 of this study describes the methodology and design for this research endeavor. Information is presented about the instrumentation, the participant selection process, the data collection procedures and analyses, ethical considerations, and limitations of this study.
Chapter 4 of this study presents the analysis of the interviews with science teachers and science leaders to enlighten the education community about the factors that influence the use of computer simulations in instructional practice.

Chapter 5, the final chapter, provides a summary of this study, identifies conclusions that can be drawn from the study and recommends suggestions for practice and for future research.
Science education is central to our broader effort to restore American leadership in education worldwide. America won the space race but in many ways, American education lost the science race.

~ Arne Duncan, U.S. Secretary of Education, Addressing NSTA in New Orleans (2009)

Since the latter half of the 20th century, there have been numerous calls to reform science teaching. It has been noted that the appeals for reform have been in response to both real and rhetorical crises encouraged by education policy makers (Klopfer, Champagne & Chaiklin, 1992). In the 1950s, the Soviets’ launch of Sputnik was a wake-up call to the United States to improve the nation’s science and mathematics curricula. This landmark event was the beginning of many years of policies and reforms that further influenced science instruction in the classroom.

Prior to 1900 many educators viewed science as a body of knowledge that students were to learn through direct instruction. In 1909, John Dewey addressed the American Association for the Advancement of Science (AAAS) and indicated that science instruction placed too much importance on the acquisition of information and not enough emphasis on the process or method of understanding science. By the 1950s and 1960s, the justification for inquiry as an approach to science instruction was becoming increasingly apparent. Joseph Schwab (1960, 1966) endorsed the idea that teachers should present science as inquiry and that students should use inquiry to learn science content: students should first be actively engaged in the laboratory experience and then learn the formal explanation of scientific concepts and principles. Schwab (1960, 1966)
suggested that students should ask questions, gather evidence, and propose scientific explanations based on their individual explorations.

*A Nation at Risk: The Imperative for Educational Reform* (National Commission on Excellence in Education [NCEE], 1983) presented an additional concern about education in the U. S. This landmark report highlighted the educational mediocrity that for decades had endangered the American industrial dominance in the fields of commerce, industry, science and technology (Southerland, Smith, Sowell, & Kittelson, 2007). Many educators consider *A Nation at Risk* to be the starting point of a movement toward standards, accountability, and a more equitable educational system (Hovey, Hazelwood, & Svekauskaite, 2005). The report detailed the need for more rigorous standards and greater fiscal support in order to promote higher expectations for all students.

In 1989, a newly organized initiative by the American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA) responded to this call to action. *Science for all Americans: Project 2061*, chaired by James Rutherford at AAAS, took a long-term, large-scale view of educational reform in science. Rutherford’s research was based on the goal of science literacy for all students. He defined science literacy as the ability to follow scientific discourse and to connect the world of science to the context of everyday life. He also stressed the importance of the ability to make science personally relevant (AAAS, 1989). Scientific literacy promotes the understanding of the co-dependence of science, mathematics and technology principles and concepts (Bybee, 1995). A fundamental premise of Project 2061 was that schools were not required to teach more science content. Rather, teachers needed to provide an in-depth focus on fewer skills so that the required science content was taught to mastery.
The project emphasized the teaching of key concepts and skills rather than specialized vocabulary and the memorization of specific procedures.

Today there continues to be a need for policy makers, researchers, and the educational community to consider ways to best meet the instructional demands for science in the 21st century. This literature review presents a comprehensive examination of studies that focus on one solution to meet this demand - the utilization of computer simulations in science teaching and learning from kindergarten through 12th grade (K-12). Considerable research during the latter part of the 20th century and the beginning of the 21st century has addressed the value of computer simulations in promoting inquiry-based science instruction.

This chapter focuses on four major research threads. The first thread considers science education and constructivist learning. Constructivist learning theory has called attention to science students’ use of pre-existing knowledge to develop understandings of new concepts (Proulx, 2006). The dynamics of inquiry-based learning in the science classroom is supported by the constructivist learning theory. Inquiry-based science instruction requires educators to develop cognitive skills that encourage student-centered learning (Minner, Levy, & Jurist-Century, 2010).

The second thread explores the use of computer simulations and science education reform. Computer technology has advanced to the point at which it can ease the use of inquiry learning on many levels and offer new instruments for representing inquiry-based science in the classroom. The third thread presented in this chapter discusses the professional development of K-12 science educators to support the ongoing use of simulations in the science classroom. Teachers must understand the practicality of using technology prior to integrating it into their instruction. The fourth and final thread provides conclusions and implications for instructional leadership, including the importance of well-informed school leaders to provide continued
support of high quality technology implementations in science classrooms. The focus of teacher training, with the support of the instructional leader, should center on principled knowledge and skills. The technology revolution has had a profound impact on teacher education in support of science instruction. Each of the research threads concludes with a synopsis of key factors pertinent to the research questions guiding this study.

**Importance of Inquiry-Based Science Instruction**

Reform rhetoric of the early 21st century has focused on the concept of inquiry as representing the core of science instruction. The *National Science Education Standards* (*Standards*; National Research Council [NRC], 1996), for example, promote inquiry as the “central strategy for teaching science” (p. 120). The *Standards* suggest that students in K-12 science classrooms develop both “abilities to do scientific inquiry” and “understandings of scientific inquiry” (NRC, 1996, p. 121). According to Keys and Bryan (2001), the abilities to do scientific inquiry includes recognizing and presenting questions, planning and executing investigations, examining data and evidence, using models and explanations, and sharing findings. The *Standards* also recommend that inquiry-based instruction is an effective method to learn science content.

Research on inquiry-based science instruction stems from constructivism (von Glaserfeld, 1995). For example, there is not one true definition of inquiry waiting to be discovered, but an understanding of inquiry is constructed by the individual. Students’ development of deep and long-term understandings of science concepts has been an important goal of the *Standards* (NRC, 1996; Olson & Clough, 2001). Understanding the ways students learn and the reasons they sometimes do not learn has become the basis of informed teaching. Keys and Bryan (2001) provided evidence that supported the notion that the efficacy of reform efforts has rested largely
with the teacher. The changing roles of the teacher, endorsed by science education reform, have encouraged guided instruction through non-traditional approaches. There is a growing trend toward the support of constructivist views for instruction and much pressure against it in the education community (Keys & Bryan, 2001).

**Background to Constructivist Theory**

The idea of conceptualizing knowledge as a personal construct is not new. During the 17th century, rationalists and empiricists claimed that individuals constructed their own insight (Kendrick, 2004). Unlike their predecessors, constructivists maintain that we have no access to an objective truth and that all knowledge is subjective and dependent on the learner (Proulx, 2006). Early development of constructivist theory can be attributed to the work of Dewey, Vygotsky, and Piaget. Dewey (1938) believed that students thrive in an environment where they are allowed to experience and interact with the curriculum. The works of cognitive developmental scientists such as Vygotsky (1997), Piaget (1952), and Bruner (1987) influenced the character of instruction for science from the 1950s through the 1980s. This transformation placed a greater emphasis on providing students with opportunities to learn the processes of science rather than simply mastering its material. Science inquiry affirmed the central role of students’ unique ideas and experiences in developing new and meaningful understandings of scientific knowledge.

John Dewey promoted the value of personal experience in learning. According to Lutz and Huitt, “Dewey placed relatively little emphasis on maturational factors and taught that human beings understand the world through their environments” (p.68). Knowledge, therefore, is constructed by the individual. Dewey suggested that a basic purpose of the education system was
to prepare young people to live in a free society and that students’ consideration of their personal experiences could provide the basis for the essential characteristics for successful living. He proposed a mutual and continuous relationship between thinking and doing. As a leader in the progressive education movement in the early 20th century, Dewey’s work set the foundation for this association.

In the mid 20th century, Jean Piaget developed one of the most significant theories in cognitive psychology and became a major pioneer in constructivism (Proulx, 2006). Piagetian theory posits that knowledge is constructed through action (Piaget, 1952). For example, students come to the learning environment with preconceptions about how the world works, some of which are invalid; as students learn, though, they construct new understandings. However, “if their prior ideas do not align with the new content, students may fail to acquire new information and their misconceptions may remain unchanged” (Falkenberg, McClure, & McComb, 2006, p. 9).

Similar ideas were advanced by Lev Vygotsky and Jerome Bruner. Vygotsky believed that one should study the process of learning and not the product. He sought to understand the ways students go about the method of problem solving. In order to assess development, he studied the interaction of subjects with a problem-solving task (Lutz & Huitt, 2004). Vygotsky supported the notion that teachers provide direct learning experiences based on students’ needs. Bruner (1987, 1990) attempted to synthesize the suggestions of the constructivist theorists and recommended that students go beyond the content or the information provided and expand their knowledge through exploration and inquiry. The goals of this theory can be accomplished by the practice he referred to as the spiraling of the curriculum, in which the same topics are introduced at increased levels of difficulty, abstractness, and complexity. New concepts are introduced by
correlating them to previous learning experiences. Using this approach, fewer concepts are presented, but the ones that are taught are explored in greater depth.

Together, the works of Dewey (1938), Vygotsky (1997), Piaget (1952), and Bruner (1987, 1990) provide the foundation for the constructivist approach to learning. This framework helps make sense out of the complexities associated with learning and teaching. In addition, the following principles should be considered in a study of student learning:

- Learning is an active process, and for learning to occur, students must be mentally involved. The incoming sensory input is primarily organized by the person receiving it.
- Prior knowledge that a student brings to current instruction may either help or hinder the creation of meaning.
- Students’ prior knowledge that is in conflict with the intended learning (meaning) can be an impediment to the new learning and be cause for the student to resist the new learning or fail to integrate it.

Constructivist Learning Theory and its Relationship to Science Pedagogy

Constructivism as a theory of practice – in addition to a learning theory – has received attention. Richardson (2003) indicated that constructivist pedagogy involves several characteristics: it is important for the science teacher to have a strong understanding of the science content; science instruction should be student-centered to foster active inquiry; group dialogue that leads to the creation and shared understanding of a topic through active problem solving should be encouraged; students should be afforded opportunities for engagement in tasks that challenge, add, or change existing beliefs and understandings, which encourages decision making set in meaningful contexts; and, the development of students’ higher-order thinking skills and individuals’ understandings of the learning process should be encouraged during each
of these endeavors. Richardson (2003) suggested that these elements vary depending on the content domain, students’ ages, students’ prior learning experiences, school context, and teaching styles.

Recent research has indicated the importance of thorough and strong subject matter knowledge in a constructivist classroom (Kubicek, 2005). This information assists teachers in their analyses of students’ understandings of the material, in supporting students in their exploration of concepts and beliefs, and in guiding classroom discussions. To support the teaching of science content knowledge, the constructivist classroom should provide students with “(a) the opportunities to develop deep understandings of the material, (b) ways to internalize it, and (c) ways to understand the nature of knowledge development” (Richardson, 2003, p. 1624). It is also important for students to develop complex cognitive maps that connect bodies of knowledge with understanding.

Numerous studies identified the correlation between teachers’ science content knowledge and student achievement and examined three areas of teachers’ science knowledge: (a) disciplinary content knowledge, (b) knowledge of the nature of science, and (c) knowledge of the objectives of the curricula and the relationship with students’ comprehension of the content (Alonzo, 2002, Gess-Newsome & Lederman, 1995). Gess-Newsome and Lederman (1995) reported that the approaches used by teachers to manage their individual knowledge influenced how they taught science content. Alonzo (2002) found that when compared to teachers with minimal content knowledge, science teachers with stronger content knowledge asked more questions, challenged their students to consider alternative explanations, and recommended more investigations. Alonzo’s (2002) study also demonstrated that those teachers with weaker science
content knowledge tended to use more direct instruction, explaining the information instead of stimulating their students’ inquiries.

Literature has also suggested that students learn by constructing their own meaning from experiences (Driver & Oldham, 1986; Sachse, 1989; Watson & Konicek, 1990). Because constructivist teaching requires a deep understanding of the disciplines, it is important to ensure that all teachers have the requisite knowledge for the courses they are expected to teach. Also, a constructivist approach requires very different science curricula and modes of science instruction when compared to the direct instruction approach. Therefore, it is essential that all teachers are provided with the tools to support constructivist learning in their science classrooms.

Active inquiry is an important component of constructivist pedagogy. Four studies suggested that when teachers have established views of the nature of science, their views are incorporated into their classroom instruction (Brickhouse, 1990; Cunningham, 1998; Lederman, 1999; Roehrig & Luft, 2004). These studies demonstrated that when teachers viewed science as an opportunity to create knowledge, they tended to provide more inquiry-based activities. Conversely, those teachers who consider science as a body of knowledge to solve problems generally planned instruction accordingly. Henze, van Driel, and Verloop (2008) determined that teachers’ understanding of the process for using models in space science instruction was consistent with their understanding of the goals and objectives for this subject matter. Magnusson, Borko, Krajcik, and Layman (1992) conducted a study on the microcomputer-based laboratory instruction of eighth grade teachers and discovered a relationship between teacher knowledge and changes in student knowledge.

In summary, the literature on science education and constructivist learning suggests that the memorization of information emphasizes “that science education is about remembering the
results of other’s [professional scientists’] research rather than developing the ability to conduct one’s own” (Claxton, 1991, p. 28). There is a division between the science of the school curricula and the practice of science. Some argue that this perception tends to reinforce blind acceptance or mistrust of scientific research (Kubicek, 2005). Science educators, science education researchers, and policy makers must consider the development of scientific literacy through instructional environments where the teacher has a strong foundation of science content knowledge. Comparable to constructivist learning theory, constructivist pedagogy supports the opportunity for the teacher to have students engage in active inquiry, problem solving, and decision making set in meaningful contexts.

**Challenges of Inquiry-Based Teaching in the Science Classroom**

The National Science Foundation (NSF), the National Research Council (NRC), and the American Association for the Advancement of Science (AAAS) made notable commitments to improve science instruction during the 1990s and early 2000s. These organizations spent millions of dollars to develop innovative K-12 programs, improve teachers’ abilities, and reform the systems that influence science instruction at school, district, state, and federal levels. According to Minner, Levy and Jurist-Century (2010), “One common goal among these efforts is to encourage teachers to use scientific inquiry in their instruction as a means to advance students’ understanding of scientific concepts and procedures” (p. 474).

A major goal of learning science in 21st century classrooms is to develop reflective, independent learning in students. The *Standards* asserted that inquiry is “at the heart of science and science learning” and identified inquiry as “the central strategy for teaching science” (NRC, 1996, p. 31). The focus of science as inquiry implies taking contemporary science education beyond simply teaching the science processes of the 1960s and 1970s. The report stated that
“inquiry is a step beyond science as a process. The Standards combine the use of processes of science and scientific knowledge as they refer to scientific reasoning and critical thinking” (NRC, 1996, p.105). However, in 2011, the National Research Council acknowledged “science education in the United States is not guided by a common vision of what students finishing high school should know and be able to do in science,” (National Academy of Sciences, 2012, p. 1). In their view, Standards frequently are long lists of detailed and disconnected facts which disregard the opportunity for the student to engage in doing science. To address this situation, the National Research Council and the National Academy of Sciences developed a framework that provided direction for the nation’s schools to increase students’ understanding of science, A Framework for K-12 Science Education (2012). The framework was designed to be the foundation for the next generation of science standards where students continually build on and revise their knowledge and abilities throughout their education. In the spring of 2012, the first draft of the Next Generation Science Standards (NGSS) identified which instructional practices should occur throughout each school year (NAS, 2012). The final release of the NGSS was published in the spring of 2013. The decision to adopt these standards is determined by each state. There is no set timeline for the adoption or implementation.

The Framework and NGSS recognized that a comprehensive approach to science education includes opportunities for students to perform scientific inquiry. The term “inquiry” in science education refers to three separate groups of activities: what scientists execute, e.g., implementing experiments using scientific methods; how students learn, e.g., actively questioning through reasoning and performing similar to the processes used by scientists; and instructional approaches, e.g., using curricula that are open to extended investigations (Minner et al., 2010). This section of the literature review discusses inquiry as an instructional approach for
science through four themes: (a) the background of inquiry-based science instruction, (b) teachers’ beliefs about inquiry-based science instruction, (c) teachers’ knowledge of and practice for implementing inquiry, and (d) instructional opportunities to institutionalize inquiry-based instruction.

**Background of Inquiry-based Science Instruction**

The rationale for inquiry as a learning approach to teaching science became increasingly expressed in the 1950s and 1960s. Schwab (1960) recommended that students should become more involved in the inquiry process in order to acquire science content knowledge and that students should work in the laboratory setting prior to being introduced to the formal account of scientific principles and ideas. This evidence should lead to explanations and the fine-tuning of these explanations. Schwab (1960) also suggested that science teachers consider four optional approaches in their laboratories: (a) textbooks can be used to present questions and describe methods to explore the questions; (b) instructional material can be utilized to pose questions, but open-ended questions should be presented for the students to determine their preferred explanations; (c) students can tackle phenomena without the textbook or laboratory-based questions; and (d) through a process he called “enquiry into enquiry,” teachers can provide students with information about scientific research and students then discuss the assumptions underlying the research. This approach provides opportunities for students to develop understandings of what comprises scientific knowledge and how scientific knowledge is generated.

With the support of the NSF, the process of learning science became as important, if not more important, than the ability to master science subject content alone (NRC, 2000). This new focus on science instruction supported more opportunities for students to be creative and pursue
their own understandings of larger scientific concepts instead of just memorizing facts. These changes were realized from the mid-1900s through the 1970s and laid the foundation for the integration of inquiry-based science instruction into curricula. Continued demands for science education reform brought forth a new concept in science instruction: “scientific literacy for every student” (AAAS, 1993; NRC, 1996). Scientific literacy was defined as knowledge of the “big ideas” of science that are needed to make informed decisions (AAAS, 1993). Among others, Bransford, Brown, and Cocking (2000) contended that significant learning requires an emphasis on the central ideas of a subject and the associations among related ideas. More recent reforms have recognized the use of inquiry in science teaching and learning to support scientific literacy, and inquiry has been identified as an essential component to contemporary science instruction. These concepts from the science research community have further influenced science education. The political climate of the 1990s focused on the ways students learned science and what scientific knowledge was most valuable in society (Collins, 1998). *The National Goals Report: Building a Nation of Learners, 1991* (National Education Goals Report, 1991) added concentration on mathematics and science with a stated goal that American students in grades 3, 8, and 12 were to demonstrate high levels of competency in science by the year 2000. An additional goal aimed to have students in the U. S. place first in the world in science and mathematics achievement.

Educators and the science community quickly responded to the demands presented in *The National Goals Report* (1991). In 1996, the NSTA and the NRC combined their efforts to author the *Standards* (NRC, 1996), which identified science content that students should know in grades K-4, 5-8, and 9-12. This document also described the standards for science teaching: professional development, assessments, content, programs, and systems. Combined, these documents brought
together a number of themes that would characterize science education reforms. The central theme denoted inquiry as the essential component of science education. The *Standards* suggested that students in K-12 science classrooms develop both “abilities necessary to do scientific inquiry” and “understandings of scientific inquiry” (NRC, 1996, p. 121). The aptitude to do scientific inquiry included identifying and posing questions, designing and conducting investigations, analyzing data and evidence, using models and explanations, and conveying findings. The understandings of scientific inquiry included the knowledge of how scientists carry out their work and ideas related to the nature of science (Keys & Bryan, 2001). The *Standards* also recommended that inquiry-based instruction would support the instruction of science content. However, the *Standards* do not provide direction for how to conduct inquiry in the science classroom, an omission that provided the opportunity for teachers to develop inquiry methods to support their individual classroom instruction.

The importance of incorporating inquiry into science instruction was further emphasized when the National Center for Educational Statistics (NCES, 2002) released the Third International Mathematics and Science Study – Repeat (TIMSS–R). Results from the TIMSS–R supported the following findings from the 1995 TIMSS: 4th grade students performed above the international average in both mathematics and science; 8th grade students performed near the international average for both mathematics and science; and 12th grade students performed below the international average for mathematics and science. The educational community responded to the TIMMS–R report through the combined efforts of the NSF, the NRC, and the AAAS. One common theme among their efforts was to persuade teachers to use scientific inquiry as a method for advancing students’ understanding of scientific ideas and practices (Minner et al., 2010).
A decade after the results from the TIMMS–R (NCES, 2002) were reported, the lackluster performance of U.S. students in science persisted. The report *U.S. Rises to International Average in Science* (Robelen, 2010) indicated that in science, the U.S. score on the Program for International Student Assessment (PISA) fell short of the averages identified by more than a dozen participating countries, including South Korea, Canada, Germany, and the United Kingdom. With so many students performing below the international average, a partial mastery of the skills required for proficiency in science was a concern. Alan Friedman, a member of the National Assessment Governing Board which sets the policy for the National Assessment for Educational Progress (NAEP), commented: “That means that a double-digit percentage of our students are just nowhere: They’re uncomfortable with science, they don’t understand it, they can’t do it, and they probably don’t like it” (Robelen, 2010, p.14). In response to this issue, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* NRC, 2011), which describes the knowledge and skills to be measured on NAEP, was updated to reflect new advances in science and research on science learning. One important element of the new framework was a major shift toward problem-solving and inquiry-based science learning. This framework shifted the focus from how many facts a student can memorize to how a student can apply knowledge (NRC, 2011).

In summary, the reform rhetoric of the 21st century placed an emphasis on the concept of inquiry in science instruction (Keys & Bryan, 2001). According to the National Science Education Standards (NRC, 1996), for example, “the development of inquiry-based instruction involves providing classroom learners with a curriculum that teaches science as a body of knowledge and as a way of knowing about the natural world based on evidence from observation and experimentation” (as cited in Beerer & Bodzin, 2004, p. 2). However, the reform effort of
inquiry-based science instruction has not been achieved in many classrooms throughout this country. The need for a bridge between the theory of inquiry-based instruction and the practice of inquiry-based instruction should be considered. Implementing inquiry-based instruction is a daunting challenge for teachers and requires a shift from what they typically do in the science classroom. Therefore, it is important to consider the instructional implications for science educators.

**Teacher Beliefs about Inquiry**

If teachers are responsible for implementing and sustaining reforms established by such documents as the *Standards* (NRC, 1996), they must have the ability to influence change. According to Brickhouse (1990), teachers’ beliefs regarding the nature of science as a purposeful body of knowledge created by an inflexible scientific method have negatively influenced their views of inquiry. Brickhouse (1990) found that instructors with more up-to-date understandings of the nature of science tended to use more problem-based approaches to science instruction. Wallace and Louden (1992) suggested that the lack of achievement of reform endeavors was attributed to the inability to take teachers’ beliefs and practices into account when developing new curricula. Teachers use their understandings to make decisions on all areas of instruction and also in adjusting to new curricula (Duffee & Aikenhead, 1992). It is therefore inevitable that teachers’ beliefs, attitudes, and practical knowledge of inquiry have direct and significant influence on teaching science as inquiry.

Tobin and McRobbie (1996) explored a description of teachers' beliefs as cultural myths that impede science education reform. They identified four major myths of secondary science instruction including, “the transmission myth, the efficiency myth, the myth of rigor, and the myth of student exam preparation” (Tobin & McRobbie, 1996, p. 225). A case study included in
this research described a high school chemistry teacher who viewed himself as a powerful transmitter of chemistry knowledge and simultaneously as a relatively powerless individual in terms of changing the chemistry curriculum. Keys and Kang (2000) contended that teachers hold personal beliefs that inquiry does promote scientific thinking and learning; however, enacting inquiry is determined by the demands of the local school district curricula. Tensions, therefore, frequently arise for those teachers attempting to incorporate inquiry-based instruction into their science curricula.

Other studies addressed the connection between teachers’ beliefs and priorities on the one hand and their classroom routines on the other. The teachers’ understandings of science as inquiry and learning as inquiry are important to consider. Kang, Orgill, and Crippen (2008) developed a survey instrument that used daily teaching situations to measure teacher understandings of inquiry. The teachers involved in the study used only three of the five essential features of inquiry identified in the standards documents (NRC, 2000). The characteristics of “evaluating explanations in connection with scientific knowledge” and “communicating explanations” were seldom found in Kang et al.’s (2008) study, which revealed that it is essential to help teachers adopt inquiry-based science instructional practices that are more consistent with science education reform.

**Teachers’ Knowledge of and Practice for Implementing Inquiry**

The *Standards* use inquiry in a variety of ways with respect to teaching (Anderson, 2002). Because inquiry is essential to science learning, it is expected to be foremost in science instruction. While research has indicated that inquiry teaching will produce positive results, it has not, by itself, directed teachers in terms of how to accomplish this instructional practice (Anderson, 2002). Keys and Bryan (2001) attempted to inform the science education community,
teachers, and educational leaders about the kinds of inquiry learning outcomes that could be realistically carried out in average classrooms as well as the student learning outcomes that should be expected. They contended that this information was significant in evaluating the efficacy of inquiry as a teaching and learning tool in science. According to Keys and Bryan (2001), teachers who implement inquiry-based science approaches should have well-developed understandings of science and pedagogical content, student learning, and methods to involve students in the practices of investigation.

Teachers who use an inquiry approach should have a deep understanding of science and pedagogical content. B. A. Crawford (2000) provided insights about the beliefs, practices, and pedagogical content knowledge associated with teaching ecology. Specifically, B. A. Crawford (2000) identified six key areas of one teacher’s instruction: (1) situating instruction in an authentic context, (2) the organization of data, (3) cooperation involving teacher and students, (4) connections with society, (5) teacher replicating the behavior of a scientist, and (6) the progression of student ownership of instructional experiences (p.925). Minner et al. (2010) reviewed findings from 138 studies of K-12 science instruction that were conducted between 1984 and 2002 and noted a clear and positive trend favoring inquiry-based instructional practices to develop science content knowledge; the findings emphasized instruction that highlights active student thinking and drawing conclusions from data selected from teaching strategies based on scientific investigations. The implementation of scientific investigations in the classroom was more likely to increase conceptual understanding of the learning process compared to activities derived from inactive instruction techniques. Minner et al. (2010) found that 51% of the 138 studies showed positive influence on inquiry science instruction and on students’ content learning and retention.
To accomplish the task of teaching inquiry-based science, instructors must develop cognitive skills that can make knowledge more student-centered, which requires an understanding of how students learn (Minner et al., 2010). The NRC (2000) addressed these skills when it described five core components as the “essential features of classroom inquiry” (p. 25) for the scientist, the student, and the teacher: (a) learners are engaged by scientifically oriented questions; (b) learners focus on evidence, which permits them to develop and evaluate justification to address scientifically centered investigations; (c) learners devise explanations from evidence to address scientifically oriented questions; (d) learners evaluate their explanations; and (e) learners communicate and justify their proposed explanations. Luft, Bell, and Gess-Newsome (2008) suggested that although the investigative activity provides the essential context for learning, the “science-specific forms of talk” move students’ thinking further (p. 3). As students gain experience with guided forms of investigation, they become more proficient inquirers. The goal of these conversations is for students to develop defensible explanations of the way the natural world works (Luft et al., 2008).

An important area of research on inquiry is related to teachers’ abilities to develop students’ understandings and ways students use science process skills in planning investigations (Tobin, 1986). Science instructors have contended that the acquisition of science process skills should be the major goal of science instruction (Gagne, 1963). Numerous studies have explored the ability of teachers to involve students in scientific investigations. For example, Blanchard, Southerland, Awad, and Granger (2007) compared the value of inquiry-based versus conventional laboratory explorations in terms of student science learning in the secondary schools. Teachers who participated in a state-level marine ecology program that mirrors “guided
inquiry” (as described in the *National Science Education Standards*, NRC, 2000) were included in the study, and individual student comprehension and performance were analyzed. Blanchard et al. (2007) found that students from the guided-inquiry treatment groups scored comparably to students who received traditional instruction. Furthermore, the Reformed Teaching Observation Protocol (RTOP) identified teachers from the guided-inquiry group as more open to listening to students’ input and alternative view points. This finding is significant because it identified inquiry-based instruction as supporting the science process traits: critical thinking, autonomy, and creativity (Harwood, Reiff, & Phillipson, 2002; Schwartz, Lederman, & Crawford 2004).

In summary, the *Standards* (NRC, 1996) endorsed the role of inquiry-based instruction in science: teacher understanding of science and pedagogical content, student learning, and methods to involve students in the practices of investigation. Whereas the *Standards* offer several examples of inquiry-based instruction, they do not offer explicit directions for how to present inquiry in the classroom. It is, therefore, up to the teacher to develop instructional plans to accomplish these goals.

**Instructional Opportunities to Institutionalize Inquiry-based Instruction**

The question of whether or not it is possible to incorporate an inquiry approach to science instruction on a widespread basis is an important consideration and has been a conversation among educators for many decades. Stake and Easley (1978) investigated classrooms across the U. S. to determine the level of inquiry instruction in science curricula. In general, they found that teachers were using curricula materials developed by the NSF to support inquiry-based instruction. However, in many cases the textbook was viewed as the authority, and teachers faced challenges in implementing inquiry instruction. In many classrooms, “science is taught
through the memorization of disconnected facts and definitions to be recalled for tests” (Falkenberg et al., 2006, p. 15). One significant issue is that the activities and thinking processes used by scientists are not always conventional methods utilized in the science classroom (NRC, 2000).

