DEVELOPMENT AND VALIDATION OF SCIENTIFIC INQUIRY WITH TECHNOLOGY: TEACHERS' PERCEPTIONS AND PRACTICES SCALE (SIT-TIPPS)

By

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To my wife Tezcan and my daughter Berra

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LIST OF ABBREVIATIONS

AAAS	American Association for the Advancement of Science
NRC	National Research Council
SIT-TIPPS	Scientific Inquiry with Technology: Teachers' Perceptions and Practices Survey

Abstract of Dissertation Presented to the Graduate School
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This study was based on the premise technology can enhance the quality of scientific inquiry-based instruction and explored the question of how science teachers use technology to attain the goals of scientific inquiry-based instruction. The instrument developed in this study (SIT-TIPPS) can serve as a useful tool for science teachers and science teacher educators regarding the integration of technology in scientific inquiry-based learning environments. For this purpose, 715 middle and high school science teachers' were surveyed for their perceptions about implementing scientific inquiry using technology and the degree to which they use technology for such a goal. Results explored whether relationships exist and the degree of these relationships among a set of variables related to teachers' use of technology for scientific inquiry purposes. Study results supported the validity and reliability of the SIT-TIPPS instrument. It also demonstrated significant relationships among teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry and the level of preparedness and frequency of using inquiry skills and technology tools in instruction. Analysis of the survey responses also documented science teachers have a variety of skills in using inquiry skills in instruction such as supporting students to explain cause-effect relationships and to

discuss scientific explanations/models/ideas with others. However, they report low comfort level and use of inquiry skills such as supporting students to identify their own misconceptions of science content; to find biases and flaws in their scientific explanations; to test scientific explanations against current scientific knowledge; and to critique experiments. Regarding technology tools science teachers report more frequent use of most commonly used technology applications/tools such as word processing, spreadsheets, presentation software, presentation devices, email, and Internet searches. On the other hand, in terms of technology tools/application, the science teachers indicate low comfort level with and the use of new and/or unfamiliar forms of technologies such as blogs and data collection telecollaborative activities.

Findings of the study have valuable implications for teacher educators, science teachers, administrators, practitioners, and educational policy makers. The SIT-TIPPS instrument can make valuable contributions to preservice teacher education and inservice teacher trainings. For example, the perceptions and practices factors of the instrument can be used to diagnose the gap between teachers' perceptions and actual classroom practices regarding the use of technology for scientific inquiry purposes. The sections that measure science teachers' comfort levels and the degree to which they integrate inquiry skills and technology tools can help identify what skills teacher candidates or classroom teachers are missing. This, in turn, can help colleges of education and teacher-training institutes design more effective science education programs that nurture teachers' skills and knowledge base for implementing technology and scientific inquiry in their classrooms.

CHAPTER 1
INTRODUCTION

There have been many efforts throughout the history of science education to improve teaching and learning in elementary and secondary schools (Abrams, 1998). The National Research Council and American Association for the Advancement of Science have contributed to efforts by publishing reports such as the National Science Education Standards (1996), Science for All Americans (1990), and Benchmarks for Science Literacy (1993) that emphasized student learning, the nature of science, science literacy, and scientific inquiry. Despite these efforts, current science curricula in the United States and many other countries has failed to prepare students for the kinds of experiences they will need to become successful science learners (Linn, Davis, & Bell, 2004). Many school science curricula still encourage the philosophical mindset of the 20th century (Bencze & Hodson, 1999) and teachers, scientists, and curriculum developers hesitate to give students freedom to investigate their own problems (Abrams, 1998). The National Research Council (2000, p. 17) reported “teachers were still using traditional, didactic methods” and “students were mastering disconnected facts in lieu of broader understandings, critical reasoning, and problem-solving skills.”

