HOW CAN STUDENTS USE THE POTENTIAL OF TECHNOLOGY AND THE INTERNET IN AN ELEMENTARY SCIENCE CLUB AS THE CONDUIT FOR CONDUCTING SCIENTIFIC INQUIRY?

By

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A Dissertation submitted to the Department of Middle & Secondary Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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This dissertation is dedicated to:

My mother who inspired me to dream.
To my husband, Don, and my three children, (Loni Perse, Greg Bosseler, and Catharine Vale),
who never let me give in or give up.
To my five grandchildren (Amanda Perse, Christopher Perse, Catarina Vale, Cristina Vale, and
Claudia Vale who allowed me time-out to work on my dissertation.

Their love and pride in me remain unwavering.
ACKNOWLEDGEMENTS

...where water gushed and fruit-trees grew, and flowers put forth a fairer hue, and everything was strange and new. The sparrows were brighter than peacocks here, and their dogs outran our fallow deer, and honey-bees had lost their stings, and horses were born with eagles’ wings. (Browning, 1888, p. 95)

Like the Pied Piper of Hamelin led the children to a joyous land, I have maintained that all students can journey to a land where learning takes place in an environment that is nourished by planting the seeds of enlightenment and curiosity for a lifetime.

That same compass has guided me as I embarked upon this doctoral study, never imagining the endless challenges that lay ahead. Arriving at this world of academe has been triumph and struggle. I owe special gratitude to those who appreciated my noble efforts and allowed me to play “such sweet soft notes as yet musicians’ cunning never gave the enraptured air” (Browning, 1888, p. 52).

Dedicating this dissertation to my family members is showering them with love and appreciation for understanding my commitment and resolve for meeting lofty goals; thank you to my Mother, Don, Loni, Greg, Cassie, Amanda, Christopher, Catarina, Cristina, and Claudia.

My entire doctoral committee has served as role models. Dr. Penny J. Gilmer, my committee chair, has remained steadfast empowering me with endless support and affection. Dr. Nancy T. Davis, Dr. David F. Foulk, and Dr. Paul Ruscher have each contributed their own special expertise and advice.

Finally, I wish to acknowledge my fellow friends and colleagues in this noble profession—TEACHER.
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Engage: Asking a question. “As teachers of science we need to keep in mind that................................. 83
Explore: Satisfying curiosity. Staying on course, we continued to probe the idea of ......................... 84
Explain: Discovering new applications. The next meeting began promptly................................. 85
Elaborate: Expanding concepts. Continuing investigations of temperature found in....................... 87
Evaluate: Evidencing learning. I could refocus the investigation to take advantage....................... 90
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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AAAS</td>
<td>American Association for the Advancement of Science</td>
</tr>
<tr>
<td>AAUW</td>
<td>American Association of University Women</td>
</tr>
<tr>
<td>ACS</td>
<td>American Chemical Society</td>
</tr>
<tr>
<td>AETS</td>
<td>Association for the Education of Teachers in Science</td>
</tr>
<tr>
<td>BNCEE</td>
<td>Biscayne Nature Center for Environmental Education</td>
</tr>
<tr>
<td>CHAT</td>
<td>Cultural Historical Activity Theory</td>
</tr>
<tr>
<td>CAQDAS</td>
<td>Computer-Aided Qualitative Data Analysis Software</td>
</tr>
<tr>
<td>CET</td>
<td>Criteria for Evaluating Technology</td>
</tr>
<tr>
<td>EESAC</td>
<td>Educational Excellence School Advisory Council</td>
</tr>
<tr>
<td>EXPLORES!</td>
<td>Exploring and Learning the Operations and Resources of Environmental Satellites</td>
</tr>
<tr>
<td>FCAT</td>
<td>Florida Comprehensive Achievement Test</td>
</tr>
<tr>
<td>FETC</td>
<td>Florida Educators’ Technology Conference</td>
</tr>
<tr>
<td>FETC</td>
<td>Florida Educators’ Technology Conference</td>
</tr>
<tr>
<td>FLDOE</td>
<td>Florida Department of Education</td>
</tr>
<tr>
<td>FSU</td>
<td>Florida State University</td>
</tr>
<tr>
<td>GLOBE</td>
<td>Global Learning and Observations to Benefit the Environment</td>
</tr>
<tr>
<td>ISTE</td>
<td>International Society for Technology in Education</td>
</tr>
<tr>
<td>ITEA</td>
<td>International Technology Education Association</td>
</tr>
<tr>
<td>ITP</td>
<td>Instructional Technology Plan</td>
</tr>
<tr>
<td>MDCPS</td>
<td>Miami Dade County Public Schools</td>
</tr>
<tr>
<td>MDSP</td>
<td>Miami Dade Systemic Program</td>
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<tr>
<td>NCATE</td>
<td>National Council for Accreditation of Teacher Education</td>
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<tr>
<td>NCTM</td>
<td>National Council for Teachers of Mathematics</td>
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<tr>
<td>NCTET</td>
<td>National Coalition for Technology in Education Training</td>
</tr>
<tr>
<td>NETS</td>
<td>National Educational Technology Standards</td>
</tr>
<tr>
<td>NOS</td>
<td>Nature of Science</td>
</tr>
<tr>
<td>NRC</td>
<td>National Research Council</td>
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<tr>
<td>NSE</td>
<td>National Science Education</td>
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<td>NSES</td>
<td>National Science Education Standards</td>
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<tr>
<td>NSF</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>NSTA</td>
<td>National Science Teachers Association</td>
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<tr>
<td>PCK</td>
<td>Pedagogical Content Knowledge</td>
</tr>
<tr>
<td>PCkg</td>
<td>Pedagogical Content Knowing</td>
</tr>
<tr>
<td>QSR</td>
<td>Non-numerical Unstructured Data Indexing Searching and Theorizing Program</td>
</tr>
<tr>
<td>SERVE</td>
<td>South Eastern Regional Vision for Education</td>
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<td>SPEP</td>
<td>School Performance Excellence Plan</td>
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<tr>
<td>SSS</td>
<td>Florida Sunshine State Standards</td>
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<tr>
<td>StaR</td>
<td>School Technology and Readiness</td>
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<tr>
<td>START</td>
<td>Southeastern Teachers Are Revitalizing Teaching Through Technology</td>
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<tr>
<td>USDE</td>
<td>United States Department of Education</td>
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<tr>
<td>USI</td>
<td>Urban Systemic Initiative</td>
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<td>USP</td>
<td>Urban Systemic Plan</td>
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ABSTRACT

The principles underlying this qualitative study were to use technology as a resource to provide new opportunities for students to engage in the process of learning science through inquiry, and to engage in action research on my teaching. The setting was a science club for fourth and fifth graders in a summer school program. As a teacher and mutual stakeholder, I guided my students with my pedagogical content knowledge through interdisciplinary patterns of collaborative inquiry.

Set in a socially constructivist environment, this action research became the catalyst for my professional growth and fostered the growth of the learning community. My goals were to engage learners in the construction of their own understanding of science, technology, and the world in which they live. To ensure that students experienced scientific inquiry, conflicting pedagogies between the established school curriculum and my own constructivist methodology prevailed throughout the study.

Through socially constructed partnerships, stakeholder club members helped define the process of learning. Product-based simulations and strategies for scaffolding higher-level learning elicited inquiry-oriented and problem-solving skills using the Internet, thereby, enriching the curriculum while teaching students to synthesize information they found on the Internet and make a step towards becoming lifelong learners.
CHAPTER 1: PROMOTING INQUIRY USING TECHNOLOGY AS A LEARNING PARTNER

Unlike the objectivist, I do not understand truth to be lodged in the conclusions we reach about objects of knowledge. How could it be, since the conclusions keep changing? I understand truth as the passionate and disciplined process of inquiry and dialogue itself, as the dynamic conversation of a community that keeps testing old conclusions and coming into new ones.

—(Palmer, 1998, p. 104)

The ultimate objectives of this interpretive research study are to generate ways to motivate students in a science club and connect them with investigations using scientific inquiry and technology for learning. According to the Urban Systemic Initiative (USI) (1995), the scientist’s goal is to understand the natural world, while technology’s goal is to make modifications to meet human needs. Benenson frames the goals of science and technology stating, “Although the goal of science is to produce knowledge, the purpose of technology is to solve practical problems” (Benenson, 2001, p. 736). Benenson reminds us that modern technology does depend on science because scientific inquiry often provides the reliable knowledge to further the technological demands. However, some of the knowledge needed for technology is not scientific at all but unfolds from everyday experiences. All developments in science and technology occur in a social context. It should be noted that when the two interact, technology could drive the science. For example, the advancement of aviation stimulated the science of aerodynamics (Benenson, 2001). For the ultimate learning to take place, it is fruitful to weave science and technology in a complex web of interrelated ideas and activities. Roth (1998) maintains that teaching activities provide an integrated approach to learning science.

To best realize the attributes of technology as a learning partner, it becomes relevant to first establish pedagogy, aligned with the National Science Education Standards (NSES) (NRC, 1996). These standards emphasize a practical way of teaching and learning about science that reflects how science itself is done while emphasizing inquiry. Inquiry is therefore a way of achieving knowledge and understanding about the world (NRC, 1996).
Establishing a Pedagogy

The vision of the NSES (NRC, 1996) of K-12 students becoming scientifically literate has students engaged in the process of learning science. Sustained inquiry-based learning is at the heart of these National Standards, which places the learner at the center (NRC, 2000). In this process, constructivist theory provides me with a powerful perspective to recognize the attitudes and knowledge my student members bring into the learning environment. Bowen (2002) highlights the need for teachers to depart from their own frame of reference to that of their students. Central to my pedagogy, are the communicative relationships that I build individually or in groups with the members of my science club.

Constructivism shifts the focus of my teaching from that of a technical expert to that of a reflective practitioner (Peters, 1998). I have defined my mission to connect and integrate all pertinent aspects of science as curriculum and science as teacher. This is my pedagogical content knowledge (PCK), i.e., my knowledge of the subject matter for teaching, which includes the strategies I use to assist my students in learning (Peters, 1998). Integrated within this model is my knowledge of the students’ developmental levels and how they learn. My knowledge of the experimental context, or existing structure where the learning takes place, finalizes the key sources that I draw upon to teach and help my students learn successfully.

The first section of this chapter defines the critical components that form the basic structure for this research study, including: Scientific Inquiry, Social Constructivism, and Action Research. In the final section, Field Experiences of My Own, I share my experiences immersed in scientific research.

Scientific Inquiry

Scientific inquiry allows us to embrace the natural curiosity of learners following the National Research Council’s definition, “Inquiry is in part a state of mind—that of inquisitiveness” (NRC, 2000, p. xii). The natural curiosity of young children asking “why” or “what” is notably missing in a middle school classroom. The NSES (NRC, 1996) express valuable insights into ways to reestablish the curiosity and motivating habits of scientific inquiry. The classic definition of inquiry learning includes: learning patterns of discovery, actively participating to solve problems, and personally developing subject matter concepts. Engaging learners in inquiry-based instruction can be dated to John Dewey’s authentic, collaborative
investigations (Crawford, 2000). According to the NSES (NRC, 1996), essential features of science inquiry include the following:

1. Learners are engaged by scientifically oriented questions;
2. Learners give priority to evidence as they develop and evaluate explanations obtained through accurate data;
3. Learners formulate explanations from evidence, relating what is observed to what is already known;
4. Learners evaluate their explanations ensuring that connections are made between the results and scientific knowledge; and
5. Learners communicate and solidify an empirically based argument. (NRC, 1996, p. 25)

Set in a constructivist classroom, scientific inquiry and technology can become a powerful team. The U.S. Department of Education Secretary, Rod Paige, spoke at a national summit on education and said, “It’s not enough now to have computers and Internet connections in schools; it’s time for the next step” (Krebs, 2002, p. 1). He challenged educators looking at the power of technology to ensure all students have the education to succeed in a knowledge-based digital age. Paige supported a move from a focus that closes the digital divide to one that enhances learning through technology in the classroom (Krebs, 2002).

The first priority of science education is basic science literacy so all students can make connections and understand the nature of science. The spirit of the NSES requires teachers to shift from depending on their textbooks to using them as a tool and reference. The NSES call for dramatic changes in education including: utilizing new ways of teaching and learning about science, using performance assessment, implementing better teacher education, and encouraging education-business community partnerships (NRC, 1996). The first standard, Standard A, clearly states, “Teachers of science plan an inquiry-based science program for their students” (NRC, 1996, p. 22). The principle, “Inquiry is shaped by human values” (Guba & Lincoln, 1989, p. 100), defines the basic emphasis of these standards, which illuminate the application of inquiry as a teaching and learning goal.

In classroom learning environments, teachers can utilize inquiry without the aid of technology. However, by emphasizing the NSES, which promote the application of inquiry, technology has the potential to expand creative projects and to demonstrate research, investigations, and knowledge (NRC, 1996). Students become engaged in inquiry, as they
become aware that scientific knowledge is neither complete nor static, and that it has no boundaries.

**Social Constructivism**

Social constructivism encourages teachers to work from students’ prior knowledge, interests, and questions so that everyone becomes actively involved in their learning. Many theorists embrace the concept of aligning social constructivism with inquiry. Bybee (2000) emphasizes this idea by quoting Dewey, “Only by taking a hand in the making of knowledge, by transferring guess and opinion into belief authorized by inquiry, does one ever get a knowledge of the method of knowing (Dewey, 1910, p. 125)” (Bybee, 2000, p. 26).

Solomon (1987) describes extended research that examines existing dual domains for constructing and storing science knowledge. This Two Domain theory takes into account the primary socialization and the secondary socialization influences children continuously construct and maintain. The socially acquired, or life-world knowledge, seeks reaffirmation; thereby, making it very durable and resistant to change. For example, students express this through early childhood and peer-group emotional attachments. In contrast, is the process of secondary socialization into the school-acquired knowledge (Solomon, 1987)? The symbolic school knowledge influences the learning and motivation in the school environment; realistically, it is not as easy to retrieve. Solomon collaborates with other research scientists documenting the difficulties of crossing over between the two domains of knowledge. Solomon’s insight cameoed, “Our pupils are strongly social beings for whom the teaching of a rigidly insulated science which makes no contact with the everyday context is simply not an option” (Solomon, 1987, p. 79). Throughout my teaching and research studies, I have attempted to weave the two domains together with some success. The “club” format gave me a platform, which was unlike a scientific setting (classroom) or the subjectivity of a social setting, but a unique combination of the two.

**Action Research**

I set this action research in a social constructivist environment to foster the growth of a learning community. This method allows me to question my practice and to act upon my thoughts about teaching. Gilmer (1997) defines action research as, “…a strategy that assists educators in solving problems, enhancing decision making practices and viewing situations through critical thinking” (p. 8). Through action research, the teacher becomes a reflective practitioner who creates knowledge about teaching and learning through the practice of teaching.
This type of study is unique because of the perspectives the teacher contributes as an active participant to the study. Black and Stave (2001) provide the *Action Research Cycle*, which became the working model for my research.

**Field Experiences of My Own**

As part of the Florida State University (FSU) doctoral program, I was fortunate to experience scientific inquiry and the processes of science through authentic research (Bosseler, 1999a). My initial authentic research took place at a local botanical garden, assisting in the collection and tagging of critically endangered plants. Although I only had a limited actual field experience, it provided me with a threshold for change in my personal and professional attitudes toward student learning. Personally experiencing data collection and analysis with a “real” research conservationist scientist helped direct my own journey of learning. I benefited from working side-by-side with a scientist and experiencing authentic scientific research, consequently, reassuring me that my students would benefit from similar investigations.

There is a link between plant endangerment, invasive exotics and loss of habitat due to construction and a growing population. The Fairchild Tropical Botanical Garden (FTBG) (2004) states, “The region's ecosystems are disrupted by expanding urbanization, agriculture and invasive exotic plants, yet urban South Florida depends fundamentally on these ecosystems” (¶3). This botanical garden in which I worked is the only national organization solely dedicated to the conservation of plant species. It is the main research institution engaged in studies of local endangered species and their reintroduction in South Florida.

We conducted our research through cultivation, propagation, and reintroduction of endemic plants into protected areas. We took care to maintain genetic origin because plants are genetically different. At the start of my field experience, I wrote in my journal:

> Saturday, and I am on my way to the Keys, involved as a scientist at last! I can share the true meaning of contextual learning, as I become a part of the efforts to expand ex-situ conservation collections of the *Opuntia spinosissima* plant. As the morning dawns, I check and recheck my gear. The world of the true adventurer is foreign to me, i.e., backpacking and experiencing the great outdoors. This was going to be a scientist’s field trip; I knew this for sure! (Bosseler, 1999a, p. 100)

Ash and Klein (2000) assert, “Making meaning from experience requires intermittent reflection, conversations, and comparisons with others, interpretations of data and observations, and applying new conceptions…as one attempts to construct new mental frameworks of the world” (p. 228). Scientific exploration and inquiry contribute to these constructions, as stated by
Glasersfeld (1993), “Successful thinking is more important than ‘correct’ answers. Successful thinking should be rewarded even if it was based on unacceptable premises” (p. 33). I continued in my journal, “Finally, at this point, I was involved in the data collecting, either measuring or recording. I reflected how learners must feel when they are withheld and then finally given permission to actively participate in science! Meaningful learning!” (Bosseler, 1999a, p. 102).

My second authentic research took place at a local nature center, enhanced by a talented and well-informed horticulturist. He suggested that I study the moth and butterfly species in the Park, comparing them to the species found in our Life Lab butterfly garden at school. The research I conducted keyed right into my classroom and our garden. My students were part of this research:

The parsley, carrots, and dill growing in our garden are good sources for the swallowtail butterfly. …I collected leaf samplings of the majority of butterfly inducing plants in order for my students to become plant detectives, classifying those plants common in both areas. Incidentally, when we did take our scientific field trip to the Park, the students felt right at home with the butterflies and plants they observed. Upon our return, the Life Lab garden became our on-site laboratory! (Bosseler, 1999b, p. 6).

Although the constant movement of the butterfly made it difficult at times, we were able to identify numerous shared plant selections and evolving patterns. Participating in this kind of research helped me experience the real world of a scientist. My students, too, were developing ideas about the processes involved in scientific and discovery learning.

Exploring Educational Reform Using Technology

Many states are presently preparing grade-level standards in science to implement by 2007. It takes time to understand and teach science concepts and 25 minutes a day is not doing it (Tweed, 2004). Candidly stated,

In spite of many reform attempts, the 20th century has ended with virtually the same curriculum it started with—a curriculum that does not effectively teach what students most need to know and that does little to improve student achievement in science, mathematics, and technology (AAAS, 2000a, p. 1).

Society has an obligation to provide an education that can prepare students to meet the challenges of society. Remarks Paige (2001):

America needs inventors, engineers, doctors, computer designers, and scientists. We need botanists, veterinarians, chemists, astronomers, and naturalists. But, in order to pursue these careers, our children need an excellent grounding in science and right now, our system is not delivering it. (p. 1)
Outdated Pedagogy

The model of learning in the past was a “factory model” (Pepper & Rowland, 2000), characterized by top-down monitoring by management and curriculum design, rather than by relying on the abilities and knowledge of educators in the classroom. In September, 1996, the National Commission on Teaching and America’s Future set the following goal, “By the year 2006, …America will provide all students in the country with what should be their educational birthright: access to competent caring teachers” (Pepper & Rowland, 2000, p. 45).

Despite a plethora of research on learning and instruction, little change has occurred in school science over the past four decades (Roth, 1998). Change can occur when reforms emerge at the classroom level, grounded in teachers’ efforts to establish a student-centered, open inquiry format. We need a new curriculum that prepares learners for a “changing future.” Meeting tomorrow’s challenges requires using technology in education, by doing things differently and appropriately for all learners in the new millennium (Riel & Fulton, 2001). According to Riel and Fulton (2001), key ingredients found most often on lists of tomorrow’s skills include the following, “(a) to think quickly, (b) to adapt to changing conditions, (c) to build alliances to address large-scale challenges, and (d) to work comfortably in a global information environment” (p. 519).

Current Standards

The nation’s goal of achieving scientific literacy focuses on the Standards as a unifying force in our society. The NSES and Florida’s Sunshine State Standards (SSS) call for dramatic changes throughout our school system, but their implementation is not a simple one (NRC, 2000). I introduce the progression for implementing both NSES and the National Education Technology Standards (NETS) in this next sub-section with accompanying background to assist in following their development.

Science Standards

The American Association for the Advancement of Science (AAAS) developed Project 2061: Science for all Americans (1989) with administrators and K-16 teachers to guide and develop a vision for educators. This collaborative effort included the National Council for Teachers of Mathematics (NCTM) and the National Research Council (NRC). Science, mathematics, and technology occupy the heart of this multistage, long-term developmental challenge. The aim of Project 2061 is to help the nation achieve scientific literacy. Benchmarks
for Science Literacy (AAAS, 1993) states what all students should know and be able to do in science, mathematics, and technology. Together, these two publications include a common core of lasting knowledge and skills essential to adulthood.

Building on the previous Project 2061 publications, Project 2061: Designs for Science Literacy (AAAS, 2000b) outlines a curriculum reform aimed at creating effective strategies for teaching what students most need to know. This book provides guiding principles and practical advice to help educators reconfigure the entire K-12 curriculum. One premise of this project encompasses the idea that the present curriculum lacks coherence and sensitivity to meet the needs of diverse student populations and our evolving global population (AAAS, 2000b).

Educators can use the learning goals found in the Benchmarks for Science Literacy (AAAS, 1993) and the NSES (NRC, 1996). However, the linkages between ideas and the implementing of such skills appear to be missing. The National Science Teachers Association (NSTA), in collaboration with AAAS, has developed an addition to the comprehensive collection of Project 2061 publications. This publication, Atlas of Science Literacy (AAAS, 2001), is a tool for developing a coherent curriculum as a progression of understanding. Harold Pratt, NSTA President, states:

To achieve coherence, a curriculum must build new ideas and skills on earlier ones—within lessons, from lesson to lesson, from unit to unit, and from year to year. With coherence in the curriculum, the concepts and processes that students learn can become more complex as they construct new ideas and develop new skills. Research has demonstrated that what students already know about a topic is one of the most significant factors determining their success in learning new, related content. (AAAS, 2001, p. vii)

The Atlas does not prescribe a particular curriculum or instructional strategy; but instead, it presents a framework and variety of different ways to design and organize learning experiences. Because “science is a process for producing knowledge” (AAAS, 1990, p. 2), this framework translates what constitutes science literacy. Through the process of science and by using technology, students acquire the abilities required for inquiry, develop scientific knowledge, and understand the work of scientists. To that effect, the Internet fosters an environment in which student understanding grows.

Hurd (2000) outlines the changes in goals of education and the current science reform. The reform movement seeks a much more responsible and self-aware citizenship in a global society. Ohler and Warlick (2001) maintain that a basic requirement for understanding education in the 21st century is facilitating conversation between all contributing educational stakeholders.
These stakeholders can and should include students, teachers, administration, parents, and the community. The research that I have conducted is one small, but important, step in learning how students can become actively involved with learning science using inquiry and the Internet.

Studies by Pepper and Rowland (2000) confirm that the problems students face at home and in their communities manifest in their behavioral traits, in what they bring to school, and in the ways they approach schoolwork. *The National Commission on Teaching and America’s Future* contends that 25% of American children now live in poverty, and the largest number of immigrant students since 1990 is now entering our nation’s schools (Pepper & Rowland, 2000). As required by the *No Child Left Behind Act*, states need to prepare all students to become problem solvers and critical thinkers. Science, when taught effectively, can be understood as a fruitful, never ending search for knowledge. Administrators ask teachers to teach a new paradigm so they can meet the demands of the 21st century. A larger number of young people must reach levels of expertise and competence, once thought to be within the reach of only a few (Pepper & Rowland, 2000).

Modern science does not give us truth; it offers a way for us to interpret and explain observed events of nature and to cope with the natural world. Visions extend beyond the classroom. Current explorations and inquiries require an integration of science, technology, and societal issues in what many have termed “a lived curriculum” (Hurd, 2000), or a reform movement that integrates not only science and technology, but the needs of society as well.

*Technology Standards*

The face of the American classroom is rapidly changing. The number of computers in a classroom does not inherently indicate the critical and higher-order thinking skills in use in that classroom. The question, “Does Internet technology improve student learning?” can be answered, “Yes,” intuitively, but with qualifications. Internet technology can improve student learning under the right circumstances, but overstating the virtues of technology is likely to lead to disappointing educational results. The National Council for Accreditation of Teacher Education (NCATE) research report (Cooper, 1999) urges teacher education programs to pay attention to the new *Educational Technology Standards and Performance Indicators for All Teachers* (Appendix A), developed by the International Society for Technology in Education (ISTE) (2003). ISTE recommends that all teachers acquire competencies in meeting the following six standards and performance indicators:
(a) demonstrating understanding of technology operations and concepts, (b) planning and designing effective technology learning environments and experiences, (c) implementing technology curriculum plans that include methods and strategies to maximize learning, (d) applying and facilitating effective technology assessment and evaluative strategies, (e) using technology to enhance productivity and professional practices, and (f) understanding the societal and human issues surrounding the use of technology. (p. 1)

Providing a vision for incorporating the study of technology across the curriculum, the International Technology Education Association (ITEA) released the Listing of Standards for Technological Literacy (ITEA, 2002). This pioneering document delineates 20 distinct standards and their related benchmarks (Appendix B) directing what students should know and be able to do in order to be technologically literate. These standards are the first step in a multi-year project aimed at describing the conditions needed to effectively support the use of technology. The ISTE provides similar performance indicators within the Profiles for Technology Literate Students (ISTENETS, 2003) (Appendix C). The standards focus on: (a) the nature of technology—students understand the scope and relationships among technologies; (b) technology and society—students understand the social and political effects of technology; (c) design abilities of a technological world—students understand the attributes of design and development of technology; (d) the designed world—students develop various technologies (ITEA, 2002).

These standards will help provide and support full implementation of the SSS in Mathematics and Science (FLDOE, 2003) and the Grade Level Expectations (FLDOE, 2000). Basic to these content standards is the ability to prepare teachers to empower students with the skills to meet standards and performance indicators. Miami-Dade County Public Schools (MDCPS) published its district strategic Comprehensive Plan for 2000-2005 (Urban Systemic Plan [USP], 2000). Foremost in this vision are the stated school-to-career goals to prepare students for graduation, employment, and postsecondary education, and to promote students as responsible citizens and lifelong learners. The workforce that will be needed for jobs in the future must have a foundation in mathematics, science, and technology literacy far beyond that which was necessary in the mid-20th (USP, 2000).

Roth and McGinn (1998) confirm that students should not only learn science, but also, learn about science, using technology as a resource to science education. They suggest a “…potential for cross-disciplinary perspectives” (Roth & McGinn, 1998, p. 215). The ISTE standards mark the beginning of a commitment for equitable and effective use of technology for learning (Solomon, 2002). As indicated by the Milken Exchange Report (Milken, 1999a),
Technology Counts, the education system will need time to transform and change the natural evolution that technology has brought forth. The Criteria for Evaluating Technology (CET) Forum, an affiliation of businesses supporting technology in the schools, has recommended the following action:

1. Define what it means to be educated within the context of a digital, knowledge-based society;
2. Respond to schools that have been transformed into high-performance learning organizations; and
3. Establish timely measures for assessing progress toward success in today’s changing world (Milken, 1999a, ¶3).

Although computer and communication technologies extend access to both human and informational resources, the role of the teacher remains the most powerful (Riel & Fulton, 2001). It is important to recognize and build upon children’s natural curiosity and desire to explore their world. Clark (1992) distinguishes, “Between birth and 4 years of age children accomplish 50% of the deviation in IQ that they will acquire by 11 years of age. By 6 years of age another 30% will have been added” (p. 17). Individuals involved in these students’ primary years of learning are fortunate. IQ remains traceable to heredity; yet, does not conflict with the belief that enriched education can increase what is called “intelligence” (Clark, 1992).

Education + Technology

To launch education into the “digital age” requires the implementation of technology into the curriculum via skills learned in real life experiences. Dependence on a single source, such as a textbook, must give way to a variety of information resources, as stated in the National Council for Accreditation of Teacher Education (NCATE) report (Cooper, 1999). Use of the Internet and other technological resources serve as a catalyst for teachers to provide learners with a different educational paradigm.

While many teachers, administrators, and community members have innovative ideas about how technology can add value to learning, there has not been a definitive, single, forward-thinking vision to drive technological investments and to bring the vision to life. Reportedly, teachers seek a new vision to guide the investment that education is making, not just in terms of content, but also in how we can appropriately use technology to teach various subject areas in better and richer ways. The formulation of the Criteria for Evaluating Technology (CET) Forum and the International Technology Education Association (ITEA) are examples of business and
education working together to achieve this goal. Gorry (1998) maintains that teachers who encourage students to assimilate technological information (i.e., employ technology without redirecting the nature of education) will only achieve disappointing results because they will be using processes that were developed decades ago. Embracing new technological change within a school in which teachers and teaching pedagogy remain essentially unchanged is counterproductive and unfruitful. To meet this new challenge, teachers must rethink the interplay of technology, teaching, and learning. Gorry further posits, “Schools that cling to conventional ways and technology may be planning for a world that will no longer exist” (p. 5). Information technology using the Internet and CD-ROMs cannot produce marvelous outcomes if the classroom environment does not provide opportunities for communication, decision-making, and genuine problem solving in a socially constructed environment.

Riel and Fulton (2001) contend that technology supports and expands the sociocultural links that help give us intellectual identity. Technology provides “power tools” (p. 519) for learning that enable students to develop the interpersonal and intellectual skills as they create and communicate their ideas. Recent studies find that educational technology also helps improve student self-esteem and attitudes toward learning, especially when used in conjunction with other reforms, such as collaborative learning (Solomon, 2002).

On the other hand, Newman (2000) contends that the debate about technology in education has become a red herring. He restates, “The way in which we choose to use various technological tools is based on what we believe about learning in the first place—all the important questions are really about curriculum and instruction” (p. 779). Educators have a crucial task to ensure that Internet technology supplements and does not supplant good teaching. What ultimately matters are the experiences learners have and what they make of those experiences.

Society demands high levels of science teaching and learning. Ohler and Warwick (2001) believe that preparing students for an unpredictable world requires vision. After much anticipation and heralding, the 21st century has arrived. The researchers foresee, “We are using brand new tools for a life that we cannot clearly see or describe today…Teaching should and could be the most exciting profession on the planet” (Ohler & Warwick, 2001, p. 4). We find ourselves at the crossroads of the 21st century, at a time that promises to be a global and digital age. Describing what he calls “web-enhanced learning” (Oates, 2002, p. 10), Vilberg praises
Web-based resources for empowering students to take charge of their own learning. These classrooms without walls are becoming commonplace.

The vision of MDCPS for learners of all ages as they prepare for the future is technology as a tool for improving—and ultimately transforming—both teaching and learning” (ITP, 2001, p. 39). Fostering educational reforms can include such strategies as making classrooms more learner-centered, changing the way teachers teach, and improving assessment. Technology can support all three efforts.

As technologies have taken hold in the past, school systems have attempted to provide the necessary education to process and accommodate these advances. Regarding today’s technological advances, dichotomies abound as researchers report conflicting data. The “silver bullets” (Dede, 2003) of multimedia-capable, Internet-connected computers may not solve the problems schools face today; yet, the NCATE taskforce reports that a growing research base confirms technology’s potential for enhancing student achievement (Cooper, 1999). What is less certain is whether these technologies will ultimately hold the key to improved learning.

According to the Web-based Education Commission established by Congress in 1998 (Peterson, 2001), evidence presented in *The Power of the Internet for Learning—Moving from Promise to Practice*, urges President Bush to focus on “e-learning” (technology), which enhances, not frustrates, learning. Peterson (2001) contends, “The Internet carries with it danger as well as promise” (p. 20). The report states that dazzling technology, which does not meet the needs of the learners, has no merit.

Our society has afforded the Internet great significance in debates about the future of education, despite the fact that technology and related Internet curriculum development remains largely underdeveloped (Hall & Newbury, 1999). In too many classrooms, word processing and Internet surfing have remained the focus of technology and computer training. Smith extends this disparity; “The World Wide Web is not an encyclopedia, dictionary or atlas, but a reflection of society, where serendipity and tangential thoughts lead to one discovery after another” (Smith, 1998, p. 52).

**Introducing the Research**

My main objective for this interpretive research was to generate ways to connect science club members with the Internet and related technologies, thereby, motivating and guiding students’ science learning. Involving students in actual scientific research gave them the
opportunity to see how *authentic science* really works. By authentic science, I mean that students used the methods and tools of real scientists to examine meaningful, real-life phenomena. Sagan says that all children innately are scientists, full of questions and curiosity, but the school science they learn is not related to their real world. By middle school, students have only retained those explanations personally constructed to account for phenomena in their rational universe (Yager, 2004).

Science club members experienced science using the Internet as an inquiry tool. Related scaffolding and higher-level learning elicited inquiry-oriented and problem-solving skills using the Internet (Dodge, 2001). *WebQuests* offered great ways of enriching curriculum while teaching fieldwork that enriched Internet inquiry. Taking the role of researcher and teacher-learner in the action research, I cleared their misconceptions about learning science. This not only enhanced my own professional development, but also, as Jenkins (2003) states, produced results that may benefit educators on a broader scale. When doing my action research, I used a case study approach as club members participated in this science club. Research by the American Chemical Society, 2002), acknowledges one of the fundamental beliefs that both teaching and research are activities that occur in communities, requires the union of both, as stated, “Like their students, teachers should view themselves as learners, being eager to try new ways of teaching…. They should use their own teaching to inquire and to improve it, so that their ability to teach through inquiry increases” (ACS, 2002, p. 157). The concept of action research recognizes the teacher in the central role of agent of change and the most qualified to interpret the results. The researcher is no longer the disconnected observer (Adams & Slater, 1998).

As this research continued, learning science through inquiry and the use of the Internet evolved as deeply related domains. Trusting the path I took, based on science as an active learning process, I achieved my plan to engage members of the Walden Sci-Tech Club in inquiry activities resembling real scientific discourse.

Guided by the NSES (NRC, 1996, p. 33), teachers guide, focus, challenge, and motivate student learning at all stages of inquiry. Inquiry into authentic questions that students generate through experiences is the central strategy for teaching science. My objectives for the Walden Sci-Tech Club corresponded to strategies Crawford (2000, p. 927) outlines as critical incidents of an inquiry-based classroom. Four key characteristics and their modification to the Walden Sci-Tech Club include:
1. Teacher situating instruction in authentic problems based on the impact of humans on an endangered species. Walden Sci-Tech Club members investigated, questioned, inquired, and eventually formed their own conclusions on the plight of the sea turtle. The resulting hypothesis required club members to use the Internet and PowerPoint software program to develop an ecologically balanced island affected by many of Earth’s systems.

2. Students grappling with data. The Living Planet: Earth Systems Curriculum (Lambert, 2002) provided an introduction to the Earth as a planet, defined as Biosphere One (1), unique in its ability to support life. WebQuests (Dodge, 2002) is an inquiry-oriented Internet program that forces collaboration. Together, these two sources directed the members’ scientific inquiry investigations.

3. Students collaborating with peers and teacher. At every opportunity, my teaching style encouraged self-directed learning while establishing a collaborative team approach. I encouraged leadership, yet I valued and respected group consensus. As a skilled teacher, I was able to create and manage a club environment that invited a social and intellectual climate suitable for all members.

4. Teacher modeling behaviors of scientists. “Inquiry into authentic questions generated from student experience is the central strategy for teaching science” (NRC, 1996, p. 31). Through inquiry-based instruction, members of Walden Sci-Tech Club engaged in authentic learning and helped to design a learning environment similar to that of real scientists. “Nobel Laureate, Leon Lederman, talked to ENC Focus providing a few remarks about science literacy: ‘Facts are important, but the younger students are, the more important learning the process of science is’” (Ridgway, 2001, p. 1).

Promoting Inquiry Using the Internet

Walden Elementary, the target school for this study, embraces a vision, “to challenge our children’s curiosity and desire to explore the world. Although we cannot see that world, we can help students ask relevant questions; develop processes for thinking and searching for answers; [and] communicate, work, and live cooperatively” (Martin, 2003, p. 2). The Walden Elementary School Center for Aquatic Nature Study promotes rigorous academics and character
development within the context of high expectations and standards for all students. The school views technology as an important part of its approach. The mission statement of Walden asserts, “The language arts/reading, science, mathematics, and technology components of our aquatic theme school will be woven with threads of advanced technology” (Martin, 2003, p. 3).

The 2003-2004 Walden mission statement outlines science achievement goals for students, “Given instruction using the SSS, students in grade five will increase their science skills as evidenced by students scoring a mean score of 272 as documented by scores of the 2004 FCAT (Florida Comprehensive Achievement Test) Science Test” (Martin, 2003, p. 21). The mean score for Walden, 2002-2003, were 270 as compared to the District’s mean score of 270. Adequate progress will be deemed to have been achieved if students increase their mean scale score to 272 as documented by scores of the 2004 FCAT Science Test. This notable increase will meet the science goal as stated by the District’s 2003-2004 District Strategic Plan. This school is proud of its multicultural, diverse student population consisting of professional and working class families. The school serves over 950 students of varied ethnicities and is in a facility, completed in 1996, on eleven and one-half acres in southwest Miami-Dade County. Approximately 90% of Walden students qualify for free or reduced-price meals. Because of the relatively low incomes of families in the area surrounding the school, the students are in need of support for basic resources to enable them to participate fully in community life.

The instructional technology mission of the MDCPS, as stated in its Instructional Technology Plan (ITP) for 2001-2004, is the integration of technology into the instructional program to improve learning and prepare students for the future (ITP, 2001). For MDCPS, preparing all students to use technology, as a communication and information tool will provide them with the information necessary to succeed in a technologically rich society. Skills in critical thinking and problem solving are key to student success. Desired student outcomes of the ITP (2001) include:

(a) students as self-directed learners appropriately using technology to access information and reach goals; (b) students as complex thinkers identifying, analyzing, integrating, and applying information; (c) students as cooperative workers using multiple frames of reference and connecting to world-wide networks; (d) students as effective communicators using technology to navigate through information; and (e) students as innovative quality producers creating original-quality products and using up-to-date technology. (p. 1)
The task of learners is to conceptualize and understand complex subject matter, and to transfer what they have learned to new situations and problems. Transferring knowledge beyond the contexts in which students learn depends on experiences and opportunities. Children differ from adult learners in the extent of their knowledge and experience. Because of this, Bransford, Brown, and Cocking (1999) acknowledge that young learners require strategies for learning and developing meta-cognitive skills. Meta-cognitive skills allow learners to examine and comprehend complex thinking processes, which enhance academic intelligence, achievement, and creative problem solving, and thereby, turning more of the learning process over to the learner (Bransford et al., 1999).

The ability to self-assess and reflect on one’s thinking enhances the transfer from concrete to more abstract and flexible thinking (Clark, 1992). Flexible thinking significantly improves people’s abilities to become active learners. As indicated by Bransford et al. (1999), learners who engage as active participants in their learning focus their attention on critical elements, encourage abstraction of common elements, and evaluate their own progress toward understanding. Because all learning involves transfer of previous experiences, teaching using such transfer allows learners to build on their own strengths, invites this transfer and stimulates meta-cognitive reflection (Bransford et al., 1999).

The objectives of MDCPS include “the integration of technology and its proficient use for all students and faculty into the instructional program to facilitate learning mathematics and science with the intent of producing technology skilled graduates” (Cortes, 2000, p. 1). My work with the Miami-Dade Systemic Program (MDSP) as a Science Educational Specialist has given me the opportunity to formulate and critique the goals of the proposed district-wide strategic plan. The National Science Foundation (NSF) and MDCPS have jointly sponsored a grant, entitled, Mathematics and Science Literacy: Bridges to Careers. This grant further substantiates the compelling evidence of the need for major pedagogical changes in education for the 21st century, including a successful and woven integration of technology.

A major goal of the district plan is to increase and to enhance the quality of mathematics, science, and technology teachers. These educational specialists and teacher stakeholders hope to transform each district school into a learning community that will accelerate achievement for its students. Each school will implement a transformative model of professional development to help build a culture of continuous learning and quality teaching.
Choosing a Learning Environment

One recommendation in the NSES (NRC, 1996) suggests that inquiry-based teaching begins with creating learning environments and experiences where learners “can confront new ideas, deepen their understandings, and learn to think logically and critically about the world around them” (p. 75). The naturalistic setting of field experiences on and off the school site allows students to build on their prior knowledge and experiences as they construct new meaning. As Kielborn (2001) states, “science investigations will allow for the students to develop a level of confidence in their skills and abilities” (p. 31). She asserts that field experiences emulating scientists at work provide students with meaningful, real-world learning.

Ash and Klein (2000) define formal and informal environments. Formal settings include long-term observations and strong assessment opportunities. In informal settings, the learner is in control of the learning and the activity. The environment or context is what distinguishes each of these two types of learning. One striking variable is the locus of control in informal settings, such as field experiences. Ash and Klein define the informal settings as, “Informal learning settings are self-directed, fun, playful, cooperative, and highly interactive, traits that appeal to all settings” (p. 219). These informal settings easily promote learning characterized by curiosity, hypothesizing, interpreting, observing, and experimenting. The NRC (2000) refers to the critical aspect of successful inquiry as reflecting on the ideas and concepts that guided the inquiry. I developed a form of synergy with students in my Walden Sci-Tech Club sessions between the formal setting in the computer laboratory and the informal setting of several field experiences.