As research in the area of inquiry-based science instruction has advanced, it has tended to move away from the question of whether or not inquiry teaching is effective and has focused more on understanding how to expand the dynamics of this instructional process. Science teachers are faced with the dilemma of determining the portions of their lesson plans that should be devoted to inquiry and the amount of time that should be devoted to traditional approaches. This is an important consideration for teachers who must respond to the major science reform efforts to use inquiry while also preparing students to pass the multiple choice science proficiency exams that have been used to meet the mandates of the No Child Left Behind Act (NCLB, 2001). Teachers may be inclined to avoid inquiry-oriented lessons due to the pressures of high-stakes testing; however, it has been determined that those who use this type of instruction realize gains in their students’ science achievement scores in the areas that measure factual recall and conceptual understanding (Wilson, Taylor, Kowalski, & Carlson, 2010). It has also been determined that the value of using inquiry-oriented activities extends beyond test scores and has a positive effect on teaching science process skills and on student interest in science (Blanchard, Annetta, & Southerland, 2008).

The literature reviewed in this section has established the importance of providing a bridge between the theory of constructivism and the practice of inquiry-based science instruction. This section explored four significant themes to understand how to build the bridge
between theory and practice: (a) background of inquiry-based science instruction; (b) teachers’ beliefs about inquiry; (c) teacher knowledge of and practice for implementing inquiry and, (d) instructional opportunities to institutionalize inquiry-based instruction. Studies reviewed in this section focused on the inquiry-based instruction approach to improve science teaching by engaging students in investigation. This opportunity provides a realistic conception of the scientific endeavor and offers a more learner-centered and motivating environment. The literature also indicates that the inquiry approach, while lauded by educators and encouraged by policy makers, continues to be rare in the classroom. This may be the result of several factors, such as the lack of effective methods for students to perform independent explorations, difficulty of including theoretical concepts with inquiry, and lack of teacher knowledge and experience. Even though inquiry should be considered as an essential component of science instruction, transforming traditional science lessons into inquiry-oriented activities can be very challenging. The integration of simulations into inquiry-based science instruction offers one possible solution to support this transition.

**Computer Simulations Support Inquiry-Based Science Instruction**

Broadly defined, “computer simulations are computer-generated dynamic representations that present theoretical or simplified models of real-world elements, phenomena, or processes” (Bell & Smetna, 2008, p. 10). Simulations can include animations, visualizations, and interactive laboratory events. In a simulated situation, time changes can be sped up or slowed down, abstract concepts can be made concrete, and inferred behaviors can be observable. A simulation is an active implementation of the processes within a representation of an object (Akpan, 2001; Miller & Castellanos, 1996). The use of computer simulations supports reforms-based science teaching, which is learner and knowledge-centered, and highlights the skills, viewpoints, and significance
of scientific inquiry (NRC, 1996). Because digital technologies have become the increasingly all-encompassing features of the 21st century, students must become more techno-literate.

Computer Simulations and Science Instruction

One solution to support the focus on instructional technology is the implementation of computer simulations. The use of computer simulations has put a new spin on science education reform, redefining the role of the teacher and reshaping the classroom learning experience, according to the Standards (NRC, 1996) and the NSTA (2001). The evolution of computer technology has provided many new tools for the presentation of inquiry-based learning in the science classroom. Computer technologies have created vast opportunities for students to engage in inquiry (Krajcik, Marx, Blumenfeld, Soloway, & Fishman, 2001) and to undertake aspects of inquiry in which they could not otherwise participate (Novak & Gleason, 2001). In fact, some of these technologies can help transform science “from canned labs and the passive memorization of content to a dynamic, hands-on authentic process of investigation and discovery” (Barstow, 2001, p. 41). Science simulations can be effective tools in helping students to understand and experience the practical applications of scientific thinking (Akpan & Andre, 2000; Coleman, 1998). Hawkey (2001) argued that technology provides a chance to rethink the meaning of scientific inquiry.

In view of the fact that computer simulations are one specific educational technology that has shown promise in supporting reformed-based science instruction, it is important to consider the potential that instructional technologies bring to the classroom. These technological methods support content-based instruction that is student-centered and inquiry-based. To accomplish this goal, the educational community is challenged to understand and participate in this effort.
Advocates of classroom technology have claimed that web-based simulations have the potential to support improved learning in all academic areas (Schacter, 1999; Sivin-Kachala & Bialo, 2000). The utilization of simulations can make scientific concepts more available and have the ability to make a positive difference in science teaching and learning (Means, et al., 1993; Sivin-Kachala & Bialo, 2000).

Thomas and Hooper (1991) described a simulation as a computer program that includes a representation of a real or hypothetical system that can be controlled. According to Akpan (2002), “the program enables the students to change the model from a ‘given’ state to a specified ‘goal’ state by directing it through a number of intermediate processes” (p. 1). The simulation program accepts commands from the user, alters the state of the model, and displays the new state. Cholmsky (2003) indicated that computer simulations have the potential to make learning abstract concepts more interactive, authentic, and meaningful. If used appropriately, computer simulations can provide opportunities for students to observe real world experiences and interact with them. Simulations can contribute to conceptual change, provide open-ended experiences for students (Sadler-Smith & Riding, 1999), offer tools for scientific inquiry, and enhance problem-solving experiences.

Several scholars, however, have raised concerns regarding the integration of educational technologies into classrooms. Cuban (2001) asserted that technologies have been used in limited ways to maintain, but not change, existing instructional practice and asked, “Are computers in schools worth the investment?” (p. 175). Cuban concluded that they are not. In a later work, Cuban (2003) acknowledged that schools in the U. S. are a step behind the computerization of our international competitors and argued that if schools cannot produce computer literate graduates to enter the workforce, this country’s global competitiveness is in jeopardy.
Wohl (2001) indicated that technology alone is not the solution for problems like inequitable funding, overcrowded classrooms, and old buildings. He strongly cautioned those scholars who suggest that technology is the miracle cure for troubled schools. However, he did acknowledge the importance of establishing a commitment to working with teachers and developing programs that assist students in understanding the features and functions of instructional technology. Wohl supported Cuban’s (2001) premise that computers frequently sit idle in classrooms, as do many books in the library. Nonetheless, computer simulations have the potential to enhance science content knowledge in the classroom.

Computer Simulations and Advancing Science Content Knowledge in the Classroom

The use of computer simulation tasks to enhance the learning of science content knowledge in the classroom has been the focus of numerous studies (Akpan, 2001; Brant, Hooper, & Sugrue, 1991; Coleman, 1998; Foti & Ring, 2008; Guzey, & Selcin-Roehrig, 2009). The constructivist position in learning theory is that the mechanics of teaching are highly interactive and therefore students should have access to multiple viewpoints and representations for information. The opportunity to use multiple instructional modalities is partially satisfied by the utilization of well-constructed simulations (Gardner, 1993; Pintrich, Marx, & Boyle, 1993; Schommer, 1993; von Glasserfeld, 1999). Simulations offer potential means of providing students with experiences that facilitate conceptual development. According to Akpan (2001), “simulations should be designed with the purpose of immersing students in real-life science encounters that require hands-on activities, higher-order thinking, and collaborative problem solving” (p. 2). A great deal of the early research on simulations highlighted whether or not students could gain knowledge from them (Akpan, 2002). During the latter part of the 20th century and the beginning of the 21st century, researchers compared traditional instructional
approaches to those using computer simulations for various topics in the physical, biological, and earth sciences.

The literature indicates that the degree of simulation effectiveness varies significantly based on the features and use of the simulation and that the combination of both traditional instruction and computer simulations may be the most valuable instructional method for teaching science content knowledge (Smetana & Bell, 2007). Boblick (1972) compared the influence of a computer simulation to a traditional laboratory experiment on student understanding of the conservation of momentum. The simulation group outperformed the laboratory group in student understanding of the curriculum. Boblick (1972) attributed the success of the experimental group that used the simulations to the students’ opportunities to gather more data in a shorter time span. Raghavan, Sartoris, and Glaser (1998) found that computer simulations in students’ exploration of floatation resulted in deeper comprehension of the concept. Use of simulations to provide initial exposure about concepts and to integrate new science content knowledge is a promising classroom application. Also, when didactic instruction provides information that relates to simulation experiences, students may form significant associative connections between instructional information and the experience (Akpan, 2002).

The utilization of simulations to support physical science instruction has been the focus of numerous studies. Marshall and Young (2006) compared the experience of prospective science teachers who used experiments to investigate collisions. One group utilized physical experiments while the other group used computer simulations in their experiments. They found that the group that used simulations had more difficulty in understanding the collision experiments when compared to the group that had access to physical experiments. Zacharia
(2005) implemented physics simulations as a part of the Predict-Observe-Explain (POE) model and found that the quality of explanations were more advanced for participants exposed to the simulation condition than for those in the textbook condition. In general, these studies demonstrate that there is an effective use of simulations for instruction in physics and the physical sciences.

Nonetheless, many science educators and researchers have been stymied by the fact that numerous conscientious physics students are still not able to master the subject (Goldberg & Bendali, 1995). Lee, Guo, and Hsiang (2008) investigated the possibility of the use of computer simulations as a solution to assist students in their understandings of physics. Their goal was to determine whether computer simulations could bridge the gap between concrete and abstract reasoning in instruction. The authors concluded that the integration of simulations into curricula provides a conceptual framework that can be used to design appropriate content based on knowledge of student learning difficulties, encourages reflection, and provides support when students encounter challenges.

Ronen, Langley, and Ganiel (1992) assessed the influence of physics simulations on student content knowledge and the influence those simulations had on secondary physics classrooms. In general, the results indicated that the teachers felt the simulations contributed positively to students’ understanding of the physics content. In addition, the teachers indicated that they would use the simulations to enhance various portions of their curricula. For the most part, students reported that the incorporation of the simulations into the curricula influenced their understandings of the physics instruction.

Other studies have explored the value of computer simulations to support instruction for the biological sciences. Hounshell and Hill (1989) compared the performance of high school
students in a computer-infused biology course to those in a traditional course. They found that
students in the computer-infused class performed at significantly higher levels than the other
students. Similarly, Friedler, Merin, and Tamir (1992) investigated the impact of a biology
simulation on student learning. Generally, the researchers found that there was a positive
impact on understanding for the students who had simulations incorporated into their instruction.
Likewise, Kiboss, Ndirangu, and Wekesa (2004) evaluated the effectiveness of computer
simulations on students’ attitudes and academic achievement in cell theory: they found that
students exposed to computer simulations outperformed the other students in acquisition of
content knowledge. Eichinger, Nakhleh, and Auberry (2000) studied ways biology students
viewed the computer lab modules (CLM) that were incorporated into their courses. Students
described the advantages of the CLMs as the flexibility of the programs, the capacity to cover a
greater number of topics in a shorter duration, the ability to work at individual paces, and the
opportunity to administer and review experiments.

Researchers have also investigated the usefulness of computer simulations to strengthen
instruction in earth science. Winn et al. (2006) compared the study of oceanography concepts
through field and simulated experiences. Results revealed no difference in overall learning
between the simulation and the field work groups. The researchers concluded that while the field
work provided an authentic experience, the simulated work provided a model-based experience
that also offered opportunities not possible in the field. Winn et al. (2006) concluded, therefore,
that the two experiences should be used to complement each other.

The studies cited in this section of the literature review for the present study focused on
the opportunities to develop science content knowledge (physical, biological, and earth science)
through the use of simulations. A number of the studies reviewed focused on whether students
could learn from simulations: the effectiveness of simulations was compared to traditional instructional methods. In addition to using computer simulations to support the instruction of science content knowledge, there is evidence that simulations enhance students’ science process skills (Monaghan & Clement, 1999; Rivers & Vockell, 1987; Roth & Roychoudhury, 1993).

**Computer Simulations and Science Process Skills for Inquiry Learning**

Throughout the 1970s and 1980s, computers in science teaching were seen as a panacea for many problems, one at the forefront of the efforts to improve the instruction of science process skills. While considerable research was undertaken to determine the cognitive achievements of students who interacted with computers during science learning, more basic questions needed to be addressed. Bell and Smetana (2008) concluded that during the 1990s and the early 2000s, numerous studies found that the influence of simulations on science process skill development was equal to or more valuable than traditional instructional methods.

For the purposes of the present study, acquisition of science process skills is defined as a cognitively complex development that requires students to have the following: “background knowledge in the areas they plan to investigate, ask appropriate questions, identify variables, formulate hypotheses, and design clear experiments” (Germann et al., 1996, p.80 ). Simulations can initiate students’ science process skills which are the basic components for scientific inquiry (Roth & Roychoudhury, 1993). Computer-supported learning environments have enabled students to plan their individual research foci, create their own data, and continue their inquiries as they raise new questions. All of this clearly demonstrates the dynamics of the scientific inquiry process (Kubicek, 2005). A number of studies cited in this section of the literature review will explore the use of computer simulations to enhance the teaching of these science process skills such as problem solving (including the opportunity to visualize and analyze data),
experiment design, and the development of critical thinking and reasoning skills. The appropriate use of simulations compared to traditional “hands on” experiments is also discussed.

Rivers and Vockell (1987) reported the findings of three associated studies conducted over a three-year period that explored whether simulations improved problem-solving skills. In general, they found that students who worked with simulations were more successful in their abilities to transfer their problem-solving skills to new situations. Monaghan and Clement (1999) tested their hypothesis that the capacity to visualize problems might contribute to students’ abilities to solve problems. They concluded that the simulations have the potential to assist students in visualizing physics problems and suggested that this could lead to an increased dependence on students’ individual mental simulations in solving similar problems in new situations.

Another important process skill in all areas of science is the ability to design experiments. Computer simulations can facilitate the manipulation of variables in experiments and models. “Students can predict, observe, and explore the effects of experimental boundaries on dependent variables in more advanced experiments than could generally be replicated in the classroom” (Kubicek, 2005, p. 8). Because simulations are used by scientists, an understanding of their pros and cons is also beneficial to developing a thorough perspective on a significant method of scientific investigation. Models provide an important instrument in science explorations and are considered an effective means of expressing knowledge of a scientific process (Thomas, 2001). Computers afford students opportunities to generate scientific models that include numerous variables and to analyze them by running through new simulation conditions. When using simulations and modeling, students tended to develop new strategies for problem solving and develop higher-order thinking skills (Cox, 2000).
Highly interactive simulations are appealing to many educators because they support the opportunity to design experiments. Sahin (2006) found that computer simulations provided strong tools to improve hypothesis construction, graphic interpretation, and prediction skills; however, their success depends on the ways they are integrated into the curricula and the ways teachers use them. Akpan (2002) found that use of a simulation before a dissection experiment improved learning and achievement, which suggests that computer-based simulations offer appropriate cognitive learning environments in which students can look for meaning, appreciate ambiguity, and acquire responsibility. Similarly, Trundle and Bell (2003) determined that students learned more about the causes of the moon phases by using simulations than solely by making nightly observations.

The opportunity for students to collect data is an important focus for teaching the scientific process, and a variety of studies have explored the influence of simulations in this area. In a study of elementary school students, Nicolau, Nicholaidou, Zacharia, & Constantinou (2007) found that students who utilized inquiry-oriented activity sequences to explore phase transformation (melting and freezing) demonstrated stronger abilities to construct and interpret data than students who employed traditional laboratory methods. In a related study, Redding (2007) addressed the concern that students are frequently capable of memorizing definitions but are rarely able to apply concepts. Redding (2007) also found that the use of simulations with middle school students resulted in significantly increased abilities to understand physics concepts and related data.

De Jong and van Joolingen’s (1998) study maintained, “scientific discovery learning is a highly self-directed and constructivist form of instruction” (p. 179). Scientific discovery encourages the development of critical thinking and reasoning skills. The authors concluded that
a computer simulation is generally suited for scientific inquiry where a student’s main task is to infer, through experimentation, traits of the model underlying the simulation. However, the study also addressed potential problems with simulations-based scientific discovery learning. According to the authors, the impact of simulations to support two critical aspects of the scientific process has not been substantiated: finding the hypothesis and predicting outcomes in an experiment.

A number of studies addressed the advantages of the use of simulations in lieu of “hands-on” experiments. According to Mintz (1993), “one of the most promising computer applications in science instruction is the use of simulations in order to teach material that cannot be taught by conventional laboratory experimentation” (p. 76). Mintz’s (1993) assertion echoed the work of Choi and Gennaro (1987), who determined that computer simulated experiences are a perfect addition to hands-on laboratory experiences. Likewise, Faryniarz and Lockwood (1992) found that students who designed their own experiments realized greater improvements in problem solving skills than students who followed traditional syllabi.

The interactive nature of computer technology can support students in carrying out inquiry-based activities. Tapscott (1996) noted:

Precisely because this new technology is interactive, it does away with the passivity associated with the traditional learning model in which the student is viewed as an empty vessel to be filled by the knowledge and expertise of the teacher. (p. 144)

Therefore, Tapscott (1996) argued, the teacher has the opportunity to become better equipped to guide the student in the inquiry process, rather than simply dictating facts to be memorized. This experience allows students to become engaged in more realistic scientific inquiry experiences.
Steinberg’s (2000) study sought to determine if there are negative implications of using simulations of real world phenomena and discovered that the impact of using computer simulations in a classroom depended on the details of the program and the instructional method in which it was put into practice. Overall, research demonstrated that simulations are at least as effective and in many cases are more effective than traditional methods for teaching science process skills. However, the level of effectiveness varies significantly based on the level of classroom implementation. Despite the numerous attainable benefits in computer technology applications, caution must be exercised in the proper usage to guarantee that there is effective comprehension by the students.

Teaching science process skills presents an ongoing challenge in science education. Jensen and Finley (1998) described the importance of the “teachable moment” to encourage discussions regarding the appropriate integration of simulations into inquiry-based science instruction. The teacher must be capable of providing appropriate guidance throughout this instructional process. Borich and Tombari (1997) suggested that digital technologies are affected by the understanding of psychological theories of learning and by the ways that organizing and relating information facilitates understanding. Teacher preparedness to integrate the use of simulations into instructional practice is a central theme of concern. While the majority of teachers involved in these studies were familiar with simulations, it was not clear how familiar they were with the integration of the simulations into their everyday science instruction. DeJong et al. (1999), for example, noted that students’ and teachers’ familiarity and comfort levels with computers might have influenced the results of their study. Sahin (2006) indicated the importance of a teacher’s ability to integrate technology into classrooms as an important consideration for success.
The limitations of the studies cited in this section must be considered. Foti and Ring (2008) explained that “simulations are squarely in the intersection between educational change and technological development” (p.104). However, this mode of teaching is only as powerful as the teacher who effectively supports this instructional method. It is important for today’s policy makers, the science education research community, and science educators to understand the vital role of classroom teachers in this process. Teachers must have the skills to provide the most appropriate instructional strategies to incorporate simulations into their inquiry-based science instruction.

**Professional Development Supports and Sustains Implementation**

Sugar, Crawley, and Fine (2004) determined that the comprehensive adoption and integration of technology can be a tremendous undertaking for most public school teachers. According to the United States Department of Education (USDOE), in 1999, 99% of all public school teachers reported the availability of computers in their schools; 84% of those teachers had computer access in their individual classrooms (USDOE, 2000). In 2002, 92% of public schools reported having Internet access in the classrooms (USDOE, 2003). However, “only a third of these teachers reported being ‘well prepared’ to integrate this technology into their classroom instruction” (Smerdon, Cronen, Lanahan, Anderson, Ianotti & Angeles, as cited in US DOE, 2003, p. 14). The key variable in this adoption process and ongoing incorporation is the teacher (Sugar et al., 2004). Teachers must understand the practicality of using technology prior to integrating it into their instruction. This section of the literature review addresses the policies that support teacher preparation for science instruction, leader support of professional learning opportunities for technology-infused science instruction, and sustainable professional
development strategies to encourage the teachers to use simulations to support their inquiry-based science instruction.

Policies that Support Teacher Preparation for Science Instruction

Since 1990, a number of initiatives have influenced the opportunity to reform the teaching and learning of science in U. S. schools. Several of these reforms have supported the inclusion of inquiry-based science curricula funded by NSF (Cohen, 1997; Penuel & Means, 2004; Raizen & Britton, 1997; Ready, 2001; Ruopp, Gal, & Pfister, 1993) and the incorporation of state and national science education standards (AAAS, 1990; NRC, 1996; New York State Education Department, 1996).

During the latter half of the 20th century and the beginning of the 21st century, a number of initiatives have influenced the possibility of reforming science teaching and learning in this country’s schools. The Standards (NRC, 1996) called upon the nation to prepare a teaching force qualified to teach science content to all students and focused on four areas: the implementation of the inquiry method in learning science content, the ability to integrate content and pedagogical knowledge, development of a lifelong learning system, and the understanding of how professional development will contribute to this process.

The issue of teacher preparation has been central to NCLB (2001) as well. The law authorized a set of regulations that had a tremendous impact on teacher preparation and professional development; it required that each classroom have a “highly qualified” teacher by the end of the 2005-2006 school year which is defined as all teachers need to demonstrate competency in the subject areas they teach (Hovey et al., 2005). However, the goal to have every teacher deemed “highly qualified” has proven unsuccessful. Fulfillment has been uneven, with nearly a third of the states showing declines in the percent of the classrooms in compliance since
the 2003-2004 school year (USDOE, 2008). Yerrick, Parke, and Nugent (1997) determined that increased accountability in the form of high stakes testing has discouraged teachers from implementing reform-based science instruction in their classrooms.

It is undeniable that there is a conflict between the science education research community and the educational policies associated with NCLB (Southerland et al., 2007). The stakeholders involved in this dilemma have included the policy makers who specified the courses of action to meet the needs of the students, the school district and state departments of education that were charged with implementing these policies, and the science researchers who examined the educational system to support learning. It is the teachers’ responsibilities to comply with federal mandates and to follow strategies suggested by the science education reform.

Nonetheless, teachers have encountered obstacles to science education reform due to a number of factors, including local school district policies and lack of administrative support, time and space for instruction, funding, and materials (Tyack & Cuban, 1995). Compounding this problem is the fear that federal spending to support science instruction is unlikely to continue (Hess & Rotherham, 2007). In 2006, the NSTA identified the importance of a highly qualified teacher workforce in making a difference in student learning. To accomplish this goal, meaningful ongoing professional development opportunities have to be made available to the majority of teachers in the U.S. schools, and school systems must devote time and resources to implement effective teacher training. Key principles for professional development, identified by the National Institute for Science Education (Loucks-Horsley, Stiles, & Hewson, 1996) included support of professional learning opportunities, integrating professional development with local and state practices, and continuously evaluating the effectiveness of professional development strategies.
Professional Development to Support Technology-Infused Science Instruction

The educational reforms of the late 20th and early 21st centuries supported change in the delivery of professional development. The technology revolution has had a profound impact on teacher education in support of science instruction. The challenge facing science teachers is to understand how to utilize these resources to support student-centered teaching and learning. The influence of technologies on science teacher education has been more all-encompassing than any preceding instructional implementation (Ronen & Langley, 2005). First, technologies are influencing the ways teachers interact with students. For example, the manner that classrooms are organized is influenced by the location of computers. Second, the Standards (NRC, 1996) included the utilization of a variety of instructional approaches that incorporate technology. Third, teachers and students are communicating in real time through a variety of computer applications such as email and Blackboard discussions.

Teachers tend to question instructional tools that they do not consider pertinent to their long-established goals. Traditionally, the focus on teacher training in the use of simulations had been on acquiring the expertise in the basic features and functionalities of the software programs. This effort was due to the low level of computer literacy on the part of many teachers, and this practice still persists in many training models (Friedrichsen, Dana, & Zembal-Saul, 2001). The traditional approach to professional development for teachers has followed a training model centered on single events (Mullens, Leighton, Laguarda, & O’Brien, 1996). These events are delivered in the form of short-term in-service workshops intended to teach isolated skills and techniques. This approach generally resulted in failure to achieve the long-lasting impact on instructional practice sought in systemic educational reform (Wells, 2007).
Fullan and Stiegelbauer (1991) found that researchers reported that training was frequently conducted in environments away from school settings and used instructional tools that were unfamiliar to the learners. Additional traditional professional designs included viewing learners as homogenous in their understanding and comfort regarding the technology innovation. Also, the literature indicates that implementations frequently did not succeed due to inadequate time spans (Means, 1998). For example, the traditional training designs failed to provide opportunities for continued support of their newly acquired knowledge of the instructional technology. Eventually, the professional development strategies that were designed in the traditional method have resulted in teachers who are not well versed in new technologies and are therefore unlikely to change their instructional practices (C. Crawford, 2003; Lewis, Schaps, & Watson, 1999; National Council of State Legislatures [NCSL], 2002).

Reeves (1998) considered the teacher’s belief system in the acquisition of instructional technology skills and determined that it is a critical component in whether or not that teacher adopts technology integration into instructional practices. Reeves’s (1998) findings were supported by the National Educational Technology Plan (U.S. Department of Education, 2004), which identified that the commitment to educational technology has failed in large part because of the shortcomings in the methods of training teachers to implement technology into their classrooms. The critical consideration in teacher training is to provide the opportunity to alter the teacher’s belief system regarding the use of technology, to turn the teacher from a traditional educator into a constructivist educator (Brickhouse, 1990). The constructivist approach would support and encourage teachers to understand and to internalize the importance of adopting an educational innovation and to put the innovation into practice in their classrooms (Lutz & Huitt, 2004; Richardson, 2003).
Possible Solution: Sustainable Professional Development Strategies

In comparison to the traditional professional development strategies, effective professional development plans should include a comprehensive plan for the maintaining the incorporation of technology in the science classroom (Wells, 2007). Science and technology have benefitted from a meaningful partnership (Flick & Bell, 2000) and a “complete science education” has involved an obligation to include technology as a tool for learning science content, processing skills, and as a topic for instruction (AAAS, 1993; NRC, 1996). The technology revolution still needs to have a profound impact on teacher education in support of science instruction. The challenge now facing science teachers is to understand how to utilize these resources and to support student-centered teaching and learning. The ideal professional development model should incorporate a plan that addresses the multiple modalities for learning: auditory, visual, and kinesthetic. The auditory component includes the opportunity for the teacher to listen to instruction; the visual component includes the opportunity for the teacher to watch the instruction; and, the kinesthetic opportunity includes the opportunity for the teacher to participate in “hands on” learning sessions.

There is emerging understanding of significant professional development strategies to establish sustained changes in the practice of integrating technology into the science curricula (Howland & Wedman, 2004). Wu, Chang, and Guo (2008) investigated the relationship between fundamental factors influencing science teachers’ intentions toward teaching with information technology. Results from a survey completed by 226 middle school science teachers in Taiwan concluded that perceived usefulness and computer self-efficacy were significant determinants of science teachers’ intentions about technology integration. The authors recommended that pre-service and in-service teachers should receive training on a regular basis to equip them with up-
to-date knowledge of instructional practices. The authors suggested the following strategies for meaningful training programs: analyze which technology best fits information-specific teaching contexts, design teacher-friendly lessons correlated to the required curriculum, and promote hands-on practices during the training sessions.

Varma, Husic, and Linn (2008) devised a targeted professional development approach to support an effective professional learning experience for technology-enhanced inquiry instruction for science teachers. They confirmed that teachers faced hurdles that were frequently associated with the lack of support for technology innovations in K-12 classrooms. The targeted training addressed these challenges and provided teachers methods to successfully implement the components in their classrooms. Schnittka and Bell (2009) explored pre-service science teachers’ management of an interactive display system (IDS) including a computer, digital projector, interactive white board, and Internet connection to assist with teaching and learning. The authors noted that the development of teachers’ content knowledge and pedagogical skills should be addressed simultaneously because the intersection of those components supports science education reform. Shane and Wojnowski (2007) explored a long-term professional development effort to include technology into K-8 curricula. From 1998 to 2002, the program combined technology with earth and environmental science instruction and provided instructors with professional development, technology equipment, and materials. The findings of this study suggested that lasting changes, such as the retention of effective existing practices and academic security, resulted when teachers were provided sufficient time to carry out the integration of technology into their instruction. This study supported the notion that profound change occurs when beliefs are restructured through new understanding (Loucks-Horsley et al., 2003).
Wells (2007) explored the importance of long-term professional development strategies to support continued integration of technology into the teacher’s instruction and identified the key design factors (KDF) for professional development programs:

- **KDF-1**: Evaluation Driven (designed around stated outcomes)
- **KDF-2**: Contextual (individual practice made relevant)
- **KDF-3**: Learner Centered (designed around participants concerns, needs, and interests)
- **KDF-4**: Duration of Process (participants’ instructional and content contact time)
- **KDF-5**: Engagement (learner is actively experiencing the innovation)
- **KDF-6**: Inquiry-Based (promote spirit of inquiry into content)
- **KDF-7**: Theory/Research-Based (grounded in pedagogy that is logical to all participants)
- **KDF-8**: Collaborative (establish professional learning communities with a focus on collective reflection)
- **KDF-9**: Support (long-term, continuous pedagogical and technical assistance)
- **KDF-10**: Sustainability (purposefully iterative professional development process to ensure durability of change). (p. 106)

Wells’ investigation of a long-term professional development process showed that this approach to sustained integration of instructional technologies promoted a shift in classroom practice and teaching centeredness (from teacher toward learner) among participants. The key design factors were determined to directly contribute to the success in promoting changes in instructional practice. Long-term support was identified as the cornerstone of the professional development process that leads to sustainable learning communities.