In addition, the National Commission on Mathematics and Science Teaching for the 21st Century (2005) reports “children are losing the ability to respond not just to the challenges already presented by the 21st century but to its potential as well” (p. 4). These reports clearly show today’s students will need to acquire a new set of skills for the 21st century (Kozma & Schank, 1998). They need to be prepared for a rapidly changing world by: (a) learning how to think about their knowledge base and to apply it flexibly and responsibly (Wiske, et al., 2005) and (b) learning how to use a variety of tools to search vast amount of information, generate new data, analyze and interpret data and transform findings into new meanings, and communicate ideas (Kozma & Schank, 1998).

In educational technology, one goal of this field is to identify effective ways to use technology tools for higher-order thinking that mesh with the assumptions of scientific inquiry (NRC, 1996). Research indicates technology offers opportunities to transform inquiry-based science teaching and learning (Edelson, Gordin, & Pea, 1999; Alagic, Yeotis, Rimmington, & Koert, 2003; Linn et al., 2004; Williams, Linn, Ammon, & Gearhart, 2004). Some researchers point out the need for using technology to promote scientific inquiry in science classrooms (Pederson & Yerrick, 2000; Carin & Bass, 2001; Williams, et al., 2004). Edelson et al., (1999) believed all the fundamental properties of computing technologies offer benefits for inquiry-based learning in the sciences.

Researchers note technology is currently being used in science classes to help build a community of learners (Bransford, Brown, & Roney, 1999; Dede, 2000); engage students in problem-rich environments to explore and solve problems (Bransford, et al., 1999); develop math or science concepts as well as collaborative skills (Stables, 1997); deal with misconceptions (Cognition and Technology Groups at Vanderbilt, 1992; Nickerson, 1995); master more complex subjects via rich interactions using external resources (Dede, 2000); and help students generate and test hypotheses and build explanations of scientific phenomena (Spitulnik, Stratford, Krajcik, & Soloway, 1998). However, there is scant literature available answering the question of how science teachers use technology to attain the goals of scientific inquiry.

Statement of the Problem

Scientific inquiry has been an overarching goal of science education (AAAS, 1993; NRC, 1996; Flick, 1997; Crawford, 1997; Edelson, et al., 1999) and a central strategy for teaching science (NRC, 1996) for decades. Although there are certain instructional methods and strategies that help teachers implement scientific inquiry in their classrooms, the use of technology can also play a significant role in meeting the goals of scientific inquiry. According to the National Research Council (1996), a goal for using educational technology in the classroom is to identify effective ways to use technology tools for higher-order thinking that mesh with the assumptions of scientific inquiry. The effective uses of educational technologies also have the potential to transform inquiry-based science teaching and learning (Edelson et al., 1999; Alagic et al., 2003; Linn et al., 2004; Williams et al., 2004).

When it comes to technology integration, teachers play a key role (Scheffler & Logan, 1999). Yet, research indicates teachers lack good instructional frameworks for effective implementation of technology into the curriculum (Bitner & Bitner, 2002). In addition to teachers' lack of experience in implementing technology into their curricula, there is little literature answering the question of how science teachers use technology to succeed in enacting the goals of scientific inquiry. A trio of factors including background knowledge with regard to science content, inquiry-oriented instruction, and technology (Pedersen & Yerrick, 2000; Williams et al., 2004) make inquiry teaching more challenging for teachers. Moreover, the pressure from external forces such as parents, administrators and society to use technology in the classroom contributes to this issue and makes teachers feel compelled to use technology in their classrooms without any clear agenda (Wiske, Franz, & Breit, 2005).

Purpose of the Study

This study, which was based on the premise technology could enhance the quality of scientific inquiry-based instruction, attempted to answer the question of how science teachers use technology to attain the goals of scientific inquiry-based instruction. The instrument developed in this study can serve as a useful tool for science teachers and science teacher educators in the integration of technology in scientific inquiry-based learning environments. For this purpose, the study investigated science teachers' self-reported perceptions about implementing scientific inquiry using technology and explored the degree to which they use technology for such a goal. It also examined whether relationships exist, and the degree of these relationships, among a set of variables related to teachers' use of technology for inquiry purposes.