Ash and Klein (2000) provide historic evidence of inquiry:

From the time of Socrates through the twentieth century work of John Dewey and Jerome Bruner, inquiry has been a habit of mind limited only by a person’s capacity to learn and furthered by selection among the many ways of getting to an answer. (p. 217)

The National Science Education Program D embedded in the NSES (1996) directs the following, “Good science programs require access to the world beyond the classroom” (p. 220). Continuing, the NSES state, “The school science program must extend beyond the walls of the school to include the resources of the community” (p. 45). Field-based investigations contribute greatly to the understanding of science and enriching scientific attitudes. The knowledge base that bridges students’ preconceptions to scientifically based conceptions supports and restructures a framework for appropriate science learning.
Kielborn (2001), in her field-based investigations, shifts control from the teacher to the participants for creating their own questions and developing their own strategy for seeking answers to these questions. Collected data and real-world authenticity document the relevancy of the field experience.

With this in mind, my Walden Sci-Tech Club members participated in the following Internet-related, informal field experiences:

1. Miami Beach Marketplace—Highlighting harvested produce from Walden’s Life Lab Garden, The Growing Classroom (Jaffee & Appel, 1982), in which members made real connections to real-life science knowledge of our living planet;

2. The Sea Turtle—Ecologist’s presentation, which illuminated the plight of the sea turtle as a prelude to design an original island community ecologically balanced and affected by Earth systems using The Living Planet curriculum (Lambert, 2002);

3. Solar Celebration—Visit to a local magnet high school specializing in science, technology, and mathematics, which showed students’ original products powered by solar energy;

4. University of Miami—Physics lecture and laboratory, which demonstrated elements of air and enlightened members to acknowledge the hidden properties of air;

5. Marine Biologist—Guest presentation, which highlighted earth’s ocean pollution and environmental awareness; and

6. Scientist—Guest presentation, which engaged members in scientific inquiry, suppositions and reasoning skills through questions like, “Is there life on Mars?”

Rationale for the Research

For over 20 years, we have known that students do not learn what teachers assume they have taught them (Yager, 2004). Skills and concepts taught as pearls of wisdom are disconnected and unrelated to the real world. Kyle, Linn, Bitner, Mitchener, and Perry (1991) propose a possible explanation:

Science education, in general, and research on science teaching, in particular, can no longer afford to lag two decades behind society and the scientific enterprise. Research
must contribute to the process of ensuring that science and technology education is oriented toward the future human needs of students. (p. 416)

In simple terms, Solomon (2002) contends that concerns remain regarding the haves and the have-nots of the digital divide. Continued commitment for equality, termed “digital equity” (p. 18), remains a challenge. Societies of today and tomorrow demand digital equity, making technology not only useful, but also accessible to everyone.

Scientists speculate that, in the next 50 years, robotic “brains” based on computers will execute 100 trillion instructions per second. These capabilities will rival human intelligence (Moravec, 1999). Educational leaders in districts across the nation continue to ask challenging questions about the effective uses of technology at all learning levels. Concurring with Paige, the National Coalition for Technology in Education and Training (NCTET) Co-Chair Neil Bush states, “Kids learn best by experience, and I think we all know intuitively that we learn best by applying concepts. The old, ‘memorize and forget’ model is failing our kids. It’s boring them to death” (Krebs, 2002, p. 2,).

The NCATE report (Cooper, 1999) documents the fact that the introduction of the computer, Internet, and technologies into schools is occurring at the same time we are addressing the need for reconsideration of effective teaching. Research suggests that we do not receive knowledge passively, but that we actively construct it from a base of prior knowledge, attitudes and values (Cooper, 1999). This deepened understanding of learning does not require a single textbook, but a wide variety of sources thereby prompting inquiry and hands-on learning. As stated in the NCATE report, as new technologies become more readily available and less expensive, they will likely serve as a catalyst for ensuring that new approaches to teaching gain a firm foothold in schools.

According to Dede, an educational technology specialist, assessment methods, the structure of learning, and curriculum must all change at the same time (Trotter, 1999). As technology moves from the fringes to the center of education, teacher preparation must also move to the core. In 2001, there were more than 88 million people in the United States and Canada between the ages of two and 22. Tapscott (1998) refers to these young people as the “echoes” of the baby boom whose voices will be heard as the Net Generation. He explains, “As children interact with each other and the exploding resources on the Net, they are forced to exercise not only their critical thinking, but their judgment” (Tapscott, 1998, p. 26). This generation, including today’s students, has no fear of technology; therefore, it is vital to teach
these “techies” by bringing them to the new paradigm of interactive learning. Textbooks are not the curriculum. Instructional materials comprise only one tool out of many that contribute to the resources for students to build on their own learning (Tapscott, 1998).

By moving from using solely textbooks to incorporating technology into learning, we can assist students, as they become aware of patterns evolving in their world of discovery. Within a constructivist framework, we can direct students to lead interdisciplinary patterns of inquiry, adjusting and positioning this knowledge to construct their own individual perspectives. From a constructivist perspective, science is not the search for truth, but a process to assist us in making sense of our world (Lorsbach & Tobin, 1992; Bosseler, 1999b).

**Statement of Research Questions**

Educational researchers value the learning process and how students get ideas based on existing personal knowledge. Linn and Hsi (2000) maintain that technology used for inquiry learning requires a careful analysis of how students learn. By inquiry, Linn and Hsi refer to the complete range of methods scientists use, including evidence gathering and reasoning strategies. My objective for this research was for my student members to be able to establish an inquiry process to employ throughout their lives.

To achieve the goal of integrated explanations, learners must become motivated to connect ideas, interpret explanations, and link patterns of new information to their existing views. The diversity among learners provides opportunities for teachers to encourage students in creative thinking by providing multiple representations of scientific research. For example, interactive technology on the Internet can engage students as critical investigators, developing further autonomy and lifelong learning strategies.

I influenced and redirected collaborative learning of science through the use of the Internet and computer technology. I used the following questions to guide this action research:

1. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?
2. How do learners make sense of scientific inquiry while using technology and the Internet?
3. How can I as a teacher enhance learning through scientific inquiry using the Internet?
4. How can I redirect my teaching strategies while using technology so that my students learn not only science content but also a love of learning science?

This research required a positive learning environment, typified by constructivist learning, which is favorable to enhance cognitive and affective aims through inquiry learning. Students can actively construct their own knowledge in classrooms that are constructivist, as well as traditional. The advantage of the former is that we explicitly ground learning in prior knowledge and experiences (Treagust, Duit, & Fraser, 1996). Teachers who view learning as a passive transfer of canonical knowledge stored in memory dismiss the connections to their students’ preexisting conceptions (Treagust et al., 1996). Becker’s (1999) survey for Internet methodology revealed that teachers who want to take advantage of the Internet’s unique capabilities are teachers who are more likely to follow a constructivist theory of learning. A social constructivist perspective allowed me to test the appropriateness of the experiential world within a community of learners.

One key feature of constructivism is that it requires the learners to become more autonomous and to take responsibility for their own learning. There is no external authority, but there is a re-conceptualization of teaching and learning. The teacher directs the students to find their own meaningful organization of their experiences. Tobin and McRobbie (1999) describe such a process in which teachers engage students in opportunities to fully test, explain, and identify theories of evidence. Understanding learners’ prior knowledge and their learning processes can help teachers plan a curriculum with outcomes that include specific instructional tasks, as well as meaningful learning.

The teacher must therefore become a facilitator of each individual’s learning through negotiation, rather than through imposition. Students’ alternative conceptions can affect instruction because they are often erroneous and difficult to change. The hallmark of John Dewey’s approach to education is that it connects children’s experiences to subject matter knowledge. The students’ views of the teaching and learning process, whether the students are active or passive learners, are important for learning. Previous knowledge helps or hinders the understanding of new information. Bransford et al. (1999) state that using what students learn in school to transfer to everyday environments is the ultimate use of school-based learning.
**My Role as a Teacher Researcher**

My professional career spans over 30 years. I earned a Bachelor of Education degree and a Master of Gifted Education degree from the University of Miami. As I reflected on my reasons for leaving the regular classroom, I came to terms with such a decision. I had to adhere to a traditionally pragmatic methodology, requiring me to teach in a way that neither matched my ideals nor addressed the way children learn best. Teaching and using gifted strategies, inquiry, autonomous, and hands-on learning have allowed me to express more readily my teaching talents. Nova University was the site for my Educational Specialist degree in Gifted Education. My thesis, *Using Higher Level Thinking Skills in The Regular Classroom*, enriched my professional role as a teacher in the gifted classroom for 24 rewarding years.

The goals and objectives for Miami-Dade County Gifted Students include critical and creative thinking, problem solving, leadership, personal growth, communication, and research. I thrived in this environment and received the Presidential Award for Science Education in 1998. I also received other science-related recognition, such as, Miami-Dade County Science Teacher of the Year and Palmetto Elementary Teacher of the Year. My winning local, state, and national awards for the school’s Life Lab Garden was an accolade for this thriving, self-sustaining, and scientific living laboratory. The Life Lab Garden was part of *The Growing Classroom* (Jaffee & Appel, 1982), a garden-based science program. The garden provided plots for students in every classroom to prepare, plant, maintain, and harvest organically grown plants. Coordinating this project for ten years confirmed and strengthened my belief that learners can experience science through active engagement in scientific knowledge and investigation (NRC, 2000). The Life Lab Garden was a stellar example of authentic science.

Enrolling in the FSU doctoral program as a distance learner addressed my quest to extend my great love for and interest in science. Six years ago, I was fortunate to join the *Exploring and Learning the Operations and Resources of Environmental Satellites* (EXPLORES!) team, formerly known as Florida EXPLORES! (EXPLORES!, 2000). This program allowed me to bring the world of weather and technology to my “junior scientists” (Bosseler, 1998). Then, five years ago, joining the *Global Learning and Observations to Benefit the Environment* (GLOBE) program enriched my teaching content knowledge, as the students in my classroom were able to reach around the world and share the power of science and the Internet (GLOBE, 2000). Information, interest, and research in this topic have grown in the last four years. I created the
Walden Sci-Tech Club to allow all students, regular or exceptional, to investigate science and to extend their technological knowledge. The research path I have taken, i.e., studying technology and the Internet, evidences a new and challenging frontier. My vision was to use the knowledge and empowerment I gained to engage lifelong learners who share my love for science.

Organizing the Chapters

Two explicit purposes have prevailed throughout the action research in which I used the Internet as a conduit for scientific inquiry. Valued equally, I have focused on the students, as Walden Sci-Tech Club members, and myself, as teacher-researcher. The Internet served as a tool for explorations and discoveries along the journey, while my students and I shared a role as active learners. Twenty years ago, the Internet served as the stuff of science fiction. Yet, threaded within each chapter in the dissertation, evidence unfolds a natural symbiotic relationship between the use of the Internet and scientific inquiry, as defined by the NRC (1996). I have not provided a roadmap for technological integration and scientific literacy, but a conceptual framework for the possibilities and the benefits of each.

I have aligned the chapters within the framework of my four research questions. I direct the first two questions toward my science club members:

1. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?

2. How do learners make sense of scientific inquiry while using technology and the Internet?

I direct the second two questions toward myself, the teacher:

1. How can I as a teacher enhance student learning through scientific inquiry using technology and the Internet?

2. How can I redirect my teaching strategies while using technology so that my students learn not only science content, but also a love of learning science?

Guided by action research, the following paragraphs provide a brief overview of the remaining chapters included in this study.

Chapter 2: Literature reveals the impact of technology on society and education’s response and responsibility towards preparing the future workforce. Enriched learning environments require teachers who stage opportunities for scientific inquiry using technology
and the Internet. This chapter presents the literature that indicates the potential for directing inquiry as a tool for learning requiring higher levels of thinking.

Chapter 3: Methodology portrays the purpose of the study of interpretive research, as I used strategies of inquiry to establish the Action Research Cycle (Black & Stave, 2001, p. 132). Based on my own constructions of a fourth generation evaluation (Guba & Lincoln, 1994), this study indicates it is ongoing, continually seeking improvement as it welcomes input from the community.

Chapter 4: Members Learning sets the stage for the three case study members, referred to as the “Triumvirate.” This chapter explores the social interactions, surveys, interviews, transcribed informal interviews, and artifacts. E-folios in the form of PowerPoint projects are examples of artifacts for the Triumvirate. The data from the Walden Sci-Tech Club members’ help to define the interpretive analysis using the QSR (1997) (Non-numerical Unstructured Data Indexing Searching and Theorizing Program) qualitative data analysis program. Bybee’s 5 E’s Model (2004) underpins the basis for the strategies for my inquiry-based instruction.

Chapter 5: Teacher-as-Researcher redirects attention to my purposes of teacher-as-researcher by examining the teaching of science in the Walden Sci-Tech Club. As I have guided and collaborated with all members, my teaching strategies have required active responses to the students’ needs. The societal makeup of the learning environment guided the coherences and consequences of this action research. My vision for developing life-long learners aims for eventual open inquiry, resembling the actions of real scientists. Pedagogical content knowledge appears as one of the linchpins for the successes and failures of the study.

Chapter 6: Reflections, Responses, & Realizations finalizes the journey I have taken as it gives meaning to what I used to be, what I had hoped to become, and what I am becoming. This applies to my Walden Sci-Tech Club members as well. My love for science and my keen interest in technology is a workable union. The story of teaching children to be lifelong learners may be written with a new ending.

Therefore, turn the pages and let the journey begin.
CHAPTER 2: LITERATURE REVIEW

Survival in the 21st century is going to depend on the science literacy of the voting citizens...[T]he goal is to produce people who feel comfortable with science and technology and are aware of the science and technology and are aware of the sources and resources that can help them understand the subject...They know how to use the library; they know how to use the Internet...Science literacy is the ability to think scientifically.

—Leon Lederman (Ridgway, 2001, p. 23)

Technology as a Tool for Learning

A fundamental concern for everyone involved in education in this time of rapid change is, “What do students really need to be learning today in order to be ready for an unpredictable future” (Armstrong & Warlick, 2004, ¶3)? From what we have experienced thus far, the best thing we can teach our children is to teach them how to teach themselves. “…Teaching models are being radically redefined as a result of computer-based media, much as the oral traditions of medieval universities were totally changed by the invention of the book” (Oates, 2002). Chapter 2: Literature Review, takes a defining look at technology and learning. The first two sections explore technology as a tool for learning and possible remediation. Inquiry methods and discovery using the Internet focus on their union in the next section, followed by Lemke and Coughlin’s (1998) Seven Dimensions of Progress.

Techno classrooms are redirecting the ubiquity of computers in our culture and ultimately transforming both teaching and learning. Public education must undergo a drastic revision to adequately prepare students for the twenty-first century. Even in the dawn of this new era, we are still seeking to develop clear and specific learning goals to help learners achieve desired educational outcomes. As Scardamalia and Bereiter (1996) express, “real school reform should not focus so much on making schooling conducive to understanding, but on making understanding the focus of schooling” (p. 54). As examined by Mandl, Gruber, and Renkl (1996), education can no longer claim, “Non vitae sed scholae discimus” (“We do not learn for life, but for school”), but must convert to “Non scholae sed vitae discimus” (“We do not learn for school, but for life”) (p. 307).
Technology can become a key component for integrating critical-thinking and problem-solving skills with the knowledge required for becoming lifelong, productive learners and contributing citizens (O’Riordan, 2000). Technology can provide the pathway for learners to learn how to learn and to eventually present their learning in ways that demonstrate understanding and expertise.

The Impact of Education Technology on Student Achievement: What the Most Current Research Has to Say evaluates the effects of technology on, and its correlation to, student learning (O’Riordan, 2000). In regards to the impact on learning, the data reveal that how we use technology has a greater relevance than whether or not we use technology. The data also confirm that most states use technology as a means to automate learning rather than to bring unique, meaningful learning opportunities to students. The computer is not a subject to be taught but; rather, it is a tool to be used to facilitate learning. Brooks, Cayer, Dixon, and Wood (2003) authenticate, “We believe that the quality of education will not be improved by technology alone, but instead by purposeful integration of technology in all aspects of education” (p. 38).

Technology and the Internet, when primarily used as a digital library, can contribute very little to science education. When used as a resource that provides new opportunities for engaging in science, the Internet can make a significant contribution. As confirmed by Tretreault (1998), the impact of technology on students is an area of research not easily undertaken or understood. Rather than asking if technology affects student achievement, Tretreault maintains it is more reasonable to ask if teachers use technology to help students learn. Some have characterized the use of technology as a “national obsession” (Tretreault, 1998, p. 9), focused primarily on getting computers into public schools. Some educators believe it is urgent for schools to use technology to train students for an economically competitive workforce. Yet, textbooks remain the core of most curricula. Whether or not we realize the potential of technology, schools must continue to provide students with basic skills such as reading, writing, and computation. Technology has few benefits without these basic skills as the fundamental framework. Technology, when used appropriately, functions as an information processor and a productivity tool to enhance content learning (Tretreault, 1998).

A Newer Paradigm

In traditional education, we have made optimal use of the printed page. The new millennium has brought rapid changes in communication. These changes require a paradigm
shift that incorporates the potential for using technology in the curriculum. Change will not occur by adding a course or a new faculty member who understands technology. Papert (2004a) reviews the parable about a brilliant engineer in the 1800’s designing a jet engine that is irreverently placed upon a stagecoach. Transferring this parable to the role of computers, (i.e. the jet engine), placed in our current epoch of technology, instead of improving the educational system, (i.e. the stagecoach), befits our present educational dilemma. Without a paradigm shift, we have an outdated system unwilling to create and acknowledge the possibilities of the technological advances. Pinar, Reynolds, Slattery, and Taubman (1998) acknowledge that teacher education must transform into a learning culture in which technology facilitates a changing relationship between students and teachers and between learners and knowledge. Pinar et al., (1998) further review Project 2061 Technology Panel’s (AAAS, 2000a) emphasis, which confirms technological literacy as a subset of scientific literacy. Technology, at its best, is a learning partner. Jordan (1993) identifies five stages of classroom computer use and integration, indicated by teacher observation (Table 2–1).

**Table 2–1**

**Teachers’ Use of Technology**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Teachers’ Use of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry</td>
<td>Lecture pedagogy; teachers become accustomed to a transformed environment that includes computer technology (basics of using technology)</td>
</tr>
<tr>
<td>Adoption</td>
<td>New technology to support traditional instruction using lecture and recitation, followed by drill and practice seatwork</td>
</tr>
<tr>
<td>Adaptation</td>
<td>Traditional instruction integrated with technology (lecture and recitation practice expanded with databases, word processing, and compact disks)</td>
</tr>
<tr>
<td>Appropriation</td>
<td>Focus transformed to include cooperative, project-based, and interdisciplinary work—incorporating technology as learning tool</td>
</tr>
<tr>
<td>Invention</td>
<td>Learning environment changes; teaching practices are increasingly viewed as a socially interactive process, extending student and professional collaboration to create projects combining multiple technologies</td>
</tr>
</tbody>
</table>

*Note: Adapted from Jordan (1993, p. 22) and SERVE (South Eastern Regional Vision for Education) (2000, p. 6)*

Integrating technology into the curriculum does more than show teachers where in a curriculum they can squeeze in some technology. Helping teachers select “digital content,” or computer-based learning resources built on the needs and learning styles of their students, is a
primary way to keep content infused with the computer methodology. According to Trotter (1999), meaningful digital content can be produced by anyone using a single CD-ROM, an interactive Web site, or a blending of these two media tools in order to motivate all types of learners. Such “…new digital, computational-based tools enable children and teachers to grapple with content in a way they simply could not do before’ says Elliot Soloway, who helped develop a software package called Model-It” (Trotter, 1999, p. 5).

The use of technology as digital content woven into inquiry-based learning may form a solid union that supports the theory of a socially constructivist classroom. Ravitz, Becker, and Wong (2000) cite principles that guide computer use in a constructivist, inquiry-based learning classroom. These principles include: “(a) collaborative and socially interdependent tasks; (b) projects employing skills and diverse tasks; (c) meaningful thinking; (d) expository writing; and (e) problem solving requiring thinking, evaluating, planning, and decision-making” (Ravitz et al., 2000, ¶3).

Technology as a Learning Partner

Technology has the potential to increase collaborative sharing and conversation as evidenced in a constructivist classroom. Becoming a techno-constructivist requires open attitudes toward the new possibilities in this age of wonder (McKenzie, 2000). These techno-constructivists are the teachers who integrate technology into the curriculum not to redefine it, but to complement it. The techno-constructivists realize the full potential of technology by expounding its virtues, having come through the previous three stages. This is the final stage of Noon’s Four-Stage Model (McKenzie, 2000), preceded by three stages of technology proficiency; (a) preliterate (no experience, having never been trained, or simply not interested); (b) software technicians (beginners using email and Web users); and (c) electronic traditionalists (traditional classroom type of functions extended).

A problem nevertheless remains. Making computer technology a learning partner will not occur unless teachers know how to use the computer and the digital content in their classrooms. Teachers must also believe in the technical pedagogy and not just know how to operate the software or maneuver the Web. Zuga (2001) advises that implementing a coherent and rigorous technology curriculum should be the main concern of professional development. The old adage, “Computers will replace teachers, as well as discourage student interaction” will not occur; in fact, teachers have now been shown to be the key to whether teachers use technology effectively.
Technology provides increased opportunities for collaborative sharing and conversation, thereby enhancing productivity.

Science teaching in the past focused on teacher-centered instruction, placing teachers and curriculum developers at the center of the educational process. As a manifestation of this 1970’s paradigm, the overstated “Balanced Curriculum” mandated that every classroom in Dade County allocate a prescribed amount of time and content to each part of the curriculum. Research by Linn and Hsi (2000) provides data indicating that new technologies can help learners visualize difficult-to-understand concepts if knowledge integration takes place. Knowledge integration occurs when learners realize connections while acting as research scientists, seeking coherence and evidence to resolve uncertainty. “To promote lifelong learning, we must offer students courses that provide scientific ideas they can revisit, reuse, and refine after they finish science classes” (Linn & Hsi, 2000, p. xxx). There must be connections between the problems they face in their daily lives and the material they study in school. Projects that lead to autonomous learning encourage students to apply what they have learned, identify and find answers to their questions (Linn & Hsi, 2000).

This technological age has resulted in the rapid proliferation of information, known in schools as content. Duffy and Jonassen (1992) refer to traditional models of learning and instruction that emphasizes mastery in the content domain. A “mental reordering” (Fosnot, 1992, p. 168) occurs in constructive learning. If learners accept new experiences, they assimilate them, then reintegrate and reconstruct previous knowledge to construct new models. Fosnot declares that such lived data reconstructions are akin to the creative process.

**Considering a Solution: Technology**

Technology has the potential of becoming the *seamless web* (Layton, 1993) as it is transformed from merely a tool for learning science to an intricately connected source for our global society. The *Atlas of Science Literacy* defines technology as ways of doing things (AAAS, 2001). Layton (1993) reminds us, “We have brought the earth to a point where our future well-being will depend heavily on how we develop, use, and restrict technology” (p. 104). According to Layton (1993), technology signals the recognition that practical knowledge has been a term of disparagement in contrast to other, more verifiably assessed, learning. Technology has not had a well-established role model in higher education, although that is quickly changing. Technology
is a relatively new school subject that is becoming a viable research source for all students, regardless of academic or occupational endeavors.

Teaching a new generation of literate and curious children requires that teachers stage opportunities for collaboration and inquiry while using technology. The use of technology as a tool provides a “symbiotic relationship” with science (Zuga, 1996, p. 231). Today’s students must be able to use technology effectively if they are to succeed in an increasingly complex society. Dede confirms, “I am fascinated by the ways that science shapes society and concerned about unreflective adoption of new technologies…. Education is society's major long-term mechanism for shaping its future, (Dede, 2003, ¶5). Educators must therefore provide opportunities for all learners to become: “(a) capable information technology users; (b) information seekers, analyzers, and evaluators; (c) problem solvers and decision makers; (d) creators and effective users of technology; (e) communicators, collaborators, publishers, and producers; and (f) informed, responsible, and contributing citizens” (ISTE, 2003, p. 2).

These performance indicators help teachers guide learners in establishing enriched learning environments supported by technology (ISTE, 2003). Effective use of technology requires learning environments that meld traditional with new approaches to facilitate learning for all students. Strategies mentioned include “active, exploratory, and inquiry-based learning in contrast to passive learning; they include authentic, real-world context in comparison to an isolated, artificial context; and they include collaborative work as contrasted to isolated work” (ISTE, 2003, p. 5).

Dede (2003) describes the misconception regarding technology as a way “…to empower ‘teaching by telling’ and ‘learning by listening’, serving as a fire hose to spray information from the Internet into learner’s minds” (p. 1). As Dede (2003) maintains, contrary to these misgivings, the way to foster independent thinkers and lifelong learners is to utilize technology to motivate and guide inquiry without using it as a crutch in every step of the learning process. Krajcik, Blumenfeld, Marx, and Soloway (2000) confirm that the use of inquiry with the aid of technology expands the range of generated questions and the discovered products from the investigations.

Students can exercise pattern recognition and problem solving skills using technology in the learning process (Dede, 2003). Working with patterns in a variety of conceptually and perceptually different settings helps children develop the ability to recognize new patterns and
build on the resources of prior knowledge. Ultimately, with this ability of connecting patterns of thinking, students can become aware of the signals that tell them they are having difficulty comprehending or connecting to new information. Thus, a new pattern connects with existing pattern frameworks. According to Dede (2003), student outcomes on conventional achievement tests rise when we implement technology-based educational innovations that encourage pattern recognition and connection making. Lest we forget, the heart and prime objective in every mathematics class, as well as other areas of the academe, is the ability to recognize patterns.

**Wise Use of Technology**

The CEO Forum On Education and Technology, established in 1996, issued a 5-year annual assessment of the nation’s progress toward integrating technology into America’s schools. The Forum also identified the need to increase national understanding about how to make the most effective use of educational technology in the classroom (CEO, 2000). Extending this study, the *School Technology and Readiness Report* (StaR) identifies schools moving from advocacy to reality. Schools assessed by StaR provide students with basic skills, as technology has few benefits without them (StaR, 1997).

Use of technology in the classroom has been shown to facilitate drill-and-practice activities that help children learn basic skills. More sophisticated uses of technology, especially for the applications and methods that support constructivist learning; require teaching application, synthesis, and evaluative strategies (Clark, 1992). A contributing element in science education reform is the practice of making the learning of science more in line with the actual practice of science and scientists. The intention is to provide students with a better understanding and more opportunities to conduct science as scientists. Studies by Edelson and Gordin (2000) convincingly present digital libraries as resources that provide opportunities and strategies for students to engage in research. Such strategies include:

(a) students investigating authentic scientific questions using real data; (b) students studying their world to explore policy options; (c) teachers helping students view science as inquiry, unlike more conventional activities; and (d) teachers providing students with a common ground that links them to the community of practicing scientists. (Edelson & Gordin, 2000, p. 5)

Although there are profound differences between scientists’ and students’ goals, the same resources that enable experts to extend their knowledge can also enable learners to extend their knowledge (Edelson & Gordin, 2000). Edelson and Gordin have developed a comprehensive,
three-step process for adapting experts’ research strategies for student learning. The first step of this process focuses on the scientists—the resources they use and their activities. The second step redesigns the tools that scientists use, replicating them for students while closely modeling the experts’ tools. The important criterion for this step is to convey the experts’ tacit knowledge and compensate for the learner’s lack of prior knowledge. The third step requires carefully constructing activities to motivate students. WebQuests (Dodge, 2001), The Living Planet (Lambert, 2002), EXPLORES! (EXploring & Learning the Operations & Resources of Environmental Satellites) (EXPLORES!, 2000), and GLOBE (Greater Learning & Observations to Benefit the Environment) (GLOBE, 2000) programs are outstanding examples of this challenging process.

Computational technologies play an important role in addressing the unique aspects of learners—their diverse learning styles and their varied levels of knowledge and interests. Soloway, Krajcik, Blumenfeld, and Marx (2000) refer to the inherent capability of learners to use technology to expand the range of questions that can be investigated and the types of information that can be readily accessed via the Internet. This investigation produces various kinds of data, including student products that can be displayed (Soloway et al., 2000). An example would be a PowerPoint™ presentation, which students develop using Internet sources, about an environmentally safe island (Lambert, 2002).

**Use of Internet by Teachers**

Ravitz et al. (2000) address Becker’s 1999 statistical review of Internet use by teachers. The Office of Educational Research and Improvement (OERI), the United States Department of Education (USDE), and the National Science Foundation (NSF) had funded this study. The study included 4,083 teachers, 2,251 derived from the national probability sample of teachers of fourth through twelfth grade classes in both public and private schools. The 20-page survey questioned teachers about their specific teaching practices. I describe two of the incompatible models for teaching below.

Traditional Transmission Instruction (Ravitz et al., 2000) is typified by: “(a) learning of facts, (b) mastery of skills (procedural knowledge), (c) absorbing content, (d) guidance by text and repetition, (e) structured environment, and (f) rigid schedule” (p. 1).

Constructivist-Compatible Instruction (Ravitz et al., 2000) is typified by: “(a) learning experience from the concrete to the abstract (procedural knowledge); (b) the relating of new
ideas to prior beliefs; (c) teacher as facilitator for discovery; (d) sense-making, content as secondary; (e) interest and effort critical with diverse activities going on simultaneously” (p. 1).

Results of the Becker study (Ravitz et al., 2000) indicate that:

1. The use of technology is believed to enliven and extend pedagogical beliefs, and a contrast between constructivist and traditional philosophies is evident.
2. Teachers who viewed the Internet more positively tended to adhere more strongly to the constructivist philosophy.
3. Teachers for whom computers are more important are more constructivist in their teaching philosophy and tend to allow student use of technologies about three times as often as traditional teachers.
4. When teachers say that computers have played an increasingly important role, they also report more pedagogical changes in a constructivist direction.
5. Changes in pedagogy in a constructivist direction are related to computer use. (Ravitz et al., 2000, p. 6)

These data suggest we are likely to meet the technology goals of learning when we entrusted such goals to constructions similar to those of the creative process.

Inquiry as a Tool for Learning

The NRC (1996) defines what all students should know and be able to do by grade twelve, including the kinds of learning experiences they need in order to achieve scientific literacy. NRC affirms the conviction that inquiry is paramount to the achievement of scientific literacy. The nature of science and the nature of inquiry are synonymous. Inquiry is also a critical component of student learning. As Tamir (1998) asserts, students should realize that scientific knowledge is not to be viewed as the final, lasting truth; but rather, today’s knowledge is the consensus of experts available today. Inquiry learning helps students learn patterns of discovery, actively participate to solve problems, and personally develop some of the concepts to be learned.

A pedagogy based on inquiry may appear difficult to teach at times, but teachers can gain satisfaction when students become motivated to learn, to ask questions and devise ways to answer them, and to demonstrate deep understanding of scientific concepts. Inquiry in Action (ACS, 2002) lists five essential features of inquiry-based learning:

(a) Formulate meaningful questions answered in a scientific way; (b) design and conduct an investigation providing evidence; (c) provide an explanation to answer question(s) about the evidence; (d) evaluate their explanation; and (e) share and communicate full inquiry (all features present) or partial (not all features present) inquiry. (p. 7)
Bransford (2001) reminds us, “Learning with understanding allows you to apply the learning rather than procedural knowledge, [which is] memorization disguised as understanding” (p. 224). Keys and Bryan (2001) inform us that research done on inquiry within rich demonstration classrooms or in classes taught by the researchers often limits understanding of how inquiry teaching and learning would look in an ordinary classroom taught by regular teachers.

**Action Research**

This study builds upon action research, a central part of the educational learning process. Action research is a strategy that assists educators in solving problems, enhancing decision-making practices, and viewing situations through critical thinking (McDonald & Gilmer, 1997). Sweeney (2000) defines action research, using the notion of “teacher as researcher” (p. 13), as a form of self-reflective inquiry designed to bring about social and educational change. Research subjects become co-participants and valued stakeholders in the inquiry process.

Teachers conduct action research in their own classroom, where data focus on the skills and practices of the professional to improve his/her own teaching. The emphasis is on practical interpretations that can be made by teachers and their students’ self-reflection. Kemmis and McTaggart (2000) propose, “Classroom action research typically involves the use of qualitative, interpretive modes of inquiry and data collection by teachers (often with help from academics) with a view to teachers’ making judgments about how to improve their own practices” (p. 569). Action research concerns actual, not abstract, practices in a social and educational setting. Using such a methodology sets the stage as an interactive process between me and my students as we work together to create shared understandings (Riel & Fulton, 2001).

Through the process of reflection, action research allows me to focus on understanding my own and others’ conceptions, as related to inquiry and the Internet. As described by Collins and Spiegel (1997), action research is not done in isolation, but we initiate it within the learning environment. It is a constructivist process set in a social situation, encouraging the examination of one’s beliefs about learning, one’s students, and one’s conceptions of the self as a learner.

According to Kemper (2000), “The aim is to improve the quality of teaching and learning. This is often expressed as a striving for excellence, since many schemes of this type attract the better teachers” (p. 8). Kemper asserts that there is a great deal of research into students’ valid conceptions and misconceptions of scientific ideas. Many students construct their
answers from a framework of inaccurate or outdated scientific theories, even though they may have been taught currently accepted ones.

Joanos (1997) describes her action research with first graders and their beliefs of science and scientists. Joanos’ action research suggests that her students were not aware of their own scientific experiences within a repertoire of ideas. Joanos created an environment in which science was less intimidating, and, as she explains, “Children not only need an understanding of science, but they also need to be able to envision themselves as scientists and to realize they can do science” (Joanos, 1997, p. 9). As Joanos’ research indicates, changes became evident through student journaling prompts, experiences in an intensely science-oriented unit, and individual audiotape interviews eliciting their perceptions of science and scientists. The teacher encouraged her students to illustrate and describe their drawings. The action research dramatically changed her approach to teaching science in the classroom, as students could realize they were doing science and could envision themselves as scientists.

History of Scientific Inquiry

The 1983 publication, *A Nation at Risk* (Bell, 1983), stunned Americans in regards to curriculum failure in their schools. Science educators continue to examine the history of science and to consider philosophers’ ideas and interpretations of scientific understanding and how the theories have changed. According to Pinar et al. (1998), in the nearly two succeeding decades, educational concerns have not been eased. Leading educators have been forced to concede that if meaningful science reform cannot occur at the state level, it must occur at the classroom and science club level.

Technology with Science

Searching through history, Saettler (1969) concludes that the Greeks based the theoretical frame of reference for their educational practices on the Sophist doctrine (450–350 BC), which sought to identify any “man” of science or learning. The word *technology* means to weave or construct. Famous among people of science is Protagoras, one of the first instructional technologists who accepted money for his teachings. Protagoras believed that education was the key to knowledge, he said, “Man is the measure of all things” (Saettler, 1969, p. 21). His beliefs emphasized how human subjectivity determines the way we understand and construct our world.

Sophists followed democratic, liberal concepts while developing the technique of analysis within the teaching of rhetoric. Plato’s doctrine, on the other hand, contrasts with that of
the Sophists by renouncing technology. Saettler (1969) states that the two Greek philosophers differed on the value of technology. Sophists accepted all forms of technology, including statecraft and handicraft. Seeking to reconcile the humanities and science, the Sophist solution combined the two into a unified whole, calling it *techne* (p. 16).

The Socratic (or Plato’s *Plutonian*) method of instruction has evolved and is defined by the give and take of guided inquiry. This Socratic questioning technique drew out beliefs in the minds of all persons, whether slaves or emperors. The questioning directed toward pupils was limited to facts already known to the pupils. The Socratic tradition provided the philosophical foundation for the separation of technology and science. In Socratic questioning, “Yes” and “No” would not qualify as answers. By trying out ideas and exchanging opinions, teachers challenged participants to think for themselves. Answers required that theory and reasoning be involved in any conclusions drawn. Some questions are still unanswered and solutions have yet to be discovered. Giving learners practice in asking specific questions and actively seeking answers, probing, and reevaluating ideas, helps prepare them to be lifelong learners.

*Inquiry with Science*

Zuga (2001) posits that this Greek tradition lays the philosophical foundation for the separation of technology and science by the very creation of the idea of science. The perception of science as abstract and theoretical, as opposed to technology’s concrete and practical aspects, continues today. The artificial barrier that separates science from technology continues to be questioned regarding its value in educating our children. The symbiotic relationship Zuga endorses places science as a branch of inquiry for technology, spearheading the advancement of technological development. For Zuga (2001), both efforts are necessary for the advancement of knowledge. The Socratic questioning method is in the *Junior Great Books Program: An Introduction to Shared Inquiry* (Great Books, 1987). Students read challenging stories and essays to facilitate a shared inquiry discussion. Using reflective thinking, participants practice asking probing questions and providing interpretive answers.

*Inquiry in Science*

Bybee (2000) states that science teaching does not show, and has not historically shown, substantial signs of inquiry. A redeeming feature of the NSES (NRC, 1996) is that they have forced us to restate what inquiry learning means by bringing it to the forefront of educational goals. Bybee (2000) states that the skills of inquiry require an understanding of scientific inquiry.
Providing more experiences with natural phenomena is not enough; hands-on inquiry is not necessarily minds-on inquiry. Students need opportunities to formulate theories and consider evidence that supports or repudiates these ideas.

Almost ninety years ago, John Dewey’s Logic: The Theory of Inquiry (Bybee, 2000) articulated inquiry learning as a variety of strategies including deduction, induction, mathematical logic, and empiricism. The choice of strategies depends on the question investigated (Bybee, 2000). One of the strengths of inquiry is that of developing questioning techniques wherein the students become the leaders, teaching others as they learn. Through my action research, the goal is to listen more closely to student discussions, learning more about my student stakeholders as we progress.

Epistemology of Science

As Lederman (1998) explains, “The ‘nature of science’ typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge” (p. 2). Educators have historically been concerned with students’ ability to understand the nature of science. Consensus presently exists among science educators and scientists on a specific definition for the nature of science, which is tentative, subjective, not yet shown to be false, and assumed to be true. Studies by Bell and Linn (2002) describe the confusing textbook portrayal of science as logical step-by-step advancements “…rather than the serendipitous, personality-filled, conjectural, and controversial nature of most scientific breakthroughs” (p.1). Berger (2002) reminds us that science does not work by an infallible “scientific method” of lockstep procedures, but rather, it proceeds dependent upon the particular branch of science investigated. It is like a jigsaw puzzle with millions of pieces, developing as it proceeds. Lopushinsky (1999) summarizes the nature of science by saying, “replacing truth with knowledge as a goal of science may lead to a better understanding of what science is and what it can and cannot do” (p. 94).

Methods of Inquiry and Discovery Using the Internet

Inquiry involves a series of problem-solving investigations that actively engage students. While building on discovery, learners become active and involved, using reasoning to find the solution to problems. Inquiry skills include observations, manipulations, and the restructuring and interpreting of events. By involving the students in inquiry activities in the classroom, the teacher encourages the children to investigate, use prior knowledge, and develop autonomous
learning strategies. Both inquiry and discovery teaching help children develop the art of critical and creative thinking. Physics Nobel Laureate Leon Lederman explains, “Science isn’t about providing answers as much as it is about asking questions…Facts are important, but the younger students are, the more important learning the process of science is” (GLOBE, 2000, p. 1).

It is important to place the spotlight on students and to create an environment in which the students engage in the important activities rather than having the teacher do them. Inquiry into authentic questions generated from student experiences is the central strategy for teaching science. Doing things in this way can alter the learning to make it more meaningful (Clark, 1992). Strategies such as higher levels of Bloom’s Taxonomy (Appendix D), which include problem solving, interpreting and evaluating data, reaching conclusions, asking and answering questions, and analyzing issues, can help put students in charge of their own learning. These instructional strategies facilitate conceptual construction so students actualize on their own theories.

Linn and Hsi (2000) maintain that technology used for inquiry learning requires a careful analysis of how students learn. To achieve the goal of integrated understanding, learners must be motivated to connect ideas, interpret explanations, and create patterned links of new information to existing views. Scaffolding student learning of science and technology can help students connect one inquiry with another, rather than having isolated experimental examples.

Innovative uses of technology should be at the highest level of Bloom’s Taxonomy scale (Clark, 1992), should be multi-disciplinary, should require either evaluation or synthesis on the part of the learners, and should require students to construct some kind of new meaning for themselves. WebQuests (Dodge, 2001) and The Living Planet (Lambert, 2002), along with GLOBE (GLOBE, 2000), EXPLORES! (EXPLORES!, 2000), and One Sky, Many Voices: Kids as Global Scientists (Songer & Sampson, 2000) are examples of systemic, inquiry-engaging, research-based projects using the Internet. These projects incorporate computer technology and real-time data collection while actively engaging students in the process of science.

Bybee (2000) recounts the observations of Joseph Schwab in the late 1950’s and 1960’s as distinguishing the stable and fluid truths of inquiry. Stable inquiry presents truths to be verified, whereas fluid inquiry verifies the revolutionary methods of science and research. Schwab contended that students should be involved in discourse about the role of technology, problems, interpretations, and debates about data.
The recommendation of the NSES (NRC, 1996) is not to limit science teaching to a single approach, but to use different strategies to better develop knowledge, understandings, and abilities. Bybee’s (2000) own recommendation is to separate *inquiry as content* from *inquiry as teaching* strategies, thus placing inquiry into two categories. Teachers use inquiry as a strategy to help students learn.

**Encouraging Higher Levels of Thinking**

Educators cannot ignore what students bring to the learning activity. As in *Bloom’s Taxonomy of Educational Objectives* (Bloom, Hastings, & Madaus, 1971), the Cognitive Domain presents and clarifies the taxonomy of learning and illustrates the importance of presenting content at multiple levels to meet the needs of a variety of learners (Appendix D). Bloom’s Taxonomy divides intellectual outcomes into six progressive levels from the lowest level of thinking, simple recall, to the highest level, evaluating information.