In summation, professional development related to the use of technology to support new teaching approaches and objectives has held great promise for improving science education in
the classroom. This review of the literature for the present study suggested that with ongoing professional development teachers can learn to use inquiry-oriented technology-science innovation to improve students’ comprehension of challenging science topics. One such innovative teaching strategy, the integration of simulations to support inquiry-based science instruction, has shown promise. Unfortunately, however, there is a dearth of literature that addresses ongoing professional development strategies to support teachers in learning and maintaining the use of simulations via technology in their science classrooms (Adelman et al., 2002; CEO Forum on Education and Technology, 1999; Moore & Stuart, 2000).

**Current State of Research on Professional Development to Support Simulations**

Current reform efforts in science education require extensive changes in how science is taught and equally extensive changes in professional development practices (Anderson, 2002; Watson, 2007; Wells, 2007). Scant methodical research has been conducted on the professional development (PD) strategies that support the ongoing use of simulations to encourage inquiry-based science instruction. Professional development that targets the use of instructional technologies in education produces unique conditions that bring to the forefront noteworthy problems using earlier PD models (Wells, 2007). The traditional method of training for teachers has followed an instructional model focused on single events intended to teach isolated skills and procedures (Watson, 2007). Generally, this technique fails to accomplish the long-term, long-lasting influence on teaching strategies sought in science education reform. To influence long-term universal change, professional development must be devised to address each teacher’s understanding of science content and science process skills taught through inquiry-based instruction. The use of web-based simulations offers one solution to encourage this practice.
While science teachers have been exposed to simulations for many years, there does not seem to be a corresponding change in instructional application (Ronen & Langley, 2005). It appears that “technology is used to sustain the existing curricula rather than serve as a catalyst for change” (Moersch, 1995, p. 40). The concept that the educational community must explore is not just whether instructors use simulations to support their science instruction, but rather how the simulations are used to improve students’ learning.

Ronen and Langley (2005) reported the following characteristics of science teachers’ utilization of simulations:

- Perceiving simulations as real experiments. The use of simulations compromises the important role of the wet lab or actual experiment.
- Focus on traditional instructional needs. Teachers only use simulations to demonstrate phenomena (e.g., biological systems or electrical circuit diagrams).
- Limited range of instructional procedures. Teachers tend to use simulations for traditional teaching methods such as drill and practice. Instructors rarely use simulations to promote inquiry-based instructional opportunities.
- Limited sphere of application. Teachers tend to discredit instructional instruments that do not support their traditional teaching objectives mandated by the local curriculum framework and the state high stakes exam.

Since the 1990s, science teachers have been exposed to science simulations. During this timeframe, the major focus on professional development has been on gaining competence in operating specific software due to the low level of teachers’ computer literacy and the lack of user-friendly simulations. It is reported that this situation continues to undermine some training models (Ronen & Langley, 2005). Transition in the focus of training should be considered due to
the advances of teachers’ computer self-efficacy and the abundance of excellent science simulations now available. Professional development strategies should support this transition process through the consideration of constructivist learning principles that support inquiry-based science instruction. A suitable training model should include a progressive format through long-term support that guides the teachers. A training model such as the Apple Classroom of Tomorrow (ACOT) scale suggests five stages for this process: “entry,” ‘adoption,’ ‘adaptation,’ ‘appropriation,’ ‘innovation.’ Research shows that it generally takes seven years to go from the top of that list to the bottom” (Reidel, 2009). Benno (as cited in Reidel, 2009, para. 4) stated that professional development is the key to closing the gap in teacher integration of technology.

This technology integration model should be considered for those teachers who seek to effectively use simulations to support their inquiry based science instruction.

In order to analyze and evaluate the decisions of teachers and science leaders to implement simulations to support science instruction, I considered the Mean’s input-output model for this study (Means, 1994, 1998). Mean’s model is a qualitative technique designed to analyze and evaluate the decisions of the teachers and their leaders in the adoption of instructional technology. For the purpose of the present study, this qualitative technique was reviewed to assess the decisions of the science on those teachers who are receiving continuous professional development strategies and their leaders who support this innovative practice. This study includes those factors which to some degree contribute to the continuity of simulation usage.

In summary, the literature has shown that successful professional development programs are based on mutual respect, long-term follow-up, agreed-upon goals and objectives, and a supportive instructional leader (Richardson, 2003). This section of the literature review
addressed the policies that support teacher preparation for science instruction and sustainable professional development strategies to encourage the teachers to use simulations to support their inquiry-based science instruction. The instructional leader should develop strategies that promote the use of simulations to support inquiry-based science instruction.

**Leaders’ Role in Support of Teachers’ Sustained, Effective Use of Simulations**

Reform initiatives such as technology-enhanced science instruction require instructional leadership to succeed. Administrative leadership at the school, system, and state level has been essential to the success of any educational reform. Many instructional leaders, however, report that they need assistance in guiding the implementation of science and technology reforms. Costenson and Lawson (1986) reported that inquiry-based instructional techniques have been unsuccessful in science classrooms to some degree because school leaders have misunderstood this mode of instruction. Knapp (1997) identified, “the lack of long-term administrative and financial support and the conflict between existing policy and reform for the failure of mathematics and science curricular reforms” (p. 228). In *The Fifth Discipline*, Senge (1999) emphasized the uselessness of reform visions that are obligatory rather than agreed upon by all participants in an educational community. Principals make instructional decisions at their schools yet seldom provide direction in the areas of science and technology (Byers & Fitzgerald, 2002; Hallinger, 2003; Spillane, 2005).

The new millennium requires instructional leaders to bring direction to the understanding of ways to best support science literacy in the classrooms. The value of the role of the instructional leader emerged in the early 1980s; this shift was influenced by effective schools research, which noted the importance of instructional leadership (Brookover & Lezotte, 1982). The importance of instructional leadership in the 21st century has been supported by the
significance placed on academic standards and school accountability. While it is acknowledged that instructional leadership is essential, it is seldom well practiced. For example, among the many responsibilities of the principal, only one-tenth of their time is devoted to providing instructional leadership that involves setting clear goals, allocating resources to instruction, managing the curriculum, monitoring lesson plans, and evaluating teachers (Whitaker, 1997). The modern era requires schools to address the instruction of science through the integration of technology, and instructional leaders must provide support for this priority. In this regard, the instructional leader could be the school principal, science coach, or science department chairperson.

The provisions of NCLB (2001) acknowledge that a paradigm shift must occur in instructional delivery, student accountability, and the methods for closing the achievement gap, including the gap in science performance. The adoption of curricula has been based on the identification of solid research that demonstrates learning gains and is therefore scientifically-based. These requirements have posed a new set of challenges for instructional leaders. Heifetz and Linsky (2002) discussed the importance of leaders who adapt to change; they asserted that it is not sufficient for an effective leader to be a technician. Leaders must be specialists who apply up-to-date knowledge. The instructional leader must be capable of encouraging colleagues to discover new methods in education. Also, designated school leaders must empower their staff members and promote resourcefulness. The mandates of NCLB (2001) require educators to be adaptive leaders in all domains, including science.

Despite the obstacles, the educational community cannot afford to sit on the fence in determining the necessary steps to improve science instruction. Senge (1999) discussed the challenge of change in an organization and highlighted the differences between external and
internal forces for change. An example of external force for change in education is the mandate of NCLB (2001): the necessity of schools to demonstrate annual yearly progress, increase performance of those students performing in the bottom quartile, and provide “high quality” teachers in their respective instructional areas. These external forces have required internal changes for schools: new instructional strategies, increased emphasis on student instruction, and provisions for professional development to name a few. Adept leaders must be change agents for their schools’ transformation. School leaders must consider creative solutions to enhance the internal changes essential to improve science teaching and learning.

Researchers have contended that leadership shapes reform (Anderson & Dexter, 2005; Berman & McLaughlin, 1997; Coburn, 2003; Coffland & Strickland, 2004; Elmore, Peterson, & McCarthy, 1996; McDonald & Schneider, 2006). Reforms that include all-embracing opportunities for instructional leaders to learn about new curricula have been more likely to accomplish positive changes in student learning (Elmore et al., 1996; Fink & Renick, 2001; Stein & Nelson, 2003). The role of principal leadership is significant in science-technology instructional innovation and the design of learning situations that enhance instructional leader’s abilities (Nelson, 1998; Nelson & Sassi, 2000; Prestine & Nelson, 2003). Many educators have called for science programs with fewer standards and greater focus on the inquiry-oriented approach of constructing knowledge (Kahle, Meece, & Scantlebury, 2000; Linn & Hsi, 2000).

It has become the responsibility of the instructional leader to create a vision for science curricula that supports this inquiry-based approach to teaching science. It has also become the instructional leader’s responsibility to support the resource needs for this implementation: professional development and technology. This leader must be aware that when computers are
incorporated into classroom instruction, they are frequently used to support didactic instruction (Adelman et al., 2002). It is incumbent upon the leader to guide the teachers to implement inquiry-oriented, technology-science innovation to improve students’ understandings of challenging science subject matter (Williams, Linn, Ammon, & Gearhart, 2004). However, there are few professional development opportunities to assist teachers and instructional leaders to learn how to incorporate technology, science, and inquiry instruction (Hallinger, 2003).

Byers and Fitzgerald (2002) presented the theoretical and empirical foundations for the Networking for Leadership, Inquiry, and Systemic Thinking (NLIST) initiative sponsored by the Council of State Science Supervisors and NASA. The authors acknowledged that research has identified a number of successful inquiry implementations; however, the shift to this reform-supported methodology has been slow. Universal components intended for change have included a collective understanding of science as inquiry, teaching resources, professional development, administrative encouragement and leadership, and technology infrastructure.

Spillane et al. (2003) identified the challenge for school leaders to provide the guidance for “going to scale” and “going to substance.” “Going to scale” involves improving the distribution of recent reforms beyond those innovative schools that catch on quickly to instructional innovation. “Going to substance” involves guaranteeing that reforms are enacted in ways that align with their intent. This change involves the necessity for local school administrators and faculty members to transform the core of existing curricula. Spillane et al. (2003) explained that in order to be successful, school leaders must cultivate specific in-school conditions, market shared visions for instruction, generate communal dependability for students’ academic success, and provide opportunities and incentives for teachers to develop instructional
practices. Effective instructional leaders empower faculty members to become experts in their subject areas.

**Conceptual Framework**

With the rapid dissemination of Internet-related technologies in the field of education, it is important to understand the nature of these innovations. Studies that attempt to understand how to design support structures to maximize the potential benefit of these technologies have increased in significance. Technology, specifically the implementation of simulations to support inquiry-based instruction, provides new educational strategies for science teachers. Technology also influences education by repeatedly making teachers’ best practices obsolete. A general agreement on the nature of educational practices using technology can be found in the literature cited in this study. However, there is generally limited consensus on the pertinent factors relevant to the initiation and success of such innovative practices. The focus of the present study was to develop an understanding of those innovative practices that encourage the sustained use of simulations in support of inquiry-based science instruction.

Within the framework of literature pertaining to the sustainability of web-based simulations, a group of significant topics was used to develop the foundation for this study. This literature review has included numerous studies that support four major themes: (a) the importance of inquiry-based science instruction, (b) computer simulations that support inquiry-based science instruction, (c) professional development that supports and sustains this implementation, and (d) the leaders’ role in improving instruction. Together, the four components of the literature provided the framework for the present study. This foundation provided the focus that guided the study’s design, data collection, and data analysis.
The Importance of Inquiry-Based Science Instruction

The first theme of the conceptual framework considers the constructivist learning theory and its influence on inquiry-based science instruction. Constructivist learning theory has called attention to the use of pre-existing knowledge to develop understandings of new concepts (Proulx, 2006). Because constructivist teaching requires science teachers to have a complete understanding of their discipline, it is important that all teachers have a thorough knowledge for the courses they are expected to teach. Also, a constructivist instructional approach requires very different science curricula and modes of science instruction compared to traditional instruction. Therefore, it is essential that all teachers are provided with the tools to support constructivist learning in the science classroom.

The literature reviewed in this study established the importance of providing a bridge between the theory of constructivism and the practice of inquiry-based science instruction. Inquiry-based science instruction requires educators to develop cognitive skills that encourage student-centered learning (Minner et al., 2010). Studies reviewed in this section focused on the inquiry-based instruction approach to improve science teaching by engaging students in investigation. However, the reform effort of inquiry-based science instruction has not been implemented in many classrooms throughout this country. The need for a bridge between the theory of inquiry-based instruction and the practice of inquiry-based instruction should be considered. Implementing inquiry-based instruction is a daunting task for teachers and requires a shift from what they traditionally do in the science classroom. This may be the result of several issues, such as the limited opportunities for students to conduct independent explorations, challenges in incorporating abstract concepts with inquiry, and the deficiency of teacher expertise and know-how. Even though inquiry should be considered as an important component
of science instruction, transforming traditional science lessons into inquiry-oriented activities can be very challenging. The integration of simulations into inquiry-based science instruction offers one possible solution to support this transition.

**Computer Simulations Support Inquiry-Based Science Instruction**

The second component of the conceptual framework guiding this study is based upon the use of computer simulations to support inquiry-based science instruction. The constructivist position in learning theory is that the mechanics of teaching are highly interactive and therefore students should have access to multiple viewpoints and representations for information. The opportunity to use multiple instructional modalities is partially satisfied by the utilization of well-constructed simulations (Gardner, 1993; Pintrich et al., 1993; Schommer, 1993; von Glaserfeld, 1999). The use of computer simulations supports reforms-based science teaching, which is learner and knowledge-centered, and highlights the skills, viewpoints, and significance of scientific inquiry (NRC, 1996). Computer simulations have put a new perspective on science education reform, influencing the role of the teacher and the classroom experience, according to the *Standards* (NRC, 1996) and the NSTA (2001).

Numerous studies cited in the literature indicated that teacher willingness to integrate simulations into instructional practice is a central theme of concern. While the majority of teachers that were involved in these studies were familiar with simulations, it was not clear how familiar they were with the integration of the simulations into their everyday science instruction. Sahin (2006) indicated the importance of a teacher’s ability to integrate technology into classrooms as a significant consideration for success. Foti and Ring (2008) explained that “simulations are squarely in the intersection between educational change and technological development” (p. 104). Despite the literature substantiating the use of simulations in support of
inquiry-based science instruction, many teachers neglect to implement this instructional tool. Teachers must possess the skills to provide the most appropriate instructional strategies and then incorporate simulations into their inquiry-based science instruction.

**Professional Development Supports and Sustains Implementation**

The third component of the conceptual framework guiding this study is based upon those professional development strategies that support and sustain the implementation of simulations. The literature indicates that implementations frequently fail due to inadequate time spans (Means, 1998). It has been found that it can take several years to develop teacher skills for a specific instructional innovation. Traditionally, the focus on teacher training in the use of simulations had been on acquiring the expertise in the basic features and functionalities of the programs. The conventional approach to professional development for teachers has followed a training model centered on single events (Mullens et al., 1996). This approach generally resulted in failure to achieve the long-lasting impact on instructional practice sought in systematic educational reform (Wells, 2007).

There is an emerging understanding of significant professional development strategies to establish sustained changes in the practice of integrating technology into the science curricula (Howland & Wedman, 2004). For example, a number of studies cited in the literature indicate that effective professional development plans should include a comprehensive design for the continued integration of technology in the science classroom (Wells, 2007). A suitable training model should include a progressive format through long-term support that guides the teachers. Therefore, it was important for the focus of the present study to include those teachers who were receiving continuous professional development support and those science leaders who supported this innovative practice. Despite the literature substantiating the importance of providing a
progressive professional development plan for the district’s high school science teachers, many of the teachers interviewed for this study still did not incorporate simulations into their lesson plans.

**Leaders’ Role in Improving Instruction**

The fourth and final component of the conceptual framework guiding this study is the leaders’ role in supporting the use of simulations to improve science instruction. It has become the responsibility of the instructional leader to create a vision for curricula that supports the inquiry-based approach to teaching science. However, the literature reports that many instructional leaders need assistance in guiding the implementation of science and technology reforms. For example, Costenson and Lawson (1986) have attributed the unsuccessful implementation of inquiry-based science instructional strategies to the limited understanding on the part of school leaders to this mode of instruction.

The role of the instructional leader is significant in science-technology instructional innovation. It has also become the instructional leader’s responsibility to support the resource needs for this implementation. Spillane et al. (2003) explained that in order to be successful, leaders must cultivate specific in-school conditions, market shared visions for instruction, and provide opportunities and incentive for teachers to improve instructional practices. For the present study, I interviewed instructional leaders that met these standards. Through the interview process, I learned that their support is vital in the sustainability of the use of science simulations.

**Summary**

Together, the four bodies of literature identified in this section, provided the framework for the present study. This foundation substantiated the focus that guided the study’s design, data collection, and data analysis.
Chapter Conclusion

In this chapter, I reviewed the theoretical and research literature that informed my study. This literature review has included numerous studies that support four themes: (a) the importance of inquiry-based science instruction, (b) computer simulations support inquiry-based science instruction, (c) professional development supports and sustains this implementation, and (d) leader support is essential to teachers’ sustained and effective use of simulations. The overarching theme is the significance of providing effective professional development strategies to sustain the implementation of simulations in the science classroom.

Few published reports have focused on professional development strategies to effectively integrate technology into science instruction. No report or research has been found that solely examines the conditions necessary for frequent, high-quality use of simulations to become a routine part of science teachers’ instructional practice. As discussed and documented throughout this literature review, simulations support inquiry-based science instruction for the 21st century. Therefore, it is important to develop an understanding of how research in learning theory, when combined with effective professional development strategies, increases the value of this study. Chapter 3 provides a discussion of methods used to conduct this research study.
CHAPTER 3

METHODOLOGY

The method must follow the question. Campbell, many decades ago, promoted the concept of triangulation—that every method has its limitations and multiple methods are usually needed.

~ Gene V. Glass, eulogizing pioneering methodologist Donald T. Campbell (Tashakkori & Teddlie, 1998)

The purpose of this chapter is to explain the methodology and methods used in the present study to investigate the conditions necessary for frequent, high-quality use of simulations to become a regular part of science teachers’ instructional practices. The study population included high school science teachers who participated in on-going professional development services to support their integration of web-based simulations. The teachers were from a large urban school district in the Southeastern United States. They were interviewed to identify trends, themes, and motivations related to the goal that guides this study. This chapter includes explanations of the research design and procedures, population sample, instrumentation, data collection, and data analysis. An explanation of the limitations of this study concludes this chapter.

Purpose of the Study

The focus of this study was to develop an understanding of those innovative professional development practices that encourage the sustained use of simulations as part of inquiry-based science instruction. With the rapid dissemination of Internet-related technologies in the field of education, it is most important to understand the function of these innovations. Studies that
attempt to understand the design of support structures which will maximize the potential benefit of new technologies in education have increased in significance. Technology, specifically with regard to simulations to support inquiry-based instruction, provides new educational strategies for science teachers. Technology also influences education by repeatedly making teachers’ best practices obsolete. A general agreement on the nature of educational practices using technology can be found in the literature (Bybee, 2000; Guzey & Selchen-Roehrig, 2009; Howland & Wedman, 2004). However, there is limited consensus on the pertinent factors which are relevant to the initiation and success of such innovative practices. By interviewing high school science teachers and their district level science leaders, I inquired about professional development practices which promote the use of simulations in support of inquiry-based science instruction.

**Research Questions**

This study investigated and described those factors that positively influence high school science teachers to use computer simulations in their instructional practice. The following questions guided this study:

1. *What factors contribute to science teachers’ ongoing use of simulations to support inquiry-based science instruction?*

2. *What factors contribute to science leaders’ endorsement of the use of simulations as part of inquiry-based science instruction?*

**Rationale for a Qualitative Research Study**

The primary goal of this study was to acquire an understanding of the factors that positively influence high school science teachers to use computer simulations in their
instructional practices. The nature of science teachers’ motivation or lack of motivation to incorporate simulations in their inquiry-based instruction offered a compelling reason to use a qualitative research design for this study. In order to examine the effectiveness of the implementation of simulations, a systematic evaluation was conducted. Qualitative inquiry was used because it captured and communicated the participants’ understanding of the use of simulations in instruction. Each participant’s point of view was a significant factor in this study.

The qualitative method used for this study was the semi-structured interview process. This process provided the opportunity to capture the perspectives of the science teachers and their leaders concerning the different stages of the implementation. The use of interviews as a data collection method began with the assumptions that the participants were knowledgeable and that participants’ perspectives were meaningful. Emergent themes evolved from the interview data which provided significant information for this study.

Patton (1990) advocated a “paradigm of choices” that sought “methodological appropriateness” as the primary criterion for judging procedural quality (p. 39). This qualitative study utilized triangulation to facilitate a comprehensive review of the data that had been collected using different methodologies. The goal was to achieve more accurate information about the qualitative results that could be used in understanding the particular science concept (Oliver-Hoyo, M. & Allen, D., 2005). Interviews were used in a complementary fashion in order to collect data that provide a holistic approach to addressing the research questions. The Title I high school science teachers, who were recipients of multiple professional development strategies, were the major group of educators to participate in this interview process. In order to obtain a different perspective of the support services, the district Science, Technology,
Engineering, and Mathematics (STEM) director and high school science supervisor also were interviewed.

Strauss and Corbin (1990) maintained that qualitative methods are used to understand the phenomena of a given situation. Conducting a qualitative study offers the researcher the chance to gain a new perspective, even for topics that have been studied extensively in the past. Eisner (1998) indicated that the use of qualitative methodology provides the dual advantage of learning about schools and classrooms and doing so in ways that are useful in understanding individual classrooms and particular teachers. Through the use of qualitative inquiry, this study sought to gain a deeper understanding of how science teachers effectively integrate simulations into their science instruction. This inquiry also sought to understand the manners in which the STEM director and high school science supervisor support this integration. During the semi-structured interview process, free and open responses in the participant’s own words were encouraged. A number of advantages in using the semi-structured interview process for this study included the following (Patton, 1990):

- Rich data, details, and new insights were acquired.
- The opportunity to have face-to-face contact with the participants was beneficial.
- The interviewer was afforded flexibility in administering interviews to particular individuals or circumstances.

This study utilized a naturalistic approach that sought to understand the phenomena in a context-specific setting (Hoepfl, 1997). The phenomenological point of view was used to develop a deep understanding of how high and why school science teachers elected to use simulations. Phenomenology constantly questions the uniqueness of the lived experience or essence of a particular phenomenon (Jones, Torres, & Armino, 2006). This research strategy is
designed to make meaning of individuals’ life experiences. As the researcher, it was my responsibility to make meaning of each science teacher’s decision to incorporate or not to incorporate simulations into personal instructional practices and beliefs. Also, phenomenology allows for the exploration of the individual’s inner world of consciousness and experience (Johnson & Christensen, 2004). This study sought to understand each participant’s feelings, thoughts, and self-awareness regarding the use of simulations.

**Research Design**

In order to gain an in-depth understanding of those factors which influence teachers and science leaders to use simulations in their inquiry-based science classrooms, I selected the phenomenological inquiry approach for this study. Through phenomenological inquiry, it was my objective to provide a research report that is rich with detail and insights into the teachers’ and science leaders’ experiences (Seidman, 2006). I used semi-structured interviews for focused two-way conversations. In these semi-structured interviews, relevant topics were initially identified and the possible relationships between these topics became the foundation for more specific questions. Some of the questions were developed during the interviews, which provided the flexibility for science teachers, science leaders and me to search for details or discuss issues. The strategies used in this study meet the criteria of phenomenological inquiry for participant selection, data collection, data analysis, and the reporting of findings (Creswell, 2003; Crotty, 1998).

**Statement of the Research Problem**

This study was designed to seek an understanding of the factors that positively influence high school science teachers to use computer simulations in their instructional practices through clear and honest dialogue. This research also sought to acquire an understanding of the decisions
made by teachers who elected not to integrate technology into their science instruction. In addition, this study sought to determine those factors which science leaders considered significant in the use of simulations to support inquiry-based science instruction in their schools. This research also sought to understand how and why science leaders may not consider the support of the implementation of simulations in their schools.

**Setting**

A large urban school district in the Southeast was selected as the setting for this study. The district’s STEM Director provided web-based simulations for each of the high school science teachers in his schools through use of Gizmos. A Gizmo is an interactive virtual model designed to support and extend student understanding of ideas and standards found in mathematics and science curricula in grades 3 through 12. In addition to offering the simulation program, the STEM Director appointed a project manager to provide follow-up support for the use of Gizmos in the district’s 10 Title I high schools. Title I high schools have high percentages of students from low-income families and receive additional funding to help ensure that all students meet state academic standards. Gizmos were also used in science classes in non-Title I schools, but, the director of those schools provided only an initial three-hour workshop for teachers about the use of Gizmos for teachers in non-Title I high schools.

The focus of this study was to develop an understanding of those innovative professional development practices that encourage the sustained use of simulations to support inquiry-based science instruction. The training provided to the non-Title I schools only included the initial three-hour workshop. The services provided to the Title I schools included the following:

- *Initial Three-Hour Gizmo Training Session.* The traditional approach to professional development for teachers has followed a training model
centered on single events (Mullens et al., 1996). This approach generally results in failure to achieve the long-lasting impact on instructional practice sought in systemic educational reform (Wells, 2007). This initial training session is designed to provide teachers with the basics of using Gizmos in their classrooms. With one, three-hour workshop, teachers tend to lack the confidence to incorporate simulations into their instructional practices.

- **Classroom Coaching Activities.** A key principle identified by the National Institute of Science Education (1996) included the integration of professional development with local and state practices. In Ronen, Langley, and Gainel’s (1992) study, teachers reported that they would use simulations to enhance their curricula frameworks. The project manager, in this phase, provided Gizmo alignments to the district’s instructional pacing guides for biology, chemistry, physical science, and earth science. The teachers were encouraged to use these alignments to support their science instruction.

- **Classroom Modeling with Students.** In their research, Borich and Tombari (1997) identified teacher preparedness to integrate the use of simulations into their instructional practice as a central theme of concern. Sahin (2006) indicated the importance of teachers’ abilities to integrate simulations into their classroom instruction as an important consideration. In this phase, the Project Manager provided classroom demonstrations using Gizmos to support the teachers’ science instruction.

- **Observation of Teacher with Feedback.** Classroom instructors taught
lessons using Gizmos while observed by the Gizmo Project Manager. The
discussion between the teachers following the lesson focused on providing
constructive feedback and nurturing self-reflection. Wells’s (2007) study
identified the key design factors (KDF) for professional development programs.
Two design factors support the use of observations: KDF-1: Evaluation Driven
where training should be designed around specific outcomes; and, KDF-2:
Contextual, individual practice is made relevant. The opportunity to be observed
teaching with Gizmos and provided with appropriate feedback individualized the
learning experience.

- **Mentor Program.** The Project Manager established a network of Gizmo Mentors
  within the implementation to help support their colleagues as they integrated
  Gizmos into their instruction. One key design factor supports the use of a mentor:
  KDF-9: Support, should provide long-term, continuous pedagogical and technical
  assistance (Wells, 2007). Establishing a mentor or “go to” person at each high
  school with a direct line of communication with the district’s Project Manager
  seemed essential for immediate support for the Gizmo implementation.

- **Higher Level Trainings.** The Project Manager provided sessions to support the use
  of Gizmos to solidify inquiry teaching skills and create lessons tailored to specific
  students’ needs. One key design factor relates to sustaining change: KDF-10:
  Sustainability, focuses on providing purposefully iterative professional
  development to ensure durability of the Gizmo implementation (Wells, 2007).
  These trainings help to ensure the sustainability of the integration of Gizmos into
  the inquiry-based science instruction.
**Entrée and Participant Selection**

The data collection for the present study was approved by the school district’s Institutional Review Board (IRB) in November, 2012. Once this approval was received, the district’s STEM director provided assistance in the participant selection process. The participants for this study included science teachers from the district’s 10 Title I high schools. The district STEM director suggested teachers from each of these high schools to interview from the following categories: low Gizmo usage, moderate Gizmo usage, and high Gizmo usage. As guidance, the following definitions were provided to the STEM director.

*Low Gizmo Usage:* Teacher usage is zero to two times per month

*Medium Gizmo Usage:* Teacher usage is three to five times per month

*High Gizmo Usage:* Teacher usage is six or more times per month

Five teachers were selected from each of these categories for a total of 15 teacher interviews. Low, medium, and high usage was identified by the STEM director through the *Gizmo Usage Reports* provided by ExploreLearning. The *Gizmo Usage Reports* were provided at the end of each quarter to the district’s STEM Director. The district’s Project Manager provided an analysis of the data available in the reports for each Title I high school. The information on these usage reports provided the opportunity to determine Gizmo usage patterns and to recognize individual users and groups of users.