Significance of the Study

This dissertation study focused on how technology is used when supporting scientific inquiry instruction in K-12 science classrooms through the development of an instrument about scientific inquiry and the use of technology. This study attempted to address an essential topic both in science education and educational technology. Even though there are some instruments targeting scientific inquiry in science education literature (Bodzin & Beerer, 2003; Brandon & Taum, 2005; Smolleck, Zembal-Saul, & Yoder, 2006), an instrument specifically targeting scientific inquiry in science classrooms where technology is used is an area of need in both fields. Such an instrument is helpful in analyzing the current practice in schools and colleges of education and in furthering the discussion on how science teachers can use technology to attain the goals of scientific inquiry. For this purpose, the researcher developed a quantitative instrument to measure teachers' self-reported perceptions and practices regarding the use of technology in attaining the goals of scientific inquiry. It connected theory and research from two fields, science education and educational technology, which can result in a change of daily practice in science classroom.

The findings of this study also fused various aspects of scientific inquiry applicable to educational technology to form a common ground to assess teacher's understandings and uses of science inquiry utilizing technology. In addition, this instrument has the possibility of being used as a useful tool to assist science teachers in the integration of technology into scientific inquiry-based instruction. Although science teacher education programs have begun to design teaching models that infuse technology, research characterizing teachers' instructional use of educational technology after completing such programs is limited (McNall, 2004). The instrument developed in this study and its results also contribute to this body of literature and help educators develop strategies toward enriching initial teacher preparation and professional development opportunities. In summation, such an instrument could be helpful by providing insight into the current practice in schools, examine factors that facilitate or hinder the use of technology for scientific inquiry purposes, provide instructional strategies to enhance inquiry-based science teaching that utilizes technology, and build upon the established knowledge base in science education and educational technology.

Research Questions

This study had two overarching research questions and five supporting questions. The main questions focused on how teachers use technology to implement the goals of scientific inquiry and the relationships between their self-reported perceptions and practices regarding this implementation. The supporting questions, however, articulated these relationships by addressing some teacher demographics and background/professional development variables as well as the level and frequency of their preparedness and use of certain inquiry tasks and technology tools. While the total scores obtained from the survey and the relationships between perception and practice items in the survey were utilized to help answer the overarching questions of the study, relationships obtained from supporting questions also contributed to answering these overarching questions. Through the creation of SIT-TIPPS, the study addressed the following research questions:

Overarching Questions

1. How are teachers using technology to implement the goals of scientific inquiry in their classrooms?

2. What are the relationships between teachers' perceptions and practices regarding the use of technology to attain the goals of scientific inquiry?

Supporting Questions

What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry in terms of:

- Teacher demographics and teacher background/professional development variables?
- How often do they support students to engage in certain inquiry skills in their science classrooms?
- How often do they use certain technology tools in their science classrooms?
- How prepared do teachers feel to support students to engage in certain inquiry skills in their science classrooms?
- How prepared do teachers feel to use certain technology tools in their science classrooms?

Theoretical Framework of the Study

Essential to the development of any instrument is a solid theoretical foundation from which issues and concepts are derived (Devellis, 2003). Because this study is interweaving two academic areas it becomes necessary to blend two established knowledge bases into a theoretical foundation on which the instrument created in this study, SIT-TIPPS, can stand.

A meta-analysis research study on inquiry-based science instruction has established that scientific inquiry-based teaching and learning promotes students' abilities to diagnose problems, critique experiments, distinguish alternatives, plan investigations, research conjectures, search for information, debate with peers, seek information from experts, and form coherent arguments (Linn et al., 2004). However, the studies explored in the meta-analysis lack a common definition for scientific inquiry-based teaching to guide the successful implementation of inquiry-based methods in classrooms using technology. By adopting the National Research Council's (NRC) inquiry standards and meshing these standards with research findings in the areas of scientific inquiry and educational technology, a theoretical framework is formed to effectively base the integration of scientific inquiry and technology in science classrooms. The theoretical framework for this study is built on the inquiry standards developed by the National Research Council in *Inquiry and National Science Education Standards* (NSES, 2000) and supported by the related literature.