Brain researchers over the last 30 years now base their conclusions about learning on specific centers of the brain and the neurological pathways that information uses to travel to those areas (Clark, 1992). Keeping in mind that the brain must be stimulated or else it loses its capability, classrooms that present learning experiences only at the lower levels are lacking and are of concern.

Apple and Jungck (1998) categorize the levels of learning knowledge are of three types:

1. knowledge *that*—factual information, basic knowledge, standardized test foci;
2. knowledge *how*—skills, how to inquire; and
3. knowledge *to*—dispositional, norms and values.

Placed in a hierarchal sorting, “knowing *that*” as an assortment of facts is certainly less important than ‘knowing *how*” to think and solve higher order skills of inquiry. Finally, “knowledge *to*” use one’s skills intellectually in a positive way. These levels are parallel to the cognitive thinking levels described in Bloom’s taxonomy (Clark, 1992). That is, the parroting of facts learned is the lowest level of knowing *that*. The second level, the knowledge *how* involves skills learned, including higher order thinking skills, and extends to the autonomous habits of problem solving. Lastly, the knowledge *to* is the highest order of thinking and involves norms, values, and properties that guide our conduct (Apple & Jungck, 1998). This high level of knowledge is actualized through inquiry learning, paramount to the achievement of science literacy (Tamir, 1998).
Digital Divide

The digital divide, introduced in Chapter 1, consists of inequalities in access to computer technology, but it is not limited to acquisition of technology. By ensuring that the necessary knowledge to effectively use the power of the Internet and technology is available to all, we can guarantee the Matthew effect (Hirsch, 2000, p. 9) does not translate itself into the core of learning. The Matthew effect dictates that those who know a lot will be able to learn even more; while, those who know little will be able to add little beyond obvious frustration and withdrawal. The digital divide translates this societal imbalance.

Richard Riley (2000), former Secretary of Education, says a cyber-segregation will surface in the coming century if we, as educators, are not watchful. He states “Too often in the past, and sometimes even now, we have set low expectations and used categories and labels—she’s disabled; he’s black; she speaks Spanish; they’re difficult labels that have denied too many children the quality education they deserved” (p. 12). Riley adds, “Equity is at the very heart of our challenge to overcome the minority achievement gap” (p. 12). A study by Wilhelm, Carmen, and Reynolds, (2002) cites minority children and children living in poor families or high-poverty neighborhoods are the least likely to have a computer at home or access to the Internet. Their schools often close some of the gap, but significant disparities remain in spite of access at school.

Tech Savvy, a two-year study issued by the American Association of University Women (AAUW) Educational Foundation, reports statistics that indicate women are underrepresented in technology (Mayfield, 2000). Pamela Haage, AAUW research director, emphasizes that girls do not need “pink software,” but the violence primarily aimed at boys is turning girls off at an early age (Mayfield, 2000). NEA Today (Green, 2000) issues further revealing studies that relate to the Tech Savvy: Educating Girls in the New Computer Age study. The hidden story is that if girls are technologically uneducated, then, therefore, the skepticism and concerns about the use of technology in the classroom are understandable, since the majority of educators are women. Haage, in his online survey of 900 teachers, “found that teachers have some of the same concerns and legitimate skepticism about the use of computer technology in the classroom as girls do” (Green, 2000, p. 31).

Educators must change the way they teach to attract girls to technology or girls will be left behind in the technology-related jobs sweeping the workforce. The gender gap is not closing as boys have more opportunities to master technology (Mayfield, 2000). Koch (1994) reveals,
“computers and other high-tech equipment have been used in and considered part of math and computer science, still predominately male domains” (p. 2). Koch’s preliminary studies on girls and telecommunications indicate that girls’ interest heightens when the activities are collaborative in nature. Girls’ participation also increases when we encourage them to be open and creative. Girls use computers primarily, according to these studies, to solve problems, communicate with friends, and find information, while boys prefer games, tinkering, and programming to solve problems. Programs implemented in learning environments free of pressures due to gender, as well as all other forms of bias and prejudice, are more likely to succeed than other programs. As Haage warns, if the technology culture and today’s girls do not find mutual ground, future employment opportunities for girls will hardly exist (Green, 2000).

**Seven Dimensions of Progress and their Application**

MDCPS is one of many districts across the nation asking difficult questions about the implementation and effectiveness of technology. The district invested over $40 million in learning technology during the 1998–1999 school year. Questions remain, such as, “Does the technology work?” or “Is technology an effective learning tool for improving academic performance?” Miami-Dade County commissioned the Milken Exchange, in the spring of 1999, to conduct a district-wide survey that aligns the schools’ technology-related learning goals with matching assessment items from a multitude of sources. Miami Dade is now able to examine the reviews and recommendations from this report (Milken, 1999b). Further data are from an online survey. No apparent *digital divide* is evident, and the student-computer ratio is 5:1 (Milken, 1999a).

The Milken Exchange on Education Technology (1999b) is part of the Milken Family Foundation. This respected research foundation dedicates itself to examining the potential role of technology and its effect on learning. The Milken Exchange collaborates with others to develop a practical guide enabling schools to analyze the effectiveness of their technology programs. These *Seven Dimensions* (Lemke & Coughlin, 1998) outline how schools can measure their own progress of the implementation of technology in classrooms. Examples of the way in which proper use of technology results in positive learning opportunities can be found in many schools.

The truth, however, is that these examples are, today, more the exception than the rule. Technology is finding its way into classrooms across the nation, but that does not necessarily guarantee that teachers or students yet have adequate access to technology, or more importantly
that they have the knowledge, skills, and abilities to use these tools in ways that advance learning. (Lemke & Coughlin, 1998, ¶1)

Using the acquired data that assess the status of technology and its use across the district, along with the recommended guidelines of the Seven Dimensions of Progress, MDCPS is better prepared for the knowledge-based society of tomorrow. While reviewing the framework of progress indicators (Lemke & Coughlin, 1998), I apply the following independent profiles to the research I conducted. Briefly stated the Seven Dimensions include:

1. LEARNERS: Are learners using the technology in ways that deepen their understanding of the content in the academic standards and, at the same time, advance their knowledge of the world around them? (Lemke & Coughlin, 1998, p. 18)

Application: Club members used the Internet an applied scientific knowledge and computer skills to send email to a scientist discussing possibilities for life on the planet Mars. This is doing what scientists themselves actually do. While communicating and integrating the technology into areas of The Living Planet (Lambert, 2002) curriculum, students were able to experience measurements, sampling and interpreting data. The Walden Sci-Tech Club members worked in collaborative teams while engaged in scientific and technology activities that were more social in nature. In addition, through WebQuest (Dodge, 2001) guidelines, club members journeyed on a virtual field trip into a tropical rainforest while initiating a research quest for unanswered questions using the Internet as an investigative guide. Members used these resources and tools to create their own environmentally safe island reflecting inquiry-based thinking and learning.

2. LEARNING ENVIRONMENTS: Is the learning environment designed to achieve high academic performance by students through the alignment of standards, research-proven learning practices and contemporary technology? (Lemke & Coughlin, 1998, p. 20)

Application: The school culture provided the students opportunities to participate in the Walden Sci-Tech Club and other science experiences. Involvement and interest were predicated upon acceptable evaluation in the regular classroom. Students collaboratively made effective use of the information and communication technology, as they became “Sci-Techies,” mentoring classroom peers in the computer laboratory. This also involved inquiry-oriented activities using the Internet and focused on searchable databases, established a school garden as they focused on unique environmental limitations, and finally, created an island (environmentally accurate),
displayed as a PowerPoint presentation. Students who expressed an interest in extending the project were encouraged to extend their goals.

3. PROFESSIONAL COMPETENCY: Is the educator fluent with technology and does he/she effectively use technology to the learning advantage of his/her students? (Lemke & Coughlin, 1998, p. 22)

Application: Not all educators are fluent using technology. I used technology and current technological tools to enhance learning activities at every opportunity. Whether it was using the closed circuit T.V. for club members presenting timely science information, discovered inquiry-oriented activities through research in WebQuests (Dodge, 2002), researched weather phenomena, or encouraged students to explore current science events, the computers were used in authentic, hands-on exploration and learning.

4. SYSTEM CAPACITY: Is the education system reengineering itself to systematically meet the needs of learners in this knowledge-based, global society? (Lemke & Coughlin, 1998 p. 24)

Application: Locally, according to the 2003-2004 SPEP (School Performance Excellence Plan) Executive Summary (Martin, 2003), the integration of technology enhanced and enriched the curriculum and required students to take on more independent roles in their own learning through the classroom computers, computer laboratory and media center. When possible, I wove the components of the aquatic theme with threads of advanced technology. I provided Walden Sci-Tech Club members, students, and professional development workshops designed to integrate Internet activities across the curriculum.

5. COMMUNITY CONNECTIONS: Is the school-community relationship one of trust and respect, and is this translating into mutually beneficial, sustainable partnerships in the area of learning technology? (Lemke & Coughlin, 1998, p. 26)

Application: The Educational Excellence School Advisory Council (EESAC) included technology skills and application as part of its annual SPEP (Martin, 2003). The levels of computer proficiency and comfort were varied and extreme among the faculty. School budgets continued to direct purchases for new computers. At least one computer with Internet connection was available for students’ use in each classroom. It seemed that students who had computers at home had an advantage with their skills and technological know-how. Both their peers and their teachers sought and appreciated the expertise of these students.

6. TECHNOLOGY CAPACITY: Are there adequate technology, networks, electronic resources and support to meet the education system’s learning goals? (Lemke & Coughlin, 1998, p. 28)
Application: The school had a Local Area Network connected to the MDCPS Wide Area Network. Each classroom was equipped with at least four multi-media computers linked to the Internet and a printer. Teachers had completed technology workshops, but not all faculty and staff were “technology-ready.” Continued efforts and updated techniques were encouraging as the resident technology support person was readily available for support and assistance. The addition of new computers had enriched the technology resources. The Division of Instructional Technology rendered support by offering courses through staff development. The “Leave No Child Behind: Enhancing Education Through Technology Plan” (2003–2004) supported the transformation of technology as a catalyst for change through a leadership training program for school principals.


Application: The recently released document, “Educational Technology Standards and Performance Indicators for All Teachers” (ISTE, 2003) delineates 20 distinct standards and benchmarks. This pioneering document describes what students in grades K-12 should know and perform in order to be technologically literate. Miami-Dade County’s Division of Instructional Technology continues to provide resource sharing, innovation, and communication to help launch schools into the Information Age.

Ways of Learning

Linn and Hsi (2000) advocate the design of learning activities so all students can find their own “learning partners” (p. 5). The authors maintain that computers, teachers, and peers can serve as learning partners. Teachers who offer rich and varied experiences can enhance learning. Through co-participation, students are part of an evolutionary community and may become, at various times, observers, peer teachers, learners, and/or facilitators. Students can sometimes explain scientific ideas to their peers better than the teacher. In addition, students can sometimes understand or reformulate scientific observations more clearly working together than by working alone. Scientific ideas can link new concepts to old ones, make meaningful connections, and lead the way to more abstract ideas.

Through adherence to the first pragmatic principle, learners make links and connections with their peers as they sort out their ideas, seeking a coherent view of science in their world. Learners reflect on and restructure their ideas as they synthesize and integrate existing ideas into
a lifelong process of knowledge construction (Linn & Hsi, 2000). In the second pragmatic pedagogical principle, the students examine relevant, real-life problems applicable to actual experiences and choices in life.

The third principle is to help students acquire an inquiry process that they can use throughout their lives. Students need to gain skills in establishing their own inquiry processes (Linn & Hsi, 2000). Finally, the fourth pragmatic principle establishes effective peer interactions, leading to an increased repertoire of social roles. Cooperative and collaborative groups, along with class discussions, offer productive experiences. Electronic discussion is especially useful as an alternative. Asynchronous electronic discussion encourages and provides opportunities for self-paced involvement and may be more gender equitable than other forms of discussion (Linn & Hsi, 2000).

Technology: Current Status

Richard Riley, former Secretary of Education, spearheaded a nationwide survey to determine school Internet access to schoolchildren. Begun in 1995, the reported five-year growth from a little over one-third of schools to 95 percent indicates that schools respond to the recognized need and expansion for access to the Internet. Riley states simply, “Technology can improve student performance and provide the competitive skills necessary for future success. It is critical that we provide a link for those in the smallest towns to the largest cities” (Olmstead, 2000, p. 3A).

Linn and Hsi (2000) describe computers as metaphors, such as “(a) visualization tools (computer-aided visualization, digital art and multimedia presentation tools such as creating cell animation, the weather dynamics, impact of earthquakes); (b) computational devices (spreadsheets and data bases including real-time data collection and research); (c) electronic libraries (Internet access replacing libraries); (d) matchmakers (connecting learners to experts)” (p. 290).

Asked how I describe computers metaphorically, my reply is, “Computers are the genies in a bottle, awaiting you, their master, to release them for all their power to be realized as you control the tasks they will perform!” The computer and computer-based technologies have the inherent ability to serve humankind and to enable people to extend their abilities in their daily lives and workforces. Through interactive technology on the Internet, learning can engage students as critical investigators, thereby helping learners to develop further autonomy and
lifelong learning skills. All children deserve an education that will prepare them to become active learners and productive citizens throughout their lives.

Using technology that facilitates student learning, encapsulates the vision that I seek to incorporate into my goals for student learning, curriculum, instructional methods, and assessments. My foremost goal is to provide the thinking tools that enable my students to become lifelong learners and to adapt to a world infused with increasing sophisticated technologies. Gorry (1998) aptly quotes Abraham Lincoln’s observations, “The best thing about the future is that it comes one day at a time” (p. 7). According to Gorry, the problem facing educators is not so much of forecasting the future as much as it is inventing and creating curricula that challenge our views of the world. Part of this realization is that the world we are preparing for is so technologically advanced, we cannot envision it.

Summary

It is impossible to deny the tremendous effects that rapid technological growth has had on our society and education. New technologies have dramatically changed the way we live, from the way we do business to the way we communicate with each other. Maddox (1999) explains, “the most important discoveries of the next 50 years are likely to be ones which we cannot now even conceive” (p. 62). Pinar et al. (1998) pose the question stated in the Project 2061 (AAAS, 2000a), “Is it the goal of technological literacy to be attained through the teaching of technology as a separate subject, or through a reflection of the technological literacy across the range of school subjects?” (p. 718). We can answer that question when we realize that the power and potential of technology has thrust us into frontiers never before imagined. Technology can no longer be isolated and kept in tow.

While we can do inquiry in learning environments without technology, when we use learning technologies, we can expand the range of questions that we can investigate. Properly introduced, it can elaborate the type of information that can be collected with selected kinds of data representation displayed. Finally, the assessments for the products themselves can be uniquely created and demonstrated in ways that go beyond the classroom (Krajcik et al., 2000).
CHAPTER 3: METHODOLOGY

The best thing for being sad is to learn something. That is the only thing that never fails! You may grow old and trembling in your anatomies, you may lie awake at night listening to the disorder of your veins, you may miss your only love, you may see worlds about you devastated by evil lunatics, or know your honour trampled in the sewers of baser minds. There is only one thing for it then—to learn!

—T. H. White (Lerner, 1996, cover)

In this timeless quote Merlyn, the wizard, advises the young Arthur of Camelot, from T. H. White’s *The Once and Future King* (Lerner, 1996). Merlyn’s lessons were pure adventures, distancing Arthur from the sadness of his youth through engaging in learning science, mathematics, history, and literature. Merlyn’s advice remains powerful today.

My research described here explored how students learned to conduct scientific inquiry through teaching that promoted a lifelong quest for pragmatic, coherent, and useful understanding of science using the tools of the Internet (Bell & Linn, 2002). I used action research as the method to view situations through critical thinking, to enhance decision-making, and to assist in problem solving (Bosseler, 1999a). Gilmer (1999) describes action research as “…a form of research in which the researcher studies his or her classroom” (p. 5).

My role as teacher researcher allowed me to examine my own teaching strategies and the student learning using the Internet as a teaching tool. This allowed me to become increasingly familiar with what my club members believed would help them learn and where that learning took place. Humerick (2002) reminds us, “One of the beauties of an action research study…is that you can evaluate your effectiveness…and change almost symbiotically depending on the needs of the class” (p. 223). My study was set in an elementary school science club, providing opportunities for goals to be set, analyzed, and measured for change. Action research promotes change, becoming especially effective in an inquiry-based classroom. Collins and Spiegel (1997) insist, “Action research is seen to complement inquiry” (p. 118).

According to Cunningham (2002), “Use value” (p. 366) was one of the goals of this action research; this research proved useful for my professional growth and for furthering knowledge for other educators. That is, I wished to be the instrument to collect and analyze
research data to, perhaps as Cunningham (2002) quoting Taylor expressed, “…inspire others with undreamt-of possibilities for renewal” (p. 366).

The mission statement for the Miami-Dade County Public Schools (MDCPS) focuses “on the integration of technology into the instructional program to improve learning outcomes and prepare students for the future” (ITP 2001, p. 1). Related staff development workshops and classes focus on this crucial need. Desired student outcomes of the Instructional Improvement Plan (IIP), and a District-wide National Science Foundation (NSF) grant, include that of students becoming self-directed learners, complex thinkers, and collaborative group members as they discover the inquiry potential of the Internet. *WebQuests* (Dodge, 2001), an inquiry-oriented activity, provides learners with activities drawn from the Internet to focus on using information rather than looking for it. Support for learners’ thinking becomes elevated to higher levels of synthesis, analysis, and evaluation.

**Purpose of the Study**

Using the computer and the Internet, I qualitatively assessed the level of negotiated constructions to determine how students come to make meaning through their technological experiences. Computers also supported inquiry learning. I used Krajcik et al. (2000) definition of inquiry as experiences to “find solutions to real problems by asking and refining questions, designing and conducting investigations, gathering and analyzing data, making interpretations, drawing conclusions, and reporting findings” (p. 283). Learners gained skills in interacting and building their own and joint constructions of thinking.

Linn and Hsi (2000) further resolve that achieving fluency in information technology requires a prolonged planning process. Although many continue to resist the challenge of learning technology and encounter the frustrations created by this new form of teaching, technology is here to stay. Educators can use technology to promote lifelong science learning. According to the American Association for the Advancement of Science (AAAS) (1989), “As technologies become more sophisticated, their links to science become stronger” (p. 27). Learning is an on-going process of organizing and restructuring prior knowledge as well as processing and integrating new knowledge.

The prior knowledge that my classroom learners, the stakeholders in this study, brought to each learning experience affected how and what they learned (Glasersfeld, 1993; Bosseler, 1999a). I explored “knowledge integration” (Bell & Linn, 2002, p. 322), promoting the
development of a cohesive view of science learning rather than a repertoire of ideas. *The Living Planet* (Lambert, 2002) curriculum promoted this knowledge integration as members incorporated different yet connected ideas about the nature of scientific inquiry.

One of my roles was that of facilitator for student members who were learning to make sense in relation to their own experience (Lorsbach & Tobin, 1992). Teaching strategies that involved collaborative learning helped to create a social constructivist environment. Here, learners tested the fit of the experiential world along with their peers. New experiences brought perturbations, which required the individual to adapt or reject as they fit into their new experiential world (Lorsbach & Tobin, 1992). I built and focused upon each member’s knowledge by sharing control with each one and by using discrepancies in scientific content as entry points for inquiry.

Constructions need to be self-sustaining and self-renewing. Crawford (2000) compares the day-to-day processes involved in creating and sustaining an inquiry-based classroom on a continuum with the traditional and discovery methods. She terms inquiry-based learning as collaborative inquiry requiring the greatest level of teacher involvement, whereas the traditional and discovery models involve the teacher as the transmitter of knowledge and the student as the receiver of knowledge. Crawford suggests that a myriad of teacher roles be available to best fit the changing environment of the classroom.

In a schematic portrayal of these models on a continuum, Crawford (2000, p. 934) places the discovery model to the left of the traditional model and the inquiry-based model at the other end of the continuum, as indicated in Table 3–1.

**Table 3–1**

<table>
<thead>
<tr>
<th>Level of Teacher Involvement in Science Learning Models</th>
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<tbody>
<tr>
<td>Discovery</td>
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<tr>
<td>Teacher least involved</td>
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*Note.* Adapted from Crawford (2000, p. 934)

The Milken Exchange on Education Technology (Lemke & Coughlin, 1998) encourages us to recognize classrooms in which teachers do not only include technology in activities, but also use technology as an effective tool for learning. O’Riordan (2000) is cautiously optimistic as educators and policymakers consider technology investments, confirming that effective use of
computer technology can be helpful and lead to improving test scores. Cheryl Lemke, executive director of the Milken Exchange, explains:

What we see from the research is that how computers are used has a lot more to do with their impact than whether or not they are used. Rather they should be mapping out strategies for all students and using technology as a tool in the process. (O’Riordan, 2000, p. 1)

I used the following questions to guide my action research:

1. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?
2. How do learners make sense of scientific inquiry while using technology and the Internet?
3. How can I as a teacher enhance learning through scientific inquiry using technology and the Internet?
4. How can I redirect my teaching strategies while using technology so that my club members can learn and love science?

In my study, I used The Living Planet: Earth Systems Curriculum (Lambert, 2002) and WebQuests (Dodge, 2001) to help me enhance student learning through scientific inquiry and to redirect my teaching strategies to include the Internet. The Living Planet and WebQuests are tools to provide seamless integration of technology into the curriculum. The Living Planet (Lambert, 2002) is an elementary earth systems curriculum providing a framework for hands-on scientific inquiry. WebQuests (Dodge, 2001) is an inquiry-oriented activity in which the learners draw most or all of the information from the Internet. WebQuests uses learners’ time well, to focus on using information rather than looking for it, and to support learners’ thinking at the levels of analysis, synthesis, and evaluation. I utilized action research in my science club as I taught science using supportive technologies. Instead of using an unstructured curriculum leading to a barrage of activities, referred to as “activitymania” by Moscovici and Nelson (1998, p. 1), I focused on students’ thinking and their questions. I conducted this research by addressing the complexity of club members’ efforts to make use and make sense of new information as they used their imagination to explore earth systems in a guided and meaningful manner.

Theoretical Framework

The theoretical perspective that best explains my beliefs and this research is social constructivism. According to Dana and Davis (1993), individual constructions of meaning and
interpretations ground educational research. Constructivists acknowledge that individuals construct knowledge through active engagement with their physical and social world (Roth, 1993; Bosseler, 2000). Exercising a constructivist paradigm enables me to acknowledge myself as a teacher and as a learner.

Denzin and Lincoln (1994) describe the evaluator as the “conduit” (p. 15) shaped by socially constructed reality. If I am the conduit, shaped by these experiences, this research becomes critically subjective and personal.

There is no single and absolute interpretive truth, but descriptions emerge, as I, the researcher, become the research instrument. Janesick (1994) develops the metaphor of the qualitative researcher as dance choreographer. Just as in dance, the body is the instrument for telling the story, the qualitative researcher must use data to convey and produce findings. As dance imitates and creates life, so does research alter and change as the research emerges. Janesick (2000) refers to “methodolatry,” criticism for the “idolatry of method or slavish attachment and devotion to method” (p. 390). Preoccupation with methods misdirects the reader away from the true meaning of the experience.

A good researcher focuses on the substance of the findings. Janesick’s analogy clearly defines the qualitative researcher stating, “A good choreographer refuses to be limited to just one approach or one technique from dance history. Likewise, the qualitative researcher refuses to be limited” (Janesick, 2000, p. 381). Research begins with an idea, just as all dances are initially ideas set in motion. By viewing research design as improvisation, the researcher selects the most appropriate methodology and proceeds. Each asks, “What do I want to say?” or “What do I want to know?” Selecting social constructivism as the most appropriate theoretical framework allows me to initiate the research project as a dancer begins the “warm-up.” Qualitative researchers concern themselves with the face-to-face realities and do not construct the research to prove something.

I maintained the vision to use technology to facilitate student learning through inquiry. I sought to incorporate technology, using The Living Planet curriculum (Lambert, 2002) and constructivist instructional methods. My foremost goals were to provide the thinking tools so club members could become lifelong learners and can adapt to a world infused with increasingly sophisticated technologies.
Interpretive Research Design

The interpretive research design for this study provided me with the tools of my trade; I sought to reflect these resources on my own human constructions. I considered how Stake (2000) refers to these constructions as “cognitive flexibility” (p. 443). As the teacher researcher, I assisted the student in constructing knowledge, and, as the author researcher, I assisted the reader in constructing knowledge. The fragmented parts of a new encounter reassembled into experiential knowledge. I was aware that there is no single, validated truth, but the realization that there is always more to know (Richardson, 2000). Without a “fixed point” (p. 934), I could invent and draw freely on these boundless, refracted crystals of interpretive research.

I qualitatively assessed the level of negotiated constructions to determine the extent of the impact of technology on the project. I assessed how the students integrate technology into the inquiry-based, learner-centered curriculum. The research required a positive learning environment and the maintenance of a constructivist climate favorable to enhancing cognitive and affective aims (Fraser, 1989). Here students were stakeholders in the constructions of new understandings while thinking and solving problems. Guiding my vision for the Walden Sci-Tech Club members was the hope that

[By] freeing them from conventional wisdom…students…realize that they become answerable for the choices they make in constructing the world as they do. When things go wrong, they cannot escape complicity and place the blame elsewhere. But they may find comfort in knowing, along with T. S. Eliot in Little Gidding, that, ‘the end of all their exploring will be to arrive where they started and know the place for the first time.’ (Chrenka, 2001, p. 695)

Action Research

For my research, I performed action research in the Walden Sci-Tech Club in which my teaching was rich in project-based inquiry. This provided me with data that reflected relevant and authentic classroom learning. I conducted action research on my teaching to help me accomplish the goals that I had set for engaging the learners of a summer school science club. In this study, the strategy of my action research enhanced the potential that technology brought to learning and so that my students could extend knowledge constructions. In a constructivist-learning environment, action research provided me with an opportunity to assess both my teaching and the students’ conceptions of themselves as learners. Within an age-appropriate educational structure, the computer connected students to the science curriculum in order to assist in the development of their critical and analytical thinking.
I wanted my students to envision themselves as scientists, sharing an understanding of science that is less intimidating and that connects to realistic personal experiences. To achieve this, I shared control of the learning environment in this summer school program with my club members. I rejected the notion of a researcher as a disconnected observer (Adams & Slater, 1998).

In an attempt to empower others as they learned to become authentic learners and thinkers, I used action research to discover the hidden dilemmas that existed between three target students from my Walden Sci-Tech Club and me. As these students constructed the knowledge, I, the teacher-researcher, facilitated my students’ learning. I adapted a conceptual framework for effective action research by Black and Stave (2001) (Figure 3-1). This action research cycle helped, guide me as I focused on its strategies (Jenkins, 2003).

**Figure 3–1. The Action Research Cycle.** Adapted from Black and Stave (2001, p. 132) and Jenkins (2003, p. 35).
My previous studies using scientific research (Bosseler, 1999a) helped me to prepare for this autobiographical challenge. Through strategies of inquiry, I directed authentic learning opportunities utilizing the Internet and Internet-field-based experiences. These opportunities became the vehicles for determining if a community of scientific discourse and activity could be established. In this natural setting, the journey did not need to include a destination; by its nature, it was ongoing and continual.

As advocated by Gallas (1995), “They [the stakeholders] begin to bring their world of experience to the classroom in the form of personal narratives and important questions” (p. 3). As stakeholders, club members transformed the classroom into a laboratory of scientists whose interests, questions, and theories emerged from the inside out, rather than from the outside in. I was aware of Gallas’ claim that “Achieving this goal requires time, a commitment to placing the child’s voice in the foreground of the science curriculum, and silence—on the teacher’s part” (p. 3). My continual development as a teacher-as-researcher empowered my students as stakeholders to join me in becoming co-developers and co-researchers as the curriculum moved through rich sources of learning, debate, and challenge. Experience by itself was not enough unless learners were able to make sense of it (Driver, Squires, Rushworth, & Wood-Robinson, 1994).

My regular classroom was full of “stuff,” in the natural and physical sciences, offering a variety of activities that encouraged observations and growth in thinking. My students strengthened their learning and curiosity as they developed new constructions. For some learners, this required a radical change in perspective because they did not realize initially that they needed to construct their own meaning. The Walden Sci-Tech Club was my classroom, where “co-construction” (Gallas, 1995, p. 11), or the building together of the members’ ideas, took place. As described by Dana and Davis (1993), I remembered that researchers who are constructivists base their methodology on individual interpretations and meanings. The use of the Internet and technology provided learning experiences that added significant value and motivation to learn science.

Case Study Approach

I had in my mind how Stake (2000) explains; “Case study is not a methodological choice but a choice of what is to be studied. By whatever methods, we choose to study the case” (p. 435). I chose to use the instrumental case study approach because it provided me with opportunities to follow my focused interests in technology and inquiry learning. By choosing
three students for the case study, I examined individuals who were quite different from each other, yet who interacted together during the inquiry and Internet learning activities.

Case researchers can select personal events and relationships of their choice while failing to pass along others. Stake (2000) expresses a note of caution, acknowledging that readers may construct knowledge differently than the researcher, so it is likely to be personally useful. Stake (1994) insists, “Studying the ways that authentic learning opportunities enhance learners’ ability to conduct scientific inquiry emerges epistemologically as an instrumental case study” (p. 237). Stake maintains each case is special because the process and the product of our learning are evident in both. Yin (1994) provides characteristics of an exemplary case study, namely, case studies must be significant, complete with compiled supporting evidence, sufficient to represent different perspectives, and reported in an engaging way.

My goal became an investigation to develop sharper and more insightful questions about what students know and to guide them to discover answers to their questions.

Development of Methods

Lincoln and Denzin (1994) describe how the traditional relationship between the reader and the writer changes as new electronic social worlds emerge, changing the concept of communications. Notably explained, “These faceless, electronic selves find themselves located in simulated communities. These communities have their own international norms concerning the public, the private, the sacred, the secular, and the rational” (p. 583). This assertion has proved itself a present-day reality as we have learned to surf the Internet, check our email, adapt to palm-sized computers, and carry out other computer-related actions. Distance learning has rapidly become commonplace and the nominal purchase of online (electronic) textbooks is changing the face of book companies. As Bill Gates contends, “Our goal is to encourage creativity and encourage initiative. Having knowledge of technology and access to technology is becoming as fundamental as literacy” (Garcia, 2001, p. 1C).

Scientific inquiry, the Internet, and action research were the three main vehicles for social construction of knowledge for the framework I used in my doctoral research. Technology and the Internet have radically transformed societal communication (Lincoln & Denzin, 1994). We have changed our dialogue “…from face-to-face interaction to text-mediated communication contexts” (p. 583). Along with creating new communities of qualitative researchers, using the laptop, interactive videos, and modems have replaced the printed page. The “The Fifth Moment”
Technology transformed essentially every phase and form of my qualitative research.

In this research study, I used the *WebQuests* (Dodge, 2002) and *The Living Planet* (Lambert, 2002) curriculum collaborative science projects. These Internet-based collaborative projects, multidisciplinary in nature, provided excellent opportunities for students to learn about different societies and cultures. I used the Savvy Cyber Teacher’s (1998) four unique and compelling applications of the Internet: (a) communications tool, (b) publication of students’ work, (c) unique sources of information, and (d) real time data information.

Table 3-2 illustrates the Internet’s effectiveness and the Walden Sci-Tech Club investigations relative to the Savvy Cyber Teacher (1998) teaching model. I believe the most significant role for teaching is to construct learning bridges between students and subject matter. The Office of School Improvement Information Wave Series #16 (FLDOE, 2000) characterizes the current reform as focused on the development of “communities of learners.” Educational reform demands that students not only know the basics, but also how to use these basics to identify and solve nontraditional problems.

The example of the plight of the sea turtle (Table 3-2), and the impact of humans on this endangered species, demonstrated this philosophy in action. It provided the opportunity for me, as the teacher, to construct learning bridges between my students and the subject. This environmentally related problem became a springboard for club members to select, research, and explore using the Internet as a resource agent. *The Living Planet* (Lambert, 2002) curriculum became a guide for learning about earth systems as students created an original, environmentally safe island. To improve the quality of student learning, I directed the activities, enabling members to develop the ability to conduct inquiry and construct scientific ideas using the Internet.
### Table 3–2

**Internet Effectiveness—Walden Sci-Tech Club Agenda**

<table>
<thead>
<tr>
<th>Application</th>
<th>Internet Effectiveness</th>
<th>Walden Sci-Tech Club Investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications Tool</td>
<td>While students worked collaboratively, projects were exciting in challenging ways that allowed students to do things they could not do with a more traditional learning environment.</td>
<td>Use of the Internet motivated and freed members to seek invaluable project resources otherwise not possible. For example, students viewed sea turtles, afflicted with ocean pollutants, off the coast of Hawaii.</td>
</tr>
<tr>
<td>Publication of Students’ Work</td>
<td>Publishing work on-line prompted comments and interactions with other students and further enhanced communication skills.</td>
<td>Using the <em>Living Planet</em> curriculum and <em>WebQuests</em> project scenarios, members collaboratively designed an environmentally safe island. The activities promoted science as inquiry, shared constructions, and peer evaluations.</td>
</tr>
<tr>
<td>Unique Sources of Information</td>
<td>Seeking information and communicating with scientists provided rare and unique opportunities for students to interact with professionals</td>
<td>Unique investigations provided a scientific framework using data entry forms on the Internet as well as access to actual scientists to promote original inquiry.</td>
</tr>
<tr>
<td>Real time data information</td>
<td>Collecting and publishing students’ scientific data encouraged collaboration. Students now access researched information that was accessible only to scientists a few years ago.</td>
<td>The impact of humans on sea turtles, an endangered species, was one focus of research and Internet studies. Timely, meaningful data assisted members as they developed environmental awareness of our Living Planet.</td>
</tr>
</tbody>
</table>

*Note.* Adapted from Savvy Cyber Teacher, 1998, p. 4
Hermeneutic Dialectic

I used Schwandt’s term, hermeneutic (1994), to refer to the interpretations and analyses I made of divergent views held by the stakeholders (e.g., club members) in an effort to understand the dynamics of the social interactions and learning by the club members. Schwandt (1994) echoes the views of Guba and Lincoln (1989) emphasizing the hermeneutic dialectic process because it is interpretive and foster interpretive constructions. I engaged the club members in the hermeneutic dialectic process. This encouraged them to share open discourse with each other and me. Their claims, concerns, and issues were vitally important to me.

Guba and Lincoln’s interpretive methodology (1994) fosters comparing and contrasting divergent constructions in an effort to achieve the emergence of shared constructions (Schwandt, 1994). These joint constructions arising during inquiry present the possibility of immediate and continuous feedback so that the group agrees or disagrees on the key issues. Although conflicting, the purpose is not to renounce the construction of others but to form connections between participants, thereby encouraging collaborative empowerment of all contributors and recognizing each other’s alternative constructions (Schwandt, 1994).

One of the constraints of hermeneutics for youngsters can be the lack of focus on continued inquiry. Collectively, the aim of the hermeneutic process is to reach consensus, when possible. When not possible, researchers may use the process to clarify and expose different views. Using an agenda for negotiation, all parties can become empowered and educated (Guba & Lincoln, 1989).

Quality Criteria

My responsibility was to make the learning environment inviting while non-threatening, and the involvement as productive as possible, without compromising ethical guidelines. I conducted immediate and continuing evaluation using Guba and Lincoln’s goodness or quality criteria (1989). Guba and Lincoln approach these criteria through the nature of the hermeneutic process itself, the constructivist authenticity criteria and the “parallel or quasi-foundational criteria” (Guba & Lincoln, 1989, p. 233). The asserted hallmark of a trustworthy and validated constructivist inquiry is the authenticity criteria (Guba & Lincoln, 1989), outlined in the next section. The parallel criteria term is recognized by having its roots and origins in positivist or conventional paradigm. While adjustments have been made for the different assumptions of the trustworthiness criteria, an anomaly of the two paradigms exists, as the beliefs of the two are
contradictory. This, according to Guba and Lincoln (1989), is “a feeling of continuing to play ‘in the friendly confines of the opposition’s home court’” (p. 245).

**Authenticity Criteria**

Guba and Lincoln (1994) propose authenticity criteria as the co-existing hallmark for quality criteria or goodness. These criteria promote involvement of the stakeholders in an opportunity for reflective social and political growth. It is at this specific point of shared control that constructivists turn away from other conventional paradigms (Lincoln & Guba, 2000).

Moving from traditional methodology, Richardson (1994) explores the metaphoric notion of crystallization, “prisms that reflect externalities and refract within themselves…. What we see depends upon our angle of repose” (p. 522). Having a number of perspectives, we emerge with different patterns from a set of given data. Richardson states, “Paradoxically, we know more and doubt what we know” (p. 522).

Authenticity criteria for this study are of the following five types: educative authenticity, ontological authenticity, catalytic authenticity, tactical authenticity, and fairness. Guba and Lincoln (1994) posit these to resolve early efforts to resolve the issues of conventional, cause-effect paradigms. Described as:

1. Educative authenticity means sharing and appreciating the constructs of others, however different, both within and beyond the primary stakeholder group. Janesick (1994) reminds us that work in the field requires “deliberate decisions about hypotheses generated and tested on the one hand and intuitive reactions on the other” (p. 213).

2. Ontological authenticity means elaborating and communicating respondents’ (i.e., the stakeholders’) own emic (i.e., original) constructions (Guba & Lincoln, 1989). This criterion relates to the notable changes that evolve through the process. It can be accomplished through stakeholders’ acknowledgment of broader and deeper understandings as they “enlarge personal constructions” (p. 114).

3. Catalytic authenticity means prompting action on the part of the research participants, which involves the catalytic approach in the hermeneutic circle. This criterion involves the willingness of participants to become involved in and changed from this process.
4. Tactical authenticity means evidencing increased understanding and communication within the group, including the reader’s own reconstruction of knowledge. Guba and Lincoln summarize (1994) the concept as, “The catalytic criterion has little impact without the tactical element. Empowering stakeholders through tactical authenticity creates the capacity for positive social change, thereby empowering actions” (p. 114). It is here that constructivist inquiry begins to resemble forms of action research. Action research creates this social change where learners mediate learning as they interact in a social environment. Working and planning collaboratively helps to establish a team spirit.

5. Fairness provides the balance to maintain and honor each stakeholder by repeatedly making it clear to the group that each member is a valued and worthy contributor. It is important to represent all voices. It is necessary to assure equal and appropriate participation for all members of the stakeholder group.

**Trustworthiness Criteria**

Through the hermeneutic process, it is possible to establish the trustworthiness criteria. Through trust and integrity, all stakeholders mutually may share in the action of the research. Yin (1994) reminds us, paradoxically, that case study style research is remarkably hard, even though many call this type of research “soft.” The convergence of multiple sources of evidence found in case studies involves a number of references of information.

Criteria for trustworthiness include:

1. Transferability (paralleling the conventional criterion of external validity) means providing as complete a database as humanly possible so the transfer of the research allows readers to make their own specific use of the existing study. Janesick (2000) reconfirms, “Qualitative research design is an act of interpretation from beginning to end” (p. 395). Unlike the quantitative researcher, proving a theory, the qualitative researcher studies a setting over a period of time, thus, developing a theory grounded in the interpreted data.

2. Dependability (paralleling the conventional criterion of reliability) Guba and Lincoln (1989) remind us that changes occurring from increasingly sophisticated constructions are the “hallmarks of a maturing—and successful—inquiry” (p.
242). According to Kielborn (2001), “Dependability is accounting for conditions in the phenomenon chosen for study to provide a clearer understanding” (p. 92).

3. Confirmability (paralleling the conventional criterion of objectivity) means co-creating understandings with the stakeholders (Denzin & Lincoln, 2000a). Through the hermeneutic process and peer debriefing, I may assure confirmability through multi-voiced reconstructions (Lincoln & Guba, 2000, p. 170).

4. Credibility (paralleling the conventional criterion of internal validity) focuses on the validity constructed between the researcher and the stakeholders. Recognized techniques for increasing the probability of credibility include, but are not limited to:

   a. Member checks ensure the single most important technique for establishing credibility (Guba & Lincoln, 1989). Member checks become crucial to ensure that I accurately record the stakeholders’ beliefs and that they are reliable interpretations.

   b. Data collecting, transcribing, and sharing means to collect, transcribe, and share data with contributing members as the research studies evolves. Elder (2002) maintains that a dichotomy exists between the knowledge constructed by learners independently or knowledge provided by authority figures, such as teachers and experts. Elder (2002) advises, “Constructing one’s own knowledge involves taking an active role and engaging in an independent endeavor while receiving knowledge from authority involves a passive role that is dependent on others” (p. 350).

   c. Prolonged engagement means to build trust to overcome any possible distortion or misinformation. Acknowledgment of stakeholders’ concerns, issues, claims, and constructions contribute to the fit between respondents’ realities and the reconstructions attributed to them (Guba & Lincoln, 1989).

   d. Persistent observations enable the researcher to focus on those elements and societal characteristics of the environment over a significant period of time.

   e. Peer debriefing engages a disinterested peer establishing a confidential and professional relationship with the researcher in order to help facilitate the study.
f. Negative case analysis means that multiple cases need to be considered and that not all cases fit (Guba & Lincoln, 1989). Denzin and Lincoln (1994) further describe negative case analysis as “...multiple interpretive communities, each having its own criteria for evaluating an interpretation” (p. 15).

g. Progressive subjectivity means that the researcher’s ideas change with time as we gather more data, test our ideas, and learn more about the stakeholder group. Keeping a reflective journal allows the researcher to follow how the ideas and constructions change with time. We only know the world of our experiences in this highly creative and interpretive practice. As noted by Denzin and Lincoln (1994), the researcher approaches the world with a set of ideas defined as relativist ontology, possessing multiple realities. Glasersfeld (1993) reminds us that this idea is not new, its history dates back to the pre-Socratics in the sixth and fifth century B.C.