The STEM director contacted each teacher via email regarding the opportunity to participate in this study. After a teacher agreed to participate, the director provided me with participants’ email addresses and school phone numbers of the school principals and their teachers so I could follow up with the details regarding the time and place for the interviews. A letter was emailed to each of the school principals requesting the opportunity to conduct teacher
interviews on their campus (Appendix A). Once this approval was received, an informed consent form was sent to each teacher explaining requirements for their participation in the study (Appendix B). An informed consent form was also sent to the district’s science leaders (Appendix C). The signed science teachers and leaders consent forms were collected after approval by the University of North Florida (UNF) IRB (Appendix D).

The interviews with teachers provided the opportunity for me, as the researcher, to seek to understand the phenomenon of motivation or lack of motivation to use simulations. In addition to teacher interviews, I interviewed the STEM director and high school science supervisor. The STEM director included in the list of potential interviewees several biology, chemistry, physical science, and earth science teachers in order to include different teachers’ perspectives on the use of simulations to support their field-specific instructional objectives. In addition, teachers from several Title I high schools were included to determine if the infrastructure at their particular schools influenced their use of simulations. The level of school leadership support of the use of simulations was important to understand as well.

**Data Collection**

Patton (1990) described three types of interviews: informal, semi-structured, and standardized. For the purpose of this study, I used the semi-structured interview. In advance of each interview, I provided the participant with an interview schedule and a list of general topics that I wanted to explore. Prior access to the interview questions provided each participant time to consider responses. The interview schedule supported the opportunity to cover multiple subjects. The information I sought in these interviews were those factors that positively or negatively influenced the use of computer simulations in teachers’ science instructional practice.
Patton (1990) emphasized that an audio recorder is “indispensable” to document interview data (p. 348). I recorded each interview to ensure an accurate collection of data. In addition, I used a back-up recorder in case any difficulties arose with the primary recorder. The opportunity to use the audio recorder to gather data enabled me to focus primarily on the interview questions and participant responses during this process. After the close of each interview, I reflected on the session, noting major themes and the data that surfaced with those gathered in previous interviews. I recorded this information and used it as an additional source of data for the final analysis. To ensure the protection of each interviewee’s identity, I provided a pseudonym for each participant and keep a master list matching the names of the participants with their pseudonyms in a secure location that was not accessible to others. An additional precaution included the transcription of each recorded interview to ensure the availability of back-up data. After each transcription was completed, I destroyed the interview recordings.

Through these interviews, I sought to gain a better understanding of the complexity of teaching science. Most importantly, I respected the voices of the study participants. I sought to understand the mind-set of those teachers who elected to integrate web-based simulations into their science instruction as well as those teachers who decided not to integrate the simulations. Qualitative research offers the opportunity to hear the voices of those individuals who influence education and to understand the interviewee’s perspective (Patton, 2002).

Qualitative research uses the naturalistic setting as the source of data. In the present study, it was important for me to conduct my research, via interviews, on the participants’ campuses. This enabled me to gain deeper insight into each teacher’s unique situation. Qualitative methods can be used to understand any phenomenon about which little information is known. It is important to document selective teachers’ reactions to this implementation since the
integration of technology into science instruction is a recent practice. As the researcher, I was the human instrument for the data collection. It was imperative for me to provide teachers with opportunities to express their thoughts and ideas through the “presence of voice” (Eisner, 1991, p. 36).

Interview questions were based on Mark Benno’s Apple Classrooms of Tomorrow2 (ACOT2) scale (Reidel, 2009, para. 4). Benno described five stages of teachers’ integration of technology into classroom practice, a process that begins with (a) entry; moves through (b) adoption (initial phase); (c) adaptation (implementation phase); (d) appropriation; and finally to (e) innovation (sustaining phase). Benno identified professional development as the key to condense these phases of teachers’ integration of technology into classroom practice.

This interview questions helped serve to develop a deeper understanding of ways each teacher elected to integrate or to not integrate simulations into his or her inquiry-based science instruction (Appendix E). The interviews of the science leaders provided insight regarding their opinions of the implementation of simulations to support their teachers’ inquiry-based instruction (Appendix F). It also presented an opportunity to learn about their intentions related to continuing this innovative professional development practice to support science instruction.

The key questions that were used to guide the interview process were generated from discussion of possible questions with the school district’s project manager as well as project managers from other school districts. I examined the questions from my own experience as the state’s Gizmo Educational Consultant. The following overarching question provided the foundation for the interviews: What are the necessary conditions for simulations to become a regular part of science teachers’ instructional practices?
Data Analysis

In the analysis of the data, I looked for ideas, concepts and attitudes from the practitioners. Marshall and Rossman (2006) discussed the data analysis procedures for interviews and asserted that transcribing interviews is not just a technical task, but also involves judgment and interpretation. It was important to identify the salient themes, recurring ideas of language, and patterns of belief expressed in each interview.

Content analysis consisted of reading and re-reading the transcripts. I looked for similarities and differences in order to discover themes and to develop additional categories. I reviewed the complete transcripts to be certain that I did not omit important information. I was cautious to not select materials that only fit my ideas. Seidman (1998) suggested a coding process for determining categories with data from interviews.

- Read and re-read transcripts;
- Notice interesting passages;
- Bracket interesting passages;
- Look for recurring ideas and concepts;
- Label ideas and concepts.

To address the study’s research questions, the interview data were analyzed using the above coding process.

Analysis of the semi-structured interview questions highlighted teachers’ insights regarding their awareness and understanding of the basics of the Gizmo program. Inductive code analysis was used for each interview, which provided an opportunity to discover patterns, themes, and categories (Patton, 2002). Next, specific segments were identified and labeled to create categories and themes (Berkowitz, 1997; Creswell, 2003). Within each category, subtopics
were considered that provided the opportunity to better understand the findings. I reflected on the study’s conceptual framework as I analyzed the data and developed the findings. Patton (2002) described this pattern of inductive analysis as “discovering patterns, themes, and categories in one’s data” (p. 453).

The analysis of the semi-structured interview data for the present study involved a review of the answers to the pre-determined open-ended questions and an exploration of the particular themes that emerged. The initial focus of the study was to assess the decisions made by each teacher and district science leader in favor of the implementation of simulations (Gizmos) to support inquiry-based science instruction. However, after reviewing each participant’s responses to the interview questions, I decided to include 2 phases for this analysis. Phase I focused on the similar views and Phase II focused on the differences among participants regarding their implementation of simulations. The information collected was analyzed in the following phases:

- Phase I: Commonality views of the participants
- Phase II: Differing views of the participants

Phase I of this investigation provided a method for analyzing and evaluating the consensus of the science teachers and science leaders about the incorporation of simulations into instructional contexts. The analysis emphasized that a technology implementation involves a variety of both specific and implied efforts on the part of the school district, school and teacher. Through the initial phase of the data analysis, I developed a deeper understanding of how four initial themes influenced the experiences of science teachers and their science leaders. The four initial themes that emerged as patterns from my data analysis included:

- Constructivism
- Technology
Professional development

Time

Through the second phase of the analysis, I also sought to develop an understanding of the differences of opinion among the leaders and teachers regarding the incorporation of simulations into instructional contexts. In general, the second phase of the data analysis produced four themes that were germane to this study. The highlighted themes include the following:

- Influence of the available technology
- Influence of the application of the technology
- Influence of the ongoing professional development strategies
- Influence on student engagement

Phase II of the analysis of the interview data provided a deeper examination of the responses from the participants regarding those efforts that to some degree influenced their experiences in using simulations. To emphasize this feature, my inquiry focused on those themes that revealed differences between perspectives of the science leaders and the actual teacher experiences. I examined the data again to determine if there were different perspectives of the self-identified high, medium, and low-using Gizmo teachers and their leaders.

**Point of View of the Researcher**

According to Eisner (1998), connoisseurship is the quiet act of appreciating the works of education. My previous role as an educator and my current role as a software representative of a web-based science program provided the foundation to understand the qualitative aspects of my study. It was important to separate my role as an employee of ExploreLearning/Gizmos from my
role as the research instrument for this study. To insure this distinction, the school district’s STEM Director agreed to select the interview candidates for this study. I did not have access to the information regarding the participants’ usage during the course of the study. Also, I intentionally selected a school district where I have not had previous contact with the teachers. The format for the semi-structured interviews provided the opportunity to develop a deeper understanding of any challenges and successes these teachers encountered as they incorporated simulations into their science instruction.

Eisner (1998) also indicated that for connoisseurship to have a public presence, the researcher must turn to criticism. It is through criticism that the researcher has the opportunity to explore the research findings. As the critic of this research endeavor, it was my responsibility to transform the data from the analysis of the interviews into a public format that described, interpreted, and evaluated this information.

**Trustworthiness, Credibility, and Ethical Considerations**

The roles of trustworthiness and credibility must be considered in this study, and speak in part to the extent to which the data are believable. Without rigor, research becomes fictional and meaningless. The accuracy can be guaranteed by considering dependability and reliability at each stage of this study, including identification of the setting and participants, selection of research methods, and data analysis. Patton (2002) stated that trustworthiness and credibility are two factors that any qualitative researcher should consider when designing a study, analyzing results, and judging its quality. Lincoln and Guba (1985) suggested the importance of providing an “inquiry audit” as one measure to enhance the dependability of a qualitative study (p. 300). The dependability of data from the teacher interviews was verified through the examination of raw data, data reduction procedures, and process notes (Campbell, 1996).
Lincoln and Guba (1985) suggested four optional concepts of credibility, dependability, transferability, and conformability in the design of a qualitative research study. The standards for credibility and dependability require the researcher to be neutral and not control the data to determine some previously decided truth. Despite my position as the Educational Consultant for ExploreLearning, a provider of science simulations, every effort was made to sidebar my experiences, expectations, and perspective. The data acquired through the interview process provided a thick, rich description of each teacher’s experience in incorporating the utilization of simulations into his or her science instruction. The concept of transferability was addressed by using a group of teacher with varied levels of use of the simulations: low, medium, and high. Finally, the concept of confirmability was provided through an independent audit of my research methods by a competent peer (Lincoln & Guba, 1985; Patton, 1990). My auditor thoroughly examined my audit trail consisting of a comparison of the recorded participant responses and the original transcripts of these recordings.

The research process for this study must be ethically sound. Each participant signed the informed consent document prior to the interview. The identity of teachers who participate in this school district’s Title I Gizmo implementation was kept confidential. During the interview process, participants were treated fairly and with respect for their opinions and experiences. As the research partner, I was conscious of the entrée provided through this school district to conduct each interview. This study was carried out in accordance with the Ethical Standards of the American Educational Research Association (AERA, 1992) and with the endorsement of the Institutional Review Board for the Protection of Human Subjects at the University of North Florida and the Institutional Review Board of the participating school district.
Limitations of the Study

Three limitations resulted from my research methodology. The limitations in this qualitative study include the use of the in-depth, phenomenological interview process, the selection of the settings for this study and the selection of the participants. These limitations are discussed in this section.

Readers may consider the selection of the in-depth, phenomenological interviews as a limitation. A majority of the questions for this study were created during the semi-structured interview process. This process provided the flexibility for the science leaders, teachers, and me to search for important details and to discuss relevant issues. The goal of this method was to have participants reconstruct personal experience within the topic of the study (Seidman, 2006). Some may interpret this approach as a limitation. Moreover, since the participants were asked to reflect on instructional practices that have been in place for more than five years, it was possible that their recollections were not completely accurate.

Patton (1990) considered the maximum variation sampling as a strong indicator of reliability and validity for the interview data. Maximum variation sampling refers to both sites and people. Because this study was conducted in a progressive, large urban school district, the selection of participants might not reflect the considerations of the educators in smaller school districts. Less advanced districts might not have the sophisticated infrastructure and financial resources to support a technology initiative such as the use of simulations. Also, since the study was limited to teachers in Title I schools, it focused on a small segment of the district’s high school science teacher population.

Participants for this study were selected by the district’s STEM Director. Because 25 teachers were initially selected from a pool of over 400 teachers, some might not consider this
selection a true purposeful-sampling of the potential participants. Because the majority of the participating teachers were in their mid-forties or older, the study was limited to seasoned teachers who might not be comfortable with the integration of technology into their instructional practices. Also, the study was limited to interviewing the teachers who had the advantage of ongoing professional development services backed by encouraging leadership to support their implementations.

Concluding Statement

The first goal of the present study was to acquire an understanding of the factors that positively or negatively influence high school science teachers in the use computer simulations in their instructional practices. The second goal was to explore those factors that positively or negatively influence district science leaders to endorse the use of simulations. The importance of motivation or lack of motivation by the science teacher to incorporate simulations in the teachers’ inquiry-based instruction offered a compelling reason to use the qualitative research design for this study, as outlined in this chapter. Through the analysis of interviews with science teachers and science leaders, the present study provided insight and understanding about the factors that influence the use of computer simulations in instructional practice. Chapter 4 provides a discussion of the data analysis used for this research study.
CHAPTER 4

DATA PRESENTATION

This qualitative study sought to develop an understanding of the components that are necessary for frequent, high-quality use of computer-based science simulations, specifically use that becomes the normal part of science teachers’ instructional practices. To attain such an in-depth understanding of those factors that influence science leaders and teachers to employ simulations in their inquiry-based science classrooms, this study employed the phenomenological inquiry approach. Through phenomenological inquiry, it is possible to provide research that is rich with detail and insights into teachers’ and science leaders’ experiences (Seidman, 2006). Semi-structured interviews, which allow for focused two-way conversations, were used. Analysis of the responses to the semi-structured interview questions highlights teachers’ and science leaders’ insights regarding the support structures provided to maximize the potential benefits of this technology.

The initial focus of the study was to assess the decisions made in favor of the implementation of simulations (Gizmos) to support inquiry-based science instruction. However, after reviewing each participant’s responses to the interview questions, I decided to include 2 phases for this analysis. Phase I focused on the consensus views and Phase II focused on the differences among participants regarding their implementation of simulations. The information collected was analyzed in the following phases:

- Phase I: Common views of the participants;
• Phase II: Differing views of the participants.

Each of these components will be specifically explored and analyzed in this chapter. The major sections and subsections for each are themes as identified in the data.

Examination of the data from each semi-structured interview incorporated pertinent educational criticism. This was done to ensure the trustworthiness and credibility of the analyzed data. To achieve this goal, the four dimensions of Eisner’s (1998) educational criticism constituted one of the tools for this analysis. Eisner’s four dimensions include description, interpretation, evaluation, and thematic.

The interview data were collected to address this study’s research questions:

• What factors positively influence high school science teachers to use computer simulations in their instructional practices?

• What factors positively influence science supervisors to support the use of computer simulations?

The interview data were examined for significant themes that established a consensus and differences regarding the participants’ considerations in using simulations.

Methodology Summarized

Science teachers, site-based science leaders, and district-based science leaders from a large urban school district in the Southeast were selected for this qualitative study. The district’s STEM director had provided web-based simulations (Gizmos) to each of the district’s high school science departments. Because the Title I high schools were the district’s initial recipients of the Gizmo program, I selected participants from these sites. Science teachers from the Title I high schools participated in these semi-structured interviews. District-based science leaders were also interviewed in order to develop an understanding of the level of support the science teachers
receive for the implementation. The interviews provided a unique opportunity to gain a comprehensive insight into each participant’s specific situation. They were conducted in December 2012, and each interview was recorded using a Sony ICD-UX523 and a back-up recording using a Sony ICD-PX312. A written transcription was made of each interview. I confirmed the accuracy of each transcription by listening to and verifying the corresponding recordings. Following the transcription of each interview, the recordings were destroyed.

Characteristics of the Participants

The participants consisted of science teachers and district based science leaders. Table 1 presents a descriptive chart of the participants’ basic demographic characteristics. Pseudonyms were used to protect the identities of each participant.

Table 2

Science Teacher and Science Leader Demographic and Course Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Age Range</th>
<th>Original Course of Study</th>
<th>Teaching Discipline</th>
<th>Highest Degree Completed</th>
<th>Range of Years of Instructional Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>46-55</td>
<td>Chemistry</td>
<td>Chemistry</td>
<td>Master’s</td>
<td>26 or more</td>
</tr>
<tr>
<td>Arnold</td>
<td>46-55</td>
<td>Chemistry</td>
<td>Chemistry</td>
<td>Master’s</td>
<td>26 or over</td>
</tr>
<tr>
<td>Carl</td>
<td>46-55</td>
<td>Engineering</td>
<td>Earth Science</td>
<td>Bachelor’s</td>
<td>5 or less</td>
</tr>
<tr>
<td>Charles</td>
<td>36-45</td>
<td>Biology</td>
<td>Biology</td>
<td>Master’s</td>
<td>6-15</td>
</tr>
<tr>
<td>Enrico</td>
<td>56 or older</td>
<td>Chemistry</td>
<td>Chemistry</td>
<td>Master’s (3)</td>
<td>6-15</td>
</tr>
<tr>
<td>Gregor</td>
<td>46-55</td>
<td>Pre-med (Biology)</td>
<td>Biology</td>
<td>Master’s</td>
<td>26 or over</td>
</tr>
<tr>
<td>Irene</td>
<td>Under 35</td>
<td>Chemistry &amp; Biology</td>
<td>Chemistry</td>
<td>Bachelor’s</td>
<td>5 or less</td>
</tr>
<tr>
<td>Jane</td>
<td>46-55</td>
<td>Biology</td>
<td>Earth Science</td>
<td>Bachelor’s</td>
<td>6-25</td>
</tr>
<tr>
<td>Marie</td>
<td>56 or older</td>
<td>Chemistry</td>
<td>Physics</td>
<td>Master’s</td>
<td>26 or over</td>
</tr>
<tr>
<td>Rosalind</td>
<td>Under 35</td>
<td>Biology</td>
<td>Chemistry</td>
<td>Master’s</td>
<td>6-15</td>
</tr>
<tr>
<td>Sally</td>
<td>46-55</td>
<td>Special Education</td>
<td>Earth Science</td>
<td>Master’s</td>
<td>16-25</td>
</tr>
<tr>
<td>Tanya</td>
<td>36-45</td>
<td>Pre-Med (Biology)</td>
<td>Environmental Master’s</td>
<td>Science</td>
<td>16-25</td>
</tr>
</tbody>
</table>
Purpose

There were two purposes for the semi-structured interviews that guided the analysis for this study. First, the responses were used to determine common perspectives among the science leaders and the science teachers regarding the study’s four initial themes:

- Constructivism
- Technology
- Professional development
- Time

The second objective in gathering this information was to determine any perceived differences between science leaders and science teachers and among science teachers who reported differing levels of use of the simulations. The following themes were significant for this phase of the study:

- The influence of available technology
- The influence of the application of technology
- The influence of professional development
- The influence of student engagement

Data Collection Method

In addition to the district’s STEM Director and high school Science Supervisor, a total of 25 high school science teachers were selected by the science leaders to participate in this study. An email message was sent to the respective school administrators requesting permission to contact the teachers to participate in this study. After a positive response was received from the administrator, I forwarded an invitation to each teacher for consideration. I received a positive response from 10 of the 25 invitees. I followed up each positive response with an email
requesting a date and time to conduct each interview. After the date and time were confirmed, I contacted each teacher by phone to serve as a reminder for our meeting.

The study used a naturalistic setting for the data collection. The interviews were conducted at either the participants’ campuses or their offices. This approach provided the opportunity to gain a more comprehensive insight into the unique situation of each teacher and science leader. Each interview varied in length, with an average of just under 39 minutes, as shown in Table 3.

Table 3
*Participant Interview Duration and Word Count*

<table>
<thead>
<tr>
<th>Name</th>
<th>Interview Duration</th>
<th>Word Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>38 minutes</td>
<td>5,553</td>
</tr>
<tr>
<td>Arnold</td>
<td>48 minutes</td>
<td>6,208</td>
</tr>
<tr>
<td>Carl</td>
<td>40 minutes</td>
<td>5,847</td>
</tr>
<tr>
<td>Charles</td>
<td>49 minutes</td>
<td>5,718</td>
</tr>
<tr>
<td>Enrico</td>
<td>34 minutes</td>
<td>4,874</td>
</tr>
<tr>
<td>Gregor</td>
<td>26 minutes</td>
<td>3,525</td>
</tr>
<tr>
<td>Irene</td>
<td>21 minutes</td>
<td>2,845</td>
</tr>
<tr>
<td>Jane</td>
<td>48 minutes</td>
<td>6,630</td>
</tr>
<tr>
<td>Marie</td>
<td>39 minutes</td>
<td>5,047</td>
</tr>
<tr>
<td>Rosalind</td>
<td>30 minutes</td>
<td>4,641</td>
</tr>
<tr>
<td>Sally</td>
<td>50 minutes</td>
<td>8,186</td>
</tr>
<tr>
<td>Tanya</td>
<td>43 minutes</td>
<td>6,168</td>
</tr>
</tbody>
</table>

**Data Analysis**

The analysis of the semi-structured interview data involved a review of the answers to the pre-determined open-ended questions and an exploration of the particular themes that emerged. Phase I of this investigation provided a method for analyzing and evaluating the consensus of the science teachers and science leaders about the incorporation of simulations into instructional contexts. The analysis emphasizes that a technology implementation involves a variety of both specific and implied efforts on the part of the school district, school and teacher. Through the
initial phase of the data analysis, I developed a deeper understanding of how the four initial themes influenced the experiences of science teachers and their science leaders. Through the major categories established in the Phase I analysis, additional issues were identified as those became apparent through the data analysis. These issues became the second phase of this analysis. Through the second phase of the analysis, I sought to develop an understanding of the differences of opinion among the leaders and teachers regarding the incorporation of simulations into instructional contexts. The subsequent sections will explain the data analysis for each of these topics.

**Phase I: Common Views of Science Leaders and Science Teachers**

This section examines the participant responses to the semi-structured interview questions that focus on those efforts that to some degree influence the experiences of using simulations. My connoisseurship was used to find significant themes in the interview data (Eisner, 1998). The data analysis revealed four important themes that were germane to the science leaders’ and teachers’ experiences. These themes include: constructivism, technology, professional development, and time. In the subsequent sections, I explain these concepts and include excerpts from the interviews to provide the participants’ perspectives.

**Constructivism**

In this study, the influence of constructivist learning on science education was addressed by the science leaders. Arnold, one of the science leaders, eloquently expressed his insight into the constructivist model and its role in inquiry-based science instruction.

Well, I think a lot of things have changed in the way we understand how people learn. And what makes really perfect sense to me is the constructivist model which says that
students come in with preconceived ideas of how things are, and through time and experience, mold those ideas into a shape that is more consistent with what reality tells us those facets of the world are. So consequently, the inquiry model matches that perfectly.

Charles, another science leader, expressed his concern regarding the opportunity for teachers to take the necessary time to implement the constructivist model in their science instruction.

I think that one of the things that was suffering as we moved into the era of high-stakes assessments was that science was becoming a knowledge dump for kids, and it was less about experiencing and touching and feeling science. So it was all factual recall. It was getting through the book. It was memorizing facts, memorizing statistics, and not about the experience of science.

The district’s science leaders expressed their understanding of the influence of constructivist learning theory on constructivist pedagogy. As mentioned in Chapter 2, constructivist pedagogy supports the opportunity for the teacher to have students engage in active inquiry. This includes problem solving and decision-making that occur in meaningful contexts.

During their interviews, science teachers and leaders expressed their understanding of constructivism and how it supports the inquiry-based science instruction experience. Inquiry-based science instruction requires educators to develop cognitive skills that encourage student-centered learning (Proulx, 2006). During the interviews, I learned that each educator had a unique perspective about teaching science through inquiry and its influence on their instructional experiences. Charles described the foundation for his support of using inquiry-based science strategies.

Most of the [Advanced Placement] students wanted to do something other than science, and I thought that was a tragedy. And looking back at their experiences though, K through 12, it probably wasn’t a surprise. So we changed what we did at [a district high school]. We moved into inquiry-based experiences for kids, and we changed the culture of the science department. And it took about four or five years, but we did see an increase in the number of students enrolled in elective courses because kids wanted to be with the science teachers.

Arnold also expressed his reason for backing inquiry-based science instruction.
Unfortunately, we tend to short-circuit the [instructional] process by relatively superficial assessment and benchmarking what students remember, rather than what students understand. So I think we get, again through inquiry, we get the opportunity to probe carefully and deeply what students actually understand, which is far more important than what they happen to remember that particular day.

A majority of the teachers interviewed implemented inquiry-based strategies during their laboratory time. Rosalind explained that she had recently begun incorporating inquiry-based strategies into her chemistry labs.

I just started doing that this year. I took the APSI, which is the AP Bio Summer Institute at USF, and that was the main focus of the workshop, was inquiry-based labs. So, this year is my first that I’m really trying to incorporate that by giving students a problem or idea, having other labs that play out, and basically having them work in groups to figure out a solution to the problem.

Enrico’s statement summarized the key points for teaching inquiry-based strategies during lab time.

My idea is to get them to understand four things: the chemical reaction occurs, the formation of the precipitate, that the formation of a gas when heat is given off and the formation of a new product. Instead of telling them, I will make them do it. I’ll get my answers.

A majority of teachers and science leaders expressed a positive attitude toward the use of simulations to support inquiry-based science instruction. Charles explained his decision to purchase web-based simulations to support the district’s secondary science instruction.

Gizmos were a good fit because they touched on 3 of the 4 elements (science, technology and math) that I had as a science supervisor. The real purpose is that the kids have an opportunity to see, touch, feel, and learn science in a new way.

Arnold clearly expressed his reasoning for being a proponent for the use of simulations.

Many of the things that we might want to do with hands-on science are not practical, not safe, or not universally accessible. Simulations give you the opportunity to engage students and inquire within those, within that realm of hands-on science, without having to deal with some of the impediments.
A number of the teachers explained that they use Gizmos to reinforce their inquiry-based lab instruction. Because Gizmos provide an opportunity to develop conceptual understanding of a science topic, the teachers reported their experiences in using them either before or immediately after conducting a hands-on experiment. Carl explained that his incorporation of the Gizmos provided the opportunity for students to reinforce further the concepts taught in his earth space labs.

What I try to do is introduce them to an idea, and then we’ll do a lecture, and then I’ll throw a lab in there, and then we’ll go to a Gizmo and use the Gizmo to reinforce the lab. I try to make it as hands-on, especially with the lower quartile kids. I try to make it as hands-on as possible, so I try to do a lab a week and a Gizmo every other week.

Gregor reported a preference for using Gizmos to teach an inquiry-based chemistry lesson rather than traditional lab instruction.

Instead of just doing the labs where you have the directions and you’re going to do this next, etc., with the Gizmos, you can manipulate variables. This is going to allow the students to look at different scenarios.

Jane expressed a preference for her students to use Gizmos instead of the opportunity for them to participate in hands-on labs.

Every time we do a Gizmo, I go through the Student Exploration sheet – that’s what I call the packet, which I have copies of over there, and then I go through the answers to see if we’re on the right page and if I’m thinking the same way as the people who made the Gizmo. And then I also print out the teacher guide and go through that. And what I have found is that there’s extra activities and information in there that can support what we’re doing. I think that I would like to see more of a push for the Gizmos, the online simulation experiments, than a lot of just the hands-on kind of you know [experiments].

Carl explained how he uses Gizmos to support inquiry-based instruction in his classes.

I use it as a support tool. I’ll do a lab where they’re hands-on with the lab, and if I don’t think I have gotten through the information, instead of re-teaching the lab I’ll use Gizmos as a form of re-teaching.

Gregor indicated that he will use Gizmos to support the instruction of a missed assignment.
For the Advanced Placement (student), if they miss a lab a lot of the AP labs are difficult to re-do, I’ll assign them a similar Gizmo to make up for that lab that they miss. I will then grade that Gizmos activity as their lab report.

A number of teachers were proponents of using inquiry-based strategies in their instruction. The literature review for the present study indicated that inquiry should be considered as an essential component of science instruction. A majority of the participants in this study indicated that the integration of simulations into inquiry-based science instruction has provided them with one possible application to support this transition.

**Technology**

In the present study, background questions directed at several of the teachers and science leaders focused on the technology available in their classrooms. Through the interview process, I was better able to understand the evolution of computer technology to the point at which it can facilitate the use of inquiry-based learning. I learned that the availability of hardware to support science instruction varied in each of the participant’s classrooms. Charles, a science leader, described the technology that had been purchased to support the district’s Title I schools’ science instruction.

In one or two schools, we did purchase laptops and made them available to the science departments. And the other schools, it just so happened that we were in this new culture of assessment with electronic testing. The schools, especially the Title I schools, were the first to begin building these computer labs that would be utilized for testing. Well, we don’t test year round, so those labs, the idea was that those labs would be utilized by content focus, by science for Gizmos, as an example, throughout the school year.

We bought LCD projectors for schools. I probably bought 20 of them over the course of three years as a supervisor. It would depend upon how a school was spending their Title I dollars, I would supplement that with technologies where needed.
With this understanding, I was interested in exploring the teachers’ perspectives regarding the available technology for their classrooms. Alberta’s statement provided the most encouraging example of a technology-rich classroom.

I’m very blessed. I have a Smart Board and I’ve had a Smart Board for probably over 10 years. My first Smart Board – when I first wrote a grant and got it and it was awesome. I have clickers – Smart Response Clickers, which I wrote a grant for that I think three years ago. The kids love it. And then in the lab we have tons of technology, because we’re always in there doing experiments.