The following essential features of classroom inquiry as described in the National Science Education Standards were used as a guideline to develop the Scientific Inquiry with Technology-Teachers' Perceptions and Practices Survey (SIT-TIPPS) instrument as part of this study:

1. Learners engage in scientifically oriented questions
2. Learners give priority to evidence in responding to questions.
3. Learners formulate explanations from evidence.
4. Learners connect explanations to scientific knowledge, and
5. Learners communicate and justify explanations (p.25).

The National Science Education Standards (2000) define inquiry-based teaching as experiences that help students acquire concepts of science, skills and abilities of scientific inquiry, and understandings about scientific inquiry. The research base used in the Standards to identify the essential features of inquiry in science classrooms is grounded in research on learning and the kinds of learning environments that promote learning. For this purpose, the NRC gives a detailed account of pioneering ideas that laid the groundwork for essential features of classroom inquiry. These features were used to determine whether scientific inquiry is an integral part of the classroom. These features are:

- Herbart's (1901) ideas about teaching that include starting with students' interest in the natural world and in interaction with others.

- Dewey's (1910) expansion of the idea of reflective experience in which students begin with a perplexing situation, formulate a tentative interpretation or hypothesis, test the hypothesis to arrive at a solution, and act upon the solution. Dewey emphasized processes and methods of science and the notion of science as a way of thinking and an attitude of mind.

- Schwab's (1960, 1966) emphasis on science as conceptual structures revised as the result of new evidence. Schwab suggested teachers: (a) provide laboratory experiences before introducing students to the formal explanations of scientific concepts and principles, (b) enable students to build and/or refine explanations from evidence, (c) allow students to pose questions, discover relationships, and propose scientific explanations based on their own investigations, (d) enable students to build an understanding of what constitutes scientific knowledge and how scientific knowledge is produced by providing them with readings and reports about scientific research in which they can discuss the details of the research or read about alternative explanations, experiments, and assumptions.

- Piaget's (1975) theory of development in which he proposed learners adapt or change their cognitive structures when they experience a discrepancy between their existing ideas and ideas they observe in their environments.

- Atkin's and Karplus' (1962) idea of the learning cycle emphasizing the roles of exploration, invention, and discovery in the teaching and learning processes.

- Bransford's et al., (1999) research findings on how people learn. These findings suggest: (a) understanding science is more than knowing facts; students should understand the major concepts, build a strong base of supporting factual information, and know how to apply their knowledge effectively, (b) students build new knowledge and understanding on what they already know and believe, (c) students formulate new knowledge by modifying and refining their current concepts and by adding new concepts to what they already know, (d) learning is mediated by the social environment in which learners interact with others, (e) effective learning requires that students take control of their own learning, (f) the ability to apply knowledge to novel situations, that is, transfer of learning, is affected by the degree to which students learn with understanding Bransford's et al., study also suggested that learning should take place in a learner, knowledge, assessment, and community-centered environments.

Guided by this theoretical framework about the essential features of classroom inquiry outlined in the National Science Education Standards, the SIT-TIPPS instrument developed in this study included items targeting: (a) teachers' use of a variety of technology tools in their classrooms, (b) their self-reported perceptions regarding the use of technology for scientific inquiry proposes in instruction, and (c) their practices regarding the use of technology for scientific inquiry proposes in instruction. As noted earlier, in addition to this framework, the researcher also made use of the related literature regarding best practices in teaching from both science education and educational technology fields when constructing the items for the survey.

The essential features of the National Science Education Standards dovetail into the literature allowing teacher perceptions and practices regarding the use of technology in scientific inquiry-based instruction were examined. This framework, in conjunction with the two bodies of knowledge, allowed the researcher to develop the constructs and corresponding items for the instrument.

Definition of Terms

The following terms can be useful in understanding the nature of this study.

Scientific inquiry refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 1996, p.23).