Setting

I selected Walden Elementary School (pseudonym) as the action research study site. I was a Science and Mathematics Educational Specialist with the Division of Mathematics and Science of the Miami-Dade County Public Schools (MDCPS). The Walden Elementary School Center for Aquatic Nature Study uses the principles of Expeditionary Learning. This approach organizes learning around academically rigorous interdisciplinary studies known as learning experiences. Long-range planning by the administration and teachers included the planned use of computers in every grade level stated as, “The utilization of technological tools will be an integral part of our total school program” (Martin, 2003, p. 1). This site is a Title I–funded school, proud of its multicultural and diverse student population. The nine hundred students span from lower- to upper-middle class. The community comprises mobile families with young children.

The State of Florida intends to measure student performance in writing, reading, and mathematics using the Florida Comprehensive Achievement Test (FCAT). Based on these scores and other characteristics, Walden had been classified by the Florida Department of Education (DOE) as a “D School,” for the 1999–2000 school year. Its “grade” increased to a “C” the following year, and maintained that level in 2002–2003.
Data Sources

I conducted a qualitative analysis of the data using a variety of sources. Concurring with Yin’s analysis for a case study (1994, p. 29), I defined the sources of data aligned with the research questions that I analyze and discuss in the dissertation.

Research Questions Focused on Student Learning

1. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?

2. How do learners make sense of scientific inquiry while using technology and the Internet?

Student projects included: (a) The Plight of Sea Turtles, (b) WebQuest-Tropical Rain Forest original PowerPoint presentations, (c) Sea Turtle Plight–field experience, (d) Living Planet inquiry explorations, (e) Island on Earth original PowerPoint presentations, and (f) E-journals (computer generated) consisting of student artifacts including data, writings, and/or drawings.

Research Questions Focused on My Teaching

1. How can I as a teacher enhance student learning through scientific inquiry using technology and the Internet?

2. How can I redirect my teaching strategies while using technology so that my students learn not only science content, but also a love of learning science?

Research related data sources for all four questions included: (a) pre-project student surveys (b) post-project student surveys, (c) transcribed interviews, (d) focused observation entries, (e) photographs and field notes, (f) reflections during the research process, and (g) E-journals providing transcribed projects and notes. I discontinued the videotaping as I felt it was not contributing to the data I sought.

I collected data for this action research study through a variety of sources. For example, I collected data from three of the summer Walden Sci-Tech Club members, one female and two males. Referring to my research questions, I reevaluated strategies to develop members’ skills as to their relevancy and timeliness. Through this discourse, I maintained equitable social relationships. I promptly addressed problems and issues. Mr. Griffin’s teaching demeanor was similar to mine in a constructivist-based learning environment, which provided a secure, safe, and exciting place for all members.
My interviews of the stakeholders (club members), through formal and informal conversations, contributed to the shared discourse. Through the transcribed interviews, as the students interacted with the computers and each other, I discussed mutual and conflicting responses with all participants. The following section includes qualitative sources for my research.

Qualitative Data Sources

WebQuests Project (Dodge, 2001). Using scientific inquiry skills and the Internet, members discovered Biosphere I (Earth), designed their own Biosphere II (an original island), and the utilized the Rain Forest WebQuest. Using the WebQuest as a baseline, they developed a body of knowledge, transformed it, and demonstrated an understanding of the content.

Interviews. I selected three students within the Walden Sci-Tech Club who were representative of the general population of elementary students in a neighborhood school. Using the letters required for application to membership as basis for selection, I was able to choose a representative cross section of student ability. I sought both male and female students with varied ethnic backgrounds, which brought a diversity of prior learning experiences. In this multiage environment, the data reflected a rich social community. Technology and Internet proficiency was not required, but interest and willingness to learn was a consideration in the selection. I asked all student members and parents to sign consent forms according to the Florida State Research Human Subjects Committee (Appendix E) and the membership form for the Walden Sci-Tech Club (Appendix F). I also used pseudonyms throughout the research study.

I used photographs, transcribed interviews, observations, and videotapes only for my doctoral dissertation work and for any publications that result from this research. I originally made videotapes during formal and informal meeting sessions, along with formal presentations of Internet projects. I found the subjects of my case studies enjoyed using the handheld tape recorder far more than having a videotaped session. The subjects were more relaxed and truer to their personal reflections. We shared the replaying of the audiotapes, adding comments and critiques along the way.

I distributed the redeveloped written pre- and post-Walden Sci-Tech Club Student Survey (Appendix G). The survey, which includes open-ended questions, measured students’: (a) views of science and the Internet, (b) information about science in the classroom, (c) ideas about science, (d) confidence in conducting scientific inquiry, and (e) abilities to learn to conduct
scientific research based on *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (NRC, 2000). The questionnaire also included a scenario for students to assess their ability to design an experiment (adapted from Cothron, Giese, and Rezba, 2000). I also distributed to participants an Internet Code of Conduct form (Appendix H).

**My Journal**

The journal I kept enlightened me and helped me to re-examine my methods. As Johnson (1996) maintains, if teachers emphasize only low-level thinking skills, technology is at best expensive and unproductive. However, using technology as a tool for information processing and productivity is appropriate for instruction. The idea is for students to become problem setters rather than mere problem solvers.

In a broader perspective, I had my students continue to participate in searching for patterns in ocean studies, environmental threats, and other related topics. This helped them with scientific reasoning as they became absorbed in minds-on explorations. Searching for patterns required consensus through dialogue with each other and working toward joint constructions in a hermeneutic dialectic circle (Guba & Lincoln, 1989).

The data I collected for this research was from the Walden Sci-Tech Club. The goals for membership included: (a) assuming responsibility for learning; (b) becoming familiar with the computer and some of its applications; (c) acquiring a positive attitude toward technology and the sciences; (d) developing new inquiry-related reasoning and problem-solving skills; e) working collaboratively with others; and f) formulating and testing questions.

**Participants and Data Collection**

As sponsor of the Walden Sci-Tech Club, I arranged weekly meetings during the summer. The stakeholders were students who were interested in science, the environment, and technology. I observed these students as members participating in the Walden Sci-Tech Club. However, I focused my study on three particular students, a female and two males.

The stakeholders and I recorded authentic science research through several sources: (a) environmental data retrieval; (b) participation in *WebQuests* (Dodge, 2001), inquiry-oriented activities in which most or all of the information used by learners came from the Internet and *The Living Planet: Earth Systems Curriculum* (Lambert, 2002); (c) computer use centered on using information from the Internet rather than spending time looking for it; and (d) computer monitoring, sea turtle investigations, field experiences, and research studies as the case study
evolved. Processes to complete these tasks required imagination and problem-solving skills, supported by analysis, synthesis, and evaluation (Dodge, 2001).

These strategies provided useful multiple sources of evidence to help me construct trustworthiness, fairness, and authenticity for this case study. Case study data collection was not limited to a single case, and I used open-ended interviews and documentary evidence. Using Yin’s (1994, p. 92) “converging line of inquiry,” I used the process of triangulation, producing convincing and accurate evidence. As multiple sources converge, the case study became more focused and reliable, thus of a higher quality.

**Data Analysis**

Denzin and Lincoln (2000b) indicate that the researcher as *bricoleur* (p. 642) should have a working familiarity with a number of methods for collecting and analyzing data sources. Yin (1994) concurs that the various sources are complementary, and a good case study includes as many as possible.

Denzin and Lincoln (2000b) discuss how qualitative analysis using computer applications can assist in empirical research. They stress that the researcher should avoid letting the software design the form and content of the interpretive activity. Reducing field materials to data that can be coded remains a formidable challenge. Weitzman (2000) underscores the potential benefits and pitfalls of using Computer-Aided Qualitative Data Analysis Software (CAQDAS) in research projects. Cautiously, Weitzman (2000) warns, “Thus it is particularly important to emphasize that using software cannot be a substitute for learning data analysis methods: The researcher must know what needs to be done, and how to do it” (p. 805).

I used the QSR (1997) computer application, specialized for the handling of unstructured text from audio transcripts, field notes, conversations, and interviews, to refine and interpret the qualitative research data as I looked for emerging patterns. This program allowed me to analyze the qualitative data I collected by combining text searches and indexing to manipulate data in various contexts.

As recommended by Yin (1994), I selected a science teacher as an external observer, to increase the reliability of the information. Yin insists, “The case study investigator must have a methodological versatility not necessarily required for using other strategies and must follow certain formal procedures to ensure quality control during the data collection process” (p. 100). I found emerging patterns that I used as valuable aids for organizing the data.
I conducted my research in accord with my major professor, Penny J. Gilmer, and committee members Drs. Nancy Davis, David Foulk, and Paul Ruscher. Dawson and Taylor (1998) profess, “The act of open talking needs to be preceded by the act of talking about the need for open talking” (p. 15). For my study, this expression defines an open meta-discourse involving the construction of a mutual understanding between my committee members and me for an educative relationship founded on trust and mutual respect. Dawson and Taylor (1998) maintain that open discourse is unlikely to exist, regardless who initiates it, without the agreed desirability of such discourse.

I informed teachers and administrators regarding the development of the research plan. Because young children are the primary stakeholders, I provided information and an activity agenda continuously available to students, teachers, and parents. I planned meetings so club members could present demonstrations of their learning during the camp sessions. I built trust through informed sharing of the research study and acknowledged active contributions of student members, classroom teachers, and administrators. The Walden Sci-Tech Club stakeholders reviewed collected data; such as, the tape recordings and their E-journals. This provided continuous and open checking by members. I respected and valued their input and included it in the constructions and reconstructions of this research study.

Dialogue can provide natural and spontaneous responses, preparing the learner for instruction and study (Gallas, 1995). Bringing their world of experiences to the classroom, learners can imagine, observe, and analyze. The club members consequently “take on the voice and the authority of scientists” (p. 3). I encouraged Walden Sci-Tech Club members to communicate and share discourse with me and with each other. I developed a dialogue with all stakeholders, contributing to joint constructions (Guba & Lincoln, 1989). This method allowed the participants to be involved and to contribute throughout every step of the research process.

My goal was to use what I learned to enhance my club members’ understanding. For example, my professional conference presentations allowed me to share my research with fellow educators (Bosseler, 1999b; Bosseler, 2000, Bosseler, 2003). Keys and Bryan (2001) write of this union of teacher and researcher:

Only when the voices of researchers are in resonance with the voices of teachers can we begin to create harmonized reform-based instruction that is enduring. We hope that teachers’ once muted voices will be raised loudly and clearly in the call to reform. (p. 642)
Ontologically, the realist maintains that there exists an objective reality governed by natural laws. The realist observes the existence of these laws, whereas the views of a constructivist are “literally created as the investigation proceeds” (Guba & Lincoln, 1994, p. 111). I shared dialectical interchange with stakeholders so that continuous revisions could transform and reconstruct knowledge. A part of the splendor of children was their honesty and willingness to be true to their beliefs while being willing to acknowledge the beliefs of others.

Summary

How important is technology? The *Benchmarks for Science Literacy* (AAAS, 1993) states that our understanding of and reaction to the potential impact of technology may be critical to civilization. It further emphasizes, “Technology is not innately good, bad, or neutral…Human experience with technology, including the invention of processes and tools, shows that people have some control over their destiny. They can tackle problems by searching for better ways to do things, inventing solutions, and taking risks” (p. 53). The latter assertion expresses the philosophy of the Walden Sci-Tech club and my action research, as together we grew and learned together.
CHAPTER 4: STUDENTS ENGAGED IN SCIENTIFIC INQUIRY WHILE USING TECHNOLOGY AND THE INTERNET

Learning and teaching should not stand on opposite banks and just watch the water flow by; instead they should embark together on a journey down the water.

—Loris Malagazzi (Burns, 2002, p. 295)

Setting the Stage

I have examined the teaching of science in a social constructivist environment as learners integrate and explore the use of technology as a teaching partner. I utilized qualitative research methodology in which technology created opportunities for inquiry and collaborative learning. As described by Linn, Davis, and Bell (2004), technology-based, inquiry instruction can engage students in independent, diverse, and challenging work. The action research cycle described in Chapter 3 guided the strategies and methodology I utilized for the summer club as we met in a science laboratory classroom and computer laboratory (Black & Stave, 2001).

Two of my research questions focus on my students, and I concentrate on providing evidence for answers to these questions in this chapter. They include:

1. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?
2. How do learners make sense of scientific inquiry while using technology and the Internet?

My research epitomizes the idea of using learning technologies to foster inquiry because it allows club members to integrate technology into their learning methodology, which may enhance their overall learning. In the first section of this chapter, I introduce the Triumvirate; that is, the name I have given for my three case study members (Belinda, Carlos, and Darryl). Throughout this study, I have tried to keep Yin’s (1994) basic required skills for a successful case study foremost in my mind:

1. Ask good questions and interpret answers objectively.
2. Be a good listener/observer and defray my own ideologies.
3. Remain flexible and adapt to unforeseen situations.
4. Maintain focus on the issues while formulating logical inferences.
5. Accept and respond to contradictory evidence.

In this chapter, the beginning section, Setting the Stage, has two sub-sections: The Triumvirate, which contains the Triumvirate’s general feelings about science and club membership, and The Walden Sci-Tech Club, which provides an introductory assessment for the logistics of the Walden Sci-Tech Club in summer school.

The Triumvirate

The three students that I selected from the 25 members of the Walden Sci-Tech Club for the case studies are two boys in fifth grade and one girl in fourth grade. I used pseudonyms for the three students: Belinda, Carlos, and Darryl. I selected three students because I felt a balance could be obtained for any issues encountered along the way. While I did not particularly seek two boys, at the time, I did not feel there was another female who would bring a broad range of characteristics and skills to the study. I welcomed the multicultural diversity of the group, as it invited multiplicity for cultural differences. Research conducted by Scantlebury and Baker (1992) confirms that teacher behaviors and strategies are part of the variables that influence gender attitudes toward science. The non-biased science classroom requires sensitivity, tact, and the willingness to examine one’s own behavior and assumptions. Brickhouse, Lowery, and Schultz (2000) further review data indicating the fundamental question is the inequity that exists is a social problem. It is important for teachers to understand personal orientation and build on the strength of the learner. Through ten years as a sponsor of an elementary school science club, I have always maintained a higher level of interest and enthusiasm with girl participants than with boy participants; yet, I felt the boys were comfortable with the girls’ talents and learned to appreciate their interest in science. Brickhouse et al. (2000) question the consequences of research that considers boys only in comparison with girls; thus, ignoring the other salient differences in a learning environment.

I strongly feel that demonstrated skills using technology place both genders in equitable and effective learning environments. Computers level the playing field. In fact, my observations clearly place computer “tech gods” (Peck, Cuban, & Kirkpatrick, 2002, p. 474) without any gender qualifier. Those students in need of assistance show respect, welcome, and admiration for the “super boy” or “wonder girl” who can swoop down, provide assistance, and fly on to the next person in need. Kahle (1990) issues a warning, “It is reasonable to criticize Western culture
which, until challenged by economic necessity, consistently undervalues the scientific potential of half of its members” p. 133).

In my study, the triumvirate participated and grew in their own unique ways, with peaks and valleys of learning observed, qualified, and assessed. The final pictures they paint provided significant scientific reasoning and inquiry projects that contributed to their growth as lifelong learners and to my growth as an educator. Let us now meet and consider the attributes of the three case study candidates.

Belinda

Belinda is a nine-year old, African-American girl in foster care with a younger sister. The foster family is very caring and loving toward her. She does have an older sister who attends college. I was fortunate to meet one of her foster sisters, who commented that belonging to the Walden Sci-Tech Club has been critical for improving Belinda’s feelings and attitudes toward school. At times, Belinda’s grades have been erratic, causing concern for her parents. The school had notified them, and Belinda refocused herself and did get back to work. Last year as a third grader, she decided that she wanted to be in the Walden Sci-Tech Club despite not qualifying as a fourth grader. This intense desire and motivation on her part prompted me to allow her to participate in the club before she had completed third grade. Mr. Griffin, her science teacher, and I discussed the situation and agreed membership would be extremely beneficial for her academically, but more importantly, socially. Belinda is learning to appreciate the broad uses of computers; however, she is most comfortable working with programs and games. Belinda is often reluctant to display her lack of computer skills to the group, but she does show potential for problem solving investigations. While she is quite willing to offer assistance to others, she needs to balance her approach as she selects her activities.

Talking—Science Talks is an informal dialogue that focuses on opening ways to talk and think about science to all students. Beginning our Walden Sci-Tech Club meetings with the Talking—Science Talks proved vital to allow thought provoking, “What if’s?” and “Why not’s?” The power of these Science Talks encourages a natural unfolding of dialogue unmatched by any recitation from a textbook (Gallas, 1995). Establishing the theme of Science Talks celebrates the attitudes of “not knowing,” “wanting to find out,” and “encouraging and appreciating all questions.” Gallas describes the point evolving from Science Talks where children take the creative leap from prior knowledge to imaginative exercises of thinking. All of this happens
within the naturalist setting of the club meetings. This type of group setting promotes social skills that encourage democracy and respect for others (Linn & Burbules, 1993).

As usual, Belinda joined in our Talking—Science Talks, but then returned to the computer to find other things and sites to keep her busy. That is, she stayed busy but pre-occupied without accomplishing very much. She was unable to find her Rain Forest WebQuest and said it was at home. She then rephrased her remarks and told me that the research was on a disk. The disk was located, but it was empty. Apparently, she tried to make the best of the situation and turned on the computer ready to take part in the group activities. She began typing the following: “The programs that I have done a lot of research and work so for a project that I am doing helps me learn more about the hydrosphere. It has me learning a lot.” (My Journal, July 29, 2003)

I reminded Belinda that she was part of the WebQuest team and that the team depends on her to cover the unique lithosphere, atmosphere, and hydrosphere in the tropical rainforests. Other more personal obstacles were in her way, too. She kept these private, but the teacher had informed me of the family situations. I wanted to keep encouraging her to come to the meetings, and I wanted her to want to come. She especially liked to use scientific terms that others less informed might not recognize. After an extended discussion about the greenhouse effect she remarked, “I wonder what would happen if the greenhouse kept going on and what would happen to the earth. I wonder what would happen if we didn’t exist anymore, would there be a greenhouse effect on earth?” (My Journal, July 29, 2003). Others joined in adding to Belinda’s supposition. These supportive comments by the group pleased Belinda.

It should be noted that Belinda often resorted to telling tales in which she purposefully left out important details or recollections that she wanted to avoid. Interrogation was never one of my objectives, so I would just let her say as much as she wished and not force the conversation as to the validity of her comments. Obviously, this was a wise decision as Belinda developed a trust in me as her teacher and her friend.

Carlos

Carlos was in the Walden Sci-Tech Club for over a year. Carlos is a nine-year old Hispanic boy, who lives primarily with his mother, but visits his father and older sister during the year. His teachers describe him as a bright student who seeks explanations and closure to new concepts. He is a worrier, showing concern for his grades; yet, he is quick to do childish pranks.
When Carlos first joined Walden Sci-Tech Club, he only had fair computer skills and a limited interest in science. He lacked the crossover that computer talent requires—the risk-taking and confidence to try alternate solutions to perplexing problems. I selected Carlos for one of the case studies because I wanted to provide him with an environment that encouraged and supported understanding. If I could accomplish that, I felt Carlos’ curiosity in science would grow as we explored and extended his technological skills along the way.

Early in the summer, I asked the members to complete the Walden Sci-Tech Club survey. Carlos became very upset and said he was not able to do it. He asked if it was like the FCAT (Florida Comprehensive Assessment Test, i.e., our statewide student assessment test for grades), and I reassured him that it was not like FCAT (FLDOE, 2003), just a chance for me to learn more about each of the club members. This explanation was still not adequate to convince him to participate. He wanted to cry, but pride kept him from allowing that to happen. Eventually, I thought of an idea—that is, to have him read the survey and dictate the answers to me. We found a corner of the room and proceeded with the survey.

Later in the summer, I assessed the productive times that Carlos proceeded with the other project-based activities and decided to discuss this with him. When I first began to question Carlos about the animals that he had selected for his designated portion of the rain forest, I asked him if there was any particular reason he had chosen three unrelated reptiles and one mammal. We had spent a great deal of time learning about the classification of animals and the scientific nomenclature. Carlos was to select a sampling from each major category; that is, he could have selected one mammal, one reptile, and one from another category. Most of the suggestions I made to him were ignored. I felt that I had better proceed with caution as I did not want to discourage him. Now Carlos turned his attention to recording the information he could activate at the Web site. At my suggestion, he highlighted the information he wanted to record and then practiced what he would say. After each recording, he listened to what he had said. He repeated the recording several times if he was not satisfied. This is how Carlos shared the rationale for providing voice recordings on the slides: “Some people are lazy and don’t want to read so they just click the little microphone thing and it will be reading it for them” (My Journal, July 15, 2003). Carlos was quite impressed and intrigued that chimpanzees and gorillas eat birds and their eggs. Continuing, I asked him if there was any additional information he planned to research, things he wondered about or questioned. Carlos asked, “You mean if I could look something
up?” I reaffirmed that I was just wondering if there was anything in the four slides he would like to further his research. He answered, “My slides are about the chimpanzee, the sloth, gorilla and orangutan. I don’t want to look anything more up. No, because I want to write about them like what I’ve written” (My Journal, July 15, 2003)

Actually, Carlos questioned that chimpanzees and gorillas eat birds and their eggs. Analyzing the above conversation, I was able to theorize that whatever research Carlos was able to collect would be finalized and in his mind, it was adequate. He did not wish to dig deeper and obviously, he was not particularly interested in pursuing further information. I was pleased that he thought about the voice simulation for the reader who might be lazy and not wish to read the printed information. Perhaps he was thinking of his own preferences.

At another day’s meeting, I felt it was an opportune time to assess if Carlos had the ability to conceptualize the slides he had meticulously written. I asked him, “What are the prey of chimpanzees, orangutans, gorillas, and sloth?” (My journal, July 31, 2003). Carlos was eager to print out the slides he had made and what he had written about the animals. He was simply parroting what he had written, such as, “Orangutan eats fruit, leaves, young birds, and bird eggs. They eat young birds” (My Journal, July 31, 2003). He continued, “The orangutan, strong and heavily built bodies.” Carlos looked at me, commenting, “Now that is interesting!” (My Journal, July 31, 2003).

I continued writing in my journal that Carlos was able to read the words, but it was clear to me that he was not mentally processing what he had written. Eventually, Carlos became cognitively involved and appeared to think about the facts; such as, the chimpanzee eats birds and bird eggs. He stated, “The sloth eats small plants, insects, small birds and bird eggs. Now that [chimpanzee] eats birds, too!” (My Journal, July 31, 2003). I asked him if it seemed strange that the sloth would eat birds, he replied, “Yes, but even stranger that the chimpanzee does. If I ever get a bird, I’m keeping it away from that orangutan!” (My Journal, July 31, 2003). Carlos read on about the size of the various animals. I asked him, “Is there anything that you imagine would try to eat the gorilla, sloth, or chimpanzee? How could we find out who eats them? That is, who preys upon them?” (My Journal, July 31, 2003). This line of questioning caused Carlos to throw his hands into the air in frustration and react by saying, “Do you mean that I must do this AGAIN? Rewrite it? Oh no!” (My Journal, July 31, 2003).
This type of reaction was not uncommon for Carlos, but reassurance from me tempered Carlos’ misinterpretation. Carlos’ need to gain assurance and clarification, but he has demonstrated growth in that direction. Carlos described himself as “experienced,” while I would describe him as more confident.

**Darryl**

Darryl is the final member of the case study triumvirate and the most enthusiastic of the three in the use of technology. Darryl is an 11 year old, African-American boy, proud of his birthplace in the Virgin Islands. Presently, he lives with his mother and a younger sister. His father, of whom he frequently speaks, has remained in St. Thomas. When interested, he absorbs a wealth of knowledge that is often expressed in unrelated contexts. Socially, he has had a difficult time in a society that does not reward bursts of unacceptable behavior. The societal, attitudinal problem led me to question selecting Darryl as a case study, but I observed the manner in which he conducted himself at the computers. He acknowledged others with respect for their needs as he quickly gained skills to problem solve while learning the processes for technical knowledge. Actually, he became more proficient as he had to find his own methods and skills using the Internet and the PowerPoint program. He has earned the gratitude of his peers and teachers with his technology skills.

The weight of a moral dilemma illuminates the shrouded feelings with which children often have to cope. I had invited a park ranger from a national park to visit Walden Elementary to speak about the endangered sea turtles and their plight. Innocently, Darryl shared the following:

In St. Thomas where I live, we eat them (turtles), not the eggs. I don’t like them. They eat the meat. At my house in St. Thomas when we see them out, we put sticks up around them. We pick them up and take them out to the water and let them go. Our neighbors try to kill them. He goes in at night digging the holes. We bring them into the house, bring a lot of sand, and put a light over them. Turtles are killed by the chemicals in the ocean (like the oil), and the chemicals when they breathe it in. It poisons the fish that the sea turtles eat, and when they eat it, they get poison in their stomach. (Informal Interview, June 24, 2003)

The others reacted with startled looks listening to what he had to say, glancing at me without saying a word. Darryl repeated that he did not like turtles being killed or eaten for food. This moral dilemma provoked a great deal of discussion with other examples, but no final answer. I asked Darryl what he thought could be done in St. Thomas and elsewhere to help save
the sea turtles, and he suggested that they should make a law like they did for manatees. “Our school should make a law for the sea turtles—a law not to eat or kill sea turtles for the meat or the eggs. Just like you can’t hunt in a national park, they should make a national law” (Informal Interview, June 24, 2003).

I mentioned that I had never thought about the killing and eating of turtle meat and the environmental effects of these acts. The discussion was somewhat of a relief to Darryl as others made comments regarding cultural differences for accepting or not accepting certain behavior. Darryl continued describing the killing of turtles as a food, but also the killing of turtles from an environmental standpoint; that is, the food chain. This was his dilemma. Bringing in the concept of environmental hazards causing the death of turtles allowed all of us to realize that this was not simply a cultural problem to investigate; we needed to consider other factors. Like scientists, we needed to approach this from multiple perspectives with solutions, if possible.

The following observation illustrates Darryl’s gradual improved relationship with his peers and teachers: “The artistic [sic] girl needs my help,” Darryl said, referring to the autistic girl who had recently come into the computer class but was not part of my study (My Journal, August 7, 2003). He hurried to her and knew just what she wanted on the computer monitor. When he came back to me, I asked him how he knew what to do, he replied, “Yesterday she was screaming and crazy. The teacher asked me to help so I put on Disney and music. She settled down” (My journal, August 7, 2003). In addition, a small boy with other disabilities was seated on the teacher’s lap. The boy seemed irritable and restless. The teacher called Darryl over to help. He showed the boy and his teacher a few different sites, and they settled on one with action and music. The young boy grew less aggressive. It worked!

Darryl’s image as a mentor in the computer laboratory took on great significance. The regular camp teachers began to seek his skills and noted changes in his attitudes toward others, especially the younger children. Gaining the respect of others began to matter to him.

The Walden Sci-Tech Club

The meetings for the summer Walden Sci-Tech Club began with a newly reclaimed direction to highlight the sharing of science experiences and to keep science learning at the forefront. Using the computer laboratory for our meetings made it too easy to focus on computer skills and neglect the dual part of our focus—experiencing and learning science inquiry. The fact that our meetings and visits together were not guaranteed, I had to take advantage of every time
we could be together. Because it was summertime, often there were numerous special activities
to take place at the last minute. The Walden Sci-Tech Club was not a priority, but as the
members began to express their desire to attend, the summer camp teachers and teacher
assistants used their permission to attend as a “carrot” for good behavior.

As the Walden Sci-Tech Club Triumvirate worked together, they built bonds of common
experiences, which assisted them in their communication and sharing. When they worked
productively with each other, they were learning important skills for life. Yet, each came with
their own personal history of experiences and knowledge. In this instance, the students built ties
by a sharing of a mutual concern, as I described in my journal:

Darryl, recently self-appointed “tech-god,” informed me that the summer camp teacher
would not let the Sci-Tech Club members remain in the science or computer laboratory
after our science meeting had ended. The new directive required that all members of the
Triumvirate would have to be on a rotation basis, and only one of them would be
assisting a class at a time in the computer laboratory. Up until this point, the Triumvirate
had their Talking—Science Talks time with me, followed by assisting regular camp
classes as they came into the computer laboratory. Their time mentoring was valued and
appreciated by the campers. Darryl reacted, expressing anger and disappointment far
more than Belinda or Carlos. “But I was born to help!” Darryl vehemently demanded.
This display, unlike most others, solicited approval and appreciative comments from the
others. Too often Darryl’s outbursts prompted disdain from the group, which was well
earned (My Journal, July 8, 2003).

Darryl’s personal comments were an expression of disappointment on his part but for a
change, they did not elicit further disciplinary action. Capturing the attention from the others in
this way brought out humor, which his peers seemed to enjoy.

During the past academic year, Mr. Griffin had taught science once a week to all
students, grades two to five in the science laboratory. He conducted hands-on science learning in
this well-equipped room. Most of the classrooms are equipped with three or four computers. The
computer laboratory adjacent to the science laboratory has 28 fairly new, networked personal
computers, and one printer. Each computer has attached headphones, but often they do not work.
During the academic school year, teachers use the computer laboratory on a teacher request,
sign-in basis. The primary use for the computers is for content learning programs; that is, basic
skills. Teachers want students’ FCAT (FLDOE 2003) review as an assessment tool. In the
intermediate classes, grades four and five, the students conduct research using computer
programs or limited Internet use. Students cannot send email and there are regulated Internet
sources.
We discussed the activities and project ideas for the Walden Sci-Tech Club meetings’ Tuesday and Thursday afternoons, 2:00 p.m. until 3:20 p.m. Normally, the 25-member group assembled in the school’s science laboratory for our investigations, then we moved to the computer laboratory next door. I decided to arrange a two-day a week schedule, as I realized that the summer computer laboratory had evolved into a quiet, “do your own game” or challenging activity during the hour each designated age group was in the laboratory. By having the twice a week science-directed session, it kept the group focused on science and the Internet-based projects. I knew I would be challenged in a fun summer camp environment, while my goals were to challenge club members to witness first-hand the timeless world of science and new technology.

The school campers had gone on a field experience to the Everglades National Park, which was a popular field trip. The county required the supervising teachers to attend a two-day training seminar before bringing their classes to the park. The content curriculum at the seminar included not only information about the animals indigenous to the park, but also studies about the ecosystems and the environment. Thus, the teachers were ready to give the student campers an opportunity to experience real-life science in an unusual setting—the Florida Everglades.

Later that day when the classes returned from the Everglades, Darryl was so excited about the snakes they had seen that he immediately began looking them up on the Internet. Up to that time, he really was not certain which animal he thought would interest him for his Tropical Rain Forest presentation. Darryl told me, “When we went to the Alligator Farm we saw snakes and alligators. So then, I decided to look up reptiles. I wasn’t sure but the site gave me a page and I went on that. I looked up snakes and lizards this time” (My Journal, July 24, 2003). Unrelenting, Darryl searched until he found what he needed, then set the speed for each slide at a four second change. He felt this was too fast to read and see the slide clearly. He analyzed this and proceeded to slow down the program. He said, “I got the covered python. I found out what it preys on and where it lives. I’ve got it set up too fast. I’ve got to slow it down. I’ve got it set at four seconds” (My Journal, July 24, 2003).

Darryl appeared to take the challenge of a problem to solve and enjoy it. Reading the captions he selected was problematic. It became obvious to me that editing was necessary. I cautiously asked him if we could edit some of the passages and invited myself to work with him.
He agreed without a moment’s hesitation. Darryl had predetermined ideas in mind as he selected the information that he wanted to use:

I wanted to do the colors, diet, habitat, and size cause that’s the most important part of the stuff about it. So I copied some of this that I needed from the Eastern Brown snake and the Carpet Python. So, I have the PowerPoint, so that when you click on the animal, it will automatically go to the page I have the research on. Someone could come on the Internet and learn something. But this is easier and more fun! I just click on one of my animals and it takes me to more information. I tried different sites to make it work and I asked my dad, too. My dad knows a lot about computers cause he’s a court reporter. (Informal Interview, July 29, 2003)

Darryl’s communication skills appeared to be somewhat of an anomaly until you were able to carefully observe them and recognize a developing pattern. In simple conversation exchanges, he gave minimal responses; but, when the question or discussion concerns technological expertise, Darryl was able to discuss the procedure with assured confidence and expanded details. Glasersfeld (1993) affirms that simple language is learned in the course of interacting with others. When such experiences give positive results, the opportunities promote social interaction. I believe Darryl felt empowered when he became the expert, the problem solver. In addition, he liked to interject comments about his father, regardless of their relevancy to the flow of the conversation. Darryl’s peers surrounded him, although they too had single parents, but they could spend time with each of their parents. Darryl would often remind me that his father lives in St. Thomas. These references to his father brought into the forefront Darryl’s hidden agenda that made his learning so conditional. My own pedagogical content knowledge (PCK) provided me with cognitive and affective resources to assist me in recognizing dichotomies that affect learning. PCK is examined in the final Chapter 6.

Probing into Inquiry-Based Instruction

This section highlights the investigatory nature of scientific inquiry, as the Internet becomes the working tool for the Triumvirate and members of the Walden Sci-Tech Club. I weave Scientific Inquiry and Social Interactions into the data analysis as vital contributors to this Members Learning chapter. Vital sub-sections of Scientific Inquiry and Social Interactions include Power of the Internet and Bybee’s—Five E’s Model, which became the vehicle for establishing the focus of this research study. Bybee’s (2000) model (described in Chapter 3) includes strategies for teaching and learning scientific inquiry. The subsection, Social
Interactions, defines the collaborative nature my students engaged in science and technology through examples and interview surveys.

Scientific Inquiry

I implemented a pilot study before conducting the study described in this document, and it indicated that I needed to focus more on science learning as the members’ technology and Internet skills became more proficient. Fostering scientific inquiry is at times “messy,” time consuming and noisy, but the rewards for this kind of learning can last a lifetime. However, it comes with a price for students to assume new responsibilities for their learning. The Living Planet Test is a formative assessment activity I asked the Triumvirate to complete in order for me to evaluate their curriculum level before starting the science program agenda. It contains fill-in-the-blank and multiple-choice questions on earth and space science. In my journal, I wrote the following regarding the selected assessment for the Triumvirate:

I distributed The Living Planet Test (Lambert, 2002) curriculum as an assessment and introductory source to help determine the Triumvirate’s prior knowledge and special interests. I planned to select activities as we progressed. Reviewing their assessment tests was disappointing because I felt I was not getting a clear picture of their science knowledge with this type of an assessment tool. Although limited, Darryl’s answers were more comprehensive than Belinda’s or Carlos’s. Viewing a diagram, Darryl was able to recognize the seasons in the Northern and Southern Hemispheres. His two comprehensive answers regarding sea turtles and the many threats they face were complete and accurate. Belinda was not able to answer any of the sixteen general science questions correctly.

(June 17, 2003)

The multiple choice question asking what percent of the Earth is covered by water was answered correctly by Carlos, although, he commented that he thought the sun was a planet and the moon was a star. He did make several attempts to answer other questions. His answers to the sea turtle dilemma were fairly clear. His final fill-in the blank question was stated as: Reducing the amount of plastic litter in the ocean would cause the sea turtle population to “increase” (Carlos’ answer) because, ”When you eat the turtle we’ll eat garbage.” It should be noted that in order for Carlos to attempt this evaluative survey, I agreed to have him dictate the answers and I wrote them down for him. Carlos’ final comment was, “I’m good at this.” (My Journal, June 17, 2003)

In each case, The Living Planet Test was practically useless to me as I attempted to effectively assess the learning level of the Triumvirate. Answers that were attempted gave little evidence of prior knowledge; yet, I felt Belinda, Carlos, and Darryl had a science background that was not evidenced by this test. Through ongoing conferences with Mr. Griffin, I became aware that the majority of science learning depended on the scheduled one hour per week curriculum taught by him in the science laboratory. Reflecting on Bloom’s (2003) Taxonomy,
the knowledge and comprehension levels of teaching and assessment are not reflective of scientific inquiry learning, but indicate a more traditional approach to learning. Teaching for conceptual understanding involves connecting newly learned material to existing knowledge. Focusing my efforts in the Walden Sci-Tech Club, I maintained that scientific inquiry flows through a constructivist environment where learning takes on meaning and purpose. In order to establish the kind of environment that I felt was most conducive to scientific inquiry learning, I wanted to inquire into their personal feelings about science.

Power of the Internet

As a research project, I asked members to use the Internet search on Google (or another search engine of their choice) on a topic related to meteorology. I gave each member his/her own 3.5” floppy disk, a small carrying case, a small legal pad, and a pencil to assist them in their Internet-inquiry research. Meanwhile, I was doing my own searching by getting a perspective on potential members’ selections for my case studies in my research. I observed a range of technological knowledge, from those demonstrating good skills with previous experience using the Internet, to those with little or no experience or interest. I gladly provided my assistance and mentored those who requested it.

I asked members to keep a record of the websites that they had found informative. Then they were to come to the board and write those that others might find helpful. Interest in use of the note pad did not last too long; instead, most students wanted to record the website titles in the “FAVORITES” icon in their individual computers. Some of the students actively pursued writing on the chalkboard. Darryl said he was looking at the site about hurricanes and what the water damage can do to the blinds in your house. He then went on the rain forest site and on to state flowers. He said, “I could show my family about the stuff I do at school. We can do that over the weekend as a family and what we can do at family meetings. We can go on the Internet” (My Journal, June 24, 2003). Interestingly, Darryl’s aunt had a computer and allowed him to use it frequently. At the start of the summer, he was quickly becoming the most advanced member using the Internet and loved to share all his findings with us. More importantly, he felt a sense of pride as others began to acknowledge his skills.

Belinda, on the other hand, did not enthusiastically embrace the Internet research opportunity. She remarked, “I’ve looked up plants and maybe I can find the place where they have gardens” (My Journal, June 24, 2003). She went no farther than this and began to socialize,
put on the headphones, and found a program that she had used before. Her investigation lasted just long enough for her, and she had no desire to dig deeper.

Carlos expressed more interest in searching the Internet. He elected to look up iguanas and wanted to continue his own personal search. He shared his interest saying, “I found out how to tell the sex of the iguana but I’d like to learn more about them. I’d like to know about what kind of things they eat and most of all, I’d like one for a pet” (My Journal, June 24, 2003). When I asked Carlos if he was able to find what he wanted about the iguana, he reassured me that he was not having any difficulties. Carlos seemed to embrace the power and searching ability of the Internet, but recognized his own limitations with the technology. He admitted he needed more time because, “I’m kind of slow with my typing” (My Journal, June 24, 2003).

**Bybee—Five E’s Model**

All Miami–Dade County Public Schools implement the NESS (NRC, 1996) to establish a knowledge base for understanding science. Guided by these standards and by actively engaging in Bybee’s (2004) Five E’s Model, learners can better inquire, question, probe, and experience science embedded in technology to become lifelong learners. As stated earlier in Chapter 1, the 5 E’s Instructional or Learning Model (Bybee, 2004) provides a built-in structure for creating a constructivist classroom that embraces scientific inquiry. The model guides students through five stages using five words that begin with the letter “E”: engage, explore, explain, elaborate, and evaluate.

**Engage: Asking a question.** “As teachers of science we need to keep in mind that thought and language are intricately related” (Varelas, Pappas, Barry, & O’Neill, 2001, p. 29). As much as possible, I had established a routine for the club in which we opened the meetings with Talking—Science Talks. Since the triumvirate team had been in the school summer camp all day, it was a welcome change to have the time to sit at a table in the center of the science or computer laboratory. Taking time for our Talking—Science Talks throughout the hectic, regular school day would not be possible. Here we enjoyed a snack and took a few minutes for a rare intimate time to relax, share ideas, and be together in our very own unique science learning environment.

Varelas et al. (2001) advocate talking science as consistent with constructivist philosophy of teaching and learning. Opportunities for science talks in class encourage the development of children’s understandings, expressed with emergent language forms. These talks can be directed
to include the specified NESS (NRC, 1996). According to Gallas (1995), children’s correct and incorrect thinking has a place of importance because it can provide an environment that invites all children into the discussion of science and the development of curriculum. Gallas (1995) outlines the process that is typical for science talks. These talks follow a process beginning with a hypothetical theory or supposition. In my mind, this is a “guess-timate,” hopefully, based on some prior knowledge, as opposed to a wild guess.

Following this hypothetical theory, students make attempts to pose a theory of “maybe,” through analogy or fact. Often clarification or explicit questions enter the discussion. Finally, the process ends with a revision of the original theory. Throughout the progression of the science talks, the participants consider almost every idea. Bakhtin (1981) says, “Language is socially constructed, and new ideas emerge from the meeting and blending of voices” (p. 40). It is at this critical point that children’s thinking becomes deeply woven into a new synthesis of knowledge and imagination, and the beauty of Talking—Science Talks becomes evident.