Tanya also provided a positive response regarding the availability of hardware to support her environmental science instruction.

We have two or three interactive whiteboards in our department. We have the laptop cart. All of the teachers have LCD projectors in their classrooms. We do have a computer lab, and there are computers in the media center. So, if it is not testing time, the media center is available for us to sign up and go use those computers.

Tanya, however, brought up an interesting point when she described her access to the school’s computers. As computerized testing was becoming the rule rather than the exception, her access to computers during the testing periods was limited.

With the amount of statewide computer-based testing, especially second semester can be difficult to get into a computer lab. My department is fortunate that we do have a laptop cart, but there are only 16 laptops in there, and they don’t necessarily all 16 work at the same time. So when I use them in the classroom, I pair students up.

Through the interviews, I learned that the availability of hardware in many of the science classrooms was overshadowed by chronic connectivity problems. I was surprised to learn that these issues were the rule rather than the exception. Each of the teachers and site-based science leaders expressed frustration with their school’s Internet issues. Carl provided an interesting explanation of the challenge he faces with the Internet connection in his classroom.

We have, I want to think, 12 working laptops. We have a wireless hot point in the room, so as long as I have them all turn off their cell phones, as all their cell phones are not pinging the hot point, then we can actually log on with our wireless computers.
Rosalind expressed her dissatisfaction with her school’s Internet connection.

I don’t know if it’s just my room, but with our laptop cart – I know some teachers use it just fine. It seems like whenever I try and use it, half the laptops won’t log into our network, so they’re not – they can’t even turn the computer on. When they do, the Internet is really slow because they’re all logged into the same router. It’s just a nightmare. I try to use the laptop cart as little as possible.

The technical challenges frequently influenced the teachers’ support of simulations. Tanya explained her encounters when she attempted to integrate simulations into her instruction.

We have a wireless router on the cart, not the best wireless router but it’s what we’ve been given. I think the school system has upgraded some of those, the technology somewhat, and things seem to be a little bit better, but sometimes it still takes a while to get everything logged in and up on the Internet and everything like that, which means they have a little bit less time during the class period to actually work on the Gizmo.

In summary, I found a wide range of responses to the questions regarding the teachers’ and science leaders’ perceptions and experiences of the use of technology to support inquiry-based instruction. Nevertheless, a general consensus emerged in support of this practice. For several of the interviewees, problems and challenges emerged; yet they agreed that the concept is sound.

**Professional Development**

The majority of the interviewees expressed a positive opinion regarding the use of Gizmos to support inquiry-based instruction. Thus, it appeared productive to consider the initial professional development opportunities that provided the foundation for the implementation and sustainability of the program. This consideration is supported by Wells’ (2007) remarks as cited in the literature review of this study. These observations emphasized the importance of including a comprehensive professional development plan to ensure positive acceptance of and the continued integration of technology into the science classroom.
The district in which the interviews were conducted elected to hire a project manager. This manager coordinated and provided the professional development services to support the execution of the Gizmo program. In this section, I discuss how participation in the initial training sessions influenced the teachers’ experiences to incorporate the Gizmo simulations. Arnold expressed his opinion regarding the importance of having a project manager to ensure the sustainability of the district’s Gizmo implementation.

If we didn’t have a project manager, Gizmos would just be another thing. It would be another product on the shelf, and we would choose to use it, or more often than not, probably not choose to use it. And this was kind of a sea-change for me because I understand the economics of a company wanting to do sustained professional developing and having the project manager. And it is not without cost. But to be honest, if you want implementation of a program that you think that the program is going to actually take you somewhere, I don’t think it’s possible to have the kind of a grassroots movement to do it.

Charles explained his reasoning to provide the funding for project management.

We needed an additional layer of support to work directly with those schools, to bring them on as adopters of the program, to be there to support them, to model best practices, to fulfill their needs as professional learners. So it’s not something that we were equipped to do at the district office. We didn’t have the expertise to do that, so we needed somebody with a lot of product knowledge, and we just simply didn’t have the time if we did have the expertise.

All of the teachers indicated that they had participated in the three-hour initial training session provided by the district’s project manager. Carl expressed his frustration with his professional development experience.

I did [receive training] over a year ago, and except for getting the initial login, I can’t really say much jumped out from the initial training. It just seemed like three hours in a room full of 30 people jockeying for computers and questions and time didn’t feel like enough. I would have liked more one-on-one time to get a comfortable feeling.

Gregor provided a more positive account of his training experience and how he applied this knowledge to his biology instruction.

I know it’s been probably three years ago that I had the initial Gizmo training session.
I learned a lot going through it myself and seeing what it could do. I learned that we could do it in class, give out class sets to students, and that’s what I do a lot with Bio Honors students. I’ll do a Gizmo in class with them and I’ll put it up on the board and I’ll go through all the steps. I’m not going to give them the answers. They have to figure out the answers as we go through it.

Marie indicated that she participated in the initial training twice.

I got what they did when they did it, but then I went back to do it, and it was like I was kind of lost. I then got kind of busy and was like do I really want to put all the time and energy into this. And then I had another opportunity to go to the training. I went to the training and now I understand this [the Gizmos].

Tanya provided a suggestion to consider follow up support after the initial training session.

If the funds could be allocated to where teachers had a substitute or some kind of coverage, and they had time to just sit in a computer lab and look at those Gizmos and try them out, that’s what I think we really need. If they [teachers] could even arrange to meet. The biology teachers are meeting this morning or the chemistry teachers are meeting in the afternoon. They’re looking and sharing and talking and discussing [the Gizmos]. You know I thought that would be a great idea.

Marie and Tanya’s responses regarding the importance of follow-up support helped me to recognize its significance when implementing a technology innovation. I received a variety of responses when I inquired about participation in classroom student-teacher Gizmo modeling sessions and observation sessions. Arnold discussed the importance of providing modeling lessons from a supervisor’s perspective.

Well, you know, we’re a huge district and we kind of jumped in with both feet. And so we trained 400 or more teachers, and just got everybody up to speed. And we said it was most important to get this into the hands of students. So what we’ve seen is a lot of different implementation strategies. We’ve seen teachers misuse the product, use it as a kind of digital babysitter, and that’s been very ineffective. We’ve seen it used with fidelity in some circumstances. And our project manager has been great as far as doing model lessons to make sure that implementation with fidelity is as good as it gets.

Arnold’s explanation helped present the foundation in support of the Gizmo modeling sessions.

However, I was disappointed to learn that many of the participants were not aware that this service was available. Carl, for example, did not know about the availability of either service but
provided a good suggestion.

I was not aware of the modeling sessions. I would almost say that would be more beneficial than the three hour introduction to the Gizmos. It should be a six hour class, and have a three hour Gizmo introduction so you know what it is. And then the second part of it would be modeling, model to the students on how to use the program.

Gregor knew about the availability of the modeling session but elected not to use this assistance.

Yes [I am familiar with the modeling sessions]. Like I said, I think I have a pretty good grasp on how to use them, so I didn’t think I really needed someone to come in and show me how to use it.

A number of teachers indicated that they had taken advantage of the student-teacher modeling sessions provided by the project manager. Jane observed a modeling session in a colleague’s classroom. I asked if she thought that this session was beneficial.

So, if a teacher goes or a representative goes and does a demo, they have people in there like from all levels of teachers that have never used Gizmos before to people that use them a lot. So I think, in a lot of those cases, they have to be basic. “Okay, this is how to access it, and this is your – how to go on login,” and very basic kind of things.

Sally indicated that she had a positive experience during her participation in a student-teacher Gizmo modeling session.

For me, just having someone else present the information is such a great benefit. I’m not just learning, but this is something different for the students. So, they’re more likely to pay attention and benefit when I have somebody else doing it. That’s a big bonus to me.

Enrico also mentioned that he found the modeling service and the mentor training to be most advantageous.

I think that the two things that I love about Gizmos was when the project manager came and did a workshop with the children and with the teachers simultaneously. I was learning automatically by just his modeling, I was learning a whole lot. I loved that. Then when he provided that mentor training and he explained how to go ahead and target each section of the [district’s teacher] evaluation and why it is relevant, that was very beneficial.

A significant responsibility of the project manager has been to develop a cadre of Gizmo
mentors at each school. The role of the mentor is to be the site’s “go to” person to provide support to teachers for the Gizmo program. The mentors participate in a special two-day workshop that focused on best practices for the incorporation of the simulations into inquiry-based science instruction. After the cadre completed the mentor training, the project manager provided ongoing communication and assistance as needed. Arnold discussed providing each school with a mentor to support its Gizmo implementation.

That [mentor] model works generally pretty well. Unfortunately, at some schools, it’s the same person that’s also on the School Improvement Team, the textbook committee, the cheerleading sponsor and everything else. So, you get that sort of old idea about 80% of the work being done by 20% of the people.

Marie indicated that her role as the school’s Gizmo mentor has been minimal.

Well, if someone has questions, I’m the go-to-person. I help people if they need help getting things set up or have questions about how to do things. I don’t get that much business from that. It’s not a very taxing thing that I have to do because they go to the training. After they request initial assistance, they’re pretty much doing what they’re doing.

Rosalind discussed the Gizmo mentor program at her school.

We’ve decided in our department that one of our physics teachers and I, are kind of like the head Gizmo people in our department. So, if somebody has questions they always come to us. Out of our department, he and I had the highest Gizmo usage throughout the year. The teachers in our department come to us if they have any questions with the program.

Through the interviews, I learned there was a positive response by the teachers and science leaders regarding utilization of the Gizmo alignments provided by the project manager. This service included providing a well-developed list of Gizmos that were correlated to the district’s science pacing guides, the Biology End of Course Exam benchmarks, Florida’s Next Generation Science Standards, and the district’s teacher evaluation rubric. The intent of providing these alignments was to offer Gizmos as an easily accessible, supplemental
resource to reinforce inquiry-based science instruction. These alignments were made available to each teacher at training sessions, site visits, through the district’s web site, and via numerous communications from the project manager via the Internet. Alberta’s statement regarding the application of these alignments was similar to the responses from several of the teachers interviewed.

I did look at them [Gizmo alignments to the chemistry pacing guide]. The project manager put it together and sent it to us. He told us what units work and I think he did that for every subject. I didn’t look at any other subject area, but I know that he made that available for us. So, when I plan my lessons I look at our website and determine which Gizmos relate to it. Those [Gizmos] are the ones I tell students to go back and use.

Sally also mentioned that she took advantage of the Gizmo alignments.

For each unit, they’ll list recommended Gizmos and give you the standard and the name of the Gizmo. That’s usually how I pare down which ones I’m gonna assign to students. I don’t have to go browsing the Gizmos to figure it out myself. I just go to the alignments.

Alberta and Sally agreed that the Gizmo alignments, provided by the district’s project manager, were a valuable asset for their instruction.

Several teachers expressed their appreciation for the alignment of the Gizmo to the district’s teacher evaluation rubric. The rubric is the district’s teacher evaluation tool. Enrico, for one, discussed how he has encouraged the colleagues at his school to consider using this document in preparation for their evaluation.

After I learned from the project manager how to use the Gizmo alignment to the [teacher evaluation] rubric, I presented this information to my teachers. If the teacher is interested in receiving a level 5 [exemplary] evaluation, this instrument will provide the necessary document to support their instructional decision.

In summary, participants reported that the professional development services provided by the Gizmo project manager influenced their experiences. A majority of teachers indicated that
they had participated in the initial training sessions provided by the project manager. The Gizmo alignments to the course-specific requirements was a service that was used more often compared to participation in the student-teacher modeling sessions, the teacher observations, and the site-based mentoring opportunities.

**Time**

I learned that the issue of time influenced numerous teachers’ experiences during the implementation of the Gizmo program. Without exception, each science leader and teacher went into great detail to discuss this topic. Their experiences aligned with the following categories: time as an excuse, lack of computer time, downtime to install shockwave and flash onto the computers, and lack of planning time. Arnold, one of the district science leaders, pointed out that the issue of not using Gizmos because of a lack of time is an unacceptable excuse on the part of the teachers.

Well, I think that there are a lot more perceived challenges or prejudices than there are real challenges. The idea that I don’t have enough time to do it [is unacceptable]. I do something that’s kind of like this; therefore, I don’t need to do this as well. The idea that participating in simulations replaces hands-on science [is unacceptable]. Those are kind of the pre-existing beliefs that create barriers to implementation.

This perception contrasted with the views expressed by a number of teachers who indicated that the lack of computer time was not a “perceived challenge.” To the teachers, time is a very real challenge that needs to be considered. This opinion was clearly expressed by Irene, Sally and Alberta. Irene indicated that computer time is an issue: “We didn’t really get any chances to use the computer lab. We got the support of getting the program, but not the support of getting this computer time.” Sally’s statement was similar to with Irene’s.

Getting into the media center’s difficult because that’s where your computer lab is, but that is where we do all of the testing, and it’s now on the computer. So getting to where I
can get seven periods or at least a chunk together so I’m not running back and forth between my classroom meeting here, and the media center, it’s a challenge.

Alberta expressed a similar concern regarding the time involved in accessing the computer lab. She stated her concern that the Gizmo implementation interferes with her time to teach the required curriculum.

Time, I think is the most important. They give us the technology, but then they need to cut other things out so that we have time to fit it [Gizmos] in. We tell our biology teachers to do them because they help for the End of Course exam. But, they also have to give mini-assessments, which take time. They have to do this and they have to do that – so there’s too much that needs to get done.

Enrico shared his thoughts regarding the time that is wasted at the beginning of the year to install shock wave and flash. These are required to run each Gizmo simulation.

The Gizmos have to be updated. That is like [the project manager] at one point had to work with our tech person for the longest time. We took care of it. Every year, we we have to go and it’s like they wouldn’t come on, it won’t happen. It takes us some time for her to go ahead and upgrade it [to install the latest versions of shockwave and flash]. It takes our time away [from our instruction]. It discourages teachers. Gizmos, you want to introduce them right at the beginning of the year. The more you do it at the beginning of the year, the more the kids get involved in it. You don’t want to do it halfway through the first nine weeks or the second nine weeks.

Gregor’s perception of the time required to incorporate Gizmos into his lessons indicated concern. He focused on how he uses the Gizmo alignment to the district’s Biology Pacing Guide.

I always go to the Pacing Guide and see what Gizmos go along with it. Again, we’re under time constraints with how much we have to teach and how much time we actually have to teach it. So, I’ll pick out one or two good [Gizmo correlations] for that section. It would be nice to do all of them. We just don’t have enough time.

Enrico agreed that the Gizmo alignment to the district’s Physics, Chemistry and Biology Pacing Guides had been extremely beneficial and saved the teachers in his science department a tremendous amount of time.

I sent them [the science teachers] the entire Pacing Guide that [the project manager] had given for physics, chemistry and biology because it was all done for us. I sent them that
and made our life very easy. If you have something done for you, it’s just much easier to incorporate it because teachers, they really don’t have time. That’s all I can say. They really don’t have time. It’s not that they don’t want to do it. It’s that time is the essence. Once [the project manager] did that, it was very helpful for us.

The issue of time was shared by a number of participants during their interviews. Teachers expressed their frustration regarding the challenge of time involved in accessing the computer labs to use the simulations for their instruction.

Summary

This section examined the general agreement among the science leaders and teachers about incorporating simulations into science instruction. Through the analysis of the interview data, I determined that there was a strong consensus among those teachers interviewed concerning the lack of adequate, available computer access time. As noted, this issue influences all of the teachers’ experiences of using Gizmos: teaching inquiry-based science instruction, availability of technology, and participation in professional development support services. Despite this challenge, for the most part, teachers agreed with the importance of considering the use of simulations to incorporate inquiry-based instructional strategies into the curriculum. In addition, most of the participants explained that they have attended the initial training sessions and have utilized the Gizmo alignments to their specific curriculum guides provided by the project manager. The following section examines the differences expressed by the participants regarding the use of simulations to support inquiry-based instruction.

Phase II: The Contrasting Perspectives of Science Leaders and Science Teachers

The second phase of the data analysis is intended to develop a deeper understanding of the science teachers’ and science leaders’ decisions regarding the use of simulations to support inquiry-based science instruction. I examined the data again to determine if there were
differences in the perspectives of the self-identified high, medium and low using Gizmo teachers and their supervisory leaders. Comparing and contrasting participants with these perspectives provided a deeper examination of the interview data. As I looked for differences, I identified themes into which those differences could be grouped. The data analysis process used an inductive method for finding those significant themes, as explained by Patton (2002). My connoisseurship as an educational consultant for the implementation of science simulations and my previous background as a classroom teacher was used to discover the important differences of those themes in the interview data (Eisner, 1998).

Based on the responses from the interview data, I have selected those themes that established significant differences among science teachers and leaders. Constructivism, for example, was not a noteworthy theme for this phase of the analysis because a majority of participants agreed on this topic when considering science instruction. However, the responses from the interviewees regarding technology were very different. As a result of these differences, two themes emerged: (1) the availability of technology and (2) the application of technology. In addition, the interview data also provided an overwhelming response regarding student engagement. Therefore, I created a separate theme, influence on student engagement.” In general, the second phase of the data analysis produced four themes that were germane to this study. The themes highlighted in this section include the following:

- Influence of the available technology
- Influence of the application of the technology
- Influence of the ongoing professional development Strategies
- Influence on student engagement
I refer to the first significant topic as influence of the available technology. Understanding participants’ perspectives regarding the availability of technology may help explain why individuals may elect or not elect to use simulations in their instructional practice. The second idea participants expressed was the influence of the application of technology. Recognizing each participant’s perspective regarding how they elected to apply the use of simulations in their science teaching was an important consideration. The third concept noted in the interview data focused on each participant’s varied perspectives regarding the value of the ongoing professional development strategies provided to support the sustainability of the simulation implementation. The final idea was the influence on student engagement. The interviews with science leaders and teachers highlighted their different viewpoints regarding how their students’ engagement of science is influenced by the use of simulations.

In the following sections, I describe these ideas and use excerpts from the interviews to build a case for the existence of these concepts in the data. Specifically, I am examining how they relate to the perspectives of the self-identified high, medium and low using Gizmo teachers and their supervisory leaders.

**Influence of Available Technology**

The first significant theme when considering the continued use of simulations to support inquiry-based science instruction was the influence of available technology. Through the interview process, I was able to understand the evolution of computer technology to the point at which it can facilitate inquiry-based science learning. The analysis of data for this section explores the responses of those teachers, who consider themselves to be high, medium, and low implementers of simulations and their perspectives of available technology that supports their science instruction. This analysis will also consider the feedback from each of the
district’s science leaders and their understanding of available technology that supports the use of simulations. The following information provides an overview of each participant’s responses to this theme. Each of these components will be specifically explored and analyzed here. The major sections and subsections related to each of the themes are identified in the data.

Science leaders’ perspectives of available technology. The literature reviewed in Chapter 2 revealed that the modern era requires our schools to address science instruction through the integration of technology. It also reiterated that instructional leaders must offer support for this priority. Through the interviews of the district’s instructional leaders, I was able to gain a clear understanding of their level of support to provide technology for the inclusion of simulations into their district’s science curricula. The district’s science leaders included Arnold and Charles. Charles described the trend in public education to provide electronic resources for students.

There is such a big move, in public education now, to move to electronic situational learning for kids. In one or two of the Title I schools, we did purchase laptops and made them available to the science department. The schools, especially the Title I schools, were the first to begin building these computer labs that would be utilized for electronic testing. Gizmos were to be used in those labs when they [the computer labs] weren’t being used for testing.

Arnold went a step further to acknowledge that in addition to the allocation of district funding for technology to support instruction, the school district’s Office of Curriculum and Instruction and Office of Instructional Technology have provided creative methods to employ this implementation.

Well, to be honest, when we really rolled out the whole district-wide implementation, I thought that we were going to have a ton of problems. I really haven’t heard about it. There have been some folks that wanted interactive whiteboards, that didn’t have them. But that’s an accessory. It’s not necessary for using Gizmos. Most of the computer type issues have been dealt with at the site level. Some of the solutions aren’t very elegant, but
they are functional. I’ve seen a lot of times when Gizmos are used in a one computer classroom and then deployed using a computer center or computer lab so that there are two parts of that instruction.

However, the teachers’ perspectives regarding the available technology for their classrooms differed from those of the science supervisors.

**High Gizmo users perspectives regarding the availability of technology.** The teachers who considered themselves high Gizmo users included Tanya, Rosalind, and Jane. Tanya’s response most closely aligned with the responses from the science leaders when asked about the accessibility of hardware to support her environmental science instruction.

We [the science department] do have a computer lab and there are computers in the media center. So, if it is not testing time, it [the computer lab] is available. However, [having] only two labs for 130 teachers [can be challenging]. That’s a high demand, especially when you throw in all high-stakes testing. There is not a whole lot of available time in the computer lab.

We do have lap-top carts [in the science department]. We share one for the 14 teachers, which usually works out. Most of us are pretty flexible. [A colleague in the science department] needs it on Tuesday; I’ll change my plans and use it on Wednesday instead.

Rosalind’s remarks were similar to Tanya’s regarding the technology that she has available in her classroom to support her biology instruction.

For science technology, we have a lot of different items. I’ve used the spectrometer machines, computer technology and obviously Gizmos. I don’t do a lot of Power Point. Videos – we just watched a college lecture yesterday about genetic engineering. The kids could get a feel for what it’s going to be like in a real lab.

The remarks from Tanya and Rosalind supported the science leaders’ rationale for the district’s investment for the integration of technology for the Title I high schools. Jane’s response regarding the availability of technology in her classroom, however, differed from Tanya and Rosalind. She explained how she has had to become creative with the use of technology in order to use the simulations in her classroom.
I bought a cord for my computer so I can attach the projector to my USB port and project the Gizmo simulations on the screen. It attaches to the long cord that’s running across the ceiling. This [set-up] enables me to project without using the laptop at the projector. I can project from my desk computer.

Tanya noted that as computerized testing has become the rule rather than the exception, her access to computers during the testing period has been more restricted.

With the amount of statewide computer-based testing, especially during the second semester it can be difficult to get into a computer lab. My department is fortunate that we do have a laptop cart, but there are only 16 laptops in there, and they don’t necessarily work at the same time. So when I use them in the classroom, I usually pair students together for best results.

Through the interviews, I discovered that the availability of hardware in many of the science classrooms were overshadowed by chronic connectivity problems. I learned that these issues were the rule rather than the exception. Despite Arnold’s explanation regarding the functional use of the Internet at each school, those teachers with high Gizmo usage expressed frustration with their school’s Internet connection. For example, regardless of the availability of technology in her classroom, Rosalind discussed the challenge she encounters with the Internet issues.

Due to the Internet issues, I try to use the Internet as little as possible. We have three computer labs at school. So, if I need a computer, I go to the computer lab. Rosalind also expressed her frustration regarding the use of the laptop cart at her school.

We do have a lot of computer labs at this school, though. We’ve got 3 full computer labs. So, if I’m doing something where I’m going to need a computer, I try to do that [use the computer lab] rather than use the laptop cart.

In summary, Jane, Tanya and Rosalind generally agreed with the science leaders’ perceptions regarding the availability of technology to support their science instruction. However, each high Gizmo user differed from the science leaders regarding the quality of the Internet connection to support the use of technology in their science classrooms. The next
section examines the perspectives of the medium users regarding the availability of technology.

**Medium Gizmo users perspectives regarding the availability of technology.** The teachers that considered themselves medium Gizmo users included Carl, Gregor, Enrico, and Sally. Each teacher discussed the availability of technology in their classrooms and schools to support the use of simulations. Carl described the availability of technology in his classroom to support his earth and space science instruction.

We have 12 working laptops. We have a Smart board. So, I can go and access Gizmos in the room as long as the Internet is working.

Enrico indicated that there is limited technology available in his classroom and in his school’s science department. He also mentioned that he would prefer not to have to use the school’s computer lab to use simulations to support his chemistry instruction.

I really wish that we would have two laptop carts in the [science] department. I wish we had more technology. I would prefer to not have to book a day [in the computer lab]. I would like to have it [laptops] in here [the classroom]. We have the wireless. We have the Wi-Fi. We can access it. I would rather have it [laptops] more class based than having to give it [simulations] for homework. Then I don’t have to give the students a week to complete their assignments [with the simulations].

Sally also described the technology issues she has experienced at her school.

I try to promote technology as much as I can. In fact, my syllabus at the beginning of the year stated this course requires regular access to a computer with an Internet connection. In my classroom, if I am trying to tie into the Internet, the reliability to get a wireless connection is 40% at best. I may have it one period and I don’t have it the next period.

The access to wireless, in my classroom, presents the same issue. I can lose my connection in here [the classroom], and so I have to double plan for every class. I have to be able to have a backup [lesson].

Unlike Carl and Enrico, and Sally, Gregor provided a mixed response when asked about the technology available in his classroom.

I have an LCD projector hooked up in the ceiling and I use my personal laptop. I do have
However, when I want to have the students access Gizmos, it’s a lot harder for me to access the computer lab to do the Gizmos.

In summation, Carl, Enrico, Gregor and Sally had varied perspectives and opinions regarding the availability of technology in support of their science instruction. Carl and Gregor agreed with the science leaders’ observations regarding the availability of technology in support of their individual science teaching. Enrico and Sally, on the other hand, expressed dissatisfaction with the availability of technology. Similar to the self-reported high Gizmo colleagues, a majority of the medium Gizmo users disagreed with the science leaders’ perspectives regarding the quality of the Internet connection in their science classrooms. The Next section examines the viewpoint of the low Gizmo users regarding the availability of technology.

**Low Gizmo users perspectives regarding the availability of technology.** The teachers that considered themselves low Gizmo users included Alberta, Marie, and Irene. Each teacher discussed the availability of technology in their classrooms and schools to support the use of simulations. Alberta chronicled the availability of technology in her chemistry classroom.

If I had a classroom with 12 computers and I could put kids in pairs to work on them, it would be great. In 1992, I piloted a program for Texas Learning Technology. They brought eight computers into my classroom and it was fabulous. I put the kids in groups of three [for each computer]. That was great for 10 years, but then of course all the equipment started breaking down. There was no money to repair the computers, so we got rid of them.

Two years ago we had a cart that had laptops in them and we would check them out for our classrooms. We had 24 laptops and the kids all went and got a laptop. That [situation] was good for the first month because I was the only teacher that used them. Then, all of the teachers started using them. Whenever you got them back, they were not the same. They were destroyed.

The science department at my school does have a computer lab. However, it’s used almost every day for testing. There is very little available time to use the computers in this lab for science instruction.
Marie described the available technology in her chemistry classroom.

    I just got a new computer, a desktop computer, and I have a seven year old laptop. I also have a Smart board. However, since I just received a new computer, the laptop really doesn’t support the Smart board software. I’m on a waiting list to get software put into my new computer.

    The school has issues with the Internet connection. The school has wireless that will work and not work. We found out, just last week, if the students turn off their Smart phones the wireless Internet will work.

Irene expressed the challenges she encounters with technology to support her chemistry instruction.

    Usually, not every student has a computer in their house. So, if you assign a project that requires the use of a computer, you really have to give them a long time to complete the assignment. Now, if I assign a project that requires the use of a computer in class, I only have four computers in my room. The available technology in my classroom is an under-advantage because not every student will be able to use it.

    The interview process found that Alberta, Marie and Irene had varied perspectives and opinions regarding the availability of technology in support of their science instruction. Marie agreed with the science leaders’ observations regarding the availability of technology in support of their individual science teaching. However, she did express her frustration with having to wait for the school technology specialist to integrate her new laptop with the Smart board software. Alberta and Irene expressed their concern regarding availability of technology in their classrooms. Alberta, for example, stated her concern regarding out-dated technology and the inconvenience to access technology in her school’s computer lab. Irene described the limited availability of computers in her classroom as an “under-advantage” to support her science instruction.

**Summary**

    Through the analysis of the interview data, I was able to compare and contrast those
themes that influence the perspectives of the self-reported high, medium, and low Gizmo users and their science leaders regarding the availability of technology in their classrooms. The science leaders, Arnold and Charles, described the technology the district purchased to support science instruction in the Title I high schools. While Arnold indicated that most of the computer issues have been managed at the school level, a majority of the Gizmo users disagreed with his point of view. For example, the high, medium and low Gizmo users overwhelmingly reported issues with the Internet connection in their classrooms and their schools’ computer labs. Another difference in opinion between the science leaders and teachers was identified as the availability of computer labs to support science instruction. While Charles and Arnold indicated that each school’s computer lab was available for the science teachers when testing is not in session, most teachers indicated that testing was almost always being done. The next section of this analysis will consider the influence of the application of technology for science instruction.

**Influence of the Application of Technology**

When considering the continued use of simulations to support inquiry-based science instruction, the next important theme is the influence of the application of technology. The interview responses allowed me to understand how computer-based simulations (Gizmos) can facilitate the progress of inquiry-based science learning. The data analysis for this section considered the responses of the district’s science leaders and examines the extent of their support of the application of technology for science instruction. This section also considers the comments of the teachers who consider themselves to be high, medium, and low implementers of simulations and their perspectives on the application of technology to support science instruction. The most important sections and subsections related to each of the topics are organized by role and level of use.
Science leaders’ perspectives on the application of technology. The district’s science leaders have made available the financial resources to purchase simulations for each of their district’s high school science classrooms. Because the leaders are considered “change agents” for innovations, the degree to which they are satisfied with the inclusion of simulations was examined. The interview process provided a comprehensive understanding of each leader’s commitment to the Gizmos. The following discussion features the science leader’s comments.