Technology refers to the use of a range of devices and technological processes specifically for teaching and learning in K-12 settings. For the purposes of the present study, the following technologies are included in the definition:

1. Computers (desktop, laptop)
2. Presentation devices (such as video projectors, LCD panels, overhead projectors)
3. Whiteboard/Smartboard
4. Wireless communication devices
5. Computer software (such as Word processors, desktop publishing, spreadsheets, presentation software, databases, simulations, games, graphing and data analysis software, video and picture editing software)
6. Graphing/scientific calculators
7. Handhelds, GPS (Global positioning systems)
8. Digital data collection devices (such as pH, pressure and temperature probes, digital microscope, Navigator systems)
9. Videoconferencing, teleconferencing
10. Internet technologies (such as e-mail, websites, online databases, virtual field trips, online simulations and games, Wikis, blogs, online learning communities)

Delimitations of the Study

This study focuses on the limited domain of science teachers who teach at the middle and/or high school level. Therefore, it cannot be generalized to other subject areas and/or other levels of schools such as elementary schools. The study concentrates on middle and high school science teachers' self-reported perceptions and practices regarding the use of technology for scientific inquiry purposes, as well as their comfort levels and uses of inquiry skills and technology tools/applications in classrooms. The term, technology, is limited to the definition described above and the concept of scientific inquiry is restricted to National Research Council's five essential features of scientific inquiry as outlined in the National Science Education Standards. For this reason, the findings of the study may not be generalized to other features of scientific inquiry, as well as other forms of technology tools/applications.

Only middle and high school science teachers who teach in the United States of America constituted the sample. The instrument developed in this study and the findings obtained from its administration may not be generalized to science teachers who are teaching in other countries.

Limitations of the Study

In this study, the term technology is limited to the definition described above and the concept of scientific inquiry is restricted to National Research Council's five essential features of scientific inquiry as outlined in the National Science Education Standards. For this reason, the findings of the study may not be generalized to other features of scientific inquiry, as well as other forms of technology tools/applications.

The participation in this study was voluntary and by convenience. There is always the possibility that the response structure from science teachers who volunteered may differ from those who did not volunteer or were not contacted.

All of the science teachers, who participated in this study, received an invitation from the researcher in electronic format via direct email or through membership to professional listservs. Hence, the sample profile does not involve those teachers who do not use email or have no access to Internet-based professional organizations. This could limit the generalizability of the results to many middle and high school science teachers in the U.S.

Organization of Chapters

Chapter 1 provides information on the role of technology and scientific inquiry in science education. This chapter identifies the significance and purpose of the study, the theoretical framework and research questions. Chapter 2 reviews the literature on scientific inquiry and the integration of technology in science education. Highlighted are the importance of the relationship between the goals of science education and the potential technology can offer to attain these goals. Chapter 3 provides a detailed description of the study design, instrument development procedure and methodology used in conducting the research. Chapter 4 interprets and discusses the data. Chapter 5 summarizes the implications of the findings.

CHAPTER 2
REVIEW OF THE LITERATURE

This review of literature provides a brief but through presentation of salient literature and research in the following areas: scientific inquiry, scientific inquiry and technology, critical concepts in the integration of technology in scientific inquiry-based instruction, and guidelines for instrument development.

Inquiry: A History and Evolving Definition

> *It is nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry.*
>
> *Albert Einstein*

The miracle Einstein was referring to in the above quote seems to have become a reality at least in science education. As DeBoer (1991) contended, the goal of science education since the late 1950s has been inquiry. This term became a central strategy for teaching science (NRC, 1996), and is held in high regard among science educators (Sherman & Sherman, 2004). Its importance in science education as a central goal has a long and established history dating back to the works of Dewey at the beginning of the twentieth century and Schwab at the turn of the century (Zembal-Saul & Land, 2002; Abd-El-Khalick, BouJaoude, Duschl, Hofstein, Lederman, Mamlok, Niaz, Treagust, & Tuan, 2004; Crawford, 1997; Edelson et al., 1999; National Research Council, 2000, Bodzin & Beerer, 2003). The role of inquiry in science education remains a perennial term and continues to be strongly emphasized by current reform reports or documents in the United States (Crawford, 1997; Flick, 1997; Abd-el-Khalick et al., 2004) such as the National Science Education Standards (NRC, 1996; 2000) and Benchmarks for Science Literacy (AAAS, 1993). Recommendations include the opportunity for students to use scientific inquiry and develop inquiry skills (NRC, 1996) and for teachers to establish inquiry-oriented learning environments (Carin & Bass, 2001) that result in better retention and understanding of the concepts (Brendzel, 2005).