Following The Living Planet (Lambert, 2002) assessment, our Talking—Science Talks evolved around our planet and the uniqueness of its continents and climate. At the onset of the Talking–Science Talks, Carlos shared with us that he had been to Arizona for the beginning of his summer. He eagerly discussed all the sites he and his father had visited. The enlivened discourse led us to discuss how the temperature made us aware of the tropical climate and summer heat here in Florida. Taking a walk in the school garden, which months ago appeared green and healthy, showed us that now the garden was fading into dry plants and soil. The term “biome” was unfamiliar to Belinda and Darryl, but surprisingly, Carlos began to think about hearing the word when he was in Arizona. A biome is a community of plants and animals, based on the environment in which the organisms live. The rain forests are one of the Earth’s eight biomes. The assignment was to find out Florida’s biomes. The group was very excited, involved and curious to explore more information.

*Explore: Satisfying curiosity.* Staying on course, we continued to probe the idea of temperature and to investigate the present climate conditions we were experiencing in Florida. To prepare for the Thursday session, I gave each of the three members a spiral-bound note-keeper and a thermometer with Celsius and Fahrenheit gradation marks. As the dialogue continued, questions arose dealing with the mercury in the thermometers. I presented to the group the established fact that scientists now realize how hazardous it is to work with mercury.
Thermometers no longer use mercury but use alcohol in place of mercury. There were still unanswered questions, so Darryl quickly looked up the answers on the Internet, sharing the information with us.

Darryl’s work on the Internet provided the right information. He informed us that alcohol is used in thermometers. Carlos questioned these phenomena, “But it looks like mercury, like the red in the thermometer rises. Then why is that?” (My Journal, June 26, 2003). Carlos was persistent in seeking answers and closure to his questions. At this point, Belinda entered the discussion telling Carlos to read more and he would know that alcohol expands as the temperature rises. Carlos’ inquisitive nature prevailed as he pressed:

So what? If the numbers are just set up beside the mercury or whatever is in there now, does that determine the temperature? In other words, you could have put degrees of 1000 to 2000 or whatever you wished. (My Journal, June 26, 2003)

Carlos’ questioning indicated that he was eager to discuss the concepts, had a deeper understanding, and questioned our purpose for further exploration. As often happens with students who ask questions, the others shrugged their shoulders as if to tell Carlos that the questioning should stop. I felt that he was seeking viable knowledge and deserved an answer. I told him he had a good point and that is why it is important to define whether the temperature reading is Fahrenheit or Centigrade. Carlos remained perplexed by the logic of the devised numbering system. The team wanted to learn something else about Fahrenheit. Belinda looked up Fahrenheit on the Internet and proudly printed out what she had found for all to read. We reviewed the Celsius and Fahrenheit method of the numbering degrees just to make sure it was clear. We then experimented in the laboratory using the thermometers.

The homework was to take a thermometer and notepad home. The assignment was to predict and record the six coldest and warmest spots at home. The students were to describe the selected areas and record the actual temperatures. Lastly, they were to write the temperatures in the note pad and repeat the measurements five times. In a humorous response to the assignment, Darryl announced, “I’m putting mine in the freezer! That will be the coldest (Everyone laughed)” (My Journal, June 26, 2003).

**Explain: Discovering new applications.** The next meeting began promptly. Fortunately, the Triumvirate had earned the time for our science in the Walden Sci-Tech Club. Each of the three had something to share about the Fahrenheit temperature readings in their homes and the results of their estimated predictions. Darryl said, “I first put my thermometer in
the freezer for two whole minutes, taking it out and it had reached 32 degrees. I timed everything I did for two minutes” (My Journal, July 1, 2003). I commented that he was conducting the investigation very scientifically by keeping the time as a constant or controlled variable. I asked if he made any predictions first and he reminded me that the placement of the thermometer in the particular chosen site was like his prediction. I had to agree. Darryl tested the hot water in the kitchen faucet measuring 110 degrees and the frozen water at 29 degrees.

When Belinda gave her temperatures of 30 degrees (stating Centigrade reading instead of Fahrenheit) in the shower and then in the microwave, Darryl proclaimed, “But it would blow up!” “No,” Belinda answered, “The microwave wasn’t on. The micro was 105 degrees” (My Journal, July 1, 2003). Darryl suggested that Belinda could have put the thermometer in the Jacuzzi, which prompted me to ask if it would be warmer there. Speaking with authority, Darryl stated that a Jacuzzi is always heated warmer than the room. Belinda continued to express her results, stating she got readings of 70 to 80 degrees, depending on which part of the kitchen she was testing. In the freezer it was 20 degrees, while in the kitchen it averaged about 75 degrees. The master bedroom was 75 to 76 degrees and the second bedroom was 87 degrees. Carlos said, “That couldn’t be! That much difference in the two bedrooms!” Belinda defended her readings stating, “Yes it could! The air conditioner was on in the master bedroom and not in the other bedroom because no one uses it! The living room was 83 degrees. That’s what I did!” (My Journal, July 1, 2003).

I encouraged the others to share their results. Darryl eagerly said he tested the pizza his family had for dinner. Everyone laughed, asking how he did it! “The pizza was 115 degrees,” Darryl said proudly. (He placed the thermometer under the crust.) No one had mentioned the terms Fahrenheit or Centigrade until Darryl said, “The water in the sink was 25 degrees Centigrade” (Informal Interview, July 1, 2003). At that moment, I interjected the need to establish the temperature readings being Fahrenheit or Centigrade and reviewed the differences in the readings. I also told them that with a simple mathematical equation, you are able to change from one scale to the other. Obviously, Carlos had not attempted to do the homework, but was contributing to the science talks. He was especially curious when Darryl said he put the thermometer next to the hair blower and it registered 195 degree Fahrenheit. Carlos asked what would happen if it (the thermometer reading) gets hotter than the thermometer? Darryl’s response was, “It is dangerous and could blow up!” (My Journal, July 1, 2003)
Finally, I asked if there was anything about these investigations or predictions that surprised them. There were no other responses, but I felt pleased that two of the three Triumvirates did take part. This homework investigation acted like a needed catalyst to open conversations dealing with science where we could begin to establish a feeling of security within the group as scientific thinkers as well as respected friends. Gallas (1995) explains the world of scientists existing among colleagues is critical to the development of theories. Yet, this world is a place where processes of imagination and wonder (akin to artists or poets) exist in experimental laboratories.

**Elaborate: Expanding concepts.** Continuing investigations of temperature found in *the Living Planet: Earth Systems Curriculum* (Lambert, 2002), we decided to test the greenhouse effect using rocks, soil, and plastic wrap. The greenhouse effect, or greenhouse gas, acts like the glass in a greenhouse and traps the gas. On a visit to the Walden Sci-Tech Club garden, we discussed the idea of the garden withstanding the hot summer heat and the greenhouse effect. We rounded up two thermometers, two plastic containers, rocks and soil from the garden. Belinda made predictions along with other interested campers who happened to be nearby; she predicted that the rocks would get hotter than the soil and retain the heat. Only Carlos made the prediction that the soil would gain heat and remain hotter than the rocks. The results of the experiment proved that Carlos’ prediction was correct.

Realizing that this experiment is much more complicated than merely measuring the comparative heat of soil and rocks, the investigation did accomplish real-life simulations with students involved in predicting temperature. We discussed the idea of variables including the type of soil and rocks that would make a difference in the results. We were careful to place the thermometers at the same level of contact, taking them out of the air-conditioned laboratory into the sunlit hallway. I valued the accuracy and inaccuracy of the predictions to encourage future calculated risks on the part of the members.

I was especially pleased that Carlos wanted to remind us that the accuracy of his theory could be traced to his earlier summer vacation. He said, “I told you about my visit to Arizona and seeing so many plants growing that were planted in rocks instead of soil. So I think the rocks will be cooler-better than that dirt for the plants. Arizona gets even hotter than Miami. I know cause I felt it!” (My Journal, July 8, 2003). Belinda praised Carlos telling him he was the only one that got it right. “Look,” Belinda said, “After 15 minutes in the sun, soil is 63 degrees and the rocks
are only 52 degrees. Ms. Bosseler, would it be even hotter if we covered both trays with something, maybe plastic? Let’s try” (My Journal, July 8, 2003). We conducted the follow-up experiment by covering the containers using green plastic wrap to simulate the greenhouse effect. We discussed at great length the new variable and the possible effects it would have on the results.

These days of science exploration opened minds for all of us as it helped initiate the experience of “what if’s” for variables; such as changing the color of the plastic wrap, the kinds of rocks, the kinds of soil, on and on. These are not difficult science concepts, but they are vital to pave the way to understanding and appreciating the nature of science. How could science be more fun than this?

The second time we investigated the rocks and soil everyone predicted correctly. The rocks and soil did get 5 degrees hotter with the green plastic wrap, which led into a discussion of the greenhouse effect. Accurate knowledge of this was sparse, but Belinda and Carlos expressed interest in the possibilities and ramifications of the greenhouse effect. As we examined the experiment, Belinda excitedly exclaimed, “Look, the container with the rocks has water dripping off the plastic wrapping. The soil doesn’t have as much! I know what that is from the water cycle. That’s condensation isn’t it?” (My Journal, July 8, 2003). Carlos reacted by making a funny face, then added, “We all know that, Belinda. Mr. Griffin had us for science you know!” (My Journal, July 8, 2003). Belinda paid no attention and even had follow-up questions, “I’m wondering, what would happen if the greenhouse kept going and what would happen to earth? I wonder if we did not exist and would there be a greenhouse effect. Oooh, I’m not going to think about that!” (My Journal, July 8, 2003).

Belinda asked Darryl what he thought would happen; that is, if the rocks or the dirt (soil) gets hotter. Darryl immediately volunteered his answer, “I think the rocks will get heated first and get hotter. Maybe it’s because of the weight cause when you put all those rocks together it heats up, hotter than the soil” (My Journal, July 8, 2003). Although Darryl’s prediction was not correct, Belinda handled it nicely. She replied, “You’re wrong but good guess. The dirt (soil) keeps the heat. So which has the hottest temperature, the ocean or the soil?” (My Journal, July 8, 2003). This time he thought a bit more carefully, “I guess the soil stays hotter, right? Wait a minute – is that why my feet get burned in the sand when I come out of the water in St. Thomas?” (My Journal, July 8, 2003).
This investigation was a learning experience for me as well as the Triumvirate. Learning what the three knew about heat, temperature, the greenhouse effect, and performing a simple science experiment constituted a relatively basic approach. We could have dug deeper into concepts for multiple variables, chemical and physical changes of matter, but this provided examples of how their prior knowledge elicited informative insights into the Triumvirate’s experiences in science. My primary purposes were to initiate an investigation using multiple process skills and make practical predictions using scientific inquiry strategies as a team. The actual investigation was practical enough for the Triumvirate to build upon prior and current knowledge. In this one investigation, I was able to assess their prior knowledge regarding heat, temperature, the greenhouse effect, and performing a simple science experiment.

Belinda wanted to show Mr. Griffin the experiment testing the soil and rocks with the thermometer. Belinda stated, “This is the rocks and the soil. Our problem statement was: Which kind of soil (ground covering) keeps the temperature the hottest?” (My Journal, July 8, 2003). Mr. Griffin asked what we considered as our hypothesis. “We all thought the soil wouldn’t win and that the rocks would be the hottest. But the soil was hotter than the rocks,” Belinda retorted. She continued, “For the experiment we did, the rocks took 106 degrees Fahrenheit and the soil took 110 degrees Fahrenheit” (My Journal, July 8, 2003). Mr. Griffin added, “Maybe this is partially a seasonal thing too. Sometimes we have to keep the variables as factors in there” (My Journal, July 8, 2003). I then asked the group if they thought that we held the variables constant. Belinda was so involved she began to speak before I could call on her. She interjected, “No way! We did keep constants, like the containers, the length of time in the sun, the thermometers, the same amount of rocks and soil, and the green plastic wrap” (Informal Interview, July 8, 2003). To their surprise when we lifted the green plastic covering there was a great deal of water dripping from the underside of the rocks than the soil.

This stage in learning encourages learners to listen to others. Linn, Bell, and Davis (2004) refer to this as “distributed cognition” (p. 327). Learners can also help their peers understand an idea by giving relevant examples and using vocabulary which is often more relevant than the teacher’s vocabulary. Linn, Davis, Bell & Eylon (2004) caution that some students disparage most comments from their class peers as well as experts (i.e. teachers, parents), whereas others rely on these extensively. I encouraged the strategy for distributed cognition to help orchestrate Gallas’ (1995) science talks and my own pedagogical interest in establishing a constructivist-

**Evaluate: Evidencing learning.** I could refocus the investigation to take advantage of these new interests and to assess their learning. I can best navigate the 5 E’s open-ended learning processes (Bybee, 2004). In *Talking—Science Talks* at the start of the Walden Sci-Tech Club meetings, my question, “What is the biosphere?” elicited curious excitement. Darryl immediately rushed to look it up on the Internet. Together we learned that the Earth is considered Biosphere 1 (One). Columbia University’s Biosphere 2 (Two) is the one built in Arizona’s Catalina Mountains in the late 1980’s. Carlos asked Darryl how he found it so quickly, “I looked in the Yahoo search for ‘biosphere.’ I found it easy. Can I print it out? I’ll make copies for everyone” (My Journal, July 10, 2003.) Darryl printed out the information and wanted to share it with the others. As he began to read it he slid over the words that he was unable to pronounce. Instead of trying to stop and sound them out, he lowered his voice and very softly uttered the unfamiliar words.

Basically, the Triumvirate and I could grasp the meaning of the Internet article. We learned that the developers constructed the Biosphere 2 in the late 1980s for $150 million dollars as an airtight replica of Earth’s environment termed Biosphere 1. Our team took turns reading about the details of the Biosphere 2. We learned the structure was a 7,200,000 cubic-foot sealed glass and frame complex that contained five biomes. Included in the structure were a rain forest, a desert, agricultural areas, a human habitat, and a 900,000-gallon ocean. A trained and conditioned colony of eight people were to live inside it for two years. All three of the Triumvirate members asked questions concerning the purpose and cost of such a project as we learned about the connection between the Biosphere 2 and projected future space travel. We also discussed what problems could arise from living in a closed system.

Carlos questioned the amount of money spent to design the structure saying, “Why would the government spend so much money on something that was just used to see how it works? Isn’t that a waste of money” (My Journal, July 10, 2003)? Carlos was not satisfied and wanted further clarification to explain the purpose of the Biosphere Two. Darryl noted Carlos’ perplexed reaction saying, “Look, here’s the address: http://www.thepepper.com/Tucson_biosphere.html and I’ll even write to them” (My Journal, July 10, 2003). In the excitement, Darryl thought the email was the US postal mailing address. Jokingly, Carlos said, “Dummy, that’s where we are
now with the Internet that you found!” (My Journal, July 10, 2003). Darryl joined in the laughter sheepishly saying he did not notice the address was just for email on the computer.

**Social Interactions**

We all enjoyed sharing the interesting information about the Biosphere 2 that Darryl had found. He discovered a world map that illustrated the biomes of the world. They knew enough about geography to recognize the continents and the major areas of biomes. Viewing the shapes of the Biosphere, I noted the geometric designs, which immediately elicited their comments as they recognized triangles, rhombi, pentagons, circles, and so on. I suggested their interests could be expressed by making their own biome. By planning ahead, I could purchase any materials they would like to use. I asked them what they would like to construct and their response was overwhelmingly, “We’re ready now! Please, can we do this today?” (My Journal, July 10, 2003). Belinda thought immediately about using the “K-Nex,” plastic interlocking manipulative that they all had seen during the field experience to a magnet school specializing in science, technology, and mathematics. Students from that school had studied solar energy and displayed their solar powered projects using the K-Nex materials.

The mood was very positive as my students made decisions, such as their wanting to make their own individual biospheres. Construction began as each member of the Triumvirate began planning and designing their biosphere using the printed copies that Darryl had made earlier, along with researching chosen sites on the Internet. When the trio actually began the hands-on construction, problems occurred. Very soon, they became disorganized and complained that it was impossible to construct anything resembling the printouts of the Biosphere 2. Totally frustrated, Carlos complained he was ready to quit. Each student echoed this sentiment. I entered the conversations and helped them realize that while the combination of shapes required a little practice, it was possible to create a new shape. There was no rule that each one had to look like the pictures.

Eventually they refocused their energies and ideas by brainstorming together and helping each other overcome the obstacles they faced. Using materials required patience to construct the biospheres properly. Linn and Burbules (1993) warn that once brainstorming ideas have yielded promising solutions, the planning and synthesis are often best performed individually. I was fearful that the direction the group had taken would resurface and lead to a unanimous decision to quit. That did not happen. After Belinda was able to construct a small biosphere, she became
disinterested and wanted to do something new and different by herself. I encouraged her to go on the computer and use the drawing program to create her own. She did attempt this for a while; she then occupied herself by looking for clipped pictures on the Internet. When the others proudly displayed their projects, Belinda watched attentively. She did not care to share her work but did show polite consideration for the others.

Linn and Burbules (1993) contend collaborative learning requires the most well developed social skills to be successful; consequently, I felt that because of the uniqueness of the Triumvirate and the Walden Sci-Tech Club, they had the potential to succeed. While experiencing collaborative learning, groups draw upon distributed knowledge (Linn & Burbules, 1993), which offer a group the combined knowledge of all group members. Distributed knowledge invites a willingness on the part of the individuals to experiment using unusual combinations of problem solving ideas. Even Belinda’s shared computer input provided more visual ideas that the others appreciated and included in their construction. The norms of group behavior did not dictate a guaranteed success but required acknowledging the uniqueness of each individual in the group and the group as it existed.

At this point in our meetings, we engaged in social interactions. The idea of mentorship carried with it a certain amount of prestige and responsibility. Since Darryl’s power and computer savvy started to redirect him and his self-concept in such a positive way, I did not want to let it diminish. I decided to give Darryl a job best suited to his emerging technological talent. I asked him to classify *The Living Planet* (Lambert, 2002) Environmentally-safe Island project disks. Individually or in teams, members of the Walden Sci-Tech Club had designed original islands with environmentally safe conditions such as those found in the Biosphere 2. Darryl would have to view these disks, alphabetize, list and classify them accordingly. He asked me if he needed to have a partner with whom to work. I said it was not necessary and the decision was up to him. This was to be his special project. It was interesting to note that Darryl even considered seeking a partner, considering his earlier social misgivings.

**Member Interview Surveys**

Listed in Table 4–1, 4–2, and 4–3, are the three Triumvirate interview surveys assessing their ideas about science using a four-point Likert Scale. This survey was administered in June 2003 and in September 2003.
Belinda’s ideas about science did change radically along with her expressed courage in herself. Referring to Brickhouse et al. (2000), understanding Belinda’s struggles and triumphs, I tried to keep in mind her personal orientation toward learning. As a new club member, her peers charged Belinda with an attitude of indifference toward furthering her academic worth. When Belinda first sought to join the Walden Sci-Tech Club she stated that she heard it was “lots of fun.” As she became more involved in our activities, I felt she redirected her purpose for membership. Belinda found that learning science was as much fun as she had heard. On several occasions, she mentioned to me the kind of science that can be boring has “too much talk.” Most importantly, Belinda connected to her own special gifts for learning by deriving personal meanings of success.

In a discussion when studying the Biosphere, Belinda offered comments about what she had found as she was becoming more familiar with the Internet, “I went to Google.com and saw all the things I could look up under science. I saw a lot of stars with the ‘microscope’ [sic]” (My Journal, July 10, 2003). Of course the group echoed the misuse of her word “microscope” instead of “telescope.” She repeated this; “I did see lots of stars with the microscope!” (My Journal, July 10, 2003). The group just looked at me waiting for me to correct her, knowing how she liked to use scientific terms whenever possible. She then realized her error, mentally searching for the right word. Keeping control, she finally said, “I did see lots of stars with the telescope!” (My Journal, July 10, 2003) and laughed at her own mistake.

I could not escape this teachable moment to tell them that “scope” in Latin means to view or see. Therefore, all those scope words do basically have similar meanings. The group generated many science terms, such as, “telescope,” “microscope,” etc. I commented that we all appreciated Belinda helping us have a lesson in Latin.

<table>
<thead>
<tr>
<th>Belinda—Student Survey</th>
<th>June, 2003</th>
<th>September, 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am good at science.</td>
<td>Disagree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>2. I am interested in a career in science.</td>
<td>Strongly disagree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>3. Science classes are boring.</td>
<td>Disagree</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>
Table 4–2
Carlos’s Ideas About Science

<table>
<thead>
<tr>
<th>Carlos—Student Survey</th>
<th>June, 2003</th>
<th>September, 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am good at science.</td>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>2. I am interested in a career in science.</td>
<td>Agree</td>
<td>Agree-computers</td>
</tr>
<tr>
<td>3. Science classes are boring.</td>
<td>Strongly agree</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>

The Student Survey that Carlos completed reconstructs his personal thoughts but do not indicate how much he has traveled ahead in this journey. The assessments in early July with which he agreed do not indicate the minimal feelings of success he had for himself in learning. The personal uncertainty of his academic performance still remains, but the strides he has made to establish his self-efficacy are noteworthy and require positive consideration.

Carlos was still concentrating on his Environmentally-safe Island, which he had planned to make as a car collector’s island. He mentioned his plans, “I looked up cars and saw some really neat pictures. Ms. B, why can’t we play music, you know, video sites?” (My Journal, July 3, 2003). My response was a firm “No!” During this session they prepared to create their Environmentally-Safe Island (Lambert, 2002), Darryl volunteered to help several of the girls and boys who were having difficulty designing their slides using the PowerPoint. Carlos, too, continued in his attempts to place car sound simulations on his island. In the midst of all this activity, a little girl became so frustrated that she was close to tears trying to use pictures of dogs on her slides. Darryl was so positive and patient mentoring her, displaying interest and humor to this younger child. Darryl returned and succeeded in helping Carlos. As the period ended, Darryl and Carlos were entertaining everyone with the very loud car sounds. We all laughed, enjoying these realistic car motor noises. Both boys departed as pals!

Table 4-3 contains Darryl’s responses to the Walden Sci-Tech Club Student Survey given at the start and end of the summer program. Learning science along the circuit of the Internet prevailed, giving Darryl a possible lifeline for future success in school and in life. The existing social systems in the Walden Sci-Tech Club were not always flexible to align with his, but the power of attaining success in a school setting overrode failure. Darryl had said at the end of the summer, “Science is science to me! It is technology, research, and fun! (Formal Survey, September 20, 2003).
Table 4–3
Darryl’s Ideas About Science

<table>
<thead>
<tr>
<th>Darryl—Student Survey</th>
<th>June, 2003</th>
<th>September, 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am good at science.*</td>
<td>Disagree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>2. I am interested in a career in science.*</td>
<td>Disagree</td>
<td>Strongly agree</td>
</tr>
<tr>
<td>3. Science classes are boring.*</td>
<td>Strongly agree</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>

*Darryl wanted to add the word technology to all three questions.

Darryl’s Student Survey results describe the past and the present command of his own constructions. Darryl’s newly found skills developing into a “tech-god” (Peck et al., 2002) gave Darryl opportunities to develop a more positive self-image and to become a contributing member of the club. No doubt, technology held the key for Darryl to feel success and peer acceptance, which he sought.

During prior meetings, the group and I discussed the concept of the greenhouse effect and pollution. The project idea for the Environmentally-Safe Island (Lambert, 2002) provided further experiences and connections to the basic climate and environmental conditions. Drawing further on this research, I presented the club with an option: In taking the ideas and concepts to another level, would the group prefer to design a biosphere or a planet? I introduced the Microsoft PowerPoint program for them to use throughout the project to communicate the results of their investigations. By learning the computer more quickly and skillfully than the others, Darryl evidenced an attitude in which he felt that he could be successful. It was not all positive, as sometimes he became angry and would negate the positive interactions he had engendered. When this would happen, his peers would distance themselves from him, not knowing what to expect next. However, Darryl did reflect on his actions and situation and showed remorse over the expression of anger. I wrote about this in my journal:

With noticeable refined skills, Darryl is ready to assist anyone, always volunteering to help others, and yet, expecting his fair share in the final analysis. He still drums his hands on the walls or tables when he is overly stimulated, angry, or frustrated but these are infrequent. I see a great and wonderful change evolving over Darryl from the days when we first met. It was a sad time for him, wanting to be a part of any team effort or group project and being rejected. Darryl and I no longer have to excuse ourselves from the group to reflect on his behavior and the effect it has on the others. (My Journal, August 7, 2003)
**Member-Interview**

I conducted an informal interview with each member of the Triumvirate after the summer had ended. I selected this period so that the three had time to reflect on their experiences and feelings regarding the experience we had shared. Table 4–4 shows the five questions that I asked and each of the three members’ responses, on September 20, 2003.

<table>
<thead>
<tr>
<th>Table 4–4 Interview Questions and Triumvirate Responses</th>
</tr>
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<tbody>
<tr>
<td><strong>1. DO YOU THINK THAT USING THE INTERNET IS MAKING ANY DIFFERENCE IN THE WAY YOU LEARN SCIENCE?</strong></td>
</tr>
<tr>
<td>BELINDA: It is, because when you go on the Internet it gives you pictures and when I do my PowerPoint, I write stuff about …say, I’m writing about fishes. I show it to you before I write about it and I learn things that I didn’t even know before studying books. When I go on the computer it helps me get better at it – learning stuff about whatever I’m learning.</td>
</tr>
<tr>
<td>CARLOS: I’m much better at science because when I first started at Sci-Tech I didn’t know much about the rain forests, and sharks, and stuff. But now that you guys have been telling me about all the science stuff, I’ve been learning about it.</td>
</tr>
<tr>
<td>DARRYL: It’s helped me because, like if you have to do different things like a science project, you write it in sloppy handwriting. If you use the computer, you have neat writing. Instead of writing with a pencil with your hand hurting, it’s just faster on the computer. You can get in different colors. (At this point, I asked Darryl if it would be easier for him to be on the computer showing me what he wanted to say.) Yes, for sure, I can show you on the computer better.</td>
</tr>
<tr>
<td><strong>2. WHAT ABOUT YOUR OWN SKILLS AS A SCIENCE INVESTIGATOR, HAS USING THE INTERNET MADE ANY DIFFERENCE IN THE WAY YOU DO SCIENCE?</strong></td>
</tr>
<tr>
<td>BELINDA: Yes, because last year I know I couldn’t have gone on <a href="http://www.com">www.com</a> and looked up what I needed to look up. Now I have all the power to look up everything I need to know.</td>
</tr>
<tr>
<td>CARLOS: When I first started Sci-Tech I was very slow at everything and I really didn’t know how to use the Internet and when I tried to use PowerPoint I was very slow. Now that I’ve been in Sci-Tech I’ve learned a lot.</td>
</tr>
<tr>
<td>DARRYL: I can do the work real faster and I know if somebody comes up to me and doesn’t know how to do it. Well, last year I didn’t know how, I had to ask somebody to help me but now I can help them. Now I just wander around on things to find answers,</td>
</tr>
<tr>
<td><strong>3. USING THE INTERNET, WHAT DO YOU DO WHEN YOU LOOK UP ON ONE WEBSITE, READ IT, AND THEN ON ANOTHER READ SOMETHING THAT DOES NOT AGREE WITH THE FIRST? WHAT PLAN DO YOU HAVE?</strong></td>
</tr>
<tr>
<td>BELINDA: I first think about it the way I think about it. If one of them says what I think of then I just go on the one that thinks like I do.</td>
</tr>
</tbody>
</table>
Table 4–4: Continued.

CARLOS: When I first started using the Internet and had to keep searching, I’d kind of “bum-out” because I got tired of searching. But now, that it’s a lot easier to search for stuff, I’m now used to it. So when I see two sites I decide which one to use by which one has more information.

DARRYL: I would look at the information that somebody would understand and which one has the most information. I go to Google and you type into different search engines. And I go to one that’s like “Look Smart” and it had things about the biosphere.

4. WHAT DO YOU LIKE TO LEARN ABOUT NOW IF YOU COULD HAVE LOTS OF TIME TO DISCOVER ON YOUR OWN?

BELINDA: I’d like to learn about flowers, plants and trees. Once I tried to plant my own tree, but it won’t work. The way I put the water and the seed in, I just planted one in my house.

CARLOS: I’d like to learn more about snakes and tarantulas and reptiles.

DARRYL: I’d like to help with the environment and save the turtles in the ocean.

5. HAVE YOU ANY ADVICE TO ANY THIRD GRADER ENTERING FOURTH GRADE ABOUT USING THE COMPUTER?

BELINDA: Sure, I’ll say that it’s real hard. If it’s something you don’t know about, you should first go to an adult. Then you try to do it without them helping you, then once you get ready to do it…say you’re doing a PowerPoint. First, go on the Internet, minimize it, and then go to whatever I need to get my research. Then go on from there. Don’t be afraid.

CARLOS: I would say that using a computer is very easy. I would say that the thing to do is to know how to work a computer and sometimes when you can’t find something on the Internet, don’t just ‘bum out’ but just keep on trying to find stuff. I would give them a little tip. I would say that Sci-Tech is lots of fun and you could really learn lots from it.

DARRYL: Sometimes when you come to Sci-Tech and learn, sometimes your parents don’t know what you’ve learned and so you should take it to your parents and show them. Like me I showed my mom and then she bought me a laptop. So now when I get mad at my sisters, I just go on my laptop. Like I’ll write a book, the whole book typed when I don’t have nothing to do. Or I’ll help my aunt with her computer. You have to learn how to type real fast. Some don’t know how to re-spell [sic] a word and they don’t know what the red line through it means.

These transcribed informal interview questions provided an insightful look at how the Triumvirate members felt about using the computer and the Internet. It also demonstrated their confidence they had gained in their technological skills. I purposely formulated the final question seeking their advice about using the computer to provide them with a unique opportunity to share their ideas with me. As each member answered the five questions, it became clearly evident that they became enablers to use critical thinking and problem solving within an Internet search, formulate decisions, create ideas, all while learning science. These activities are not at the
lower cognitive levels of Bloom’s (2003) Taxonomy. This is not to suppose that each of them will continue to grow and attain exceptional status, but it does appear to be an awakening for the potential.

At the start of the summer, I conducted a survey asking several questions about the nature of science. Darryl enthusiastically proclaimed, “Science is fun!” Belinda elaborated, “Science for me is to learn. Say I want to be a doctor it will be easier because I will know some stuff from school.” Carlos informed us, “Science is a learning activity” (Informal Interview, June 26, 2003). My next question was, “Why is it important to learn science?” Darryl’s answer was seriously stated, “Because everything has a carechin (sic, creation).” Belinda answered the question by using a new word, autistic, in her vocabulary, “Science is important to learn because it helps a lot of people that are autistic” (Informal Interview, June 26, 2003). Carlos answered by including everything, “Science is important to learn more about the world, stuff around you, and the environment.” (Informal Interview, June 26, 2003). Each of their answers seemed to be very “textbooked answers,” lacking the depth that stems from experiencing science in the real world.

At the close of the summer meetings, we shared ideas stemming from the preceding months together in the Walden Sci-Tech Club. Having participated in the summer, I felt the Triumvirate would hold valuable insight into rationale for joining the club. The answers I recorded were thoughtful and reflected the real-life science project-based learning that they enjoyed in the summer:

When I asked, “Why do you want to be in the Sci-Tech Club?” Belinda answered, “Because it shows you stuff like wildlife and how to deal with the rain forest and if you want to be a science teacher you would already know to be one. I could contribute because I am good at making stuff and I’m a technologist.” Carlos, recounting his summer memories, answered, “So I learn more about science. Also, I want to learn more Earth’s natural disasters. Also, because science is all over the world and I need to know it. I can contribute helping kids find the websites that has something to do with science.” Darryl’s candid answer reveals his interest in science saying, “First I want to be in Sci-Tech because I want to know more about science, more about how the world was created, how grass was created and trees, who made it? I asked Mr. Griffin and he says he really doesn’t know.” The Triumvirate enjoyed answering these questions and was willing to continue. (Informal Interview, September 13, 2003)

There was a vast difference in the quality of the answers to the Sci-Test Survey as compared to the more traditional Living Planet Test (Lambert, 2002). Participating in the Walden Sci-Tech Club gave the members the unique opportunity to become scientific thinkers without the currently accepted day-by-day rigid adherence to the FCAT objectives. Yet, all of our
investigations comply with the Florida’s SSS. Inquiry and problem solving are central to the standards-based teaching of science.

I asked each member of the Triumvirate, “What is science?’ and “What is physics?” Because physical science is often the most difficult area for most elementary school teachers to teach, I was curious to learn if the Triumvirate knew anything about the subject. Belinda said, “Science is ability to know how to name plants, and it helps you to name things about science. Physics is gravity and if your body is on the ground you have gravity, but if your body is not on the ground, you don’t have gravity and everything will be flying around” (Informal Interview, September 13, 2003). Darryl thought hard about it and finally said, “I think science is a mixture of knowing and discovering solutions or purposes to our world. I think physics is a lot of laws of electricity” (Informal Interview, September 13, 2003). Carlos reminded us, “Science is a learning experience for children to learn more—a subject that is important and learn more about. Physics means how things work. How magnets work. How liquid turns into gas. Also how volcanoes form” (Informal Interview, September 13, 2003). Obviously, each had a different conception but they shared their prior knowledge and came up with a product of thinking based on their own thought processes. Those actual experiences appeared like photographs, retelling the story, or imaging the story that was so clear in their minds that they processed the reality of it.

Implementing Investigative Learning Strategies

This third section focuses on the strategies I used to implement scientific inquiry thinking and problem solving, as the Triumvirate and Walden Sci-Tech Club members used the Internet. E-Folios became documents to assess their learning. Through the Web-Quest simulations, real-world attitudes and collaborative projects helped enhance attitudes for life-long learning.

PowerPoint E-Portfolios (E-Folios)

Walden Sci-Tech Club members treasured their disks where they stored their E-Portfolios. These E-Portfolios became invaluable tools for maintaining a record and marking their own progress, as well as landmarks for continuing lengthy, and at times, difficult work. The singular most negative aspect was the limited amount of ongoing work that could be placed on each disk. Of course, the newer CD or DVD has almost limitless possibilities for storing information. E-Portfolios, also known as, “E-Folios,” helped my learners take an active role in the educational process. These E-Folios helped learners “buy into” the educational process instead of the idea of education “happening to them.” In the educational process, the E-Folio was
a worthy tool to evaluate student artifacts. In the Walden Sci-Tech Club, E-Folios further enhanced cognitive distribution (Linn et al., 2004), so vital to successful science and technology literacy. Garthwait and Merrill (2003) remind us, “In fact, the e-folios were as much a ‘working ground’ as an exhibition gallery” (p. 24). Working through the problems of saving work on the e-folio was an exercise in perseverance for us all.

**Environmentally-Safe Island**

Creating and presenting an environmentally safe island became a springboard for designing an Internet project, as an individual or group endeavor. Carlos elected to work alone, first designing an island with only cars of all types of models. Darryl had recently discovered how to simulate sounds on the slides. Carlos was delighted to have Darryl use his expertise in making loud car noises on his slide. After much attention from the others, Carlos noted that everyone else kept to the theme, an environmentally safe place using the Biosphere 2 concepts as a prototype. He confided in me saying, “I think having cars on an island is not such a great idea, but it was fun. Now I’m going to make ‘Shark Island’” (My Journal, July 3, 2003). I agreed and told him I was pleased to have him reevaluate his plan. Carlos continued, “Yeah, I’m thinking about the pollution, you know from gas fumes and all. This time I’ll do better, but I’ll need help again. Who can help me?” (My Journal, July 3, 2003).

I reassured Carlos that when he was ready someone would be available, but this time I would like to see him learning how to perform the clip art attachments, which were more simplified. He had mentioned the sound effects that he learned from Darryl for his Car Island. Upon completion of the clip art and text, he could ask Darryl about the simulation. I wanted Carlos to break away from dependency on others and redefine his own gifts and abilities.

Carlos did complete two slides, one being the cover with the title, “Shark Island” and his name along with clip art pictures. Then Darryl helped Carlos place the voice simulations into the slides. The second slide was titled, “Information [sic] About Sharks.” The information listed was that the island was beautiful, you could stay at a hotel, and the hotel had a pool. There were humorous clip art pictures in the slide, thanks to Darryl volunteering his skills. Carlos did not care to learn these skills, but was eager to get them into the project. He was proud of the results whether he did them or Darryl assisted.

Darryl surprised me by seemingly working with another boy and a girl, Adam and Cathy. It was obvious that he had a difficult time giving into their suggestions and ideas. It was
necessary for me to go to the team several times and encourage more collaboration on everyone’s part. Darryl did bend to the wishes of the other two by putting in all the clip art pictures they selected, but that was all. Eventually, the team disbanded and asked permission to each work alone. Darryl was oblivious to their displeasure, rushed up to me to come view the first slide. I followed him back to the computer, viewed the very elaborate slide, and listened to his voice recording:

Hello, welcome to Darryl, Adam [pseudonym], Cathy [pseudonym] and to our island where you can come to get your college diploma, where you can go to the ATM machine, where you can have a trip day to play video games and computers, to read as much books as you want, meet the mayor, me and my world. (My Journal, July 1, 2003)

Adam and Cathy came to view and listen to the slide then turned and went back to their own individual project work. Obviously, they were disenchanted with Darryl taking over the production. Afterward, I spoke with Darryl about the entire incident, trying to help him consider the feelings of others. He listened and seemingly understood that his ideas had taken over theirs. I explained that it is sometimes a difficult task to be a helper or tutor and yet include the wishes of his classmates, as they want to learn, too. Darryl’s role as a tutor may eventually assume more responsibility for monitoring group activity (Linn & Burbules, 1993), but presently, he needed to learn how to share his knowledge and expertise more effectively (My Journal, July 1, 2003).

My rationale for selecting the Environmentally-Safe Island (Lambert, 2002) provided an opportunity to engage the Walden Sci-Tech Club in an activity that brought into play choices to be made for completing an original and creative science project, while introducing the PowerPoint computer program. Within the scope of the assignment, the students rendered decisions regarding the following: island location, climate, weather, natural resources, native plants and native animals. As the project evolved, it took an uncalculated direction to become an island created for vacationers. I was not disturbed by this turn of events, as I readily understood the learning environment of a summer camp taking control. Additionally, I recognized the enthusiasm and high interest level using the computers with success in a program that elicited originality and creativity.

The Triumvirate approached this assignment with an unwavering intent to create something that was uniquely theirs. Belinda was required to stay in the classroom for the first part of this project. When she did return several days later, she worked at her own pace trying to gain the necessary skills to use the PowerPoint program. Belinda enjoyed getting suggestions and
assistance from several of her friends, joining in with a group that had completed several slides. She was pleased that she, too, was able to begin making creative choices of her own.

**Rain Forest (Coming Together)**

Those who were working on plants and animals did not have a background for the scientific nomenclature. Carlos attempted to read the scientific nomenclature and names that were unfamiliar to him. Finally, Carlos asked how to pronounce the Latin words for the classification of plants and animals. We stopped for a few brief minutes as I explained the classification system, its history, and its necessity throughout the world. I asked him what he planned to do. Carefully, Carlos shared his plan:

I get the pictures, and make the pictures big. Maybe get six pictures or so and make them big so they look pretty. Like, say something what the pictures are about and that stuff. I’m going to go to the Internet and look for tropical trees and tropical plants of the rain forest. I would go on the Internet, Goggle, and get the pictures and describe what they’re about. I’ll look for tropical trees and tropical plants; I mean tropical rain forest trees. (My Journal, July 31, 2003)

Carlos now spoke and planned with authority in his voice. It was powerful hearing him, although he was not always like this. He needed to maintain that spirit of excellence. I feel Carlos’ confidence has a chance to flourish over sustained time, but it still requires nurturing. His self-assessment remained questionable when faced with criticism. I believe Carlos greatly benefited from his own successes that were enhanced by caring teachers. Eventually, he has the potential to actualize his self-esteem to an even greater degree.

Carlos and I then looked at some Web sites together. Continuing with his project, Carlos sought further confirmation and encouragement. Each time he read his script, he anxiously awaited my comments to confirm that he was doing a good job. Once he sensed that he could do the work, he proceeded on his own for a limited time, and then sought continued confirmation from me. Carlos asked repeatedly, “Was I good?” “Really, was I good?” “What should I do now?” (My Journal, July 31, 2003).

As he began his quest for information, he made comments to himself, “This is all too much, too much!” Carlos would question his judgment with every decision, saying things like, “Which picture do you think is the best?” (My Journal, July 31, 2003). Carlos was not being critical in judging what he wanted to display. Once he found any reasonable picture, it necessitated that he put it into the slide. I made a comment about one of the pictures, rejecting it because it did not appear to be photographed in a tropical rain forest. This disturbed Carlos and
he said, “But what’s wrong with these pictures? I like them. It’s so hard to find the Web site again. Can’t I just use the pictures I have? Why can’t I just say, ‘This is a picture of an island’?” (My Journal, July 31, 2003). I reminded Carlos that he had four nice pictures on his first slide, to be used as the cover. Now on the second slide, it was time to get into the research sites by having him show a particular plant or animal and describe it in detail. I then pointed out to him that the picture did not show a tropical rain forest and that it was not a picture of an island.

Carlos responded, “Maybe it isn’t an island, but there is water there. Can I say, ‘This is a picture of a rain forest token [sic] from the top of a mountain?’” (My Journal, August 5, 2003). I suggested that he describe the picture as that of a tropical rain forest taken from an aerial view or a mountaintop. Carlos repeated this same sentence several times. After listening to himself, he decided it was good enough to proceed. For the next picture, Carlos said, ‘I’m going to say for this one: ‘This is a picture…’ No, I would say, ‘If you were to look at a picture of a rain forest, this is what it would look like’” (My Journal, August 5, 2003).