Charles explained his support for the Gizmo software initiative that encourages inquiry-based instructional experiences.

We do like the adaptability of the product. So when we’re looking at a “5E” lesson [Engage, Explore, Explain, Elaborate and Evaluate] for instance, Gizmos can be utilized in multiple places during the “5E” lesson, whether it’s used as the original engagement tool, whether it’s used later on as the explain tool or the elaborate tool. We can plug Gizmos in wherever it best fits for whatever lessons we’ve developed.

Arnold also clearly expressed his reasoning for being a proponent for the use of simulations.

Many of the things that we might want to do with hands-on science are not practical, not safe, or not universally accessible. Simulations give you the opportunity to engage students and inquire within those, within that realm of hands-on science, without having to deal with some of the impediments.

However, Charles provided an important caution regarding the integration of simulations into the science curriculum.

One thing that I had to be cautious with my director and others, who aren’t necessarily science people, is the misconception that Gizmos take the place of wet labs. They look at it as an opportunity to get more labs done more cheaply, still teaching the kids a science concept. So, I have to pull back the reins on those days or when those people make those types of suggestions.

I always have to be very cautious [regarding] how people are interpreting the online component. Because there is such a move, a big move in public education now, to move to electronic situational learning for kids. And there are places that are endorsing these types of experiences over really getting the kids into a lab. And there’s something to be said for actually touching and feeling science in person too, right?
Arnold explained that he appreciates the versatility of the Gizmos, but emphasized that it is not the entire solution to support inquiry-based science instruction.

It [the Gizmo implementation] has had a real positive effect on our district and on the teachers who use it. The [Gizmo] project manager allows me to take my eyes off of it so that I can focus on some other things that need to be done. Gizmos are a part of the solution; but, it is not the [entire] solution.

Charles agreed with Arnold’s position regarding the success of the implementation.

I think that it [the Gizmo implementation] has been very successful. I’m pleased with how the program has come along. As a product, and especially with the professional development tools, it’s been flexible enough for us to hang on during change. As we grow it [the implementation] grows. It wasn’t just fit for one or two years. The program has added value and consistency to our experience for the students and for the teachers. So, it’s become a part of our way of instruction.

The interview process of the district’s instructional leaders provided a high level of support for the inclusion of simulations. Both leaders expressed satisfaction regarding the teachers’ utilization of the Gizmos. However, Charles warned that the use of simulations should not replace the opportunity for students to participate in the hands-on lab experience.

The following subsections discuss the teachers’ perspectives.

**High Gizmo users perspectives on the application of technology.** The literature reviewed for the present study indicated that teachers must understand the practicality of using technology prior to integrating it into their instruction. The interviews elicited each participant’s experience. Jane, Rosalind and Tanya, the self-identified high Gizmo users, provided a unique point of view. As noted, the science leaders encouraged the use of simulations. However, they noted that the use of Gizmos should not replace hands-on lab experience. In contrast to the leaders’ opinions, Rosalind stated that she prefers the use of Gizmos over the hands-on lab opportunity.
I like using those [Gizmos] kind of in lieu of labs. Instead of having to set a whole lab for a whole classroom full of kids, [I use Gizmos] since the Gizmo is so interactive. It’s a student-oriented learning [experience]. So, a lot of them [students while] on the computer are recording their own results, making their own conclusions and doing all the same things. But, it is a lot less work on my end and they are still learning the same amount of material.

Jane also mentioned her preference to use simulations to replace the hands-on lab experience.

However, she emphasized that the use of labs and simulations are not mutually exclusive.

A lot of my students are – I hate to say - very basic. So a lot of inquiry-type activities, the – even the so-called “hands-on” experiment, they’re not really getting – even if you tell them ahead of time and during [the experiment]. They aren’t really capturing why they’re doing the activity. However, I like the Gizmos because they’re being guided [through the experiment]. They are learning through questioning and inquiry.

Tanya, who served on the district steering committee that supported the initial Gizmo purchase, indicated that she has found a variety of ways to incorporate Gizmos into her lessons.

We use those [Gizmos] in a variety of different ways in the classroom: as labs, as teacher-directed activities, and as lab make-ups. Sometimes when we do a hands-on [experiment] and the students aren’t there, then they can simulate and do something similar [like] using the Gizmos. We provided feedback to the county that this is a tool that really was very helpful in our teaching process.

In summary, the responses from these three respondents did not indicate strong agreement with their district’s science views on the application of simulations. Each teacher provided a rationale for her views. Tanya’s response was more closely aligned with her science leaders. The next subsection examines the viewpoint of the medium Gizmo users.

Medium Gizmo users perspectives of the application of technology. Carl, Enrico, Gregor, and Sally, the self-described medium Gizmo-using teachers, discussed how they apply technology in their classrooms. Carl explained why he regards himself as a medium Gizmo user.

I consider myself as a medium user. The Gizmos for earth and space science are better [compared to the Gizmos for physical science], so I’m utilizing them more this
year. A very important consideration for me is to go into the website and get familiar with the Gizmos. I should do them on my own to determine which Gizmos are best for the class level.

Sally, who also teaches earth and space science, explained her rationale for the medium use of Gizmos. She indicated that she incorporates simulations.

I consider myself a medium Gizmo user. I found more Gizmos when I was teaching chemistry. I find fewer available Gizmos now that I’m teaching earth and space science. However, since earth and space [science] brings together so many different concepts, I have the option to bring in Gizmos from other topics to support my current instruction. For example, I used the Element Builder Gizmo from the chemistry selection because we needed a background to be able to understand how to do carbon 14-dating.

Gregor discussed how the testing schedule has governed his use of Gizmos to support his biology instruction.

Probably right now I’m a medium Gizmo user. There have been times when I’ve been a high Gizmo user. It just depends on the timing. Plus, there is limited computer availability nowadays with all the different testing we have, [which require the use of computers] including the FCAT make-ups and all the make-ups [for the other exams]. It’s a lot harder for me to get access to the computers to do the Gizmos. Therefore, I don’t do them as much as I used to. For the AP [Advanced Placement] kids, usually it’s not a problem because they all have their own computers and they can so it on their own time.

Enrico provided a justification for his medium Gizmo use in his chemistry instruction.

I really wish we would have two laptop carts in the [science] department. I wish that I had more technology. At the present time, I have to book a day in the computer lab. I would rather use Gizmos in class instead of having to assign it for homework. If I had my way, I would use the Gizmos more frequently for direct instruction instead of assigning it for homework.

In summary, the responses from the medium using Gizmo teachers differed in several important ways. Carl, for example, expressed his satisfaction with the availability of simulations. In contrast, Sally indicated that there are fewer available Gizmos to support earth and space instruction compared to other content areas. The responses of the medium users were similar to their high user counterparts insofar as they diverged from those of the science leaders. Gregor in
particular expressed his frustration, regarding the limited availability of computers and its influence on his use of the simulations. Similarly, Enrico described his creative methods of incorporating the simulations into his chemistry instruction.

The following subsection examines the viewpoint of the low Gizmo users regarding their application of technology.

Low Gizmo users perspectives of the application of technology. Three of the teachers interviewed considered themselves as below-average Gizmo users: Alberta, Irene, and Marie. Alberta, for example presented a negative scenario and provided reasons related not to the product but to the process.

There is so much to teach. If I do a Gizmo activity in class, I would need to then walk the students to the media center, if it’s available. It usually would not be available. We waste five minutes walking to the media center and five minutes walking back. If a student is absent, what happens the next day? How does that student make up the work? If a student can’t stay after school, he can’t make up the work. If I say, “You can do it at home,” he’s going to say, “I don’t have a computer at home.” So that’s why I make Gizmos optional.

Marie also justified her low usage by referring to the lack of time to take her students to the computer lab.

I’d say that I’m a low Gizmo user at this point. I think that I would be more of a Gizmo user if the computers were more readily available. It’s just so complicated to take them [the students] down to the computer lab.

Irene cited her students’ performance as a reason for her low Gizmo usage.

I would consider myself a low user only because I don’t use those [Gizmos] anymore this year. Now last year, I would have considered myself a high user. But I don’t see any difference between the two years as far as student performance.

Despite Alberta and Marie’s decision to limit their use of simulations, they agreed that there was a positive influence on student learning with the use of Gizmos. Marie, for example, pointed out how the use of simulations develops conceptual understanding.
The benefits [of using Gizmos] include [the opportunity to develop] a better understanding of the concepts. Students figure it out on their own once they see something happening rather than just saying this and that. That’s pretty good if they can figure it out on their own. I mean sometimes it happens and sometimes it doesn’t [happen].

Alberta also expressed how the use of Gizmos influences her science instruction.

It’s a different type of learning, a different type of teaching – where the students become, I guess, their own boss. They become the stakeholder in their learning. The teacher becomes the facilitator instead of controlling the classroom.

In contrast, Irene explained that the lack of computers in her classroom have limited the opportunity for inquiry-based, student centered instruction.

[Because the students do not have access to computers], I find that it is a one-sided lesson. The kids watch me do something and it’s really not helpful to them. Whereas when they are using the computer, they’re initiating the learning and its student – centered learning.

I don’t find it as helpful [due to the lack of available computers at my school]. When I’m doing it [the Gizmo], it’s not the same kind of learning. I don’t find it helpful.

Each participant’s response was similar to those of the other respondents regarding limited availability of computers at their schools. Despite their decision to use Gizmos on a limited basis, Marie and Alberta did express an understanding of the value of incorporating simulations for student-centered instruction. However, Alberta noted the discrepancy between her demanding teaching assignment and the time required to incorporate simulations into her lessons. Irene went a step further when she indicated that computer access is not only a problem at her school, but is also an issue at her students’ homes. Therefore, her students have no opportunity to access simulations.

**Summary**

This section considered the perspectives of the science leaders and teachers regarding the application of technology in their classrooms. Analysis of the interview data enabled me to
compare and contrast those factors that influence the perspectives of the levels of Gizmo users and their science leaders. The science leaders, Arnold and Charles, described their considerations regarding the use of the simulations. The leaders agreed that they intended for teachers to use the Gizmos but not to replace traditional hands-on lab activity with the simulations. However, some of participants from the high and medium group indicated that they have elected to use the simulations in lieu of the hands-on lab activity. This is in direct contrast to the leaders’ objectives. For example, Gregor and Jane, indicated that instead of merely doing the labs – for which explicit directions are used -- the Gizmo program provides the opportunity for the student to be guided through the experiment. They are learning through questioning and inquiry. Teachers Charles and Arnold indicated that the simulations provide an excellent tool to support inquiry-based instruction. But they also agreed that the simulations are not the only resource that could be employed. However, several teachers indicated that they use only the simulations in their instruction.

The following section of this analysis considers the influence of the professional development strategies.

**Influence of the Professional Development Strategies**

This section considers the influence of the professional development strategies. It was noted in the literature review that ongoing professional development strategies are likely to improve the use of simulations. Specifically, the interviews with science leaders and teachers reinforced this point. The data analysis for this section considers the responses of the district’s science leaders and those teachers who consider themselves to be high, medium, and low implementers of simulations.
Science leaders’ perspectives on the professional development strategies.

The interviews provided insight into the leaders’ commitment to the professional development services available, in particular those that affect the use of Gizmos. The district science leaders indicated support for appointing a project manager to coordinate the instructional experiences and encourage the use of simulations. They also provided commentary on the level of services being provided to schools and the services they found effective or ineffective.

Charles explained that during the early stages of the Gizmo implementation in the Title I schools, the district provided the funding for project management services.

In [this district], we’ve done the best we could to make sure that our teachers are always prepared to teach kids. And having that layer of support [project management services] is essential. We spent a lot more time at those Title I schools than we did at the other schools during that first year of the implementation.

With the support of the project manager not only were we providing them [the teachers] with the tool [Gizmos], we were also providing them with support through modeling and pd [professional development] on site. The project manager worked with the teachers during their off periods and lunch periods. We certainly provided them with a wonderful [training] option.

Arnold also provided a rationale for the importance of providing this service.

[The project manager] has been far more effective than I could anticipate. And it’s two things. It’s his ability to know and to do his job effectively and professionally and his sensitivity to the individual teachers that he’s working with. [The project manager] is able to go in and model lessons and be extremely patient with the people that he’s working with. And [he is able to] overcome some of those obstacles to implementation and to show them what the model looks like when it’s done appropriately. He is able to explain in very plain language how you can do this without having to endure all of the teacher excuses. There are a million excuses, and [the project manager] methodically and quantitatively debunks each of those as he goes along and does a great job. We have seen huge gains in the number of student use and teacher use [of Gizmos] at the Title I schools. And I directly relate that to having the project management in those sites.

The district science leaders provided a strong justification for the need to appoint a project manager to encourage the use of simulations. The interviews also provided information about the level of support that must be provided to project managers. Arnold explained the
importance of the project manager service to encourage a positive instructional experience for the teachers.

My role is to identify resources and make sure the resources get to where they’re supposed to be. In developing the Gizmos implementation, I established a cadre of Gizmos points of contact at each school. So each school has a certain person, usually not the department chair, who has agreed to be trained and to be an early adopter of Gizmos. This point of contact is the liaison for communications with the project manager and myself. We let them know where we are with the implementation [at their school], where we are with upcoming trainings, and how we can support schools and teachers that are struggling [with the Gizmo implementation].

Charles also endorsed such a role for the project manager. He also mentioned the influence of the project management services on the district’s improvement on high stakes science exams.

Well, I think from sitting here, the project manager was probably the best thing we did. The product is the same, regardless of what school is using it [Gizmos]. Knowing that many of schools science scores improved, can’t be directly correlated to Gizmos, but we know that it is a part of it. It was one of those ingredients for success, right? Sitting back and knowing that we did what was right for the kids was great. But I think that it all goes back to project management in those sites [Title I schools] to get it [Gizmos] off the ground.

Arnold noted the services he considers most beneficial.

The initial training [provided by the project manager] works well. The [Gizmo student – teacher] modeling [provided by the project manager] works really well. I think that recognizing and appreciating the Gizmo mentors for their hard work is great. I think that the correlation that was done between Gizmos and the EET [Educator Evaluation Tool], our evaluation system, was very helpful and comforting.

In summary, the leaders expressed their support for a Gizmo project manager and the services he provided. With this in mind, it seems useful to distinguish between the effective and ineffective professional development strategies from the perspectives of the teachers. The next sub-section examines the point of view of the high Gizmo users regarding their perspective of the professional development services to support their Gizmo implementation.

High Gizmo users perspectives on the professional development strategies. The high
Gizmo users were Jane, Rosalind, and Tanya. In the previous sub-section, I noted Arnold’s positive attitude regarding the project manager’s professional development services. These services included

- the initial training sessions,
- the student-teacher modeling sessions,
- oversight of the Gizmo mentoring program, and
- the development of the Gizmo correlations to the district’s teacher evaluation tool.

In contrast to Arnold’s endorsement, Tanya, and Rosalind had elected to participate only in the initial training sessions. Tanya explained that the Gizmos are fairly intuitive. Therefore, the teachers at her school required little support beyond the initial day of training.

At my school, I have made sure that the teachers understand what a useful tool that they [the teachers] have at their hand. I have shown them which ones [Gizmos] are applicable to the chemistry curriculum or the physical science curriculum.

At my school, most of the teachers really have not had too much difficulty. I mean they’re [Gizmos] pretty user friendly so they haven’t needed a whole lot of support. However, there have been discussions at our Professional Learning Community meetings, our PLS meetings, about, you know, I used this one, it was helpful.

But my teachers really haven’t needed a whole lot of help. We’ve talked about how they can be used and how different teachers have used them in different ways. We started sharing ideas when we first got them [Gizmos] a couple of years ago. Most of the teachers have just taken off with them.

Rosalind received her initial Gizmo training several years ago. She agreed with Tanya that the need for follow-up support has not been necessary.

I received the initial training a couple of years ago. I think by the time I had done the training, I had familiarized myself so much with the Gizmos because it is such an easy thing [product] to use. One of the things that I learned was about logging the kids and they can do it [independently].

In contrast, Jane’s response confirms the necessity to provide services beyond the initial
training session. She described the support that she had received from the project manager and the ExploreLearning team.

We’ve had people come to the school that worked for the Gizmo Company [the project manager and his certified trainer]. And they were – everybody is always helpful. And they’re always – I don’t remember everything they say, but they’re telling me things that I could do that I wasn’t even aware that we could do through the Gizmo.

To summarize, Tanya and Rosalind explained why they have elected to participate only in the initial training session provided by the project manager. Their viewpoints differed from the science supervisors in this regard. Jane did note that she received benefits from her participation beyond the initial training sessions. In this respect, she was in agreement with the science leaders’ position.

The next sub-section examines the perspectives of the views of the medium Gizmo users regarding professional development services.

Medium Gizmo users perspectives on the professional development strategies. The medium Gizmo users were Carl, Gregor, Enrico and Sally. They offered their perspectives on the professional development services. Earlier, I noted the science leaders’ endorsement of these services. It was also noted that some of the high using Gizmo teachers have elected to participate only in the initial training sessions. When asked about his opinion regarding these services, Gregor’s response was closely aligned with those of his high-using counterparts Rosalind and Tanya.

I know it’s been probably three years ago that I had the initial Gizmo training session. I learned a lot going through it myself and seeing what it could do. I learned that we could do it in class, give out class sets to students, and that’s what I do a lot with my Biology Honors [students].

The people who taught us or gave us training provided their name and everything if we ever needed help. Truthfully, I really didn’t need any help because it was pretty self-
explainatory once you got going in it [Gizmos]. I think only once or twice I might have emailed the trainer with specific questions, but really I didn’t need that much follow-up.

Gregor also indicated that he had taken advantage of the Gizmo alignment with the district’s biology pacing guide.

I always go to the pacing guide and see what Gizmos go along with it. Again, we’re under time constraints with how much we have to teach and how much time we actually have to teach it. So, I’ll try to pick out one or two good ones [Gizmos] for that section. It would be nice to do all of them. We just don’t have enough time. But yes, I do take a look at what they suggest [in the Gizmo alignments].

Carl, who did participate in the initial training session, acknowledged that he has needed additional assistance to develop an understanding of the features and functions of the Gizmo program. When I inquired about his participation in the support services beyond the initial training session, Carl indicated that he had not taken advantage of these opportunities. For example, he acknowledged that he was aware of the Gizmo alignment but has not utilized it. He admitted that he had no knowledge of the availability of the student-teacher Gizmo modeling sessions.

No. I was not aware [of the student – teacher modeling sessions], and that would be more beneficial than the three-hour introduction to the Gizmos. It should be a six-hour class, and have a three-hour Gizmo introduction so that you know what it is. The second part of it would be the modeling [how to use the program in the classroom]. Every other lesson we get through the county has some sort of modeling.

Enrico provided a completely different perspective regarding his participation in the professional development services.

I am the Gizmo mentor at my school. The two things that I have loved about the Gizmo [program] include the participation in the student-teacher modeling session when [the project manager] came in [to the school] and did a workshop with the children and the teacher simultaneously. I was learning automatically by just his modeling, I was learning a whole lot. I loved that. Then when [the project manager] took that mentor training and he explained how to go ahead and target each section of the teacher evaluation [EET] and why it is relevant, I felt real good about it.
Sally discussed the support she has received from the project manager in her role as the school’s Gizmo mentor.

During first year [of the mentor program] there were a couple of classes provided suggestions [for how to use Gizmos in the classroom]. I would take the summary [of these suggestions] and post it for the other science teachers. At one time we had a lot of new science teachers coming in, and I was working with them individually. Then we lost positions. So the teachers that we currently have at [this school] are all familiar with using Gizmos, and I haven’t had any questions and I haven’t offered any additional assistance.

To review, the medium Gizmo users provided varied responses regarding the professional development services. Gregor’s reaction to the follow-up opportunities were similar to those responses from his high user counterparts, Tanya and Rosalind. He said that the Gizmo program is fairly intuitive and therefore, in his opinion, does not require follow up support. This view differs from that of his science leaders. As is true of Charles and Arnold, Gregor, Enrico, and Sally have relied on follow-up services such as the Gizmo alignments, the student–teacher modeling sessions, and the Gizmo mentoring program.

The next sub-section examines the perspectives on this component of the low Gizmo users.

**Low Gizmo users perspectives on the professional development strategies.** The low Gizmo users were Alberta, Marie, and Irene. The initial training session generally paved the way for teachers to consider the use of simulations. Marie indicated her need to participate in an additional initial training session.

The first time I went through [the initial training session], I think I went through the three hour training at least twice because the first time I was just kind of like a deer in the headlights. I was just kind of like saying what, I sound like one of the kids. I’ve been hanging around them too long. The second time I took the training, it was a lot more helpful for me for some reason. Maybe I just needed a second exposure.

Alberta also discussed the difficulties she encountered when she participated in the initial
Gizmo training session.

I remember being a little frustrated with it [the initial training session], because it was like there were too many of us in the room, and there were too many people talking at the same time. I need to really focus when I do something. The practice one [Gizmo] that we did was something on ecology, and that wasn’t my background. The training wasn’t in my subject area, so I wasn’t interested in it. That’s just like a student, right?

These teachers appeared to have concerns about the initial Gizmo training sessions. Thus, I sought to determine if there were aspects of the project management services that they would consider valuable. As is true of the high and medium users, some of the low Gizmo users indicated that they had taken advantage of the Gizmo alignments to their science pacing guides, state standards and biology end-of-course exam. Alberta referred to the value of these alignments to support her chemistry instruction: “I think giving us more information and putting out the [Gizmo correlations to the] pacing guides have been a huge help to us.” However, she mentioned that the district provides too much information. This contributes to making the science teachers less creative.

Now we are given just so much, I mean ancillaries. We [the district] buy textbooks which includes ancillaries, we have CD’s, we have DVD’s, we have Power Points. Teachers nowadays don’t even have to be creative. I think that this has affected our instruction.

Marie discussed how the availability of the Gizmo alignments has provided a good tool to support her chemistry instruction.

The pacing guide has Gizmos embedded in it, so those are the Gizmos that I’m trying to use the most. That’s a beneficial thing, having those Gizmos embedded so I’ll know this will be helpful. I can look at the alignments and sometimes even the worksheets that go with the Gizmos works well with what I’m doing.

Irene’s response regarding the Gizmo’s correlations with the district’s pacing guides was less positive.
I am aware [of these correlations], but none of it influences either of my two classes [chemistry honors and zoology honors]. The standards are not as evenly matched when you’re talking about chemistry, and again, zoology [compared to biology]. So it’s not as, I guess, helpful as, say it would be for biology. I think that it’s great for biology, just not as good for the other subjects. I think that they can still use some more modification.

To summarize, in contrast to the high-and medium-Gizmo using teachers, Alberta and Marie experienced some challenges when they participated in the initial training sessions. When asked about the other project management services, each teacher was familiar with the Gizmo alignments for their respective subject area. However, Alberta expressed her displeasure with the abundant resources provided by the district versus the limited amount of time to use these instructional tools appropriately. Irene complained that the Gizmo alignments for her disciplines were not evenly matched to the biology honors and zoology honors courses. The three participants in this category indicated that they were not familiar with the opportunity to participate in the student-teacher Gizmo modeling sessions. In addition, they were not aware of the Gizmo mentoring program at their respective schools. The next and final section will provide a summary of the findings and commentary in this section.

**Summary**

This section examined the viewpoints of science leaders and teachers pertaining to the professional development strategies used to support their Gizmo implementations. The analysis of the interview data provided the opportunity to evaluate the factors that influenced the perspectives of Gizmo users and their leaders. Arnold and Charles, the district’s science leaders, commented on the professional development services provided by the district’s Gizmo project manager. Arnold and Charles agreed that science teachers should take advantage of these services. Nevertheless, some participants from the high user group indicated that because they felt that the use of Gizmos was intuitive, it is unnecessary to participate in the
additional professional development services. A popular instructional resource, of which many of the users have taken advantage, includes the Gizmo alignments to the district’s curriculum pacing guides. However, one teacher from the low user group indicated that too many programs are endorsed by the science leaders. Thus, she concluded that the time is insufficient for her to take advantage of these alignments. Participants from each category indicated that they were either not familiar with or had not had the time to participate in the student–teacher Gizmo modeling sessions or mentoring program.

The following section of this analysis considers the influence of student engagement in their science instruction with the inclusion of simulations.

**The Influence on Student Engagement**

This section considers the influence of the use of simulations to promote student engagement for inquiry-based science instruction. The literature review for the present study noted that the teaching and learning of science in most U.S. classrooms is characterized by teacher lecture and discussion approaches (Weiss et al., 2001). However, the National Science Board (2002) found that students may be learning science without actually understanding the subject. Since the inclusion of technology provides a great possibility for students to develop a deeper knowledge of science topics, it was important to gain a meaningful understanding of this concept. Specifically, the interviews with science leaders and teachers highlighted their perspectives regarding how their students’ engagement in learning science is influenced by the use of simulations. The data analysis for this section considers the responses of the district’s science leaders and those teachers who consider themselves to be high, medium, and low users of simulations.

**Science leaders’ perspectives on student engagement.** The interviews offered insight
into the leaders’ expectations regarding the level of student engagement when using simulations to enhance science instruction. The district science leaders, Arnold and Charles, indicated both quantitatively and qualitatively how they judged the influence of this innovative instructional tool on student participation. Arnold explained how he has judged student engagement quantitatively.

And so what we’ve seen anecdotally is that even using Gizmos badly is associated with student gains in learning, as demonstrated on semester exams and the end of course exams, when compared to not using Gizmos at all. And of course, implementation with fidelity shows us greater learning gains. Of course, we know that that’s only correlated because the kind of people who tend to do things with fidelity are the kind of people who tend to do anything with fidelity. Consequently, their outcomes tend to be better.

In the course of parsing out this data for my supervisor, I analyzed the Gizmo usage reports and determined the number of student log-in and student views. This information verified the level of student engagement, with the simulations, in each teacher’s class.

Charles explained his rationale for providing simulations to enhance student engagement for troublesome science topics.

The topic that I am considering is Natural Selection. There are many simulations that get at the concept of natural selection and cover evolution. For students, especially in Florida, teaching evolution can be a challenge at times. The simulations provide the opportunity to see that evolution really does have a scientific and even mathematical basis. And they are able to collect data in a nonthreatening experience. It helps them [the students] see the true biological definition of evolution and explains a natural phenomenon. This is great for students because I think one of the biggest difficulties in anyone’s conception of evolution or natural selection is that they don’t understand deep time and they don’t know what 1,000 years really is. They don’t know what 10,000 years is. They certainly don’t know or can’t conceptualize what 1,000,000 years is. And by using a simulations, it can replicate 1,000,000 years.

In summary, the leaders provided two different perspectives regarding the importance of the use of simulations to encourage student engagement in science. Arnold provided a quantitative explanation when he discussed the influence of using Gizmos on positive assessment results. Charles, on the other hand, offered a qualitative rationale by describing how the use of simulations encourages student engagement when teaching a troublesome science topic.
this in-mind, it seems beneficial to distinguish each teacher’s view of the use of simulations to engage their students. The next sub-section considers the perspectives of the high Gizmo users regarding their perspective of students’ engagement when simulations are incorporated into their science instruction.

**High Gizmo users perspectives on student engagement.** The high Gizmo users include Jane, Rosalind, and Tanya. In the previous sub-section, I mentioned Arnold’s and Charles’ rationale for the encouragement of the use of simulations to support science instruction in their school district. The semi-structured interviews provided the opportunity to learn about the point of view of each high Gizmo user regarding the level of student engagement in their classrooms with this innovative instructional tool. Tanya expressed her support of the use of simulations to encourage student inquiry.

Well, the inquiry–based activities are really what get the kids interested and excited about doing science. That is what helps them to relate things to what’s really going on in their own lives. They are not going to learn much science if they aren’t enjoying it as they go along. They’re just following and trying to get by.

However, when you put those tools for inquiry [simulations] into their hands, that’s what really helps them to understand it [the science concept]. What is even more important, in my view, is for the students to enjoy science. I try to do that through a variety of different ways. Gizmos are one of those tools that are fabulous because they [the students] are so used to technology. So they [the students] relate to it [the simulations] really well.

Jane agreed with Tanya when she noted that the use of simulations has provided an excellent means to encourage student involvement for inquiry-based science activities. However, she also mentioned that her students have been slow to adapt to this mode of instruction.

I like for my students to be able to think and answer questions and come to conclusions on their own and to discover knowledge on their own. This [strategy] is what is emphasized with inquiry. However, students are hesitant and resistant to do this [inquiry-based learning].

At this level, in high school, if they [the students] haven’t had it [use of simulations] before, they’re resistant to anything that isn’t fairly rote. They’re resistant to open-ended
[questions]. It makes them uncomfortable, and so, by using certain activities with the Gizmos, it shows them that they can come to a certain understanding of a concept without someone telling them, “This is where you’re going. This is what you’re getting.”