At this point, I showed Carlos that the pictures had small identifying numbers on them, which he might have wanted to use. Carlos glanced at me, looked at the six numbered plants on the screen, and shook his head in agreement without saying a word. Carlos was ready to get to work as he was focusing, searching the net for research information he could use. Finally, Carlos announced:

Now I have an idea to do a PowerPoint like Darryl, by taking the pictures off the Internet, copy and paste them into my slides like a slideshow. But, instead of writing the information, I’d like to record my own voice talking about the plants and animals in the picture. I can have my information recorded into the PowerPoint. Is that ok? (My Journal, July 31, 2003)

I was delighted to tell Carlos that it was a wonderful idea and to ask where he was going to obtain the research information. He responded, “I’ll get it from websites like Darryl. You’ll see what I can do” (My Journal, July 31, 2003). Throughout the process, Darryl and I tried to encourage Carlos, saying he should be proud of what he planned to accomplish. I repeated that it was a fine presentation and encouraged him to enjoy it and not make it difficult for himself.

**Web-Quests**

Using Bloom’s (2003) higher levels of analysis, synthesis, and evaluation, Dodge (2002) has opened doors for inquiry-oriented activities using the web (Internet) in a challenging and resourceful way. Dodge sums up the general principals of his WebQuests in the word FOCUS:
Find great sites (Select quality Internet sites).

Orchestrate your learners and resources (Individual and group accountability).

Challenge your learners to think (Take your learners to task).

Use the medium (Use your imagination).

Scaffold high expectations (Create new beginnings). (Dodge, 2002, ¶6)

The Tropical Rain Forest WebQuest opened a treasure of opportunity for a doable, compelling task. Working in teams, the members set out to search for information that each designated role demanded. Due to an unexpected change of plans, i.e., all Internet lines were down, we were able to meet and discuss the continuation of the rain forest project. Again, Darryl shared the sites that he had found on the Internet. I asked if there was a connection between these animals that they were finding on the Internet and those at the local Metro Zoo. Darryl said the “weather” here is like the tropical rain forests, with animals such as the bearded pig and the tapir. Carlos asked what the difference was between where we are and a tropical rain forest. I answered, “How can we find out? What if we research our particular designated living thing and find out about its habitat first” (My Journal, July 15, 2003).

The slides for the rain forest WebQuest could not be saved because the simulated voices of Darryl and Carlos embedded in the slides took too much disk space. We worked for hours in vain. The task was to save the PowerPoint on a disk, but having the simulated voices made the transfer too large. Carlos tried to copy each slide separately with the recorded descriptions but that would not work either. Belinda stayed close to the problem; whereas, Carlos grew agitated and wanted to give up. In addition to the recording problem, Carlos realized he had neglected to save his work on a disk or the hard drive of his computer. This distressed him terribly. The whole idea for this special work session was to redo the slides that had not been saved on the hard drive or the disk. We failed on both attempts but we each learned a valuable lesson. That lesson is: Save your work!

Benenson (2001) concurs with Hennessy and McCormick (1994), sharing a valid point when describing *The General Problem-Solving Process in Technology Education*, “In rich problem solving contexts, problems emerge out of dilemmas presenting a personal challenge. Learning arises when means are sought to resolve those dilemmas” (p. 744). Designing a PowerPoint presentation on tropical rain forests required the development of problem-solving skills for all subjects, especially for Carlos.
Concluding the Chapter

According to Yin (1994), the demands of case studies on a person’s intellect, ego, and emotions are far more demanding than those of any research strategy. But, may I add, the wealth of untold treasured experiences has made the journey unforgettable for me. “An inquiring mind is a major prerequisite during data collection, not just before or after the study” (Yin, 1994, p. 56). My intrinsic interest in science inquiry and the Internet has grown largely through the experiences of this research. Through extensive transcriptions in My Journal, artifacts, observations, informal and formal surveys, and E-Folios, I have been able to follow the ongoing odyssey of the Triumvirate as members learning in the Walden Sci-Tech Club.

In the following, Chapter 5, I present the teacher as researcher, maximizing data collection and analysis to extend my own learning while continuing to direct the study. The accurate design of qualitative data requires the acknowledgment of the existing systems, which play upon the Triumvirate and members in the Walden Sci-Tech Club. I bring these into focus in the next chapter. “One of the enduring difficulties about technology and education is that a lot of people think about the technology first and the education later” (CEO, 2000, p. 13). The next chapter illustrates my attempts to create a symbiotic relationship between the two elements.
CHAPTER 5: TEACHER-AS-RESEARCHER

A teacher who can arouse a feeling for one single good action...accomplishes more than he who fills our memory with row on row of natural objects, classified with name and form.


Using Inquiry and the Internet

My teacher-as-researcher study examined the teaching of science in a social constructivist environment in which I integrated and explored the use of technology in a summer science club setting. I provided opportunities for my students to learn science while fostering inquiry and collaborative learning. Such methodology promoted a teacher-as-researcher approach, and I, as the teacher, became a partner with the members of the Walden Sci-Tech Club. In this chapter, I specifically examine the following research questions:

1. How can I as a teacher enhance student learning through scientific inquiry using technology and the Internet?
2. How can I redirect my teaching strategies while using technology so that my students learn not only science content, but also a love of learning science?

Technology has changed dramatically, but has student learning changed using technology? The number of computers in the classroom does not determine the potential and effective use of technology in student learning. Evans (2002) reminds us that we must consider other forces, and we must strive in order to reach our goal of “…apply[ing] the power of technology in ways that empower learners and teachers, enlighten the mind, and enrich our lives” (p. 1).

Papert, renowned expert on children and computing, sees the learning environment of the future as one that places children in a position in which they actually use the knowledge that they learn (Papert, 2004b). Papert (2003) has interesting views on technology, such as, the belief that the real army for action and change in the educational system is the force, Kid Power. Children who have grown up with computers demand changes in learning that are at least as good as what they can experience otherwise. His views on technology address possibilities for the future:
It takes intellectual chutzpah to be serious about replacing “using technology to improve education” by a similar sounding statement with a very different meaning: “inventing new visions of education in the context of a digital world” (Papert, 2003, ¶7).

Papert offers this prescription for the challenges that education faces teaching toward a technology revolution. This chapter focuses on ongoing assessment of my own teaching in this action research study. I have used formal interviews and surveys, as well as, informal transcribed interviews to assess data from the Triumvirates’ classroom teachers. In forming this Walden Sci-Tech Club, my aim was to guide learners through a plethora of experiences and investigations that would help them establish their own problem solving skills. I wanted my students to use technology and inquiry to solve problems, much like scientists do. If given the right tools, my students could formulate explanations through guided inquiry, a stepping-stone toward scientific inquiry.

The analysis of qualitative data requires the acknowledgment of the existing systems, which played upon the Triumvirate, who were members in the Walden Sci-Tech Club. Later in this chapter, I examine these systems to provide the reader with a glimpse into the teacher-as-researcher approach. For the analysis, I utilize the Cultural-Historical Activity Theory (CHAT) (Peal & Wilson, 2001) to determine which strategies promoted scientific inquiry while using technology and the Internet as my tools.

Some critics questioned my idea of bringing science and the Internet into a summer camp environment, which some consider as a time for fun and games. However, in actuality, in our meetings, we had multiple opportunities for fun and exciting science investigations guided by inquiry learning. The goals of the school summer camp were not only to have fun, but to also integrate basic skills that align with the FLDOE (2003) and FCAT questions. With this emphasis, I combined the serious with the fun side of the summer camp. At times, the existing systems of the summer camp prompted contradictions to my goals, but the overall growth of the club members far outweighed these (Koszalka & Wu, 2004).

The following vignette from my journal demonstrates a few of the challenges at each Walden Sci-Tech Club meeting:

A good day at Walden Elementary, hoping to keep the “little family” together and focused. They are so unpredictable, the unexpected always happening! On Tuesday, Belinda had something on her mind keeping her from directing her attention to her work. It was difficult to keep her from using the headpiece earphones that included music for her to listen to rather than the discourse of the club. I had sat with Carlos to set up a step-by-step process for transferring pictures to his project. Today when I arrived, Darryl
raced to show me what he had accomplished finding extensive information on the food chain we had been discussing. “Look!” said Darryl, “Mother Nature Fan Club!” Meanwhile, Carlos had continued his work, sharing his script for his slides seeking positive reaction from anyone who would stop to listen and view his work (My Journal, August 19, 2003).

I valued our meeting times together as a special part of the day, as I, too, assumed many roles. Crawford (2000) describes the teacher in an inquiry-based classroom as one using collaborative inquiry. In collaborative inquiry, the teacher becomes a part of the students’ learning process as they collaborate to develop conceptual understandings. On a continuum, Table 3-1 illustrates the level of teacher involvement required in creating and sustaining a collaborative inquiry-based classroom. That is, the discovery method has the least teacher involvement, the traditional method has slightly more, and the inquiry-based method requires the greatest teacher involvement. In collaborative inquiry, the teacher is using science instruction to encourage the students to solve problems.

Such teaching strategies are more demanding and complex than that of just a facilitator or guide. The roles a teacher assumes flow in and out, day by day because there is so much to understand and process. Crawford (2000) defines science as inquiry as “…engaging students in the kinds of cognitive processes used by scientists when asking questions, grappling with data, drawing inferences, redesigning investigations and building theories and revising theories” (p. 934). Woven into the inquiry, Crawford defines the term critical incident as “…a series of interactions between teacher and students eliciting actions that resemble the descriptors of inquiry-based instruction that appear in the National Science Education Standards (NRC, 1996)” (Crawford, 2000, p. 919). These standards embrace science inquiry as both a content and pedagogy.

My students in the Triumvirate had been attending the Walden Sci-Tech Club for over a year, sharing school related activities but had no real bonds of friendship with each other at the start of the summer. They acknowledged me as a teacher and friend of their regular science teacher, Mr. Griffin. Interesting to note, when I was an adjunct professor at a local university, Mr. Griffin had been a student of mine, studying elementary school science (he always made a point of sharing this with the students and club members). Mr. Griffin maintained a very hands-on science laboratory woven into Florida’s SSS. In general, few of the classroom teachers at this school contributed supportive, science curriculum. Therefore, the class’ regular weekly laboratory session with Mr. Griffin was the extent of science classroom instruction.
Rice (2004) reviews findings of the U.S. Department of Education’s *Glenn Commission Report* (2000), “…clearly states that the “most powerful instrument for change, and therefore the place to begin, lies at the very core of education—with teaching itself” (p. 5). The Report further indicated that the preparation students in the United States receive in mathematics and science is not judged acceptable. “Research in science education clearly demonstrates that hands-on science instruction results in higher levels of science achievement and improved attitudes toward science (Rice, 2004). The state of Florida moved toward implementation of the science portion of the FCAT in spring, 2004, allowing the test to be a practice for the endorsement of the 2004-2005 FCAT. My vision for science learning acknowledges FCAT achievement, along with the NSES (NRC, 1996); yet, implicate the students’ role as a lifelong learner making connections and worthy contributions to their future world.

One of my roles as an educator is to guide and facilitate learning. Activities in the Sci-Tech club encouraged and supported student inquiry, promoted discourse among members, and challenged members to accept and share responsibility for their learning. Student understanding of scientific inquiry required that I help students understand:

…that there is no fixed sequence of steps that all scientific investigations follow. It is my responsibility to direct, guide, and model elements of the inquiry process and provide opportunities to practice the skills. Different kinds of questions suggest different kinds of scientific investigations. (Lederman, Bybee, Clough, & Hilkowitz, 2004, ¶10)

I am a guide, providing materials and a focus point for engaging students in spiraled forms of inquiry. I am the lighthouse, maintaining a beacon for guidance when needed. So, what can we say are the end results in the pathways that we take? O’Neill and Polman (2004) connect with the NSES (NRC, 2000), which aim for students to develop scientific ways of thinking. Science as inquiry involves students’ own questions and interests initiating an investigation. The amount of structure, guidance, and coaching I provide for the Triumvirate and other club members is critical in determining the level of inquiry in the learning environment. My goals are different from those one would expect from a traditional science teacher. Instead, the vision of scientific inquiry prepares students either for careers in science or for life in a society shaped both by scientific discoveries and inventions.

Brickhouse et al. (2000) indicate that caring, educated teachers unknowingly instill most of the important science misconceptions. Brickhouse et al. (2000) maintain, “the issue for us is not whether they are learning, but what they are learning in science class” (p. 443). Working as
an educational specialist with teachers throughout the county, I have been able to glean special skills and talents that worked for them. In many classrooms, I observed a plethora of professional wisdom among the teachers. Each science club meeting gave me the unique opportunity to engage the members into using their talents. As described by Papert (2004b), “What we need is kinds of activity in the classroom where the teacher is learning at the same time as the kids and with the kids” (¶4). That is, we want a classroom in which the teacher is a learner and a member of the learning community, not just a purveyor of knowledge. I continuously strove to accomplish this type of classroom.

Critical to the direction that science learning advances was the use of the 5E’s Instructional Model, described earlier in Chapter 4 (Bybee, 2004). I was familiar with the 5 E’s Instructional Model through professional development workshops offered through Miami-Dade County. By aligning Bybee’s model to the SSS, which combined active, collaborative learning within a constructivist environment, I was able to respond to my members’ needs.

At its best, the Internet can be an invaluable learning tool to assist learners in doing inquiry because it allows students to gain tremendous insight into the questions and theories they are investigating. The Internet provides a conduit of possibilities, allowing students to interact with the phenomena of using technology in ways to develop learning that is more integrated. Novak and Krajcik (2002) recognize the problematic potential of the Internet and the challenges to “…‘shrink the jungle’ and provide students with a compass when searching the Web but without minimizing the richness and depth of valuable possibilities for various information gathering” (p. 20). What appears to be one of the benefits of the computer is that it does provide students with a window of learning in which they can be comfortable as they adapt it to their personal style.

Described in increments from most teacher directed to least teacher directed, these levels include:

1. **Structured inquiry**—The teacher defines the materials, procedures, and the problem without student knowledge of the outcome. Students engage in a hands-on activity and draw conclusions, but follow precise instructions from the teacher (as exemplified using *The Living Planet* (Lambert, 2002) for the initial PowerPoint projects).
2. *Guided inquiry*—The teacher chooses the question to be investigated and supplies materials. The purpose is to continue to highlight scientific ways of thinking and doing, but to give more responsibility to the learner (as exemplified by the ozone news article and the WebQuest Rain Forest simulation).

3. *Open inquiry*—The teacher frames the investigations by defining learning goals, and students formulate the problem from a topic selected by the teacher. The student designs and explores an investigation using sound science practices, closely resembling the actions of real scientists (Novak & Krajcik, 2002) (as exemplified by the extended WebQuest Rain Forest simulation).

Learning using technology, including the Internet, has evolved, bringing with it unanticipated potential far more than I could have ever envisioned at the start of my dissertation project. Novak and Krajcik (2002) affirm that the power of learning technologies supports inquiry-based science teaching and learning. Furthermore, the power of the Internet greatly enhances the investigation of questions and the collection of data. Students create products to demonstrate understanding and to enhance their interpretations. As a teacher, it was my hope that students would use higher-level inquiry, i.e., asking questions and seeking answers, as they became independent science learners.

*Structured Inquiry*

The hands-on science in the Walden Sci-Tech Club allowed the members to actively participate in the formulation of research questions and processes. I directed my efforts to transform mindless information gathering into guided inquiry, whereby, I provided learners with the skills needed to conduct scientific investigations. In our project-based science club, I encouraged all members to make independent selections within a wide range of choices.

Gilmer (2002) emphasizes a distinction between scientific inquiry and student inquiry. Namely, scientific inquiry looks at the way scientists investigate the natural world and the postulates they use to support it; whereas, student inquiry is the skills students’ need, combined with the strategies students learn as they conduct investigations. This is my vision for engaging the Triumvirate in rigorous scientific inquiry, maintaining “an equilibrium between challenge and opportunity” (O’Neill & Polman, 2004, p. 246) while using the investigative skills of science. Those timeless skills of science include, but are not limited to forming questions, testing hypotheses, and formulating logical conclusions through observations, inferences, tests,
comparisons, predictions, interpretations, and communications (O’Neill & Polman, 2004). In the Environmentally-Safe Island of the Living Planet (Lambert, 2002), I introduced the Triumvirate and club members to the PowerPoint program, which gave them opportunities to exercise their skills and techniques using scientific research. Carlos had managed to complete the Environmentally-Safe Island along with various artifacts using technology. Darryl quickly saw the elements of the PowerPoint program, acting as a vital collaborative link helping Carlos make the necessary conceptualizations to complete his island. Belinda did not get to finish her island because of behavioral problems.

**Guided Inquiry**

Our investigations included more than those referred to as “hands-on science,” as Bell and Flick (2002) remind us:

> The explosion of digital technology has created a revolution similar to the "hands-on" movement of the 1960s. The flexibility, speed, and storage capacity of contemporary desktop computers is causing science educators to redefine the meaning of hands-on experience and rethink the traditional process of teaching. (p. 1)

Searching the Internet for research forced my students to make informed decisions. Learning to assess their own decisions and to become reflective thinkers helped my students create projects of higher quality. The members acted like scientists by sharing their knowledge through text, sound, and graphics. This was hands-on, minds-on science learning. Through these inquiry experiences, they became more motivated by what they were able to accomplish by producing these projects. Wittrock and Barrow (2000) cite Hurd’s (1995) description of our knowledge-intensive society and the emphasis vital for students as “…learning to learn or life-long learning…including how to find sources of reliable information, how to access new knowledge, and how to use it” (p. 34).

I was fully aware that as a teacher in an inquiry-based classroom, I had to continually assess what abilities my students had or were developing, and whether I was achieving my objectives (NRC, 2000). Being a reflective practitioner allowed me to promote an atmosphere of success within the Walden Sci-Tech Club (Peters, 1998).

Of the three case studies, Darryl’s accomplishments often ran parallel to his failures. In the following vignette, Darryl had discovered how to place his voice simulation into his rain forest production. I listened as Darryl read his slides and could sense that he was parroting meaningless words. Darryl did not question the words he had copied into his Rain Forest
PowerPoint slides or think of how to pronounce them. He proceeded to practice reading the slides he had created, and I sensed he was not satisfied with the product, as transcribed below:

I had made a few vain attempts to offer assistance when he was researching and writing the information. From prior episodes with him, I knew I had to proceed with caution. Darryl’s reading and comprehension skills did not equate with his computer skills. He continued to resist my offers to help in any way. He seemed to resent my recommendations but vitally needed changes so his slides would be acceptable for the project and his team. Words like meter and tortoise were barely audible because he really seemed uncertain as to their meaning or pronunciation. Frustrated at himself and assessing his own shortcomings, he shouted, “Forget it! I’m not going to do it!” The entire slide was deleted and he walked away. (My Journal, July 17, 2003)

I understood Darryl’s newly found confidence lay in his computer skills, but the failures of the past, which he had experienced throughout his learning, quickly surfaced in an academic setting in which he was challenged. Within the realm of the social construction are the individual’s personal beliefs about their performance abilities in a given domain. Jackson and Songer (2000) cite Bandura’s construct of self-efficacy as germane to the belief of one’s confidence and performance.

Jackson and Songer (2000) examine the potential of research collaborations on the social construction of knowledge. When properly facilitated, collaborations can increase student achievements and learning. Research indicates strategies for collaboration foster the objectives of a project in which students need to integrate multiple data. The Rain Forest WebQuest requires this kind of collaboration. Darryl was not only feeling his own dissatisfaction, but he had become sensitive to the group’s expectations in his new leadership role, as I wrote in my action research journal:

The group looked at me waiting to see how I would react. I felt the need to dispel any of my comments and those from the group, making eye contact to warn them to just ignore Darryl’s outburst. Although still maintaining the anger and disappointment, Darryl seemed more controlled than in the past. After about 15 minutes he quietly returned to the group, seated himself at his computer. I sat next to him, asking if I could just go through the slides, show him the changes needed, and help him get the project going. I told him I was not familiar with reptiles, and we could both learn together. He agreed and the two of us began to tackle the task. (My Journal, July 17, 2003)

My research shows that learning technologies can aid students in doing inquiry in ways that they would not otherwise be prepared to do. Darryl and the other members of the Triumvirate found technology enabled them for successful learning, both as an individual and part of a collaborative group. I felt the strength of these issues came to light through Darryl’s
self-directed search for a way to make his PowerPoint production more interesting. It was necessary for him continuously to assess his project, forcing him to dig deeper into his own newly attained computer skills and problem solving skills, as evidenced in Darryl’s interview:

I was roaming around because I was bored. So, I went to every clip, like Default Design. It said, “Insert” and I thought it meant to insert a floppy disk. Then I went to “Movies and Sound.” Then I thought about it and said, “Let’s go there.” It said “Sound” so I went there. So I clicked it and I started recording the sounds of my voice. I typed in my name. So I said, “Cool! Cool!” Then I said, “Ooh! Ooh! I have to tell Ms. Bosseler! I’m going to tie a string on my finger to remind me to tell Ms. Bosseler how I did it!” I began to record. (Informal Interview with Darryl, July 15, 2000)

This vignette illustrates how technology can help develop abilities for learning through scientific inquiry learning. I have encouraged this type of reasoning and problem solving as members have shared learning how to learn. “Learning technologies are tools used by students to ask and investigate, ‘What if?’ questions” (Novak & Krajcik, 2002, p. 2). They further define the learning technologies as those that we use to promote learning.

Through these learning technologies, notably the PowerPoint and the Internet, I was able to generate questions that helped construct cognitive meaning. Use of the Internet in the Walden Sci-Tech Club provided members with numerous opportunities to assess a variety of sources of information, collect various types of scientific data, present these data with various analytic tools, and promote collaboration and sharing within the science club meetings and throughout the school summer camp. Carlos sought quick solutions as a problem solver but woven into his frustrations were strategies I directed his way to allow him to grow, “I don’t know what or how to do it! Why do I have to move the pictures? How can I move the pictures from the Internet?” (Informal Interview, July 27, 2003).

I repeatedly described the role Carlos was to play as a member of the team and his responsibility to provide information in the role he selected as a zoologist. Carlos quickly found an inappropriate picture of an indigenous tribe, which another team was researching, as well as descriptions of barks of rain forest trees. Carlos’ uncertainty continued as he informed us, “I’m only doing five slides on animals. Can I only do one sentence for each slide?” (My Journal, July 27, 2003).

Along with Carlos, I, too, was reaching a level of frustration as I tried to find the key to dispel his confusion and redirect his investigatory skills. I wanted to allow Carlos and all members of the club to have the opportunity to create multiple representations of their own
understanding and learning (Novak & Krajcik, 2002). Carlos continued to focus on the limitations and constrictions to his learning before he even considered the processes he would be invoking in the investigation. Carlos expended energy without feeling success. The levels of inquiry described by Novak and Krajcik (2002) came to the forefront of my mind as I tried in vain to diminish Carlos’ indecision and fear of failure. The concept of inquiry learning places the responsibility for learning on the student, but I questioned my own assessment of Carlos’ level of self-directed learning. Understanding Carlos’ frustration and teacher dependency for decisions, I felt I was slow to move him from the structured inquiry to the guided inquiry stage. In this instance, Carlos listened to Darryl and followed his lead of logic problem solving. I chose strategies and activities that I felt were most appropriate for the Triumvirate and club members. Darryl was ready to move forward within this learning cycle. Considering Belinda’s learning level, I felt she belonged mid-way between Carlos’ structured level and Darryl’s leap to open inquiry. My use of technology as the magic key for entry into the kingdom of science was working – but not as quickly as I had hoped.

Open Inquiry

The special guest appearance of a District scientist to our Walden Sci-Tech Club meeting was a special treat for the members. My purpose in inviting a scientist was to provide a missing link for my students as they became immersed in taking the role and recognizing the attributes of a scientist. Our guest talked about science, and the ways in which a scientist has to figure out an experiment or an investigation. His presentation was especially supportive of my belief that the scientific method is not a single sequence of activities leading to infallible truths. Our visiting scientist posed an open-ended question to the group: “Is there life on Mars?” The room became enlivened with shared conjectures for the possibilities that life could exist on the planet Mars. I had used The Living Planet (Lambert, 2002) as a segway to initiating interest and thinking about the systems on Earth that make it habitable. Designing the Environmentally Safe Island as structured inquiry proved successful in preparing the way to our guided inquiry. The Rain Forest WebQuest investigations invited members to use their research and creative skills for these related project-based exercises using guided inquiry strategies.

I designed this open inquiry approach to move us forward into higher-level thinking and scientific inquiry. However, it did not work. In the Triumvirate, Belinda and Carlos were immediately consumed with the PowerPoint presentation, losing their focus on the program
possibilities and ignoring all research. Darryl was the only one who captured the creative possibilities and then left that to explore Mars research. Darryl has been able to make this cognitive leap through his skills using the computer. Open inquiry mandates acknowledgement that scientific research adheres to the following:

Scientific claims change as new evidence, made possible through advances in thinking and technology, is brought to bear on these claims, and as extant evidence is reinterpreted in the light of new theoretical advances, changes in the cultural and social spheres, or shifts in the directions of established research programs. (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002, p. 505)

Textbook teaching frequently leads students to believe that scientists can absolutely prove scientific hypotheses, theories, and laws, in spite of new theoretical advances. The annually imposed and often dreaded, science fair projects are prime examples of this “cookbook method.” The discovery of the tenth planet in our solar system gave credence to my beliefs of the tentative nature of science as I have expressed to my students. Lederman et al. (2002) distinguish knowledge as “knowledge obtained as scientists observe, compare, measure, test, speculate, hypothesize, and create ideas and theories” (p. 501). They argue there is no cookbook, recipe-like stepwise procedure that leads to valid solutions or true knowledge.

As stated by Lederman et al. (2002), there is no singularly preferred or informed nature of science, and the nature of science is tentative. Science as inquiry, as stated in the NSES (NRC, 1996), does not endorse as rigid an approach as the scientific method. To meet this standard of science as inquiry, I have my students investigate questions by using the methods of inquiry, not by memorizing facts of science. That is, I take away the doldrums of textbooks and let technology be our “liberator” (Ballard, 2004, ¶4). “When we take a kid along the way, either physically or through tele-presence (i.e., computer enhanced) and they see the process, that’s when science becomes humanized” (Ballard, 2004, ¶4). Children with their natural curiosity are born scientists.

Through the Walden Sci-Tech Club, I have tried to “grab” those pre-fourth and -fifth graders by opening the doors and their minds to the world of science. Ballard (2004) asserts that our educational system has the power and ability to extinguish the flame of curiosity in our students. Our mission in life should be to grab kids when they are excited and to keep the flame alive. He emphasizes the pre-fourth and -fifth grades as a starting point. “If you can get them to the tenth grade, you’ve won the game” (Ballard, 2004, ¶6).
Using Strategy Tools

It is up to me, the teacher (called facilitator, action researcher, or club sponsor), to facilitate the constructivist learning process in the classroom, club meetings, and the school garden, science or computer laboratory. The heart of the constructivist pedagogy demands the building of understanding, not through a linear process, but through a process, that blends prior knowledge with the first-hand knowledge gained in newly realized experiences (Bybee, 2004). The challenges of today’s educational environment demand that we travel a journey in which we realize that the inquiry pathways are neither straight nor narrow.

This second section of Chapter 5 examines the teaching strategies of inquiry for achieving understanding of science concepts and processes. From the perspective of social constructivism, the Action Research Cycle provides a glimpse of the roles my students and I assumed as we met various challenges. The Cultural-Historical Activity Theory (CHAT) (Peal & Wilson, 2001) allows me to focus on the concepts of human-computer interactions within the structure of systems, as applicable to my doctoral research. Finally, the Assessments section highlights the successes and challenges set into focus through the interviews and surveys of the individual classroom teachers and the science laboratory teacher, along with my own science journal. The Chapter’s conclusion finalizes my perspective of the teacher as researcher.

Social Constructivist Perspective

Introduced earlier in Chapter 1, Becker’s (1999) study Teaching, Learning and Computing maintains that constructivist teachers are more likely successfully to have students use the Internet than traditional teachers. As a teacher of the gifted and of an established, successful enrichment program for over 20 years, I strongly concur with the results of the Teaching, Learning and Computing study. Carvin (2002) introduces further connections between constructivism and computers. He confirms that if we are to assume that teachers want to make the best use of the Internet, i.e., value its interactivity, opportunities for collaboration, and creativity, and then the teachers themselves must be open to these very same strategies for learning. They must value similar attributes.

In our constructivist setting, a timely newspaper article evoked a lively Talking—Science Talks based on ozone levels found in urban and rural areas of New York (Callahan, 2003). As usual, the Triumvirate met in the computer laboratory as I read the results of the research study on ozone analysis in two different and distinct locations. In the pollution studies, scientists
discovered to their amazement, that buttonwood trees planted in New York City’s concrete jungle grew twice as large as those that were planted in the countryside. This is not what they had hypothesized. The trees that grew in the city grew to about 5 feet. The same kind of trees that grew in the country only grew to 3 feet. Their hypothesis was not accurate, but the data did lead them to draw conclusions about how ozone affected the growth of buttonwood trees.

Walden’s science laboratory teacher, Mr. Griffin, joined our discussion as he described the difference in air pollution, “The scientists had to adjust their prediction (hypothesis) to account for the greater amounts of ground level ozone captured in the countryside. Rural ozone, settles in the open fields after blowing in from the city” (Interview, July 8, 2003). Belinda was especially interested in this happening in New York City because she reminisced about visiting there. I wanted to dig deeper, so I asked her what she could say about the investigation. Belinda offered her own ideas:

The scientists must have figured that there was a lot of air pollution in the city. They didn’t think that there was much pollution in the country. Sometimes scientists think something that they think is so correct, is absolutely wrong. (Interview, July 8, 2003)

I provided Belinda with time to express herself, as she was most comfortable in doing. That is, allowing her to speak with authority and acknowledge the wisdom she was presenting to us that scientists could make mistakes. Belinda enjoyed sharing her science ideas when she felt she could express them freely without fear of contradiction from her peers. In this instance, she immediately processed the steps of the investigation and was able to theorize the results of scientists’ findings.

Research findings by Olitsky and Loman (2002) placed great importance on students’ discussing and answering questions among peers. These kinds of Talking—Science Talks initiate a level playing field where everyone can be scientific, and everyone has equal opportunity for important questions that provoke energetic discussion (Gallas, 1995). This timely article provided an excellent segway to illustrate to the Triumvirate a more accurate conception of the scientist in the real world. Regardless of the scientific investigation performed, scientists use evidence, apply logic, and construct an argument for their proposed explanations. The results of scientific investigations are communicated throughout and the results are made public whether the evidence is supported or not (AAAS, 2000b). Kielborn (2001) cites Koch, acknowledging, “Students need experiences that allow them to realize that science does not always lead to a single right answer” (p. 151).
Tyler and Peterson (2004) warn of occasional undue confusion on the part of young learners when they issue incorrect predictions about a scientific investigation that they have initiated. Handling contradictory bits of evidence along with the lack of a way of interpreting the new phenomenon often plagues novice scientists. Reexamining an investigation or experiment to modify its procedures and strategies often become difficult for young learners. Anomalous results that should be ignored are sources for disappointment with science in general and further science investigations. In Chapter 4, within the Bybee’s 5 E’s framework, I illustrate the Triumvirate’s experience in dealing with contradictory data. In the following example, Carlos expresses himself when searching for answers:

Now, if I would pick from a science book or a computer, I would pick a computer. Cause sometimes when you’re learning out of a science book, it gets kinda’ [sic] well, you just sit there, and it gets…kinda [sic], you just sit there. But when you’re on the computer, it gets exciting and you get to go everywhere, every website to go and look up different things. Your mind can shoot off in different directions. If we’re doing out of the science books we’re only doing one thing. On the computer you are doing lots of things.
(Informal Interview, August 14, 2003)

I share Carlos’ descriptive comments on the use and value of the Internet and learning. Carlos feels an overload of choices in open inquiry, so it stops him short. The Internet impacts social relations and practices as it provides Carlos with a plethora of opportunities to engage in both synchronous and asynchronous conversation and explorations. Obviously, at times, the choices are almost overwhelming. My role as a guide (Crawford, 2000) requires the utilization of teaching strategies that emphasize the ability effectively to solve problems. When we use technology as a tool to promote learning, it becomes a learning technology (Krajcik et al., 2000). Learning technologies can be powerful cognitive tools that help teachers’ foster inquiry. These learning strategies allow students to engage in aspects of inquiry that would not otherwise be possible. The NSES state, “A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for collection, analysis, and display of data is also part of this standard” (NRC, 1996, p. 175).

Computers, software, probes, hand-holds, digital cameras, the Internet and the like all have the potential to assist students toward in-depth and integrated understanding. By providing dynamic visuals to represent abstract concepts, these tools support students in their active pursuit of constructing meaning. These tools also allow students to create multiple representations of
their understanding. Learning technologies help students access a variety of information, aid students in collecting various types of scientific data, provide visualization and analysis tools, and promote collaboration and sharing of data, both within the classroom, as well as with other classrooms in the community. These tools may be used to help students create various hypermedia artifacts to represent their understandings (Krajcik et al., 2000). They may also help students create models of complex systems.

**Action Research Cycle**

The action research I performed proved to be rich in project-based inquiry teachings, providing data that reflects relevant and real classroom learning. *The Action Research Cycle*, introduced in Chapter 3, adapted from Black and Stave (2001) and Jenkins (2003) became the foundation and the conceptual framework for this research study. Through strategies of inquiry, I manifested the five steps of the research cycle in the following ways:

1. **Select Area:** As I remained focused on my research, I felt it necessary to alter my four research questions to more accurately interpret the configuration of the corresponding data:
   a. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?
   b. How do learners make sense of scientific inquiry while using technology and the Internet?
   c. How can I as a teacher enhance student learning through scientific inquiry using technology and the Internet?
   d. How can I redirect my teaching strategies while using technology so that my students learn not only science content, but also a love of learning science?

2. **Collect Data:** I collected data through my transcribed journal entries, member E-Folios, formal and informal interviews, surveys, observations, videotapes, student drawings, and artifacts. Members were able to reflect through informal interviews, artifacts, and E-Folio entries.

3. **Organize Data:** I organized and shared the data with the contributing members and encouraged communication for furthering self-reflection.
4. **Analyze and Interpret Data**: I used the QSR (1997) software for qualitative data analysis to assist me in analyzing data as I sought patterns within my teaching and members’ learning. Activity theory helped me identify contradictions and coherences in the activities.

5. **Take Action**: I used the data analysis to frame effective strategies for scientific inquiry using the Internet.

The action research cycle can be evidenced in this excerpt taken during our immersion into the Tropical Rain Forest project:

A change of plans and we were able to meet and discuss the continuation of the Rain Forest project [selected area]. At this point, I took another look at the pictures Carlos had placed in the slides [collect data]. I reminded him that it was time to dig deeper by examining specific tropical rain forest animals and to include a vivid description of their habitats in the layers of the rain forest. Carlos had three appropriate pictures framed into his first slide but no defining information to accompany it [organize data]. Carlos hesitated, unsure of the next task. I reminded him that his pictures needed the detailed research information. I reassured Carlos that selecting pictures of a tropical rain forest was excellent; but now, it was time to research the actual information that was needed to accompany the pictures [analyze and interpret data]. Overhearing this, Darryl, too, suggested that he had some real “cool” sites that Carlos could use, too. Carlos did work with Darryl to find the websites, then asked me to look at what he had found [take action] (My Journal, July 31, 2003).

The discussion continued as Carlos shared his work and thoughts with me:

The bark of the tree is thin because of the rain in the rain forest. Now, is that enough to say for this picture of the rain forest? Is that ok? I don’t know why I keep looking for the pictures and can’t find anything that’s right! Can’t I only do one sentence for each slide?” Look, what if I put in these pictures, (pointing to tribes of the rain forest)? (Informal Interview, July 31, 2003)

At this point, I reminded Carlos that other group members would be researching the indigenous tribes of the rain forest. Knowing he needed a little reassurance, I commented that he had made an excellent start and I would be looking for some interesting information about any animals he decided to select but to stick with animal information. Carlos was not very pleased with what I said, but I wanted to wean Carlos away from the didactic teaching styles and give him opportunities to make choices within given perimeters. My role as collaborator and research director necessitated that I encourage Carlos and treat him as a valued member of the research team. Finally, I told him to decide which animals he wanted to investigate and that would determine how many sentences he would write. “You can do it! Just think of the kinds of animals
and information you would find interesting to read if you were the reader” I insisted. (My Journal, July 31, 2003)

*Cultural-Historical Activity Theory (CHAT)*

As I continued collecting my data, it became apparent that within the existing systems in the Walden Sci-Tech Club, complex structures guided my successes and failures in this learning environment. In order to achieve my goals, I needed to identify and develop the existing systems in the summer club. The CHAT (Peal & Wilson, 2001) model offered a way to look at social interactions so that I could examine both the contradictions and the coherences in such social interactions. Including both subject (human participants) and tools (technology), the CHAT model helped me to gain a deeper understanding of technology’s impact on individuals and learning systems.

For example, within the system, Darryl had established “symbolic capital” (Olitsky & Loman, 2002); that is, teachers and other members of Walden Sci-Tech Club referred to him as “techie” or “computer whiz.” He had developed positive identities for the computer. Carlos strove for this same recognition, and eventually he developed this symbiotic capital as well. Late in the summer, I asked Darryl if things were different now in the computer laboratory. His response was:

Yes, they sure are different. In my group now they tell me what to do instead of me telling them what to do. Like they found the clip-art on the sea animals at Sea World and they have different sea animals there. So, we’re doing it on sea animals. That’s why we’re naming this Sea World. (Informal Interview, August 12, 2003)

I asked Darryl how he felt about this change. The fact that his group has gained skills over the summer using the Internet and the PowerPoint program. Also, I asked Darryl if he was in charge of the team and if he was happier not having to tell them what to do. Darryl reached over one of the team member’s neck, pulling them into the conversation:

I’m not in charge of the team, but I am the head of it. Hey guys, are you happy from me not telling you what to do? YES, YOU ARE! In my group people tell me what to do instead of me yelling and telling them what to do. We’re all geniuses! (Informal Interview, August 12, 2003)

Obviously, Darryl does take risks. In these school science systems, the drive to look smart and be well liked is important capital for these students (Olitsky & Loman, 2002). Darryl is no exception; however, his rise to a high volume of symbiotic capital came very quickly. At times, he needs reminding that other people’s feelings matter, too.
Together, the Action Research Cycle and CHAT provide a framework for the learning environment that I established at the Walden Sci-Tech Club site (Foot, 2001). Sewell argues that in social scientific discourse, structure is frequently misinterpreted as impervious and constraining to human activity. Yet, he contends that in social systems, people shape their practice by structures; while, conversely, the structures reproduce the people’s practices. This duality redefines structure as a “process” that is subject to change (Sewell, 1992). Blanton, Moorman, and Trathen (2004) maintain that Engeström’s model of collective activity is capable of capturing the dynamic relationship among users involved in technology integration. “The model seeks to account for learning and development by including both human participants and tools in the analysis of individual and collective activity” (Blanton et al., 2004, ¶12). Figure 5–1 (adapted from Cole & Engeström, 1993) illustrates the movement associated with the CHAT model. The primary movement indicates the flow of the Subjects to their Objects, and from their Objects, on to their eventual Outcomes. My primary Tools are the PowerPoint program and the Internet, influencing the flow of the activities. Rules or Schemas are structured within the Community where a Division of Labor mandates control or power. Activities are always in a state of flux, leading to transformation and transitions of knowledge (Koszalka & Wu, 2004).

Figure 5–1. Cultural-Historical Activity Theory Model as Applied to Self
Table 5–1

Application of the CHAT model

<table>
<thead>
<tr>
<th>Primary movement</th>
<th>Subjects</th>
<th>Objects</th>
<th>Outcomes</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Self as doctoral candidate</td>
<td>Earn doctoral degree</td>
<td>Accomplish my own professional mission</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inspire members’ love for science learning</td>
<td>Experience pleasures of learning and teaching</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employ possibilities of scientific inquiry using the Internet</td>
<td>Initiate process of collaborative inquiry to summer club learners</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Encourage lifelong learners</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Contradictions</th>
<th>Coherences</th>
</tr>
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<tbody>
<tr>
<td>My Pedagogy</td>
<td>Summer Camp Pedagogy</td>
</tr>
<tr>
<td>SSS embedded in project-based activities</td>
<td>Stress FCAT</td>
</tr>
<tr>
<td>Project-based computer literacy</td>
<td>Adherence to traditional methods</td>
</tr>
<tr>
<td>Lead science inquiry to lifelong learners</td>
<td>Knowledge for knowledge sake</td>
</tr>
<tr>
<td>Embedded assessments</td>
<td>Standardized assessment</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tools</th>
<th>Rules or schemas</th>
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</thead>
<tbody>
<tr>
<td>Using the Internet</td>
<td>FSU Doctoral program</td>
</tr>
<tr>
<td>Actualizing scientific inquiry</td>
<td>Overly stressed FCAT preparation and testing</td>
</tr>
<tr>
<td>Conceptualizing the nature of science</td>
<td>Science-technology learning limited</td>
</tr>
<tr>
<td>Applying the PowerPoint program</td>
<td>Programs blocked for Internet transmittals</td>
</tr>
<tr>
<td>Following Sunshine State Standards</td>
<td>Inability to burn CD’s for storage of programs</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Communities</th>
<th>Division of labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSU Doctoral Program</td>
<td>Rules governed by summer camp staff</td>
</tr>
<tr>
<td>The Triumvirate</td>
<td>Contradicting rules for my summer Walden Sci-Tech Club</td>
</tr>
<tr>
<td>Walden Elementary School Summer Campers</td>
<td></td>
</tr>
<tr>
<td>Walden Elementary Summer Teachers</td>
<td></td>
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</table>
Cultural-Historical Activity Theory starts with the activity system, in this case, the Walden Sci-Tech Club, as we pursued the goal of science learning using the Internet. Vital to the underscoring power of this theory was the inclusion of the system itself, as I pursued a specific goal in a purposeful way, working within coherences and contradictions in a multiple activity structure (Peal & Wilson, 2001). In Table 5–1, I apply the CHAT model to my research and depict the elements that convey the components and forces that constantly enter and affect the given structure.

I have distinguished the basic elements to effectively examine the CHAT model as applicable to the Walden Sci-Tech Club environment by examining elements of this theory:

1. **Tool(s):** Influence the flow of the activities, helps to mediate the activities. The *tools* that influence the activity system are the use of the Internet, actualizing scientific inquiry, conceptualizing the nature of science, following the SSS, and attaining skills and application of PowerPoint computer program.

2. **Subject(s):** Individual(s) as participant(s). The central relationship is between me as the *subject*, and the activity systems’ purpose(s) or object(s).

3. **Object(s):** Purpose of the activity system. The basic *object* is my pursuing of a doctoral degree in science education, and in doing so, inspiring a love for science and technology, while instilling inquiry learning.

4. **Rules/Schemas:** Guiding rules for acceptable interactions that act upon subject(s) within the activity system. The *rules or schemas*, which regulate the systems, include the rules and guidelines for summer campers, recommended FCAT theme for Walden camp, and Florida State University doctoral policies.

5. **Communities:** Environmental context (community of people) mediated by rules that help accomplish system purposes and outcomes. The Walden summer camp maintained a dual purpose: a camp for summer activities and a camp for accelerating FCAT (FLDOE, 2003) concepts. Within that community, the Walden Sci-Tech Club prevailed.

6. **Outcomes:** Tools are used to mediate activity and actualize objectives of the activity system. The *outcomes* referred to are my doctoral degree, my professional mission, and inspiring my students with lifelong love of learning science.
7. *Division of Labor*: who is doing what toward the objective (Peal & Wilson, 2001)? My goals as a teacher researcher and sponsor of the Walden Sci-Tech Club were inconsistent with those of the Walden summer camp.

The *Coherences* and *Contradictions* are powerful components that help drive the system. Maintained by Sewell (1992), these structures are multiple and intersecting, driven by their very nature to change. The *Coherences* and/or *Contradictions* acknowledge inevitable conflicts in the functioning of any system. These contradictions manifest themselves as problems or breakdowns but they are viewed in the system as indicators for negotiable progress. *Contradictions* point to possible ways where practices can shift and new development can take place.

**Assessments—Successes and Challenges**

It is critical that students learn to evaluate the information they encounter in their learning, especially using the Internet. Performance-based and project-based assessments, such we used in the Walden Sci-Tech Club, make evaluation meaningful and pertinent to the learning. Learning technologies all have the potential to assist students toward in-depth and integrated understanding. Linn et al. (2004) remind us that learning environments can play a major role in assessments for learning by demanding far more effort than traditional standardized methods. Students can also benefit from assessments generated from their peers, as well as from experts, models, and animations. As Linn et al. (2004) confirm, “Critical appraisal of scientific materials characterizes successful scientists yet rarely becomes a component of science instruction” (p. 348). Continuing, the NSTA recommends that students communicate and defend their conclusions in conducting investigations and in analyzing the data (Lederman et al., 2004). By granting this authority to the Walden Sci-Tech Club members, club members value the articulation of their own ideas and assessments as avenues to further their individual understandings.

The next section, *Classroom Teacher Interviews*, provides an in-depth glimpse into the regular science teachers’ ideas on the Triumvirate’s regular classroom attitudes and inquiry learning. It should be noted that these embedded assessments are sensitive to the degree of knowledge integration and to their diverse teaching styles as well. Table 5–2, 5–3 and 5–4 illustrate the essential features of classroom inquiry and their variations adapted from Bybee’s *5 E’s Model* (2004). At the heart of the *5 E’s Model* is the employment of teaching strategies that promote short- and long-term investigations. These investigations often take unanticipated
directions. The final sub-section, *Evaluation of Triumvirate Student Roles*, discusses each teacher’s assessment of the level of inquiry learning for each of the members of the Triumvirate. The final sub-section describes an Informal Interview with the *Science Laboratory Teacher*.

**Classroom Teacher Interviews**

The three members of the Triumvirate had each attended Walden Elementary for at least one year prior to my forming of the science club. I asked current and past teachers, along with the science teacher, Mr. Griffin, to complete two data surveys, including a general comment section. According to the NRC (2000), an inquiry-based teaching and learning environment has five essential features that apply across *all* grade levels to *all* learners. My own interpretations of these five features are that the students:

1. Engage in scientifically-oriented questions that are meaningful and relevant;
2. Give evidence that allows them to develop and evaluate explanations for scientific phenomena;
3. Formulate explanations from evidence to address scientifically-oriented questions by building on their existing knowledge base, which requires the use of cognitive processes;
4. Evaluate their explanations while making connections between their results and the currently accepted scientific knowledge; and
5. Communicate and justify their results to solidify empirically-based arguments.

I distributed the first survey form just prior to the close of the 2002 academic year, and then proceeded to distribute it to the teachers in the fall of 2003. I used Bybee’s (2004) 5 E’s model as a basis for each of the Triumvirate’s teachers to assess the degree of scientific inquiry in a follow-up survey. I include the transcribed comments made by the students’ classroom teachers to add greater authenticity to the collected data. I examine the second survey in the following section, *Evaluation of Triumvirate Student Roles*.

Table 5–2 shows Belinda’s teachers’ responses to Belinda’s learning ethic. I aligned their teacher responses with Bybee’s 5 E’s Model. Belinda’s third grade teacher is no longer at the school (for their transcribed responses, see Appendix I).
Table 5–2
Belinda—Student Role

= 4th grade teacher = Science laboratory teacher = Ms. Bosseler

<table>
<thead>
<tr>
<th>Student Roles</th>
<th>Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage:</td>
<td></td>
</tr>
<tr>
<td>Engages in scientifically oriented questions</td>
<td>Poses a question</td>
</tr>
<tr>
<td></td>
<td>☐ Ω</td>
</tr>
<tr>
<td>Explore:</td>
<td></td>
</tr>
<tr>
<td>Gives priority to evidence in responding to questions</td>
<td>Determines what constitutes evidence and collects it</td>
</tr>
<tr>
<td></td>
<td>☐</td>
</tr>
<tr>
<td>Explain:</td>
<td></td>
</tr>
<tr>
<td>Formulates explanations from evidence</td>
<td>Formulates explanation after summarizing evidence</td>
</tr>
<tr>
<td></td>
<td>☩ Ω</td>
</tr>
<tr>
<td>Elaborate:</td>
<td></td>
</tr>
<tr>
<td>Connects explanations to scientific knowledge</td>
<td>Independently examines other resources and forms the link to explanations</td>
</tr>
<tr>
<td></td>
<td>☩ ☩ Ω</td>
</tr>
<tr>
<td>Evaluate:</td>
<td></td>
</tr>
<tr>
<td>Communicates and justifies explanation</td>
<td>Forms reasonable and logical argument to communicate explanations</td>
</tr>
<tr>
<td></td>
<td>☩ Ω</td>
</tr>
</tbody>
</table>

More ——— Amount of Learner Self-Direction ——— Less
Less ——— Amount of Direction from Teacher or Material ——— More
Table 5–3 shows Carlos’ teachers’ responses to his learning ethic. I have tried to align their responses with Bybee’s 5 E’s Model (for the teachers’ transcribed interview responses see Appendix I):

Table 5–3
Carlos—Student Role

<table>
<thead>
<tr>
<th>Student Roles</th>
<th>Variations</th>
</tr>
</thead>
</table>
| **Engage:** Engages in scientifically oriented questions | ☐
| | Poses a question | ☐
| | Selects among questions, poses new questions | ☐
| | Sharpens or clarifies question provided by teacher, materials, or other source | ☐
| | Engages in question provided by teacher, materials, or other source | ☐
| **Explore:** Gives priority to evidence in responding to questions | ☐
| | Determines what constitutes evidence and collects it | ☐
| | Directed to collect data | ☐
| | Given data and asked to analyze | ☐
| | Given data and told how to analyze | ☐
| **Explain:** Formulates explanations from evidence | ☐
| | Formulates explanation after summarizing evidence | ☐
| | Guided in process of formulating explanations from evidence | ☐
| | Given possible ways to use evidence to formulate explanation | ☐
| | Provided with evidence | ☐
| **Elaborate:** Connects explanations to scientific knowledge | ☐
| | Independently examines other resources and forms the link to explanations | ☐
| | Directed toward areas and sources of scientific knowledge | ☐
| | Given possible connections | ☐
| **Evaluate:** Communicates and justifies explanation | ☐
| | Forms reasonable and logical argument to communicate explanations | ☐
| | Coached in development of communication | ☐
| | Provided broad guidelines to sharpen communication | ☐
| | Given steps and procedures for communication | ☐

More ← Amount of Learner Self-Direction → Less
Less ← Amount of Direction from Teacher or Material → More
Table 5–4 shows his teachers’ responses to Darryl’s learning ethic. I have tried to align their responses with Bybee’s 5 E’s Model (For their transcribed interview responses see Appendix I):

Table 5–4

Darryl—Student Role

<table>
<thead>
<tr>
<th>Student Roles</th>
<th>Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage:</td>
<td></td>
</tr>
<tr>
<td>□ = 4th grade teacher</td>
<td>□ = 5th grade teacher</td>
</tr>
<tr>
<td>Engages in scientifically oriented questions</td>
<td>Poses a question</td>
</tr>
<tr>
<td>Explore:</td>
<td></td>
</tr>
<tr>
<td>Gives priority to evidence in responding to questions</td>
<td>Determines what constitutes evidence and collects it</td>
</tr>
<tr>
<td>Explain:</td>
<td></td>
</tr>
<tr>
<td>Formulates explanations from evidence</td>
<td>Formulates explanation after summarizing evidence</td>
</tr>
<tr>
<td>Elaborate:</td>
<td></td>
</tr>
<tr>
<td>Connects explanations to scientific knowledge</td>
<td>Independently examines other resources and forms the link to explanations</td>
</tr>
<tr>
<td>Evaluate:</td>
<td></td>
</tr>
<tr>
<td>Communicates and justifies explanation</td>
<td>Forms reasonable and logical argument to communicate explanations</td>
</tr>
</tbody>
</table>

More ——— Amount of Learner Self-Direction ——— Less

Less ——— Amount of Direction from Teacher or Material ——— More
Teacher Evaluation of Triumvirate Student Roles

The NRC’s (2000) Table 2–6 titled, Essential Features of Classroom Inquiry and Their Variations (Table 2–6; NRC, 2000, p. 29) asks the teacher to assess the degree of structure, guidance, and coaching provided for the student in their learning environment. Each teacher in my project volunteered to complete the survey form regarding the variations of classroom inquiry learning environments. The more responsibility the student takes, the closer the teachers can evaluate the student as more self-directed, situated closer to the left hand column. Although inquiry-based learning cannot simply be characterized as one or the other, the available levels of inquiry allow the teacher to determine the degree of inquiry as to “open” (less amount of direction from teacher or material) to “guided” (more amount of direction from teacher or material).

Table 5–2 examines Belinda’s inquiry assessment as stated by her fourth grade teacher, the science laboratory teacher, and me, as science club sponsor. None of the teachers interviewed regarded Belinda as exhibiting extreme guided or open inquiry roles. Her strongest levels of self-direction fell within the roles of elaboration; that is, connecting explanations to scientific knowledge. Her greatest need for teacher direction fell within the range defined as exploration. This role involves obtaining accurate evidence, just as a scientist concentrates on empirical data to explain how the natural world works. I have felt especially grateful that Belinda has come so far with the Walden Sci-Tech Club and with me. Belinda especially profited from our Talking—Science Talks where she felt comfortable to informally discuss the science that was on her mind and to make conjectures without being discouraged by the teacher or classmates. Olitsky and Loman (2002) describe this as co-generational dialogue. There were no hidden clauses for discussions, which allowed Belinda to thrive, revealing a child aware of much more than I realized. At times, I was acting like a buffer so the “big picture” comes through and I witnessed her potential as an achiever, often surprising herself with her accomplishments or allowing herself to become immersed in the possibilities of extending her thinking.

The following informal interview traces Belinda’s thoughts as she relates to the existing system in the Walden Sci-Tech Club, evaluating herself. In this informal interview, I could ask Belinda, “Is using the Internet helping you learn science?” She quickly answered:

Yes, because when you go on the Internet it gives you pictures and you can read it. Every time I do my PowerPoint I write stuff about stuff. Say, I want to write stuff about fishes, I go on it and even before I show it to you, I learn stuff that I didn’t even know before. It
helps me learn something I didn’t know when I’m studying and when I go on the computer, it helps me get better at it. Stuff about whatever I’m studying. Before I didn’t think I could just go look up something I wanted to look up, but right now, I just feel that I have all the powers to do what I want to do. If I can’t get answers then I just go on another website that can probably answer my question. (Informal interview, July 31, 2003)

When Belinda was first using the Internet, she was not comfortable having to seek help or taking the time to keep refocusing her efforts. Instead of working at overcoming obstacles, she would become distracted. Since then, she has advanced a great deal, as illustrated when she states, “I have to think differently” (Informal interview, July 31, 2003). This is an expert analysis for her to make. She has realized that she is quite capable of thinking differently.

Carlos is the second member of the Triumvirate team. Table 5–3 indicates that Carlos’ science, fourth, and fifth grade teachers gleaned changes in his becoming more self-directed. Inconsistencies are evident; for example, his fourth grade teacher selected two items in the same row, indicating a very high need for teacher direction on one coupled with a high rating for more independent learning for the other. I concurred with the dual rating, due to Carlos’ alternating attitudes and involvement in learning. A noticeable change in Carlos on his commitment to learning tasks and his self-concept started to prevail. I discussed this with him on several occasions and encouraged him to stay focused while setting higher standards for himself.

It became important for Carlos to be considered “smart” at the computer. Witnessing Darryl’s quick rise to fame as a “tech god” exasperated Carlos’ frustrations at the start of using PowerPoint. Olitsky and Loman (2002) describe this need for active participation as indicating the student’s wish for identification as a learner, skilled in the classroom or any learning environment. However, a dichotomy exists for many who seek a socially accepted status and hope to attain reputation as a science or computer savvy learner. Olitsky and Loman (2002) offer this perplexing dilemma as a struggle when a student will take a level of risk in science learning when his/her ideas may be rejected based on new evidence or Carlos has been able to bridge the gap, but Darryl and Belinda have had their difficulties, too. Carlos had to learn to act, not to react, to any obstacles to completing his project.

I reassured Carlos that nothing needed to be done over again to his slides for the Rain Forest project, while encouraging him to consider adding more information. “We know that there are predators and prey. What kind of animal do you think would prey upon any of these animals? For instance, I asked what animal would you think would go after a gorilla?” (Informal
Interview, July 29, 2003). He responded, “Probably a cheetah. I would think something bigger than it is and faster. Right?” My response was, “Excellent! So how could you find out what goes after a gorilla?” Finally, Carlos’ ideas began to flow. The following vignette from my journal illustrates Carlos’ work ethic and need for more guided inquiry:

You would go and look up the animals and what they eat. Which pictures do you think I should use? Here is what I will say, “This is a picture token [sic] from the top of a mountain by a helicopter.” No, I’ll say, “This is a picture token [sic] from the top of a mountain of a rain forest. If you were to look at a rainforest, it should look like this. (Informal Interview, July 29, 2003)

It took a great deal of effort for Carlos to remain steadfast to redo his slides and complete what he felt was a quality product. I asked him what he had intended with the CD that I was making for their projects. His answer surprised me saying, “I’ve worked so hard…I think I want to save this until I’m an adult and show it to my children!” (Informal Interview, August 12, 2003)

As the third member of the Triumvirate, Darryl’s student role survey (Table 5–4) provided interesting clues as to his independent and dependent learning. Darryl demonstrates strong amounts of self-direction throughout. The fifth grade teacher who indicated Darryl’s self-direction into the column indicating more teacher direction is a prime example of a traditional teacher who teaches using traditional pedagogy. Prior to mastering computer skills, Darryl’s social acceptance was close to non-existent. As described earlier, Olitsky and Loman (2002) analyze a social status that exists in classroom learning environments and other structured systems. Darryl was able to achieve science (computer) capital and with that, there was a change in his social capital. He battled with this dual role, often unsure which one he wished to maintain.

On one occasion, Darryl was in his glory, leading the way with skill and agility. Asked how he found the perfect site for the Biosphere research, he said it was from a list of sites I gave him several weeks before. He had earmarked it as a “Favorite” and was able to pull it up on the computer. Excitedly, he continued:

Friday you weren’t here and look what I found! There! There! Right there! It’s got all these sites - about 2 dozen sites. I went to Google and Arizona Biosphere 2. ….Look at them! Look at all the others! They didn’t want to work today. I was just looking for some of the other ones because I have so many! I’m a genius! Everyone knows I am! I’m a superstar! My world! Here’s my PowerPoint (indicating he’d like to show it). Belinda’s response is that she doesn’t want to see it again and neither does anybody else. So he takes her clue, saying, “and that’s a wrap!” (Translated television slang meaning, “and that’s the end!” (My Journal, July 10, 2003)
This kind of a “self” attitude did not enhance Darryl’s social capital, but fortunately, Darryl’s bid for social acceptance began to flourish as he experienced friendships and admiration from his peers and teachers.

**Informal Interviews With Science Laboratory Teacher**

Mr. Griffin and I met so we could share discourse about each of the Triumvirate members. Mr. Griffin, science teacher for all second through fifth graders at Walden Elementary, has taught Darryl for three years, while I have known Darryl for over two years. I felt his assessment of the Triumvirate would be especially valuable. I asked Mr. Griffin to share his thoughts on Darryl as a student in his science laboratory; Mr. Griffin wholeheartedly agreed saying:

Evaluating Darryl in the science laboratory, I would say this year there has definitely been a big change. For the first two years in the laboratory, many times he was fiddling with something on his desk, flipping through books while I’m trying to teach. When he comes into the lab now he is engaged and ready to explore. At times he behaves in quite the opposite behavior mood, with no real direction and in a disorganized manner. At other times, he is guiding the other students in the lab, especially with computer related activities. He is able to do these things having gained skills to expand the knowledge he has on the particular topic. He’s come a long way this year (Informal Interview, September 27, 2003) [See above. Did I change the quote so it is right now?]

I mentioned to Mr. Griffin that the computer had opened so many opportunities—so many doors for Darryl that did not exist prior to finding his computer gifts. Mr. Griffin commented, “Darryl has always expressed an interest in science, but now he is really tuned in and asking meaningful questions, He’s come a long way, especially over the summer. He’s pretty much glued into whatever science we’re doing, without all those outbursts of anger” (Informal Interview, September 27, 2003). Mr. Griffin added, “I’m pleased to see him as a special ‘techie’ working with other students.” I added, “I’m pleased that I see him more organized in his thinking and going deeper as a problem solver, too. Gaining social capital matters to him and affects the way he views himself and others. The leadership attributes are evident, too” (Informal Interview, September 20, 2003). The discussion evidenced that Darryl’s inquiry skills placed him moving forward into the “open” inquiry of learning, as suggested by his integrated knowledge of the computer and science (Bybee, 2000; Linn et al., 2004). We both felt that Darryl’s academic future rests in his own hands; that is, attaining academic approval with peer and teacher acceptance and continued progress.
As our informal interview continued, I asked Mr. Griffin how he would assess Belinda in the science laboratory:

Belinda’s attitude toward learning science had always been threatened by her short attention span and distractions. She would have a purse or jewelry to occupy her thoughts instead of framing science learning as a priority. Belinda valued, and continues to value, friendships and fairness. Presently, she is more glued to what we’re talking about in science, especially our hands-on science investigations. I see her in the hall and she is more settled down, more mature. I don’t know if it’s coming of age or a combination of that with what she’s been doing in the Sci-Tech. She doesn’t have a computer at home, so whatever she does, it is in school. Belinda thrives on positive feedback. (Informal Interview, September 27, 2003)

I shared with Mr. Griffin that the Talking—Science Talks were especially beneficial to a student like Belinda who enjoys the intimacy of the meetings and comfort in exchanging dialogue without fear of reprisals. Sometimes she wanted to explore things on her own, but just did not know where to start. At other times, she was not very engaged or motivated and wanted assistance throughout the entire activity. She seemed to fit nicely into the middle of the “guided” and “open” inquiry (Table 5–2) (Bybee, 2000). Mr. Griffin added, “Yes, however, I think she is learning to balance her approach. She has a lot of obstacles to overcome (especially in her home life) and requires a lot of attention. I’ve noticed that she has become more efficient in school and especially, in Sci-Tech Club where I see your patience and caring. Belinda realizes this and in turn, performs and improves in her academics as well as in her social attitude toward others” (Informal Interview, September 27, 2003).

Finally, Mr. Griffin shared his assessment regarding Carlos’ learning in the science laboratory:

The first several years in the science laboratory were an invitation for Carlos to waste time and enjoy the pleasure of his friends’ company. He was easily distracted and needed to settle down. He was pestered by his limited science knowledge and his basic desire to succeed. Between my efforts and those of his classroom teacher the difference was obvious. This year I see him as very capable in science and on the computer. (He isn’t as talented as Darryl is on the computer, but he’s probably better than me.) Once there is certainty that what he is trying to accomplish is correct, he becomes very self-directed. (Informal Interview, September 20, 2003)

I agreed, adding that Carlos displayed a broader sense for seeking independent learning, which can become an attribute for future success in school. I reflected on the immense challenge of the computer and the Internet, which seemed to take its toll on Carlos; when he made blunders, he would temporarily lose all confidence. Mr. Griffin agreed,
Yes, Carlos does come back up after he’s made a blunder, but the uncertainty is often seen. Each of the Triumvirate has come a long way working with you and the Sci Tech activities using the Internet. It has brought up their self-esteem, their self-confidence. I have seen a big change in each of them” (Informal Interview, September 20, 2003). I noted that Carlos’ search for synthesizing and extending information found on the Internet can result in a higher level of thinking and problem solving. This is what we envision for lifelong learners. (Informal Interview, September 30, 2003)

Concluding the Chapter

In Chapter Five, I have examined my role as the teacher-as-researcher and the strategy tools that I have aligned with my research questions. The data analysis obtained through this research study has evidenced patterns of learning consistent with my theoretical framework.

According to Crawford (2000), the following ten roles, which I have adapted, involve the teacher as:

1. motivator—I have generated interest and encouraged students to take responsibility rewarding self-directed learning
2. diagnostician—I have encouraged students to express and describe their ideas so that I can assess their understanding
3. guide—I have directed students to establish their own strategies for problem solving techniques
4. innovator—I have involved students in timely processes and experiences by sharing communication
5. experimenter—I have redesigned instruction by assessing students learning
6. researcher—I have actively participated in action research to evaluate my teaching and student learning
7. modeler—I have demonstrated problem solving strategies, attitudes, and processes used by scientists
8. mentor—I have shared experiences of learning with students and building team support
9. collaborator—I have encouraged the student in student-as-teacher role and in the exchange of ideas
10. learner—I have encouraged sharing of new ideas for student and teacher learning together.
Having assumed these essential roles has aided in preparing me for my most honorable role—that of a teacher. In Chapter 6, my final chapter, I share a personal look into the journey taken for this dissertation and the consequences of the interpretive research as it has guided me.
CHAPTER 6: RESEARCHER-AS-LEARNER

“Would you tell me, please, which way I ought to go from here?” “That depends a good deal on where you want to get to,” said the Cat. “I don’t much care where”— said Alice. “Then it doesn’t matter which way you go,” said the Cat. “So long as I get somewhere,” Alice added as an explanation.

—(Lewis Carroll, 1865, p. 64)

Over 100 years ago Lewis Carroll wrote this excerpt from Alice’s Adventures in Wonderland (1865), and yet, its message still speaks to us in our technology-driven, information age. Where do our students and we, as educators, want to go from here? We acknowledge where we have been and where we presently are, but where will our travels take us as we search for answers to “learning about learning” (Burns, 2002, p. 295)? Where should our journey take us next as we continue to strive toward our goal for educational excellence?

In an unpredictable future, our students need to continue to be literate, but such literacy requirements have changed. Today it requires skills that are reflective of the information environment. Tomorrow it will require this and more. The question remains, what do students really need to be learning today in order to be ready for the cosmic future in a networked world?

If we utilize learning technologies in a social constructivist environment, which allows students to create multiple representations of their understanding, then scientific inquiry will prevail within a digital age (Novak & Krajcik, 2002). Inquiry invites collaborative projects that develop in-depth and integrated understanding of science concepts and science process. In an inquiry-based classroom, utilizing learning technologies closely emulates how scientists work in the real world. Reminded by Novak and Krajcik (2002), “Inquiry places learners at the center of knowledge building” (p. 1). Therefore, it seemed advantageous to explore the concept of inquiry learning styles, blended with learning technology, in order to ignite the cognitive and creative potential for all learners.

As I have written each chapter for this dissertation, I focused on the four research questions that have guided this action research, stated as:

1. What can members of an elementary school science club learn by conducting scientific inquiry using technology and the Internet?
2. How do learners make sense of scientific inquiry while using technology and the Internet?
3. How can I as a teacher enhance student learning through scientific inquiry using technology and the Internet?
4. How can I redirect my teaching strategies while using technology so that my students learn not only science content, but also a love of learning science?

As I searched for answers, I intertwined embedded questions within these four research questions postulated after my earlier pilot studies. Additionally, I felt a keen and escalating awareness acknowledging the avalanche of technology that has dramatically transformed our society in less than a decade. From the initial formulation of my research questions, my earlier pilot studies prompted me to redirect my focus. I had conducted my pilot studies at a before-school science club, attended mainly by my gifted students along with some students from the regular classrooms. Early research questions, such as, “In what ways has using the Internet influenced students' attitudes toward science” and “How are students more able to conduct inquiry-based problem solving as a result of using the Internet?” could not provide a natural setting that deployed a wide range of interconnected experiences (Denzin & Lincoln, 2000). The action research data represented by the case studies showed evidence of my science club members’ efforts embedded within the teaching strategies I used with those same students. In other words, the Bosseler effect would be giving my gifted students a double dose of my PCK as compared to those members in the regular classroom, and the quality criteria of credibility would be altered.

Additionally, at that time I did not recognize the social structure that dominated the club. According to Scardamalia and Bereiter (1996), “School is a place where the pursuit of understanding is supposedly given a high priority, but it is also a social institution with conditions of its own which students adapt, and it is therefore important to examine whether these conditions favor adaptation through or without understanding” (p. 149). The social structure of information access is rapidly changing (Solomon, 1987). Concurrently, the pace and the selected projects that I had issued in the pilot study became an activity-mania problem (Moscovici & Nelson, 1998). As I earlier defined, “activity-mania” refers to an unstructured curriculum leading to a barrage of activities; thereafter, I structured the present Walden Sci-Tech
Club to include *The Living Planet* (Lambert, 2002). This served as a solid frame of reference for the ensuing curriculum.

Throughout my teaching and research studies, I have attempted to weave the two domains, scientific inquiry and technology, together with formidable success. The “club” format gave me a platform that was a unique combination of a scientific setting with the subjectivity of a social setting. As the Walden Sci-Tech Club became organized, the existing social influences (Solomon, 1987) transformed from rigid insulated science to collaborative investigations. Interesting to note, new members to the group initially assumed the interaction and social exchanges were pointless. As the neophytes themselves became engaged, they assumed the same “scientific attitudes” as their predecessors. As the CHAT model postulates, personal and social constructions gave meaning to the experiences (Solomon, 1987).

Within the context of each chapter, I have sought possible answers to pedagogy built on inquiry that can promote the motivation to learn, the proficiency for accurate and meaningful questioning and answering, and a deep understanding of scientific concepts. I have grown and learned a great deal pursuing these doctoral studies; yet, only through the completion of my dissertation am I better able to understand my journey, where it has led me, and eventually, where I wish to venture from here.

This final chapter invites an introspective look into my journey where I have engaged in action research. The three major sections presented include “3 R’s”: Reflections, Responses, and Realizations. The first, “Reflections,” explores my personal background as a teacher and researcher along with professional extensions and experiences using technology.

**Reflections**

*Beginning the Journey*

For over 25 wonderful years, I remained in the classroom as a facilitator and team leader of a kindergarten through grade three gifted enrichment program. I based my methodology upon the models of Renzulli (Clark, 1992) and Bloom (2003), as we prided ourselves on guiding learners to use critical thinking and problem solving strategies, all accomplished without the use of textbooks. Teaching elementary students for those years had taken me from my roots as a product of pragmatic teaching to the social constructivist pedagogy that I embrace today. I had already cultivated constructivist pedagogical beliefs, which I utilized for teaching gifted learners.
With the advent of technology in the classroom, I embraced the possibilities for transforming teaching and learning using this new and exciting tool. I had purchased the original Logo Writer turtle graphics, which allowed my students to create science stories enhanced with very basic graphics. Coinciding with the success of this was a weather team I created using a simulated weather station that allowed students to become meteorologists using programmed meteorological tools, just like real scientists. The “information highway” arrived early for me to jump aboard!

The opportunity to join the Florida State University EXPLORES! (2000) assisted in extending my vision for students interested in science to belong to a school science club that actually made science learning meaningful, tackling the weather “storm by storm.” Learning and training with actual scientists through the EXPLORES! program strengthened my focus to bring scientific inquiry into my teaching. Finally, using the protocols for GLOBE (2000) enriched my vision to engage my junior scientists in real-life and meaningful science investigations. Real-life science began as students recorded daily weather protocols, sent them through the Internet to actual global scientists, and shared the data with the entire school.

My responsibilities in the gifted program required adherence to a method of teaching, using specific strategies of learning and thinking, whereby I was able to integrate a hands-on, garden-based science program, Life Lab: The Growing Classroom (Jaffe & Appel, 1982). Aligning the gifted strategies to a methodology that invited inquiry and enriched intellectual freedom became the perfect venue for me to grow as a teacher-facilitator. I realized the potential power of allowing students to take a hand in learning by using prior knowledge and engaging in cognition, problem solving, and higher-level thinking activities (Bloom, 2003). The students were displaying more autonomy, as they developed lifelong learning skills. My intellectual curiosity piqued as I began to question how my pedagogical beliefs and style of teaching—one in which I had actualized a social constructivist learning environment—held the key to my success and the learning success of my students. Following the thesis for my Specialist Degree in Gifted Education, “Students in a Regular Classroom Engaged in Higher Level Thinking Activities,” I theorized that through teachers’ professional development, those same strategies, labeled “gifted,” could be extended to any child in any classroom.
Inquiring into Technology

My curiosity and interest in using technology did not go unrewarded. Volunteering to attend professional development workshops and the Florida Educator’s Technology Conference provided me with the most current technological possibilities that could benefit my students. The idea for a science club, woven into computer activities and the school garden, connected my vision to reality as members could harvest the benefits of hands-on, meaningful learning. I was honored as Dade County’s Elementary Science Teacher of the Year, 1998, and Dade County’s Elementary Computer Teacher of the Year, 1996, for establishing my center as an example of technology in the classroom. Winning the highly prestigious Presidential Award for Excellence in Science & Mathematics Teaching, 1998–1999, was a tribute to my teaching strategies of integrating the technology with the learning of science. I appreciated the national recognition that I received for my pedagogical beliefs, which I could share with other educators. This award helped to bring further technology into my school as it came with a sum of money that I directed toward the purchase of a computerized teaching board and a class set of portable writing computers.

Extending My Horizons

A challenging opportunity presented itself for me to continue my personal pedagogy, yet leave the classroom and dedicate my energies as a countywide science and mathematics curriculum specialist. I felt my contributions could best be realized by responding to a need for assisting teachers in over 25 schools, to look at the teachers’ own methodological beliefs as aligned with teaching inquiry, the SSS, and assessing student progress and the level of teachers’ effectiveness. It was at this juncture in my professional career that I sought the academe studies at Florida State University.

Throughout my work as a Science Educational Specialist, I was fully aware that the focus on reading and mathematics to prepare for the FCAT (FLDOE, 2003) overshadowed the subject of science learning. Reflecting on the content teaching that I did as a classroom teacher for the first ten years of my professional career, I always taught science because I personally loved teaching it, learning about it, and watching my students appreciate it almost as much as I.

The question becomes relevant, “Will states be ready to implement science assessments by 2007” (Tweed, 2004, p. 40)? All students must first be given a chance to learn science. Twenty-five minutes a day is not doing it. The emphasis on reading, writing, and mathematics
must include integrating science. As Tweed has declared, “The gauntlet has been thrown down, and the challenge is on” (p. 40). Placing science learning as a required, but virtually less important, elementary subject cannot remain the same. Armed with the power of new technology, the outlook for science learning is becoming less grim.

In spite of acknowledging the broader scope of science learning, the teachers and teacher aides at Walden felt that preparing for the FCAT did not need to include either science or technology in hands-on research. Because of my differing beliefs while conducting the Walden Sci-Tech Club, I felt, at times, I existed as a pleasant, but bothersome nuisance. My metaphoric role as The Pied Piper of Walden helped to change this erroneous concept.

The second section of this chapter, “Responses,” directs attention to the action research for this study, as scientific inquiry, technology, and the Internet become integrated studies.

Responses

...And ere he blew three notes...Out came the children running.
All the little boys and girls, with rosy cheeks and flaxen curls,
And sparkling eyes and teeth like pearls,
Tripping and skipping, ran merrily after
The wonderful music with shouting and laughter. (Browning, 1888, ¶12)

Playing the Piper

As the Pied Piper of Hamelin (Browning, 1888) musically charmed the children out of the Hamelin village, I felt a metamorphic parallel to the Pied Piper. As this age-old story unfolds, a mayor, whose village is overrun with rats, strikes a deal with the Pied Piper. The Piper is successful in ridding the village of rats, but the community fails to pay him his due payment for the deed. In retaliation, he plays his flute and leads all the children (but one), out of the village of Hamelin. I identify myself as the Pied Piper of Walden, leading the students, who are bored by the textbooks and traditional methods of teaching and learning, out of the drudgery of didactic teaching of science. However, I have also come to realize a problem in this vision that I have created. It has been difficult for me to acknowledge that every student will not find science as exciting and fun as I do. Like the Pied Piper, I feel that I have the “magic” to entice all my students to want to learn science. I have had to adjust to the realization that circumstances out of my control can affect the motivation of learners. Nevertheless, I will probably continue to imagine myself as the Pied Piper.
My goals for engaging in this doctoral program were the following: First, I sought an opportunity to learn and to extend my understanding of science and my pedagogy to engage learners. In addition, becoming a member of the research community appealed to me. I have always had tremendous respect and admiration for those who continue to learn and search for new knowledge and understanding.

Struggling as a Learner

In 1996, I enrolled as a candidate for a doctoral degree as a distance learner at Florida State University (FSU). Prior to that time, I had expressed an interest in furthering my educational specialist degree in gifted and pursue a doctoral degree in science education. I sought a learning environment where I could satisfy my interest in science and technology while being engaged as a teacher.

As I began working with my major professor in an advisory capacity and getting to know her as a professor in the science classes, I was reliving my early years at the University of Miami. My other committee members also became my professors, which provided me with mentors who genuinely cared about my learning and about me. As part of the FSU doctoral program, I had the opportunity to learn while re-examining my own teaching skills. I had experienced learning science content, but I had never reflected on my own pedagogical beliefs—my pedagogical content knowledge (PCK) (Cochran, DeRuiter, & King, 1993). My plan of study placed me in courses that strengthened my beliefs and helped me to confirm my own pedagogy as a social constructivist.

My first semester as a graduate student was quite an enlightening experience. During the summer, classes were scheduled locally, and I began to examine my own teaching doctrine, awakening to the realization that not everyone shared my teaching beliefs. I reflected:

In my own coursework, the action experiments conducted with the class revealed many things. Several in the class were “I-don’t-do-science teachers;” although our instructor encouraged us to participate, question and redesign action experiments to bring out the elements of inquiry. Bringing in items from outside the classroom allowed us to become intimately involved in the process. We were contributors, not merely users. (Bosseler, 1999a, p. 98)

This period in my studies became vital as I found what it was like to become bored and confused in some classes in which I was enrolled when the teacher used traditional pedagogy. This experience allowed me to empathize with the young learners in my own classrooms, as I did not want to bore or confuse them. It was an eye-opener. It all began to make sense to me as to the
“why” my students loved to come to my classes and what the possibilities for their future as lifelong learners could be. The following vignette shows how I furthered my understanding of the differences between a social constructivist methodology and a traditional pedagogy:

A visit from another physics professor swayed my confidence and focus as he attempted to “teach” me on a knowledge level, never altering his approach as he repeatedly tried to explain about sound waves to me without my comprehending his language or his way of thinking. I had become accustomed to an approach that began to ease my mind of doubt or failure (Bosseler, 1999a, p. 98).

For weeks prior to this encounter, the class shared in the bounty of scientific discovery. To then be thrust back to a traditionally didactic style of delivery was not acceptable. At this time, too, I realized how much I enjoyed and benefited from the Talking—Science Talks (Gallas, 1995) conducted in some of my courses. For instance, participating in a mock trial that emulated societal prejudice was a standout experience. At the onset of my doctoral program, I did not feel isolation as a distanced learner, as I was immersed in this stage of my learning. Sharing discussion or debating issues, whether on the Internet through conference sessions or through shared interviews, enlivened me as I continued forward. Unfortunately, as my support group narrowed, I began to waver in my determination to complete the program.

My committee, most especially my major professor, sensed this detour and worked with me to try to rectify the problem. She encouraged me to initiate my presence more into the academe by attending and presenting my thesis at major research and science conferences. Meanwhile, I continued to gradually redefine my own goals, hoping to keep focused on the final outcome—my doctoral degree. Writing has never been an academic strength, so the processes involved in achieving my goal demanded a lot. Rejections are not always easy to accept, but managing self-reflections are necessary and help us to grow. Even though I sought this intellectual challenge, I had forgotten what it was like to meet a challenge of this sort head on. Fortunately, I did have a cheering support group, consisting of my major professor, committee members, and of course, loving family. Many times I saw myself as a marathon runner, crowds cheering me on, crossing the finish line, and gasping my last breath!

I did persevere, thanks to the turning point in this journey that opened my eyes to the power and purpose of the academe world I had only seen from a distance. My major professor asked me to share my science learning experiences for a SERVE publication, Meaningful Science: Teachers Doing Inquiry + Teaching, (Bosseler, 1999a). I acknowledged the privilege of contributing to this project as a teacher researcher. I learned a great deal about my limitations,
my strengths, and myself. I am most proud of this publication and feel it can be a valuable resource to my fellow teachers.

*Acting Within Action Research*

Through this step-by-step action research experience, I have been able to examine my own teaching practices. By undertaking this action research study, I have been able to focus on aspects of my own teaching and not on the assessment of other teachers, as I did in my job as a science specialist. Establishing the Triumvirate in the summer Sci-Tech Club at Walden Elementary became the perfect setting for the challenges that lay ahead. Earlier in the year, servicing Walden as their science and mathematics specialist, I felt welcome at Walden with Mr. Griffin and other staff members.

As highlighted earlier, weaving scientific inquiry with technology appeared to be the perfect format for teacher research. I have been able to collect data, acting as the principal investigator, to provide insight into making decisions, and to continue my own professional development. I had never reflected on my own pedagogical beliefs, except to react to the required balanced curriculum of the 1970’s. Abiding to a prescribed teaching method that included a rigid time schedule forced me to create my own methodology. While still teaching full time, I adhered to the county’s dictate, I taught the traditional “3 R’s” Monday through Thursday; but, Friday was the day my students and I could escape to worlds of learning, enchanted by our own discoveries and inventions. Inquiry and curiosity were the only tickets required to take virtual journeys into the Amazon rain forest, to a newly discovered planet, or to trek across the Sahara Desert.

The action research cycle guided me in this research study and provided me with the mental tools to examine my own *pedagogical content knowledge* (PCK). My PCK became the instrument that defined the Walden Sci-Tech Club experiences (Cochran et al., 1993). *Pedagogical content knowing* (PCKg) is an interrelated and integrated understanding of the four components of pedagogy as evidenced through the action research. The following four components list the implications of the developmental model as evolving in the Walden Sci-Tech Club (Cochran et al., 2003):

1. *Knowledge of pedagogy*—This is the knowledge of knowing how to teach, which is not learned in textbooks. The novice teacher does not usually display the integrated nature of a teacher’s stated pedagogy or expertise. This defines
professional teacher of science. Early on, my pedagogical model was that of a constructivist-learning environment where I used strategies for scientific inquiry. I sought questions in place of answers.

2. Knowledge of students—Understanding the students’ abilities and their learning strategies requires experiences as a teacher in order to assess a student’s abilities and prior knowledge. I felt my caring and interest in every student could be reflected in my students' wanting to succeed. As the Pied Piper, I prided myself on motivating learners.

3. Knowledge of subject matter—This is the kind of knowledge that teachers need to know in order to teach. In spite of the complexities of science, I felt my curiosity and interest in science could transfer to my students making the complexities of the subject less difficult.

4. Knowledge of environment—This is the knowledge that reflects my adaptive interpretations where learning occurs. It defines the systems of the learning environment and the degree of learning success encumbered in the existing systemic conditions.