I still have to lead them a lot of times because they are very, very unsure and resistant and hesitant to do anything that doesn’t provide the answer. They want someone to tell them, “Is this right, is this the answer?” instead of exploring and finding out for themselves.

With the use of simulations, they [the students] have to explore and find out for themselves. I think that it makes them uncomfortable because there are expectations regarding what they [the students] need to be doing.

Similar to Arnold’s response, Rosalind focused on her students’ performance on the state’s high stakes exams as a result of her biology students’ involvement with simulations.

I think it [the use of simulations] helps the kids think for themselves. I think that’s probably the biggest thing. I think that it helps them to become independent learners. I can justify this by looking at their test scores. My kids scored the highest in our school on their [Biology] End of Course (EOC) exams and then they actually scored fourth in the district on their EOCs.

I was blown away. I had no idea what to expect because the EOC was brand new. I think that the EOC for Biology is very inquiry-based. ”Here’s the information, figure out what it means to find your answer.” Doing Gizmos, as well as other things, I believe really helped the kids think for themselves and be able to figure out the answers.

My students hardly ever ask me questions. They know better. They’ll ask, “What’s the answer to number 2?” I’ll respond, “I don’t know, but page 55 knows.” So they [the students] know that they’re going to have to figure out the answer anyway. I don’t dish out the answers to them. I think that has really helped to motivate them and figure out the answers independently.

To review, Tanya and Jane agreed with the science leaders that the use of simulations has encouraged a high level of student involvement in their classrooms. Jane, however, reported a high level of student resistance to the use of simulations. She explained that her students are uncomfortable with the use of simulations to learn new science concepts despite the fact that they tend to be tech savvy outside of their classroom environment. Rosalind agreed with Charles regarding the positive influence of simulations on student performance for the high stakes exams.
The following sub-section considers the viewpoints of the medium Gizmo users regarding their perspective of students’ engagement when simulations are incorporated into their science instruction.

**Medium Gizmo users perspectives on student engagement.** Carl, Gregor, Enrico and Sally represent the medium Gizmo user group for this study. Each participant presented their viewpoint regarding their students’ perceptions of the use of simulations to encourage science understanding. Carl indicated since his students are interested in technology, the use of instructional technology [i.e., simulations] is a natural fit.

They [students] love video games, they love their phones, so this [the incorporation of simulations] is a natural extension. The greater the level of student engagement [can be attributed] to the more interactive science activity.

The lower quartile students don’t seem to be reading the [science] book or listening to the lectures. For whatever reason, they either don’t understand it [the science concept] or they don’t have interest in it [the science concept]. So the more animated and interesting I can make it [instruction], the more interested they [the students] will become [in learning science].

Contrary to Carl’s opinion regarding the use of simulations to provide more bells and whistles into his instruction, Sally insisted that her student remain hesitant to take advantage of the simulations in her physical science class.

I have a resistance from some students who do not want to make the effort to get on a computer and complete their assignments [with the aid of the simulations]. But you know what, they [the students] make excuses for [not doing] other assignments, too.

For those students that are actually doing them [simulations], I can cover more material. Also, for those students who need reinforcement, I will pick out a couple of Gizmos and suggest that they complete the associated assignments for extra credit. My goal is for them to learn the [science] topic.

Gregor also mentioned that he encourages his students to use the simulations for reinforcement of a science topic.
When we do a simulation, I give everyone a handout that they have to complete and turn in for a grade. So if they’re not engaged in it [the simulations], they are not going to be doing the assignment or receiving a grade.

The opportunity to use simulations encourages a different type of instruction. It’s different [my instruction] than just standing up here [in front of the classroom] talking and having the students fill in the blanks [on a worksheet]. It is also different than having the students sit at their desk, look at their book and fill in the answers [in a workbook].

Enrico explained that the level of his students’ understanding of chemistry has increased with the use of simulations.

I think [that I consider incorporating simulations in my science instruction] because the kids are getting it [chemistry]. It doesn’t matter how much you do on the whiteboard, on the overhead [projector] and on a Power Point. Other than [providing] labs, this [the simulations] are actually hands-on [instruction]. They are doing it [the simulation]. They are manipulating it [the simulations]. I know that they are challenged by it [the use of the simulations]. Initially, they think, “Oh, this is easy. This is great. This is an easy grade.” [However], by the time you’re into [teaching] ionic and covalent bonds, it’s [the simulations] are pretty challenging.

To summarize this sub-section, Carl, Gregor, Enrico and Sally provided varied responses when asked about the level of their students’ engagement with the use of simulations. Carl, Gregor and Enrico explained how the use of simulations encourages student engagement to support their inquiry-based science instruction. Enrico indicated that his students have developed a better conceptual understanding of advanced science topics with the assistance of this instructional tool. Sally, however, explained that many of her students refuse to do any assignment on the computer and, therefore, refuse to use the simulations.

The next sub-section examines the perspectives on student engagement with the low Gizmo users.

**Low Gizmo users perspectives on student engagement.** The low Gizmo users include Alberta, Marie, and Irene. From this group of teachers, Marie presented the most positive viewpoint regarding the use of simulations to engage her students.
I like for them to see things, to get a visual. I can draw pictures, but it's not moving. This is the entertainment generation. They want to see things, they want to see these things moving. They want to have fun. The students want to play. They enjoy working with the simulations because they can manipulate the variables. I think that this is very important.

When I do a Gizmo, the students are more involved. There's a population of students that are visual learners and they want to see how it works. I think that it cements an idea in their head so much better.

On the other hand, Alberta mentioned that the level of her students involvement with simulations depends on their past experiences.

The level of student engagement using the simulations depends on their past experience. If they had a good past experience, they're going to do well with it. I have not modeled one in class. They have done it independently. And again, I have 130 students. I have 20 students that want to do them all the time and the remaining 110 students do not want to work with Gizmos. Do I think that they don't do it because they don't like it or they don't do it because they're not interested in it. These students would prefer to do other things.

Irene explained that she does not encourage the use of simulations to increase student engagement in her zoology and biology classes.

I use other instructional methods to encourage student interest and the development of conceptual understanding in my zoology and biology classes. I think that there are other methods for students to visualize a science topic. The student can use the book or videos. You don’t have to stick a kid in front of a computer.

To review, in contrast to the science leaders and a number of the high- and medium-Gizmo using teachers, Alberta and Irene admitted that they do not use Gizmos for their classroom instruction. A majority of their students have elected not to use the simulations based on their past experiences with this instructional tool. Alberta indicated that there is a small percentage of students who independently use the simulations and have exhibited a high level of engagement. This interest is based on their past experiences. Irene explained that she prefers not use computer assisted instruction for any of her students to support her biology honors and
zoology courses. However, Marie explained that simulations offer the opportunity for students to visualize a chemistry concept in real time. She explained that this generation of students requires a visual component to keep them motivated.

The next and final sub-section for this section of the data analysis will provide a summary of the findings and commentary for this section

**Summary**

This section considered the perspectives of the science leaders and teachers regarding student engagement in their science instruction when using simulations. The examination of the data from each interview provided the opportunity to compare and contrast the reasons that encourage or discourage student engagement with the use of simulations. The science leaders, Arnold and Charles, explained their thoughts regarding the importance of student engagement with simulations to encourage inquiry-based science instruction. Arnold explained that quantitative data supports the fact that those students who are engaged in the use of simulations perform better in their science assessments. The comments from one of the high Gizmo users, Tanya, supported Arnold’s statement regarding the notable increase in student performance on the high stakes exam, by attributing her students high engagement in the use of simulations. Charles explained that the development of conceptual understanding of difficult science topics requires the use simulations. A number of participants from the high, medium and low groups did agree with Charles regarding the importance of encouraging student engagement with simulations to promote science achievement. For example, Rosalind mentioned that the use of simulations in her chemistry classes guides students to become independent learners. Enrico mentioned that his students have developed a better conceptual understanding of advanced science topics with the assistance of simulations. Marie explained that simulations offer
the opportunity for students to visualize a chemistry concept in real time.

On the other hand, there were a number of participants from each group who disagreed with their leaders and a number of their colleagues regarding the importance of fostering student engagement with the use of simulations. Jane, for example, reported a high level of student resistance to the use of simulations in her biology classes. She explained that her students are uncomfortable with the use of simulations to learn new science concepts despite the fact that they tend to be tech savvy outside of their classroom environment. Sally explained that many of her students refuse to do any assignment on the computer and, therefore, refuse to use the simulations. Alberta explained that the level of her students’ engagement in using simulations is dependent upon their past experiences with this instructional tool. Irene indicated that she prefers to use the textbook or videos to engage her students in their biology or zoology instruction.

**Chapter Summary**

The qualitative data analysis, in this chapter, was presented to answer the research questions. *What factors contribute to science teachers’ ongoing use of simulations to support inquiry-based science instruction?* *What factors contribute to science leaders’ endorsement of the use of simulations as part of inquiry-based science instruction?* Analysis of the semi-structured interview questions highlighted science leaders’ and teachers’ insights regarding their awareness and understanding of the inclusion of simulations to support inquiry–based science instruction. Inductive code analysis was used for each interview, which provided an opportunity to discover patterns, themes and categories (Patton, 2002). Within each category, subtopics were considered that provided the opportunity to better understand the findings. I looked at the data in two different ways during the data analysis. After a priori categories were established in the Phase
I analysis, additional issues became apparent through the data analysis. These issues became the foundation for Phase II of this analysis.

Phase I of the analysis of the interview data examined the responses from the participants regarding those efforts that to some degree influence their experiences in using simulations. To emphasize this feature, my inquiry focused on those themes that established a consensus for the considerations of the science leaders and teachers experiences. The data analysis revealed four important themes that were germane to the science leaders’ and teachers’ practices. Those themes included constructivism, technology, professional development, and time. A majority of the participants in this study agreed with the first theme, the significance of the constructivist learning theory and its influence on inquiry-based science instruction. These participants also agreed that the inclusion of simulations to support science teaching is an important consideration. There were a wide range of responses to the questions regarding their experiences of the use of technology to support this innovative instruction. Nevertheless, a general consensus emerged that supported this practice. The following theme highlighted the participants’ involvement in the professional development experiences which complements the use of simulations in the science classrooms. Most of the teachers reported that they participated in the initial training sessions and took advantage of the alignments of their course specific curriculum, developed by the project manager. The analysis of the final theme, time, provided a strong consensus among many of the participants for this study. Most teachers indicated that the lack of time influences their opportunity to incorporate simulations into their instruction.

Phase II of the analysis of the interview data provided a deeper examination of the responses from the participants regarding those efforts that to some degree influence their experiences in using simulations. To emphasize this feature, my inquiry focused on those themes
that establish differences between concerns of the science leaders and the actual teacher experiences. I examined the data again to determine if there were different perspectives of the self-identified high, medium, and low using Gizmo teachers and their leaders. The first theme, influence of available technology, identified definite differences of opinion between leaders and teachers. The leaders indicated that the computer labs in the schools were to be used for instruction when they were not used for testing. However, the teachers reported that testing was ongoing and, therefore, the computer labs could not be accessed for instructional purposes. In the analysis of the second theme, the influence of the application of technology, several of the high-using teachers indicated that they use simulations instead of wet labs to support their science instruction. Again, this is not the intention of the science leaders. The third theme, the influence of the professional development strategies, also provided differences of opinion between the leaders and their teachers. The leaders indicated that the teachers should take advantage of the ongoing professional development services to fine tune their skills to adapt the simulations to their instructional practices. Nevertheless, several teachers from the high user group indicated that the use of the simulations was intuitive and, therefore, further support was not necessary. Several of the participants said they did not have available time in their schedules to take advantage of these services. The participants also provided differing opinions regarding the final theme, the influence on student engagement. Despite the endorsement of the leaders to incorporate simulations to engage students in science instruction, a teacher from each category indicated a preference not to use this instructional tool.

The final chapter provides a summary of this study, identifies conclusions that can be drawn from the study, and recommends suggestions for practice and for future research.
CHAPTER 5
SUMMARY, DISCUSSION AND CONCLUSION

Introduction

The concluding chapter presents a summary of the study and its findings from the collected data and the interview process. Specific emphasis focuses on the responses that address the research questions. The purpose of this study was to examine those factors that influence high school science teachers’ use of simulations to support inquiry-based science instruction. Interview data were also collected to address the study’s second research question that related to the role of the instructional leaders and how they influence this instructional methodology.

As the practice to integrate simulations into science instruction has become more common, it is anticipated that teachers and their leaders will consider adopting newer methods to teach science content knowledge and process skills. In particular, science teachers and their leaders must expand their understanding of how to best use technology-based simulations by participating in continuous professional development strategy opportunities. This chapter reviews the analysis of the findings from the science leaders’ and their teachers’ interview data and concludes with an examination of the study’s limitations and recommendations for future research and instructional practice.

Summary of the Study and Methodology

The education community has been confronted with student performance problems that have created a profound impact on current science instruction. The marriage between education and technology has provided one possible strategy to enhance science instruction for the 21st century. However, technology alone is not the universal solution (Salomon, 2002). Anecdotal
evidence from school districts has indicated that resistance to technology adoption occurs among a significant portion of educators and their students in the United States. A variety of studies have pointed out that technology has limited effect on those teachers not adequately and appropriately trained (Sandholtz, 2001). Science leaders and their teachers need to understand that the influence of participating in ongoing professional development strategies will assist in the incorporation of simulations into their inquiry-based science instruction.

The STEM Director from a large urban school district in the Southeast provided web-based simulations, Gizmos, to teachers in each of the district’s high school science departments. In addition, the STEM Director also appointed a project manager to provide follow-up support for the use of the simulations in the district’s 10 Title I high schools. It was important to understand the level of influence the ongoing professional development strategies had on the teachers’ implementation of the simulations.

With the expanding use of computer-based simulations to support inquiry-based science instruction, it is vital to understand those support structures for teachers that best facilitate the use of this instructional tool. There is a general agreement in the current literature regarding the nature of best practices regarding the value of technology to enhance instruction (Akpan & Andre, 1999; Bayaktar, 2002; Bell & Smetana, 2008; Chen & Howard, 2010). However, there is less agreement regarding the significant factors that are germane to the initiation and success of such innovative practices. Through this qualitative study, I attempted to find increased understanding of those practices that encourage the continuous use of simulations in support of inquiry-based science instruction.

To address the research questions, analysis of the semi-structured interview questions highlighted the decisions of the science leaders and teachers to incorporate simulations into their
science instruction. Initially, I selected the Means (1994, 1998) input-output model to analyze and evaluate the decisions to implement simulations. This model was designed to examine the considerations of incorporating technology supported reforms into practice. The literature indicates that implementations frequently fail due to the inadequate time constraints of having technology integrated as a regular component of teachers’ instructional practices (Means, 1998). Therefore, it was important for the focus of this study to be aware of those teachers who received continuous professional development support. It was also important to consider the decisions of those leaders who supported the sustainability of this innovative practice. This model provided the foundation for the analysis of my research data and the participants’ comments.

After the initial review and analysis of each participant’s responses to the interview questions, the analysis evolved to a two-phase model for this investigation. As described in the previous chapter, Phase I provided the opportunity to focus on the common views of science leaders and teachers that to some degree influence their experiences in using simulations. Phase II sought to develop a deeper understanding of each participant’s considerations to use this instructional tool by examining the differences in their responses. I re-examined the data to determine if there were differing perspectives of the self-identified high, medium, and low users of simulations and their supervisory leaders. The opportunity to compare and contrast participants’ responses provided a deeper assessment of the interview data. This interview process provided a unique opportunity to gain a comprehensive insight into each participant’s specific situation.

The next section will examine the research questions and the major conclusions from each question.
Review and Discussion of the Major Conclusions of the Study

The following section in this chapter discusses the five major conclusions that have been determined through two levels of data analysis. These findings are associated with the analysis of the study’s primary research questions. The first research question asked, what factors contribute to the science teachers’ ongoing use of simulations to support inquiry-based science instruction? The second research question asked, what factors contribute to the science leaders’ endorsement of the use of simulations to support inquiry-based science instruction? This section ends with a discussion of several new conclusions that emerged from this study.

The Use of Simulations Can Positively Influence Science Instruction

The interview data from the study’s primary research question reported a general consensus by the teachers in favor of this instructional tool. As mentioned in the literature, the use of computer simulations supports reform-based science teaching that is learner-centered and highlights the skills, viewpoints, and significance of scientific inquiry (NRC, 1996). A majority of teachers from the self-reported high, medium and low users of simulations indicated that the incorporation of this instructional tool has helped to support this transition. A number of teachers explained that they use simulations to reinforce their inquiry-based lab instruction. For example, one teacher mentioned that he uses simulations to reinforce lessons in his earth-space labs. He also indicated that this practice is especially beneficial for the students who are performing in the lower quartile. Another teacher indicated that he uses simulations to support the instruction of a missed assignment. This teacher grades the activity associated with the simulation in lieu of a student’s lab report.

Data used to consider the research sub-question came from the responses of the semi-structured interviews with the science leaders. During the interview process, both leaders Charles
and Arnold expressed their rationale for providing this instructional tool to the district’s high school science teachers. Charles explained that simulations provide support to incorporate three of the four STEM components: science, technology and mathematics. He added that the use of simulations offer students the opportunity to see, touch, and learn science in a new way. Arnold also expressed his rationale for being a proponent of the use of this system. Simulations, he said, provide the opportunity for students to engage in hands-on science, without having to be stymied by some of the physical impediments.

Within this study, the science leaders and their teachers were found to have positive views regarding the use of simulations to support inquiry-based science instruction. Both science leaders, Charles and Arnold, did warn that this instructional innovation was not to be used in lieu of providing a hands-on lab opportunity for the student. Charles, for example, indicated that the current trend in education is to move toward electronic learning formats for science students and away from the conventional modes of instruction. Arnold also expressed his appreciation for the versatility of simulations for science instruction but clearly stated that they are not the entire solution. However, the interview data revealed that not all teachers agreed with the intentions of the science leaders regarding the use of simulations.

Several teachers reported a preference for using simulations to teach their respective science courses instead of providing the traditional lab instruction. Gregor, for example, reported a preference for the use of simulations to teach an inquiry-based chemistry lesson as an alternative for providing the traditional lab instruction. Jane, also, expressed a preference for her students to use simulations as a substitute to their participation in a traditional earth science lab. In general, the use of simulations appears to have had a positive impact on teaching inquiry-
based science. Also, the science leaders appear to be proponents of the use of this instructional tool.

The first conclusion from the study is that the use of specific web-based simulations, Gizmos, can have a positive impact on inquiry-based science instruction. Interview data from the science leaders and teachers reported strong support for this instructional tool. Both groups of participants indicated that the use of simulations provides the opportunity to develop the conceptual understanding of a challenging science topic. The science leaders cautioned that simulations should not be used in lieu of the traditional hands-on labs; however, a number of science teachers reported a preference for the use of simulations.

**Technology Must Be Available to Support the Use of Simulations**

The interview data from the study’s primary research question reported an agreement among a majority of the teachers from each group of Gizmo users that technical challenges frequently influenced their support of the use of simulations. A majority of the teachers reported two major areas of concern regarding their available technology. The areas of concern included limited access to technology and Internet connectivity issues. A majority of the teachers indicated that scheduling time in their schools computer labs presents a challenge. In the study, Tanya and Gregor mentioned that as computerized testing has become the norm, their access to the school’s computer labs has been curtailed. Alberta added that the science department at her school has a designated computer lab. However, this computer lab is frequently used for testing, and her students’ access is limited. A number of the high, medium, and low using Gizmo teachers also shared the same view regarding the issue of Internet availability in their individual classrooms. High using teachers Rosalind and Tanya reported the challenges that they encounter
when they attempt to log into the network. Sally, a medium using teacher, mentioned that she is fortunate if most of her computers have a wireless connection 40% of the time.

The data used to consider the research questions came from the responses of the semi-structured interviews with the science leaders. During the interviews science leaders Arnold and Charles described the technology the district has purchased to support science instruction in the Title I high schools. A number of their comments regarding technology in their district were not compatible with the responses from the participating teachers in the study. For example, both leaders indicated that each school’s computer lab was available for the science teachers when testing is not occurring. However, a majority of the teachers reported that testing was almost always using the available time in the computer lab. The issue of the slow Internet connection at each site was also addressed by the science leaders. Arnold, for example, stated that most of the computer issues have been dealt with and corrected at the individual school sites.

As cited in the literature review for the present study, the recent and rapid distribution of Internet-related technologies in the schools has created the need to develop a more effective understanding of the nature and effects of these innovations. The data from the responses to the interview questions revealed different perspectives from the science leaders and their teachers regarding Internet issues which influence the use of simulations in their schools. Charles reported that the Title I schools were the first to begin building computer labs that were to be used for electronic testing. Gizmos were to be used in the computer labs when the labs were not used for testing. However, a majority of the teachers reported challenges regarding access to computers and the slow Internet connection. In general, teachers reported computer challenges which influence their use of simulations to support inquiry-based science instruction. However, the
science leaders maintain that their teachers do not have issues regarding their access to
technology to support the use of simulations.

The second conclusion highlights the availability of technology to use the simulations. Differences were determined between the science leaders and their teachers regarding this issue. Both science leaders described the computers that were made available to the science teachers in the Title I schools to access the simulations. However, a majority of the teachers reported challenges regarding access to computers and the slow Internet connection. The technology challenges reported by the teachers have influenced their use of the simulations to support their inquiry-based science instruction.

The Challenge of Time Influences Teachers Usage of the Simulations

The interview data indicated a general consensus among the science teachers regarding the issue of time that influenced their Gizmo usage. The teachers’ experiences aligned with the following categories: lack of time, downtime to install Shockwave and Flash onto the computers, and lack of planning time. Teachers from the medium and low user groups described their challenge in finding the time to access the computer labs to use the simulations. For example, Irene and Sally clearly stated that they do not have the time to access the computer lab due to their tight schedules. Alberta explained that even when the computer lab is available at her school, she has to devote many hours to the administration of mini-assessments and additional district-mandated requirements. Gregor also indicated that he is under time constraints with the amount of information that he is required to teach. Enrico described the wasted time that is devoted to installing shock wave and flash onto the school computers to run the Gizmo program.

During the interview process, science leaders Arnold and Charles expressed their thoughts regarding the issue of time. Both leaders explained that the issue of time should not be
an excuse regarding the teachers’ consideration of using simulations. Arnold, for example, clearly stated that the issue of not using Gizmos due to the lack of time is an unacceptable excuse on the part of the teachers. He further explained that the lack of time is more of a “perceived challenge” than a real challenge.

A number of studies cited in the literature review compared the influence of a computer simulation to a traditional laboratory experiment. For example, Boblick’s study (1972) attributed the success of an experimental group that used the simulations to the students’ opportunities to gather more data in a shorter time span. If this is generally the situation, then the issue of the planning time that it takes to incorporate simulations into the curriculum should be reconsidered by a number of the science teachers who participated in this study.

The third conclusion focuses on the issue of time that influences the teachers’ use of the simulations. The interview data revealed that one science leader, Arnold, believed that the lack of time is an unacceptable excuse on the part of the teachers for electing to not use the simulations. The “perceived” challenge that Arnold mentioned was in direct contradiction to what the teachers discussed. The challenges of time described by the teachers included the following categories: lack of computer time, downtime to install shockwave and flash onto the computers, and lack of planning time.

**Key Professional Development Strategies that Encourage Sustainable Simulation Implementation**

The interview data indicated a consensus among each group of Gizmo users regarding their participation in a number of opportunities provided by the district appointed project manager. Rosalind, Tanya and Gregor indicated that because the use of Gizmos was intuitive, they did not find it necessary to participate in the additional professional development services.
The Gizmo alignments to each of the course specific pacing guides were identified as a well-accepted resource that was developed by the project manager. Each teacher further emphasized that they have taken advantage of the alignments for their respective areas of instruction. Many of the teachers also mentioned that the alignments have provided an easy instructional tool to integrate particular simulations into their instruction. A number of the participants from each user group mentioned that they were either not familiar with the ongoing professional development opportunities or did not have the time to participate in the services. The teachers from the low using Gizmo group said that they were not aware of the student-teacher modeling sessions or mentoring programs that were available.

To address the study’s second question, responses from the interview data addressed the science leaders’ support of the project manager and the accompanying professional development services. Science leader Arnold pointed out that the teachers can have numerous excuses for not incorporating simulations into their science lessons. However, the project manager was able to systematically overcome these objections through the support that he made available. For example, Arnold explained that the project manager was able to manage some of those obstacles by providing student-teacher modeling sessions. He attributed the gain in both the teacher and student usage of the simulations in the Title I schools due to the services which have been provided by the project management program. Charles also indicated that the project manager’s support of a site-based Gizmo mentoring program has also proven to be successful. He also indicated that there has been a direct correlation between high usage and high scores on the state science exams.

The literature review for the present study indicated that the teacher’s ability to integrate the use of simulations into instructional practice is a central theme of concern identified in a
number of studies (Adelman, et. al., 2002; Flick & Bell, 2000; Ronen & Langley, 2005). Foti and Ring (2008) explained that “simulations are squarely in the intersection between educational change and technological development” (p.104). However, this mode of teaching is only as powerful as the teacher who effectively supports this instructional method. Teachers must have the skills to provide the most appropriate instructional strategies to incorporate simulations into their inquiry-based science instruction. Also, science leaders must provide the necessary professional development services to support this implementation. In general, the interview data indicated a strong agreement between both science leaders regarding the importance of providing ongoing professional development services. The science teachers reported a consensus with their leaders regarding participation in the initial training sessions and the value of the alignments of the simulations to their course specific curriculum guides. However, the teachers differed in their participation in the ongoing, available professional support opportunities.

The fourth conclusion involves the significance of professional development strategies to support the sustained use of simulations. Data from the science leader interviews revealed a number of explanations regarding the ongoing support strategies provided by the appointed project manager. Charles indicated that he has determined a direct correlation between high simulation usage and high scores on the state science exams. Arnold explained that the project manager was able to systematically overcome the objections of the reluctant teachers by providing initial training sessions, alignments of the simulations to the course specific pacing guides, and teacher-student simulation modeling sessions, to name a few. Despite these offerings, a number of the teachers stated that they were either not familiar with the ongoing professional development opportunities or did not have the time to participate in these services.
Student Engagement in Inquiry-based Science Instruction is Positively Influenced by the Use of Simulations

As mentioned in the literature review for the present study, students with positive attitudes toward science are more likely found in classrooms that use innovative teaching strategies (Myers & Fouts, 1992). The examination of the interview data from the study’s first research question reported a general consensus among the teachers regarding the positive influence of simulations on student engagement. A number of participants from the high, medium and low using groups expressed the importance of encouraging student engagement to promote science achievement. For example, Rosalind mentioned that the use of simulations in her chemistry classes encourages students to become independent learners. However, there were also a number of participants from each group who disagreed with the importance of encouraging student engagement. For example, Sally explained that many of her students refuse to do any assignment on the computer and, therefore, refuse to use the simulations.

To further address the research questions, an examination of the interview data provided an understanding of the science leaders’ considerations regarding the level of student engagement with simulations to advance inquiry-based science instruction. Arnold, for example, explained that quantitative data confirms the fact that those students who are engaged in the use of simulations perform better on their science assessments. Conversely, Charles offered a qualitative rationale by describing how the use of simulations encourages student engagement when teaching troublesome science topics.

The importance of student engagement in science instruction was mentioned numerous times throughout the literature review. Chen and Howard (2010) indicated, “technology holds great potential for students to develop deeper knowledge and execute reflective thoughts by the
specific tasks that they otherwise will not have access to” (p. 133). Through the analysis of the interview data, it was certainly clear that science leaders Arnold and Charles understood the importance of student engagement with simulations to encourage inquiry-based science instruction. In general, a majority of the high, medium and low users also agreed with the importance of using this instructional tool to promote science inquiry. However, there were also a number of teachers that insisted that their students prefer not to participate in any computer-based instruction.

The fifth conclusion involves the importance of student engagement with simulations. The interview data revealed a clear understanding on the part of the science leaders, Arnold and Charles, regarding the significance of student engagement to encourage inquiry-based science instruction. In general, a majority of the teachers agreed with their science leaders concerning the positive influence of simulations in their science classrooms.

The overall conclusion of this study is that the use of simulations requires a multi-faceted approach to ensure sustainability. As noted, science leaders must continue to encourage the high, medium, and low users of simulations to consider the ongoing use of this instructional tool. Also, science teachers must do their part to ensure the successful implementation. As noted, the availability of technology must be a major consideration. Teachers must have access to computers with reliable Internet connectivity. Two notions of time emerged in the interview data. Ample time must be afforded to access computers both in the classrooms and in the schools’ computer labs. Sufficient planning time must also be available to enable teachers to decide how to best incorporate simulations into their instruction. Teachers must consider participating in the ongoing professional development strategies that the district has made available. For example, teachers should take advantage of the opportunity to participate in
student-teacher modeling sessions. The further development of the mentoring program at each site should also be considered. Hopefully, if all of these factors are in place, the level of student engagement with simulations will encourage the sustainability of this educational innovation.