“Realizations” brings us to the final section, as I examine and review the research findings and how I met the quality criteria for interpretive research. As I write this lasting section, technology continues to move ever forward in our cultural milieu.

Realizations

Using What the Research Tells Us

We have become aware that modern technology significantly impacts our society and our daily lives. Our public schools must reflect and support this societal change. As Paige (2002) indicates, we are beyond basing our schools on an agricultural timetable, set up a century ago. We are in a technological age and must embrace it.

In Chapters 4 and 5, I have analyzed the data that became the warp and the weft woven together to connect me to my research. The data suggest that appropriate experiences with educational technology can promote important cognitive changes in children, including improvements in content knowledge, basic academic skills, and strategies for comprehending written instructions and devising problem solving plans. We need more research to pinpoint how productive learning takes place with educational technology.
Reviewing the data in Chapter 4 and 5 provides the reader with glimpses into the formulation of Guba and Lincoln’s interpretive methodology (1994). I strove to involve and empower the participants (stakeholders) in hermeneutic dialectic processes, fully aware of the potential limitations for youngsters to be able to remain on a continued or sustained inquiry. Conflicting ideas and investigations frequently helped the group to arrive at hermeneutic and improved constructions. The occurrences prompted opportunities for all voices to be heard. At times, this met with resistance, especially noticeable between Belinda and Darryl who reacted to the societal constraints placed upon them. The ultimate goal of the hermeneutic dialectic process is to focus on consensus for joint constructions to emerge through this subjective approach.

**Attending to Quality Criteria of Interpretive Research**

It was important to the success of this study that I remain connected to Guba and Lincoln’s (1989) quality criteria throughout the research as a method I could use to increase the reliability and trustworthiness of my research findings. As the constructivist investigator, I resolved to be guided by the contrasting methodology becoming “iterative, interactive, hermeneutic, and at times intuitive, and most certainly open” (Guba & Lincoln, 1989, p. 143).

Two sets of criteria that form the benchmarks for fourth generation include the authenticity and the trustworthiness of the hermeneutical/dialectical process (Guba & Lincoln, 1989). The first criterion for fourth generation, authenticity, contains the following set of criteria. I address each criterion accordingly: Catalytic authenticity, Educative authenticity, Ontological authenticity, Tactical authenticity, and fairness.

**Authenticity Criteria**

*Catalytic authenticity*—enlightenment through the research. By my conducting action research, I have facilitated the process of change in my own teaching and learning. Upon first starting the process of action research, I felt skilled and fully qualified as a teacher; however, the more I experienced and learned, the greater my need became to continue learning. Practicing to be a more sensitive listener so that I can learn more about my learners, whether students or fellow teachers, has been rewarding and lasting. Realistically, all educators may not share my pedagogical beliefs; if I am able to open windows of doubt and catalyze change toward the methodology of interpretive inquiry, I will be grateful (Guba & Lincoln, 1989).

*Educative authenticity*—how others and I have learned of my research findings and have understood my constructions. Throughout my research, I have felt enlightened as I designed,
wrote, and rewrote each draft for every sentence, every page. My committee members have remained steadfast, loyal to the ideals of quality research evolving. Most notably, my major professor has jointly “held the oars,” but never taken them from me in times of distress, as she has guided me along this journey. Amendments and contradictions were part of the process; I am able to fully appreciate that process now.

**Ontological authenticity**—through the process of action research, my personal constructions and those of the stakeholders change. These mutually shared meanings provided evidence for a commitment to tasks. Triumvirate members’ desire to complete a project using PowerPoint, even though I would not give grades, showed their desire to feel pride in the completion of the project, which became a standard phenomenon. Darryl was especially enlivened by the power of authenticity, which he wore as a newly crowned “tech-god.” Surprisingly, he graciously accepted sharing his power when he sought responsive laughter from the group and was ready to “fool around.”

**Tactical authenticity**—degree to which I empower stakeholders and participants to act, by my sharing their responses and interpretations. Hereafter, I hope that through these collaborative efforts, stakeholders will examine, as needed, modify, and revise their constructions. My goals for the club continued, as club members became stakeholders, evidencing varying degrees of control for their own learning. Darryl achieved this; Belinda was on her way to self-actualization; and Carlos eventually did develop signs of self-efficacy. Carlos let go of some of his fear, thereby, entrusting his own empowerment. Belinda’s comments are worthy as a contributing source for interpreting her own learning:

> It wasn’t easy because you have to do the PowerPoint then go on the Internet to find information about the things. It was pretty hard. It was fun because I got to learn about the PowerPoint. I got help, a lot of help. The way I handled it, I found something on the Internet. When I did, I said to myself, “Well, this is something good that I should put on my PowerPoint. Then I can make it to impress everybody so it just wouldn’t be boring. That’s how you give good information.” (Informal Interview, August 5, 2003)

> It was challenging, yet often confusing, to develop and maintain constructs. This was especially difficult, as I had to deal with school environments that polarized two teaching styles. It was forbidden to have open negotiation in the hierarchical setting of the summer camp; whereas, concerns, issues, claims, and constructions were mandatory as shared power within my constructivist setting in the Walden Sci-Tech Club (Guba & Lincoln, 1989). I felt frustrated as I, too, suffered from the results of overly extended disciplinary actions prescribed for the
Triumvirate, especially those applied to Darryl. Regretfully, I do not feel I was valued as a teacher by the establishment, but more realistically, as a computer-literate volunteer interested in the summer campers doing some science.

*Fairness*—efforts to devise joint, collaborative, and shared constructions honor the input from all stakeholders equally. I honored each stakeholder, repeatedly making it clear to the group that each member was a valued and worthy contributor. Regardless of the trivial nature, I granted my personal support to their claims, concerns, and issues. Darryl’s emic constructions, for example, contributed to the framework for the plight and survival of sea turtles. His lived experiences assisted the group to legitimize the problem. It was important to represent all voices (Guba & Lincoln, 1989).

**Trustworthiness Criteria**

Trustworthiness, the second criterion for increasing the reliability of qualitative data, contains the following set of set criteria. I addressed each criterion accordingly:

1. **Dependability**—by including in-depth vignettes, these findings provide the reader with thick descriptions illuminating the nuances and learning styles of the Triumvirate. Developing these authentic communication patterns with the members establishes continued trust and rapport with the researcher (Janesick, 2000).

2. **Transferability**—accurately providing multiple sources of data describing the setting, context, and culture in which the study took place, which the readers can decide to apply to their own specific situation.

3. **Confirmability**—through the hermeneutic process and peer debriefing, I have shared powerful reflections, interviews, and interpretations that the reader can trace to their sources.

4. **Credibility**—credibility refers to the natural fit between the stakeholders’ realities and the reconstructions attributed to them, included as:
   a. **Data collecting, transcribing, and sharing**—stakeholders were the ubiquitous force that defined the collection of this valid and reliable information. These young club members in my study experienced both active and passive roles as they grew more independent in their learning and as they experienced progress toward a coherent perspective on
scientific inquiry (Bell & Linn, 2002). Whatever the source, whether transcribed informal or formal interviews, E-folios of their PowerPoint presentations, investigative artifacts, or surveys, I allowed their voices to be heard.

b. **Member checks**—the club members were the backbone of my research study (Janesick, 2000). Encouraging members to participate in the *Talking—Science Talks* (Gallas, 1995) developed a unique and trusted base for ensuring accurate interpretations. Issues that arose and could become previewed became manageable. Fortunately, the members of the Triumvirate were generally eager to review their transcribed interviews and slide presentations.

c. **Peer debriefing**—debriefing allowed me to share my ideas, problems, and concerns with my peer, Mr. Griffin who helped provide credibility to the study. Familiarity with the school setting was helpful, as Mr. Griffin interacted, offering advice with the emergent design, as my research proceeded. Presenting my research at educational research, science and technology conferences gave me unique opportunities to share my findings with fellow educators, a vital link to the social process of action research.

d. **Persistent observations**—as a persistent observer in this naturalistic inquiry, I became a part of the process to maintain quality. I heard and trusted all voices in the inquiry effort (Lincoln & Guba, 2000).

e. **Progressive subjectivity**—demonstrated in my own constructions through case study entries recorded at different points in the evaluation process (Guba & Lincoln, 1989, p. 248). Transcriptions of interviews and student artifacts emerged as a record of the changing constructions of my students within the science club. My transcribed journal was a powerful resource, as I recorded my own personal constructions that allowed me to choose my own reality, individually and collectively (Guba & Lincoln, 1994).

f. **Prolonged engagement**—encouraging prolonged engagement became a part of the mission that I established to bring this research to completion.
My pilot study was beset with intermittent membership; thus, I became exceedingly cautious to select case study members that would remain throughout the study. I did not require mandatory attendance at the summer camp setting for the Walden Sci-Tech Club. The carry-over from meeting to meeting sparked high interests and expectations of team commitments to investigatory projects. Mentoring and co-teaching with Mr. Griffin, the full-time science laboratory teacher, allowed additional opportunities to build rapport.

Reflections

As a qualitative researcher, I am aware of my own need to draw upon my experiences as a resource in the inquiries. At regular intervals throughout the study, I reminded myself to keep progressive subjectivity at the forefront. Realizing that change is central to the growth and refinement of constructions, I valued the ongoing constructions of the stakeholders, whether using the Internet for collaborative projects, discussing ideas with my students during Talking—Science Talks meeting times, learning science during field experiences, or exploring scientific phenomena in the science laboratory. The self-fulfilling prophecy of finding what I wanted to find became less problematic using the tape recorder that provided me with a natural, timely analysis of the data.

The use of the transcribed tapes yielded credible data reflecting the group’s claims, concerns, and issues in this naturalistic setting. Immediately following each visit to the Walden School, I transcribed the interviews that had just taken place and recorded my own observations in my reflective journal. These scenarios were rich with descriptive data I could not have retrieved in full had I delayed expressing them. By my reviewing the recordings over an extended period of time, multiple sources of evidence surfaced.

The student interviews evolved in such a positive way as the stakeholders transcended from shy brevity to a comfort level whereby they preferred holding the recorder themselves. Their technology takeover skills allowed them to immediately replay what they had recorded; thereby, member checking to clarify issues could immediately be resolved. I further enhanced the sophistication of my constructions because I was able to transcribe without losing the fidelity of what my students said.
Through the careful observations made in my reflective journal, I was able to keep an accurate record of the changing constructions of the stakeholders. Recording my interpretations as I transcribed the club meetings and our Talking—Science Talks helped me in monitoring member checks to ensure these descriptions rendered themselves from an informed position. Acknowledging these illustrative notes assisted in keeping track of the emerging patterns over time from all the stakeholders involved. Throughout the study, Mr. Griffin contributed informed, sometimes alternative, interpretations to help assure high-quality analyses for peer debriefing.

Collectively, the credibility criteria verify the goodness of the hermeneutic process itself. This was the burden of my learning as a qualitative researcher. The extended time I required for my research leaves no doubt, which helped to establish trust and prolonged engagement that added depth to the study. But, consideration should also be given to the dilemma of allowing my own prescriptions for a worthy research study to take precedent over those of the club members (i.e., the stakeholders).

The original research questions posed for my initial pilot study became mired in the strategies for learning science as fun. If having fun learning science was one of the goals, I did accomplish that. The overriding caveat that I did not recognize at the time involved the societal aspects bound within the group’s framework. The title of my preliminary research read: “How Can Student Learning, Attitudes, and Social Interaction be Affected Using Internet Technology to Learn Science?” This initial study examined the exploration of science in a constructivist classroom as patterns of knowledge in the application of technology skills emerged. I posed these four original research questions through action research in my own classroom:

1. Will students, through technology involvement, become excited when exposed to learning experiences that go beyond automated information assimilation and develop habits of autonomous learning?

2. Through collaborative scientific research, will action research in science education connect student’s individual perspectives to form patterns of knowledge?

3. Will barriers to student learning be diminished through guided inquiry and exploration? Do students’ values, beliefs, and efficacy about themselves become more positive?
4. Will student motivation and enhanced learning for science change through project-based collaboration?

As my second study ensued, I felt the need to acknowledge the developing constructions of the Sci-Tech Club members without my need to infiltrate and infuse my personal goals and beliefs. It was time for me to become the learner, the listener, and the doer along with my students. Using regular intervals to record developing constructions that I could uphold, alter, or delete initiated a change in my teaching pedagogy. My beliefs could not take precedence over my students’ beliefs, but be given equal privilege.

In this second study, I recognized powerful developing constructions developed using Engeström’s model of human interactions (Figure 5–1). By adapting and applying the CHAT model (Peal & Wilson, 2001) I was able to illuminate the dynamic relationship among users as they integrated technology in our ever-changing, societal system. The title of my prospectus read: “How Can Students Use the Potential of the Internet in an Elementary Science Club as the Conduit for Conducting Scientific Inquiry?” It framed my research questions for the study:

1. What can members of an elementary school science club learn by conducting scientific inquiry using the Internet?
2. How do learners make sense of scientific inquiry using the Internet?
3. How can I as a teacher enhance learning through scientific inquiry using the Internet?
4. How can I redirect my teaching strategies while utilizing technology so that my students can learn science more successfully than in traditional classrooms?

The final development of this dissertation includes common strands throughout that can be recognized as the research evolved, yet provides evidence of the prevailing input from the power of the stakeholders that I sought and respected. The definition and appreciation of my pedagogical content knowledge (Cochran et al., 1993) guided this study while allowing the stakeholders to join me in utilizing technology and the Internet while learning science. The title of this dissertation now reads, “How Can Students Use the Potential of Technology and the Internet in an Elementary Science Club as the Conduit for Conducting Scientific Inquiry?” My 2nd and 4th research questions changed slightly from those in my prospectus:

2. How do learners make sense of scientific inquiry while using technology and the Internet?
4. How can I redirect my teaching strategies while using technology so that my students learn not only science content but also a love of learning science?

The sequences of my study take on a journey of their own, each step along the way enriching that which I used as brick (i.e., action research and the quality criteria) and that was the mortar (i.e., inquiry, technology and the Internet).

**Beginning a New Journey**

Concurrently, the focus of Dade County’s Instructional Technology Plan (Cortes, 2000) remains the integration of technology into the instructional program to improve learning outcomes and to prepare students for the future. To achieve the seamless integration of technology into teaching and learning requires the active participation of all stakeholders. To initiate this plan, all District schools provide professional development services. The County has not wholly realized its vision, as its teachers do not integrate the technologies even of word processing and searching the Internet into their teaching. Paige (2002) reminds us:

> The problem is not that we have expected too much from technology in education – it is that we have settled for too little. Many schools have simply applied technology on top of traditional teaching practices rather than reinventing themselves around the possibilities technology allows. The result is marginal—if any, improvement. (¶3)

Burns (2002) posits that the teacher’s own proficiency guides the choice of which methodologies he/she uses in teaching. My choice of using the PowerPoint program allowed the technology that I taught to be embedded within the science activities. The initial use of the PowerPoint to create the Environmentally Safe Island (Lambert, 2002) resulted in the unique and fascinating use of the program. As each activity evolved, the science literacy came to the surface, and I was better able to assess the completed product. Darryl provided a prime example of this approach, as I conceded gradual control to him and decentralized my own authority. This, in turn, empowered Darryl to cultivate his own skills and learning concepts.

Having technology student mentors provided opportunities for my students to share their expertise in technology and science and to learn how to help each other learn, all the while developing stronger interest in science and technology. To Bybee’s (2003) 5 E’s Model (Engage, Explore, Explain, Elaborate, and Evaluate), which I have detailed throughout this study, we can add an additional “E” (E-search) (Chessin & Moore, 2004) to foster inquiry-based learning. These new ideas in the learning model encompass the use of any electronic media including Internet research and PowerPoint presentations. I, too, witnessed our Walden Sci-Tech Club
members’ performing their “E-searches” as authentic tasks that demonstrated their new understanding and skills. This is an especially useful and modern component that can occur at different stages in the 5 E’s Model (Bybee, 2003).

Journeying “down the rabbit hole” may take us where we want to go, but like the Cheshire Cat reminded Alice, that depends a good deal on where we want to end up (Carroll, 1865). My sincere wish for education and for each and every classroom is for inquiry to become the prevailing state of mind, where we rigorously test thoughts and ideas, not just the students’ retention of textbook information. If you are wondering, what our three Triumvirate members are doing…

1. Darryl is a member of the Future Teachers of America in middle school, continuing to teach, assist, and mentor classmates and teachers using his computer skills.
2. Carlos has gone to a magnet middle school continuing an attitude change and direction.
3. Belinda has a new family and is in fifth grade. Thankfully, she has been returned to Walden Elementary School.

I plan to return to Walden Elementary School, re-activate the Walden Sci-Tech Club with Mr. Griffin, become a working model for pedagogy for scientific inquiry, and re-establish a mentorship relationship with Belinda for her final year at Walden. Now that this part of my journey has ended, it is my hope that others will follow their dream and continue to pursue knowledge in our noble profession. I have asked myself, “Why am I doing this?” My answer is always the same. I am an example of that which we, as educators, are trying to instill in our students. I am a lifelong learner. My hope is that this research will inform other teachers so they, too, will be a guiding force for young and old learners alike to acknowledge all that there is in this world to see, to question, and to explore.

This journey has, at times, been a struggle. As I progressed through each step, I sensed the magnitude of my accomplishment. The encouragement and cheerleading along the way from my colleagues, friends, and family, was powerful. For this, I am most especially grateful to my major professor, who never allowed me to give up my quest. My committee has been intuitively patient, respectful of my academic potential. It is my wish that throughout this study, I have
become “the ‘passionate participant’ as facilitator of multivoice reconstruction” (Lincoln & Guba, 2000, p. 171). This journey has prepared me for the next one.
APPENDIX A: EDUCATIONAL TECHNOLOGY STANDARDS AND PERFORMANCE INDICATORS FOR ALL TEACHERS

NETS for Teachers

National Educational Technology Standards for Teachers

Educational Technology Standards and Performance Indicators for All Teachers

Building on the NETS for Students, the ISTE NETS for Teachers (NETS-T), which focus on preservice teacher education, define the fundamental concepts, knowledge, skills, and attitudes for applying technology in educational settings. All candidates seeking certification or endorsements in teacher preparation should meet these educational technology standards. It is the responsibility of faculty across the university and at cooperating schools to provide opportunities for teacher candidates to meet these standards.

The six standards areas with performance indicators listed below are designed to be general enough to be customized to fit state, university, or district guidelines and yet specific enough to define the scope of the topic. Performance indicators for each standard provide specific outcomes to be measured when developing a set of assessment tools. The standards and the performance indicators also provide guidelines for teachers currently in the classroom.

I. TECHNOLOGY OPERATIONS AND CONCEPTS.

Teachers demonstrate a sound understanding of technology operations and concepts. Teachers:

A. demonstrate introductory knowledge, skills, and understanding of concepts related to technology (as described in the ISTE National Education Technology Standards for Students);

B. demonstrate continual growth in technology knowledge and skills to stay abreast of current and emerging technologies.

II. PLANNING AND DESIGNING LEARNING ENVIRONMENTS AND EXPERIENCES.

Teachers plan and design effective learning environments and experiences supported by technology. Teachers:

A. design developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners.

B. apply current research on teaching and learning with technology when planning learning environments and experiences.

C. identify and locate technology resources and evaluate them for accuracy and suitability.

D. plan for the management of technology resources within the context of learning activities.

E. plan strategies to manage student learning in a

http://cnets.iste.org/teachers/t_stands.html

5/2/03
III. TEACHING, LEARNING, AND THE CURRICULUM

Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning.

Teachers:
A. facilitate technology-enhanced experiences that address content standards and student technology standards.
B. use technology to support learner-centered strategies that address the diverse needs of students.
C. apply technology to develop students' higher order skills and creativity.
D. manage student learning activities in a technology-enhanced environment.

IV. ASSESSMENT AND EVALUATION.

Teachers apply technology to facilitate a variety of effective assessment and evaluation strategies.

Teachers:
A. apply technology in assessing student learning of subject matter using a variety of assessment techniques.
B. use technology resources to collect and analyze data, interpret results, and communicate findings to improve instructional practice and maximize student learning.
C. apply multiple methods of evaluation to determine students' appropriate use of technology resources for learning, communication, and productivity.

V. PRODUCTIVITY AND PROFESSIONAL PRACTICE.

Teachers use technology to enhance their productivity and professional practice.

Teachers:
A. use technology resources to engage in ongoing professional development and lifelong learning.
B. continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology in support of student learning.
C. apply technology to increase productivity.
D. use technology to communicate and collaborate with peers, parents, and the larger community in order to nurture student learning.

VI. SOCIAL, ETHICAL, LEGAL, AND HUMAN ISSUES.

Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply those principles in practice.

Teachers:
A. model and teach legal and ethical practice related to technology use.
B. apply technology resources to enable and empower learners with diverse backgrounds, characteristics, and abilities.
C. identify and use technology resources that affirm diversity.
D. promote safe and healthy use of technology resources.
E. facilitate equitable access to technology resources for all students.

http://cnets.iste.org/teachers/t_stands.html

5/2/03
APPENDIX B: INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

Listing of standards for technological literacy

The Nature of Technology

Standard 1: Students will develop an understanding of the characteristics and scope of technology.

Standard 2: Students will develop an understanding of the core concepts of technology.

Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5: Students will develop an understanding of the effects of technology on the environment.

Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Standard 7: Students will develop an understanding of the influence of technology on history.

Design

Standard 8: Students will develop an understanding of the attributes of design.

Standard 9: Students will develop an understanding of engineering design.

Standard 10: Students will develop an understanding of...
understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities of a Technological World

Standard 11: Students will develop abilities to apply the design process.

Standard 12: Students will develop abilities to use and maintain technological products and systems.

Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

Standard 14: Students will develop an understanding of and be able to select and use medical technologies.

Standard 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.

Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

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APPENDIX C: INTERNATIONAL STANDARDS FOR TECHNOLOGY EDUCATION: NATIONAL EDUCATIONAL STANDARDS FOR STUDENTS

Technology Foundation Standards for All Students

Profiles for Technology Literate Students
(Performance Indicators and Examples and Scenarios)

Standards for Teachers

The technology foundation standards for students are divided into six broad categories. Standards within each category are to be introduced, reinforced, and mastered by students. These categories provide a framework for linking performance indicators within the Profiles for Technology Literate Students to the standards. Teachers can use these standards and profiles as guidelines for planning technology-based activities in which students achieve success in learning, communication, and life skills.

Technology Foundation Standards for Students

1. Basic operations and concepts
   - Students demonstrate a sound understanding of the nature and operation of technology systems.
   - Students are proficient in the use of technology.

2. Social, ethical, and human issues
   - Students understand the ethical, cultural, and societal issues related to technology.
   - Students practice responsible use of technology systems, information, and software.
   - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

3. Technology productivity tools
   - Students use technology tools to enhance learning, increase productivity, and promote creativity.
   - Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

4. Technology communications tools

http://cnets.iste.org/students/s_stands.html

5/2/03
• Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
• Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5. Technology research tools
• Students use technology to locate, evaluate, and collect information from a variety of sources.
• Students use technology tools to process data and report results.
• Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6. Technology problem-solving and decision-making tools
• Students use technology resources for solving problems and making informed decisions.
• Students employ technology in the development of strategies for solving problems in the real world.

http://cnets.iste.org/students/s_stands.html
APPENDIX D: BLOOM'S TAXONOMY OF THE COGNITIVE DOMAIN

BLOOM’S TAXONOMY OF THE COGNITIVE DOMAIN

Knowledge
- observe and recall information
- knowledge of dates, events, places
- know major ideas
- mastery of basic subject matter
- verbs: list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where

Comprehension
- understand information
- grasp meaning
- translate knowledge to a new context
- interpret facts, compare, contrast order, group, infer
- causes predict consequences
- verbs: summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend

Application
- use information, use methods, concepts,
- theories in new situations
- solve problems; use required skills or knowledge
- verbs: apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover

Analysis
- see patterns, organize the parts,
- recognize hidden meanings, identify components
- verbs: analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer

Synthesis
- use old ideas to create new ones
- generalize from given facts
- relate knowledge from several areas
- predict, draw conclusions
- verbs: combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what is it?, compose, formulate, prepare, generalize, rewrite

Evaluation
- compare/discriminate between ideas,
- assess value of theories, make choices based on argument, verify value of evidence
- recognize subjectivity
- verbs: assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare
APPENDIX E: FLORIDA STATE UNIVERSITY HUMAN SUBJECTS COMMITTEE FORMS

Marcia L. Bosseler, Educational Specialist  
Division of Mathematics & Science  
Miami-Dade County Public Schools  
Miami, FL 33132

November 15, 2002

Dear Parents,

Research suggests that elementary children learning science by hands-on investigation integrated with technology is one way that can help our children become critical thinkers and life-long learners. Recent research indicates that science and technology can be presented in active rather than in passive learning. We will study science and weather using technology as well as other ways of hands-on, inquiry learning. I want to study if the children's use of technology changes and elaborates the learning process as new ideas are negotiated through everyday interactions.

This work will be part of some research that I am planning to conduct for my doctoral degree in science education at Florida State University. I would like to photograph, interview, videotape and videoconference the students as they are engaged in my science club. Your children will have a chance to view the videotape, too. I think your child will have fun learning science this way, but the long-term benefits may include an appreciation for science and technology, a love for learning, and development of critical thinking skills.

I am hiring another person to do some of interviewing and to audiotape the children's responses, so the children will feel they can openly share their ideas on these innovations. The interviewer will use a pseudonym for your child and will transcribe the data using the pseudonym.

The photographs, interviews, and videotapes will only be used for my doctoral dissertation work. The results of the research study may be published and presented at professional meetings, but your child's name will not be used. Your child's grade will not be affected by participating in this project. I will be the only person who will use the data for my doctoral research and dissertation at Florida State University. The videotape will be destroyed by October 1, 2006.

I would greatly appreciate obtaining your permission by completing and signing the form below. If you have any questions, please feel free to call me at (305)230-5059 or (305)984-3375.

Sincerely,

Marcia L. Bosseler  
Educational Specialist, Division of Mathematics & Science

___ I give permission for my child to participate in Mrs. Bosseler's project.
___ I do not give permission for my child to participate in Mrs. Bosseler's project.

<table>
<thead>
<tr>
<th>Child's Name</th>
<th>Parent's Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parent's Signature</td>
</tr>
</tbody>
</table>

Date

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November 15, 2002

Dear Students,

As we observe the weather and learn science while connecting all this with computer technology and the Internet, I would like to take pictures, videotape, and videoconference with you. Your grades will not be affected by your participation in this project. Participation can be stopped at anytime without penalty. Also, someone will interview you other than me. That sounds like fun; doesn’t it? I think it will be, too! I’m going to school now, too, and this is my homework assignment!

I will be sharing all of this with you, and then I promise to throw away the video when you are in the eleventh grade, by June 30, 2008.

Please sign your name below if this is agreeable with you. Thank you!

Sincerely,

Mrs. Marcia L. Bosseler

---------------------------------

Please sign: ______________________

Date: ____________________________
February 13, 2003

Dear Parents,

Your son/daughter is interested in participating in the Sci-Tech Club at WALDEN Elementary School. The Club will meet weekly on Wednesday afternoons from 2:00-3:30 p.m. (Please arrive on time to pick up your child.) The meetings will take place in the Computer Laboratory. We will be learning and using the Internet to explore science, along with hands-on experiments.

We are looking forward to sharing these experiences with your child as the marvelous windows of science open for them! Our first meeting will be Wednesday, February 19, 2003.

Sincerely,
Ms. M. Bosseler, Educational Specialist, Div. of Math and Science
Mr. T. Gannon, Science Laboratory Teacher

******

Kindly sign and return to Mr. Gannon, Science Laboratory

My child, ____________________________, has permission (student's name)
to participate in the Sci-Tech Club at WALDEN Elementary.

Signed, ____________________________ (parent or guardian's name)

Homeroom Teacher's Name ____________________________
After the meetings, my child will arrive home by the following:

______________________________
APPENDIX G: WALDEN SCI-TECH CLUB STUDENT SURVEY

Name: __________________________

WALDEN SCI-TECH CLUB
Student Survey

1. Your Views of Science and the Internet
Please check the box that best shows how much you agree or disagree with each statement.

   a. Learning science on the Internet makes science easier for me to understand.  □  □  □  □
   b. I prefer to learn science on the Internet with others rather than by myself.  □  □  □  □
   c. I understand and like science more when I get information from the Internet than from textbooks.  □  □  □  □
   d. I feel I am thinking like a scientist when I use the Internet to investigate and answer hypothetical questions.  □  □  □  □
   e. I am more curious about information I find on the Internet and like to search for answers to my questions.  □  □  □  □

   f. What do you think science is?

   __________________________________________________________

   g. Why/why not is it important to learn science?

   __________________________________________________________

   h. In the past, how did you research an experiment you for the Science Fair? What was the experiment?

   __________________________________________________________

   i. Where do you get your ideas about science?

   __________________________________________________________

   j. Are you able to use the Internet at home? □ Yes □ No. At school □ Yes □ No.
   k. About how much time do you spend on the Internet in a week?

   l. What is your favorite activity to do on the Internet? What is your least favorite?

   __________________________________________________________

   k. Research informs us that using the Internet provides opportunities to find solutions to real problems, (for example, the endangered sea turtles), using inquiry questioning and conducting investigations. Has the Internet helped you solve a problem or complete a task?

   __________________________________________________________

   __________________________

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II. Information about your Science Class
How often do you take part in the following types of activities in the science class you are in right now?

- a. Memorize basic facts and formulas that are emphasized in the textbook.
- b. Do hands-on/laboratory activities
- c. Work on projects that take a week or more
- d. Get to design and plan science investigations with a group or team
- e. Use the Internet to explore your own science problem, investigate, gather data, interpret findings, then share the results using a multimedia presentation
- f. Collect scientific data from the Internet
- g. Analyze data from several sources related to the same problem or event
- h. Use the Internet to find science information, becoming involved and excited from the search
- i. Write a report or do a presentation to explain your thinking or reasoning

III. Your Ideas about Science
Please check the box that best shows how much you agree or disagree with each statement.

- a. I am good at science.
- b. I am interested in a career in science.
- c. Science classes are boring.

IV. Your Confidence in Conducting Scientific Inquiry
Please check the box that best shows how confident you feel about each of the following.

- a. Thinking of a research question related to a science issue
- b. Finding science-related information on the Internet
- c. Stating a hypothesis
- d. Designing and presenting an experiment
- e. Collecting data
- f. Collecting data from the Internet
- g. Making graphs and tables to report data
- h. Writing reports
- i. Explaining the results of an experiment
- j. Studying a problem that doesn’t have a clear solution
- k. Defending a point of view or idea
Read the following newspaper article and design an experiment to answer a specific question related to the plight of sea turtles.

THE PLIGHT OF SEA TURTLES

Florida is an important place for the endangered sea turtles of the world. Sea turtles nest on our beaches and find food in our estuaries. All sea turtles are either threatened or endangered and are protected by a law called the Endangered Species Act.

The life cycle of every sea turtle starts on a beach, which is where females lay their eggs. There are several threats to sea turtles. They might include:

1. Chemicals dumped in the oceans have caused a serious virus, fibropapilloma, which causes tumors to grow.
2. The nesting areas of many sea turtles are gone or are part of tourist resorts, where bright lights confuse their nesting habits.
3. The habitat of sea turtles has changed due to human population growth that limits their natural habitat.
4. Sea turtles mistake discarded plastic containers, bags, and balloons for food.
5. People eat the eggs of sea turtles as a delicacy.
6. Other

What question do you want to specifically ask? [ ]

Which of the possible reasons for the sea turtles' plight is o. that can be changed and what method do you think you can do to help solve it? [ ]

What materials will you use to test your experiment? [ ]

What will be your plan? [ ]

How will you collect and share your findings? [ ]
APPENDIX H: INTERNET CODE OF CONDUCT

Thank you for your cooperation.
Marcie L. Bosseler

INTERNET CODE OF CONDUCT

1. I, ____________________, have been made aware of and promise to follow the Dade County School Board's Acceptable Use Policy when using the Internet.

2. I promise only to use the computer for educational activities that are approved and supervised by a teacher or designated adult.

3. I will not send personal email, access chat lines, send or search for profanity or any inappropriate material.

4. I promise to tell my teacher or other adult if I see or find any inappropriate material or information on the Internet.

5. I will never give out any personal information about myself without my teacher's permission.

6. I understand that if I do not follow the Acceptable Use Policy, I will have violated the Code of Student Conduct which will result in disciplinary action and the loss of future computer use.

STUDENT SIGNATURE ______________________________ DATE ________

PARENT SIGNATURE ______________________________ DATE ________

TEACHER SIGNATURE ______________________________ DATE ________
APPENDIX I: SCI-TECH CLUB TEACHER’S SURVEYS

Darryl 4th grade teacher
ENGAGE: I found that Darryl would become engaged with a topic at first. He seemed to like the excitement of a new concept or topic.
EXPLORE: He would usually do some exploring, but then he would stop after finding one solution. I didn’t usually see him trying many different ways to solve a problem.
EXPLAIN: As far as explaining concepts, I think Darryl would try to explain ideas in his own words. Sometimes he would relate them to other experiences. At times he would be able to make conceptual connections between new and former experiences.
ELABORATE: Sometimes he would use terminology inappropriately and with little understanding. Darryl could usually demonstrate his understanding of concepts.
EVALUATE: He had more success showing understanding orally than through written answers.

Darryl 5th grade teacher
ENGAGE: Darryl asks for the right answer; less self direction when he sharpens or clarifies info. He has a wealth of info. It’s a matter of choice what he allows himself to do. Somewhere he has developed a tremendous wealth of knowledge.
EXPLORE: Lets others do the thinking and exploring (passive involvement) but does compare his ideas with those of others.
EXPLAIN: Tendency to bring up irrelevant experiences and examples.
ELABORATE: He frequently ignores previous information or evidence.
EVALUATE: He is able to compare others’ current thinking with that of others and perhaps revises theirs.

Darryl Science Lab teacher
Last year, Darryl seemed very, very teacher directed. I always had to be on top of direct Darryl, explaining and re-explaining what he had to do. This year, Darryl is more self-motivated more dedicated to what he is supposed to do. I find him, more capable and more able. "You give him the ball, he gets on the computer and he is able to run with it." You give him anything to do on the computer and he’ll work at it until he does it. In fact, he may be one of the top students on the computer in the whole school from what you have taught him and what he is able to now teach himself to do. Other teachers and other students rely on him. When one of his teachers is in the computer lab, he has Darryl assist him and all the other students. He is able to do these things having gained skills, especially beginning with the PowerPoint presentation.

2003-2004
DOES DARRYL ASK QUESTIONS IN THE SCIENCE LAB CLASSES?
Mr. Griffin—This year there has definitely been a big change. Last year, a lot of times he was fiddling with something on his desk, flipping through books while I’m trying to explain. Now he’s tuned in, asking questions, elaborating, expanding the knowledge he has on the particular topic. He’s come a long way. This year. He’s pretty much glued into whatever science we’re doing.

WHAT ABOUT BELINDA? HOW WOULD YOU DESCRIBE HER LEARNING IN THE SCIENCE LAB?
Mr. Griffin—I would say, Darryl and Belinda are somewhat similar, unlike Carlos who arrived more self-directed. Belinda required the greatest amount of supervision to keep her interested. She was easily distracted with a short attention span. Presently, she is more glued to what we’re
talking about in science. I see her in the hall and she is more settled down, more mature. I don’t know if it’s coming of age or a combination of that with what she’s been doing in the Sci-Tech Club. She doesn’t have a computer at home, so whatever she does it is in school.

Mr. Griffin — Carlos has had a change, too. He was easily distracted and needed to settle down more. This year I see him very capable on the computer. He isn’t as talented as Darryl is on the computer, but he’s probably better than me.

MS. BOSSELER — I THINK WHAT I SEE IN DARRYL IS THIS NEWLY FOUND CONFIDENCE. I SEE IN CARLOS THE CONFIDENCE, BUT WHEN HE MAKES AN ERROR, IT SEEMS TO TEMPORARILY DESTROY THIS NEWLY FOUND CONFIDENCE.

Mr Griffin — I agree. Yes, Carlos does come back up after he’s made a blunder but the uncertainty is often seen. Carlos was about your average learner, while Darryl and Belinda were at the lower end of the bell curve there. But they’ve come a long way working with you and the Sci-Tech Club activities using the Internet. It has brought up their self-esteem, their self-confidence. I’ve seen a big change in these two. Each student is different and special, having their own special ways of learning.

MS. BOSSELER — THAT APPEARS TO BE ONE OF THE BENEFITS OF THE COMPUTER, GIVING LEARNERS A WINDOW OF LEARNING THAT THEY CAN BE COMFORTABLE WITH AS THEY ADAPT TO THEIR OWN PARTICULAR STYLE.

Carlos 5th grade teacher
ENGAGE: Carlos tends to express current understanding of a concept or idea. Student will offer the “right” answers (most of the time).
EXPLORE: Carlos enjoys testing around with materials and ideas. He also tries different ways to solve a problem or answer a question. Carlos demands or seeks closure at the end of teach activity.
EXPLAIN: Carlos tends to explain concepts and ideas in his own words. He also uses appropriate scientific language, accepts explanations w/out justification.
ELABORATE: Carlos often makes conceptual connections between new and former experiences.
EVALUATE: Tends to ask new questions that take him deeper into the lesson.

1-21-04
Ms. Bosseler — Today growth was powerfully evident for Carlos and Darryl in the following ways:

Darryl and another member wanted to use the same computer because their previous work had been saved on the same computer. Moving them to a new computer would necessitate copying the PowerPoint on a floppy disk, which isn’t possible due to the limitations of the computer lab setup. The other alternative was to take turns. Derek solved it better than I did — suggesting they share the time, each using the computer during a club meeting session. He was very proud of the information he had added to his bird review. Both agreed this was a good solution.
NOTE: Carlos’ search for extending informational search on the internet results in a higher level of thinking, synthesizing an original use for information. When searching the Internet for his Mars presentation, Carlos came upon a NASA website, “The Space Place,” a NASA site experiment.

Carlos—Look what I found! Remember this summer when we did the experiment to make ice cream, and everyone did it? Can we take this idea from NASA and do the same thing?

Ms. Bosseler—Would you like to show us how to do it? That is, demonstrate how to test spacecraft material?

Carlos—No, I want everyone to do it.

Ms. Bosseler—That’s a great idea. We’ll start off the next meeting with this experiment and everyone can work in teams. Will you agree to assist me at the beginning?

Carlos - Yes, I’ll do that.

Comments by Mr Griffin, 2003–2004
About Belinda—Using the ACS, 2002 and the 5’E’s model, I find that Belinda fits nicely into the middle of “guided” inquiry and “open” inquiry. Sometimes she wants to explore things on her own but just doesn’t know where to start and at other times she is not very engaged or motivated and wants assistance throughout the entire activity. She is, however, learning to balance her approach. She has a lot of obstacles to overcome (esp. her home life) and requires a lot of attention. I’ve noticed that she has become more efficient in school and especially, in Sci-Tech Club. Ms. Bosseler is very patient and caring with Belinda. Belinda realizes this and in turn, performs and improves in her academics as well as in her social attitude toward others.

About Darryl—has always been very inquisitive in my science lab class. He comes into lab engaged and ready to explore but many times behaves in quite the opposite behavior mood, no direction and in a disorganized manner. Since joining the Sci-Tech Club and taking part in the Internet activities, he has learned to settle down and manage his time. Inquiry thinking is a lot better. His homeroom teacher has also seen this change and has shared that with me. Not only is he more focused on the task at hand but he is more organized in his explanations but also is now very helpful explaining, elaborating, evaluating, and guiding the other students in the lab, esp. with computer related activities.

About Carlos—As Carlos’ science lab teacher for the past 2 years, I’ve seen a noticeable change in his approach to learning. When he joined Sci-Tech Club he was unsure of himself and his capabilities. He would always require direction and guidance with each project of activity. Over time, while working with Ms. Bosseler, he has built his confidence and improved his abilities. He now engages and explores on his own. Afterwards, he independently justifies his knowledge or findings and successfully communicates it to others. With just a little guidance Carlos has progress a long way, like the metamorphosis of a butterfly’s change.
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BIOGRAPHICAL SKETCH

Marcia Lee Bosseler received a B.S. degree in Elementary Education in 1958 and an M.S. in Gifted Education and Computer Science in 1983 from the University of Miami. She received an Educational Specialist degree in Gifted Education and Educational Leadership in 1989 from Nova University. She has taught gifted education, all elementary school levels, and science methods at the university level. For three years, before retiring in 2003, she was an educational specialist for Miami-Dade County’s Division of Mathematics & Science. Currently, she is a Science Education Consultant for the Miami Museum of Science and Planetarium.

She has presented papers and professional development workshops at national science teaching conferences; such as, the National Association for Research in Science Teaching (NARST), the National Science Teachers Association (NSTA), the Association for the Education of Teachers in Science (AETS), and the Florida Association of Science Teachers (FAST), She has presented at the Florida Educational Technology Conference (FETC).

She published a chapter in a SERVE monograph, entitled *Meaningful Science: Teachers Doing Inquiry + Teaching Science*. In 1998, she was awarded the prestigious Presidential Award for Excellence in Science Education. She has won state awards for gardening and environmental projects.

She identifies herself to a metamorphic parallel to Robert Browning’s *Pied Piper of Hamelin* (1888). She feels that she has the “magic” to entice learners to love science, as she; realizing not all students will find science exciting and motivating. She hopes the music they hear is void of the drudgery of didactic teaching but beckons, “All the little boys and girls…tripping and skipping, ran merrily after the wonderful music with shouting and laughter” (Browning, 1888, p. 74, 82-84).