**Limitations of the Study**

A number of limitations of the study should be pointed out, as they could possibly influence the results and the sense-making using the results. These limitations in this qualitative study include the researcher’s potential bias, the use of the in-depth, phenomenological interview process, the selection of the settings for this study, the selection of the participants, the focus on one way of putting inquiry into practice and on the use of one kind of computer simulation. These limitations are discussed in this section.

My potential research bias could be considered a limitation for this study. Denzin explained, “Interpretive research begins and ends with the biography and self of the researcher” (Denzin, 1986, p. 12). Who I am determines, to a large extent, what I want to study. Having served as the state’s senior representative for ExploreLearning’s Gizmos for the past eight years, I have had many occasions to work with schools and school districts to support their integration of simulations into their science instruction. Through this collaboration, I have developed a great interest in understanding those strategies that are and are not successful. My perspectives as a researcher, the methodologies I choose, and the questions I ask in the interviews have evolved around my prior knowledge and experience.

Readers may consider the selection of the in-depth, phenomenological interviews as a limitation. A majority of the questions that I asked the participants were a result of the conversations that I had with each person and were not planned in advance. This process provided the flexibility for the science leaders, teachers and me to search for important details
and to discuss relevant issues. The goal of this method was to have participants reconstruct their experiences within the topic of the study (Seidman, 2006). Some may interpret this approach as a limitation. However, because the participants were asked to reflect on instructional practices that have been in place for more than five years, it was possible that their recollections were not completely accurate.

Patton (1990) considered the maximum variation sampling as a strong indicator of reliability and validity for the interview data. Maximum variation sampling refers to both sites and people. Because this study was conducted in a reform-minded, large urban school district, the selection of participants might not reflect the considerations of the educators in smaller school districts. Less advanced districts might not have the sophisticated infrastructure and financial resources to support a technology initiative such as the use of simulations. Also, because the study was limited to teachers in district’s Title I schools, the initial training sessions were provided five years prior to the time of the interviews. Therefore, this study relied on each teacher’s recollections of their experiences to implement a program that has been in place for a long period of time.

Participants for this study were selected by the district’s STEM Director. Because 25 teachers were initially selected from a pool of over 400 teachers, this selection represented a small purposeful-sampling of the potential participants. However, some might consider the selection of 25 teachers too small for this study. Because the majority of the participating teachers were in their mid-forties or older, the study was limited to seasoned teachers who might not be comfortable with the integration of technology into their instructional practices. Also, the study was limited to interviewing the teachers that had the advantage of ongoing professional development services backed by encouraging leadership to support their implementations.
Keys and Bryan (2001) described inquiry-based science instruction as, “including opportunities for students to identify and pose questions, design and conduct investigations, analyze data and evidence, use models and explanations, and to communicating findings” (632). Bell, Smetana and Binns (2005) further described inquiry as having four specific levels based on the information provided to the student at each point. The purpose of this study was limited to explore the use of simulations to encourage open inquiry. At this level, questions are investigated that are student formulated through student designed/selected procedures. This study did not consider the following levels of inquiry: confirmation inquiry, structured inquiry, and guided inquiry.

Bell and Smetana’s (2008) study of computer simulations determined that these dynamic representations have the potential to present theoretical or simplified models of real world phenomena or processes. For the purpose of this study, simulations are constructed with an underlying model that is based on some real-world behavior or natural/scientific phenomena (such as models of the ecosystem or simulated animal dissections). The significant standard is that the simulation include some interactivity on the part of the user, with a focus on inputs and outputs of the representation (D’Angelo, et al., 2013). Some sources distinguish between types of simulations, such as symbolic and experiential (Gredler, 1996). When a student is not an active participant in the program, the simulation becomes symbolic. When a student is an active participant in the program, the simulation becomes experiential. Because this study only focused on experiential simulations, some readers might consider this application a limitation to this study.

In summary, the limitations for this study include my potential bias as a researcher, the use of the in-depth, phenomenological interview process, the settings for the study, the selection
of the study’s participants, and the focus on one way of putting inquiry into practice and on the use of one kind of computer simulation. Although these limitations should be considered, they should not affect the value of this study’s results for understanding the circumstances in the school district I examined and for others interested in expanding the use of simulations in science instruction.

**Recommendations for Educational Leadership**

Recent dissemination of Internet-related technologies in schools has created the need to develop a more effective understanding of the nature and effects of online simulations that support the methodology of science instruction. When integrating technology effectively into this system, this process occurs at a high financial cost. The educational community looks to the science leaders to provide strong support for the investment in this project. It is therefore imperative for these leaders to have an understanding of specific, ongoing strategies that support the continuous integration of simulations. Concerns that surfaced in this study regarding this imperative must be considered by science leaders. These difficulties include the lack of available computers, the slow Internet connection in each school, the lack of adequate planning time, and the lack of participation by the teachers in a number of ongoing professional development strategies.

As documented in the literature review, inquiry-based instructional techniques have been unsuccessful in some science classrooms in part because school leaders have misunderstood this mode of instruction (Costenson & Lawson, 1986). A number of studies confirmed that principals make instructional decisions at their schools yet rarely take the lead in the areas of science and technology (Byers & Fitzgerald, 2002; Hallinger, 2003; Spillane, 2005). However, the attention given to STEM in recent years requires instructional leaders to bring direction to the understanding of ways to best support science literacy in the classrooms. The modern era
requires these leaders to address the instruction of science through the integration of technology and to provide ongoing support for this implementation. Most importantly, they must be capable of empowering their staff members and promoting resourcefulness.

It is the responsibility of the science leader to create and encourage a vision for science curricula that supports the use of innovative instructional technology tools, such as simulations. It has also become the instructional leader’s responsibility to support the resource needs for this implementation. Based on the interview data from this study, science leaders should consider the availability of functioning computers, Internet access, adequate planning time, and opportunities for the teachers to participate in the available professional development services.

It is the leader’s responsibility to support the resource needs for the implementation of simulations in the science classrooms. They must be aware that when the teacher does not have access to computers with Internet access, the implementation of simulations cannot occur. Likewise, when the Internet connectivity in a classroom is unpredictable, an additional barrier is established. One solution that the science leader should consider is to provide a site-by-site analysis of each school’s technology issues. If computers with reliable Internet access are made available, there will be a greater likelihood of a sustainable implementation.

Science leaders must consider a reassessment of the focus of training due to the advances in teachers’ computer self-efficacy and the abundance of excellent science simulations now available. The science leaders must take into account professional development strategies that support this transition process through the consideration of constructivist learning principles to encourage inquiry-based science instruction. The science leaders interviewed in this study have provided a variety of opportunities for their teachers to encourage and sustain the use of
simulations. It is important for these leaders to communicate these professional development opportunities with the site-based administrators in their school district. The site-based administration must be encouraged to promote the variety of opportunities for their teachers to participate in the professional development services offered by the project manager. Since a number of these services are provided within the classroom, there is no need for the school to incur the expense of hiring substitute teachers. One on-site project management service was reported as successful by those who participated in the student-teacher modeling session. A number of teachers stated that having the opportunity to observe the project manager using a specific simulation in a lesson was meaningful. The encouragement of the on-site mentoring program is another opportunity that the leader should promote. The chance to have a “go-to” person who is knowledgeable in the use of simulations ensures a quick response for those teachers who have questions regarding the execution of this instructional tool.

It is the responsibility of the science leaders to inspire teacher interest in the incorporation of simulations into their instructional practice. Perhaps by addressing the challenges that were described in this study, the leader can provide more strategic assistance for the use of simulations, the teaching of inquiry and the fostering of student engagement in science.

**Recommendations for Science Teachers**

As documented in the literature review, during the 1990s and early 2000s science teachers have been exposed to computer generated science simulations. During this timeframe, the major focus for professional development has been on educating teachers to become competent in operating specific software. Educators found that there was a low level of teachers’ computer literacy and a lack of user-friendly simulations. It is reported that this situation
continues to overshadow some training models (Ronen & Langley, 2005). A suitable training model should include a progressive format through long-term support that guides the teachers.

The use of technology to support new instructional methods and goals has held great potential for advancing science education in the classroom. The review of the literature for the present study suggested that with ongoing professional development teachers can learn to use inquiry-oriented technology-science innovation to improve students’ comprehension of challenging science topics (Guzey & Selcen-Roerig, 2009; Ronen & Langley, 2005; Sandholtz, 2001). Integration of simulations to support inquiry-based science instruction has also shown promise. It is the science teachers’ responsibility to insure that they have the essential skills to appropriately integrate simulations into their instruction.

As revealed in the interview data, it is the teacher’s responsibility to schedule the time to participate in the professional development services in order to develop a comprehensive understanding of the most effective use of simulations to meet their instructional needs. The following recommendations should be considered by the science teacher:

- Participation in ongoing support services: classroom coaching, student-teacher modeling sessions, and teacher observation with feedback sessions;
- Participation in discussions of best practices for the use of simulations to support inquiry-based practices in their professional learning communities;
- Use the methods suggested by the school district’s science leaders to support areas of deficiency in student performance on quarterly and annual assessments;
- Observe colleagues’ use of simulations during common planning times;
- Share suggested teacher developed lesson plans that incorporate simulations.
The school district for the present study has provided the support structure for a successful implementation of simulations for each science teacher. It is incumbent upon each teacher to take advantage of these instructional opportunities to insure an exceptional use of the simulations to support their inquiry-based science instruction.

**Recommendations for Future Research**

The purpose of this study was to develop an understanding of those factors that contribute to the continuous use of simulations in support of inquiry-based science instruction. Based on the data collected from the study’s interviews and its major conclusions, the following topics are recommendations for future research: use of web-based science simulations, available technology, and professional development strategies. Each topic will be further discussed in this section.

Overall, this study’s qualitative interview process was instrumental in developing an understanding of those factors that influence science leaders and teachers to consider the implementation of simulations. Future research should consider providing case studies of those self-identified high, medium, and low users to gain a more in-depth understanding of the use of simulations in support of inquiry-based science instruction. Another consideration for research should be to provide a quantitative analysis comparing high, medium and low usage of simulations to results on the state’s high stakes science exams. Perhaps, the results from this study will offer science leaders a significant rationale for the continuation of the simulation program’s implementation.

A second consideration for future research would be to provide continued explorations into the availability of technology in support of the use of simulations. As mentioned in the study’s literature review, the education community strongly considers investigations in the field
of educational technology research to provide a compelling rationale to support investment in these projects (Ringstaff & Kelley, 2002). Providing a quantitative analysis comparing the availability of technology with simulation usage would be a worthwhile consideration for future research. This study could offer important information for school districts’ instructional technology departments when considering the allocation of their funding resources. An additional consideration for research would be a case study regarding the use of simulations on the new Internet-based instructional tools, such as iPads. Because a variety of these new instructional tools are now being placed in numerous classrooms, providing the opportunity to understand how these tools influence the use of simulations would be compelling information for science leaders, curriculum leaders, and instructional technology leaders.

The final suggestion for research involves the opportunity to provide a more global understanding of professional development strategies in the support of the sustainable use of simulations. Continuous teacher support appears to be essential in order to sustain an effective technology-infused program using the current science curricula (Sivin-Kachala & Bialo, 2000). The present study only focused on those Title I schools that received ongoing professional development services. Future research should consider comparing the teacher and student usage of simulations between those schools that have available ongoing professional development services to those schools that have just have the availability of the initial training sessions. Despite the ongoing professional development opportunities that have been made available to the science teachers in this school district, a number of teachers identified themselves as low users of simulations. Future research should consider how to best motivate those teachers who are hesitant to incorporate simulations into their instructional practices. This study was conducted in a large, reform-minded urban school district with the resources to provide project management
services. Because many small and rural school districts do not have available funding for this type of support, an analysis of the comparison of usage between these districts would be beneficial.

In summary, three areas for future research were discussed in this section. The first recommendation is to increase understanding of web-based science simulations through additional research including a quantitative analysis. The second suggestion involves providing further inquiries regarding the available technology to support the use of simulations. The final recommendation is to expand research regarding professional development strategies to support the sustainability of the implementation of innovative teaching practices.

**Conclusion**

Through the use of the phenomenological point of view, this study attempted to gain an understanding of the ways science teachers effectively integrate Gizmo simulations into their science instruction and understand the manner in which the science leaders support this instructional resource for their schools. Through the analysis from the semi-structured interview data, the following conclusions emerged:

- The use of simulations can positively influence science instruction;
- Technology equipment and related services must be available to support the use of simulations;
- The challenge of time influences teachers’ usage of simulations;
- Ongoing professional development strategies to encourage sustainable simulation implementation must be available;
- Student engagement in inquiry-based science instruction is positively influenced by the use of simulations.
The suggestions for future research mentioned in this section can possibly increase the science leaders’ and teachers’ understanding of the best practices to support this instructional innovation.

Phase I of this study’s analysis provided the opportunity to focus on the consensus views of science leaders and teachers that to some degree influence their experiences in using simulations. It was determined that there was a strong agreement among those teachers interviewed concerning the lack of adequate, available computer access time. As noted, this issue influences all of the teachers’ experiences of using simulations. Despite this challenge, for the most part, teachers agreed with the importance of using simulations to incorporate inquiry-based instructional strategies into the curriculum. In addition, most of the participants explained that they have attended the initial training sessions and have utilized the alignments of the simulations to their specific curriculum guides.

Phase II of this study intended to develop a deeper understanding of each participants’ considerations to use the Gizmo simulations by examining the differences in their responses. Through the analysis of the interview data, I was able to compare and contrast those themes that influence the perspectives of the self-reported high, medium, and low users of simulations and their science leaders regarding the availability of technology in their classrooms. The science leaders described the technology the district purchased to support science instruction in the Title I high schools. While one leader indicated that most of the computer issues have been managed at the school level, a majority of the simulation users disagreed with his point of view. For example, the high, medium, and low users overwhelmingly reported issues with the Internet connections. Another difference in opinion between the science leaders and teachers was identified as the availability of computer labs to support science instruction. While the science
leaders indicated that each school’s computer lab was available for the science teachers when testing is not in session, most teachers indicated that this is generally not the case.

The struggle to have policy makers, educational researchers, and the education community as a whole concur on the proper method of integrating technological tools into the science classroom curricula continues to present a challenge. This study established that the use of online simulations offers a viable tool to provide inquiry-based science instruction. Science teachers must continue to understand and develop their skills to effectively use simulations. Science leaders must continue to work at supplying the necessary resources to support their teachers’ implementations. Only with the teachers’ complete understanding of the effective use of simulations and their leaders’ focused, continued support of this initiative will the sustainable application of simulations continue to evolve appropriately.
November 8, 2012

Dear School Principal,

My name is Arlene Fonda, and as a doctoral student at The University of North Florida in the department of Leadership, School Counseling, and Sports Management, I would like to request selected science leaders and science teachers on your campus to participate in a timely research study on the use of Gizmos to support inquiry-based science instruction. This research study is being supervised and has been approved by The University of North Florida Institutional Review Board (IRB) and Hillsborough County Public Schools (HCPS approval number: RR1213-384). Members of your faculty are being asked to participate in this study because of your school’s involvement with Gizmos and the support services associated with this implementation. By participating in this research, your science leaders and science teachers will contribute significant feedback on the use of these web-based simulations and on the support services that the district has enlisted.

The participation of your science teachers and science leaders is voluntary. The focus of this study is to develop an understanding of those innovative practices that encourage the sustained use of simulations in support of inquiry-based science instruction. Your science leaders and science teachers experiences are highly significant to me and for this study. All responses will be kept strictly confidential. In addition, all interview data will be maintained securely. Your science leaders and science teachers’ participation in this study will include being interviewed by me regarding their experiences using Gizmos in the high school science classrooms at your school. The anticipated time for the interview will be one class period, and it will be recorded and transcribed. All responses will be kept strictly confidential. In addition, all interview data will be maintained securely.

While there is no financial compensation for your school’s participation, science teachers and science leaders who agree to volunteer will have the chance to share their experiences with the educational community who are considering the use of Gizmos to support inquiry-based science instruction.

For all questions about having selected science teachers and science leaders from your school participate in this study, please contact Arlene Fonda (Phone: ; E-mail: ). Should you have any concerns regarding this study, please contact my faculty advisor, Dr. Kasten (Phone: ; Email: )

If you are interested in selected science teachers and science leaders from your school participating in this study that will consist of sixteen total Hillsborough County volunteers and are at least 18 years of age or older, please copy and paste this entire form into an e-mail, fill in your name and date, then send it to Arlene Fonda: , which will serve as your electronic signature and official consent to participate. Upon receipt of
this e-mail form, I will e-mail you verification that selected science teachers and science leaders from your school are officially participating and contact each participant to set up an interview time.

Thank you for considering your school’s involvement in this study. It is my hope that you choose to participate.

Arlene Fonda

University of North Florida Leadership, School Counseling, and Sports Management

Principal Consent Form

I, ______ (principal) _______, agree to permit science teachers and science leaders to be recruited at my school for the Use of Web-based Simulations to Support Inquiry-Based Science Instruction Study at _____(Name of School)___ in xxx xx, 2012. I understand that my teachers may, at anytime, without fear of any negative consequences, withdraw from this study.

________________________________   Date _____________
Principal Signature
Principal Phone Number ________________________________
Principal E-mail Address ________________________________

________________________________   Date _____________
Principal Investigator Signature
Please e-mail this form to Arlene Fonda or deliver a signed hard copy to Arlene Fonda,
UNF INFORMED CONSENT LETTER: SCIENCE TEACHER

Dear Teacher,

My name is Arlene Fonda, and as a doctoral student at The University of North Florida in the department of Leadership, School Counseling, and Sports Management, I would like to formally invite you to participate in a timely research study on the use of Gizmos to support your inquiry-based science instruction. This research study is being supervised and has been approved by The University of North Florida, its Institutional Review Board (IRB), and Hillsborough County Public Schools.

You are being asked to participate in this study because of your involvement with Gizmos and the support services associated with this implementation. By participating in this research, you will contribute significant feedback on the use of these web-based simulations and on the support services that the district has enlisted.

Your participation is voluntary. You may elect not to participate, or elect to stop your participation at any point during the research process without fear or penalty or any kind of negative consequence. The focus of this study is to develop an understanding of those innovative practices that encourage the sustained use of simulations in support of inquiry-based science instruction. Your experiences are highly significant to me and for this study.

Your participation in this study will include being interviewed by me regarding your experiences using Gizmos in your high school science classroom. The anticipated time for the interview will be one class period, and it will be recorded and transcribed. All responses will be kept strictly confidential by requesting that you select a pseudonym. In addition, all interview data will be maintained securely. Please note that there are no foreseeable risks associated with this study and you may elect to withdraw without penalty at any time.

While there is no financial compensation for your participation, teachers who agree to volunteer will have the chance to share their experiences with the educational community who are considering the use of Gizmos to support inquiry-based science instruction.

For all questions about volunteering for this study, please contact Arlene Fonda (Phone: __________________________; E-mail: __________________________). Should you have any concerns regarding this study, please contact my faculty advisor, Dr. Kasten (Phone: __________________________; Email: __________________________) or The University of North Florida’s institutional Review Board IRB Vice Chairperson Dr. Krista Paulsen.

Thank you for considering your involvement in this study.

Sincerely,

Arlene Fonda: __________________________

Dr. Katherine Kasten:

I ___________________________ (print name) confirm that I am at least 18 years of age and agree to participate in this study. A copy of this form was given to me to keep for my records.
Signature: _______________________________ Date: ___________________________
APPENDIX C

UNF INFORMED CONSENT LETTER: SCIENCE LEADER

UNF Informed Consent Letter and Form: Science Leader

XXXX XX, 2012

Dear Science Leader,

My name is Arlene Fonda, and as a doctoral student at The University of North Florida in the department of Leadership, School Counseling, and Sports Management, I would like to formally invite you to participate in a timely research study on the use of Gizmos to support your inquiry-based science instruction. This research study is being supervised and has been approved by The University of North Florida and its Institutional Review Board (IRB).

You are being asked to participate in this study because of your involvement with Gizmos and the support services associated with this implementation. By participating in this research, you will contribute significant feedback on the use of these web-based simulations and on the support services that the district has enlisted.

Your participation is voluntary. You may elect not to participate, or elect to stop your participation at any point during the research process without fear or penalty or any kind of negative consequence. The focus of this study is to develop an understanding of those innovative practices that encourage the sustained use of simulations in support of inquiry-based science instruction. Your experiences are highly significant to me and for this study.

Your participation in this study will include being interviewed by me regarding your experiences using Gizmos in your high school science classroom. The anticipated time for the interview will be one class period, and it will be recorded and transcribed. All responses will be kept strictly confidential by requesting that you select a pseudonym. In addition, all interview data will be maintained securely. Please note that there are no foreseeable risks associated with this study and you may elect to withdraw without penalty at any time.

While there is no financial compensation for your participation, science leaders who agree to volunteer will have the chance to share their experiences with the educational community who are considering the use of Gizmos to support inquiry-based science instruction.

For all questions about volunteering for this study, please contact Arlene Fonda (Phone: _____________________________; E-mail: _____________________________). Should you have any concerns regarding this study, please contact my faculty advisor, Dr. Kasten (Phone: _____________________________; Email: _____________________________) or The University of North Florida’s institutional Review Board IRB Vice Chairperson Dr. Krista Paulsen

Thank you for considering your involvement in this study.

Sincerely,

Arlene Fonda: _____________________________ Dr. Katherine Kasten: _____________________________

I _____________________________ (print name) confirm that I am at least 18 years of age and agree to participate in this study. A copy of this form was given to me to keep for my records.

Signature: _____________________________ Date: _____________________________
APPENDIX D
UNF IRB APPROVAL LETTER

MEMORANDUM

DATE: November 26, 2012

TO: Ms. Arlene Fonda

VIA: Dr. Katherine Kasten
      LSCSM

FROM: Dr. Krista Paulsen, Vice Chairperson
      On behalf of the UNF Institutional Review Board

RE: Review of New Project Revisions by the UNF Institutional Review Board IRB#369422-2:
    “Use of Web-Based Simulations To Support Inquiry-Based High School Instruction: An Analysis”

This is to advise you that your project, “Use of Web-Based Simulations To Support Inquiry-Based High School Instruction: An Analysis” was reviewed on behalf of the UNF Institutional Review Board and has been declared Exempt, Category 2.” Therefore, this project requires no further IRB oversight unless substantive changes are made.

This approval applies to your project in the form and content as submitted to the IRB for review. All participants must receive a stamped and dated copy of the approved informed consent document. Any variations or modifications to the approved protocol and/or informed consent forms that might increase risk to human participants must be submitted to the IRB prior to implementing the changes. Please see the UNF Standard Operating Procedures for additional information about what types of changes might elevate risk to human participants. Any unanticipated problems involving risk and any occurrence of serious harm to subjects and others shall be reported promptly to the IRB within 3 business days.

Your study has been approved as of 11/26/2012. Because your project was approved as exempt, no further IRB oversight is required for this project unless you intend to make a change that might elevate risk to participants. As an exempt study, continuing review will be unnecessary. When you are ready to close your project, please complete a Closing Report Form which can also be found in the documents library called “Forms and Templates” in IRBNet.

As you may know, CITI Course Completion Reports are valid for 3 years. Your completion report is valid through 8/11/2015 and Dr. Kasten’s completion report is valid through 3/30/2014. If your completion report
expires within the next 60 days or has expired, please take CITI’s refresher course and contact us to let us know you have completed that training. If you have not yet completed your CITI training or if you need to complete the refresher course, please do so by following this link: http://www.citiprogram.org/. Should you have questions regarding your project or any other IRB issues, please contact the research integrity unit of the Office of Research and Sponsored Programs by emailing IRB@unf.edu or calling

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within UNF’s records. All records shall be accessible for inspection and copying by authorized representatives of the department or agency at reasonable times and in a reasonable manner. A copy of this approval may also be sent to the dean and/or chair of your department.
APPENDIX E

SEMI-STRUCTURED SCIENCE TEACHER INTERVIEW QUESTIONS

Semi-structured Teacher Interview Questions

Background Questions:

1. Please share your pseudonym, teaching background, and age.
2. What science course(s) do you teach?
3. Describe the technology available in your classroom.
4. Describe how you incorporate inquiry-based strategies into your science instruction.

Teacher Learning-Related Questions:

1. What did you learn about integrating simulations into your science instruction during the initial 3 hour Gizmo training session?
2. What kinds of support did you receive when you first attempted to integrate Gizmos into your classroom instruction?
3. What are the factors that influence you to consider incorporating Gizmos into your science instruction?
4. Do you consider yourself a high, medium, or low user Gizmo user? Why?
5. Have you taken advantage of the Gizmo alignments to the state standards and district pacing guides? If so, how have these resources supported your classroom instruction?
6. Have you participated in classroom teacher/student modeling sessions provided by the district’s Gizmo Project Manager? If so, what did you learn from your participation?
7. Have you participated in classroom observations from the Gizmo Project Manager while using this program? If so, what did you learn from the feedback from this session(s)?
8. Have you received support from the school-based Gizmo mentor? If so, please describe the type of support that was provided.
9. Has your teaching changed as a result of your participation in these Gizmo support opportunities? If so, please describe this change.
10. Has the use of Gizmos changed the level of student engagement in your classroom? If so, please describe this change.
11. Please describe how you are using Gizmos to support your inquiry-based science instruction.
12. Do you consider yourself a low, medium, or high Gizmo user? Please explain your decision to incorporate Gizmos into your instruction.
13. What challenges have you encountered by including web-based simulations?
14. What benefits have you perceived from incorporating Gizmos into your inquiry-based science instruction?
15. Are there any support services of the Gizmo program that you would like to improve? If so, please provide an explanation.
16. Are there any additional comments that you would like to discuss regarding the use of Gizmos to support your inquiry-based science instruct
APPENDIX F

SEMI-STRUCTURED SCIENCE LEADER QUESTIONS

Background Questions:

1. Please share your pseudonym, teaching background, leadership background, and age.
2. What science course(s) have you taught?
3. Describe how you envision the incorporation of inquiry-based strategies into your science teachers’ instruction.

Science Leader - Related Questions:

1. Why have you elected to provide simulations to support your teachers’ science instruction?
2. How have you become aware of the opportunities of Gizmos and their potential impact on student learning?
3. How have you made the Assistant Superintendent aware of the value of simulations to support science instruction?
4. What is your role in supporting the Gizmo implementation in the district’s schools?
5. What factors led to your decision to provide a district project manager to support the Gizmo implementation in your Title I schools?
6. How has the project manager affected Title I teachers’ consideration of the use of simulations to support inquiry-based science instruction?
7. What technology have you made available to Title I schools to maintain the use of simulations for science instruction?
8. What will influence your decision to continue to provide Gizmos to support teachers’ inquiry-based science instruction in the future?
9. What has been the most successful experience regarding the influence of Gizmos to support inquiry-based science instruction in Title I schools?
10. What has been the most challenging experience regarding the influence of Gizmos to support inquiry-based science instruction in Title I schools?
11. What would you do differently if you had the opportunity to redo the first year of the Gizmo implementation?
12. What would you do differently for subsequent years of the Gizmo implementation?
13. What advice would you give to science leaders in other school districts regarding the first year of their Gizmo implementation?
14. What advice would you give to science leaders in other school districts regarding subsequent years of the Gizmo implementation?
15. Have your teachers’ instructional practices changed as a result of their participation in the Gizmo support opportunities? If so, please describe the change.
16. Can you identify a specific science concept that has been difficult for your teachers to teach but was made easier with a Gizmo or Gizmos? Please discuss this experience.
17. Are there additional support services that you could suggest that would be beneficial to support your Gizmo implementation? If so, please discuss these suggestions.
18. Are there any additional comments that you would like to discuss regarding the use of Gizmos in support of your teachers inquiry-based science instruction?
REFERENCES


President’s Committee of Advisors on Science and Technology (PCAST). (1997). *Report to the President on federal energy research and development for the challenges of the twenty-first century*. Washington, DC: PCAST.


Redding, C. (2007). *Does the use of go! Motion computer simulations affect the way in which students can represent their understanding of position, velocity and acceleration by graphing compared to traditional methods?* Unpublished manuscript, Department of Leadership for Middle Level Science, University of Pennsylvania, Philadelphia, PA. Retrieved from credding@mtps.com


BRIEF RESUME

ARLENE KORR

Education

2013  Doctor of Education in Educational Leadership  
       University of North Florida  Jacksonville, Florida

1998  Florida Certification, Educational Leadership  
       University of North Florida  Jacksonville, Florida

1976  Master of Education – Special Education  
       Kent State University  Kent, Ohio

1973  Bachelor of Arts – Elementary Education  
       Rider College  Lawrenceville, New Jersey

Experience

1999 to Current  Florida Senior Account Executive

       ExploreLearning – Charlottesville, VA

       Renaissance Learning – Wisconsin Rapids, WI

       HOSTS Learning – Vancouver, WA

1987-1999  Duval County Public School District

       Assistant Principal

       Exceptional Student Education District Specialist

       Classroom Teacher for Varying Exceptionalities

Current Professional Certifications - Florida

       Educational Leadership (All Levels)

       Special Education (Grades K-12)

       Elementary Education (Grades 1-6)