Inquiry has been a broadly defined and characterized construct in science education (Looi, 1998; Windschitl, 2003). Although its definition varied among science educators, its presence (Newman, Abell, Hubbard, McDonald, Otaala, & Martini, 2004) and importance was always accepted and promoted. Carnes (1997) identified three broad classifications of the definition of inquiry as: science processes or a scientific method; scientific processes and content knowledge; and scientific processes, attitudes, and knowledge. Looi (1998) also identified three categories from a different perspective. His categories of inquiry include: active involvement of learners as in hands-on, experiential or activity-based learning; a discovery approach as in the development of process skills associated with scientific methods; and promoting metacognitive knowledge and skills.

The National Science Education Standards (NRC, 1996) defined scientific inquiry as:

> The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world… Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. (p. 23)

In the same respect, Linn et al., (2004, p. 4) described inquiry instruction as "engaging students in the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, debating with peers, seeking information from experts, and forming coherent arguments." Abd-el-Khalick et al., (2004), on the other hand, distinguished between the terms *inquiry as means* (or inquiry in science) and *inquiry as ends* (or inquiry about science). In their descriptions of scientific inquiry

inquiry as means refers to “inquiry as an instructional approach intended to help students develop understandings of science content” and *inquiry as ends* refers to “inquiry as an instructional outcome” which they explained enables students to “learn to do inquiry in the context of science content and develop epistemological understandings about the nature of science and the development of scientific knowledge, as well as relevant inquiry skills such as identifying problems, generating research questions, designing and conducting investigations, and formulating, communicating, and defending hypothesis, models, and explanations” (p. 398). Abd-el-Khalick et al., (2004) cautioned us that these aspects of scientific inquiry were often neglected because of the misconception that students develop understandings about inquiry implicitly by simply doing science.

Why Inquiry?

Inquiry-based learning environments can provide students with the opportunity to generate and revise their thinking in interdisciplinary contexts (Myers & Botti, 1997) and achieve the goal of developing general inquiry abilities, acquiring specific investigation skills, and understanding science concepts and principles (Edelson et al., 1999). Sherman and Sherman (2004) added that engaging in inquiry helps students develop an appreciation of “how we know”; an understanding of the nature of science; and skills to become independent inquirers. According to a recent review of the literature by the National Research Council (2000), positive effects in cognitive achievement, process skills, vocabulary knowledge, critical thinking, and attitudes toward science document the importance of students receiving explicit instruction on skills needed to engage in inquiry.

The National Science Education Standards (NRC, 1996) emphasized the contributions of inquiry-based instruction to teaching and learning science. According to NRC (1996),

> When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. (p. 2)

In addition, while offering a less content-oriented, metacognitive, collaborative, argumentative, and communicative learning environment (Berge & Slotta, 2005), learning through inquiry can also empower students to become independent, lifelong learners by allowing them to gain an appreciation for discovery (Llewellyn, 2002). It also enables students to develop their own ideas by building connections between their existing ideas and new ideas (Berge & Slotta, 2005). Inquiry-based approaches engage students in cognitive processes used by scientists such as asking questions, developing hypothesis, designing investigations, dealing with data, drawing inferences, and building theories (Crawford, 2000). Doing this allows learners to develop a broader understanding of science and improves their critical reasoning and problem solving skills (Bodzin, 2005). Moreover, inquiry can also contribute to the development of science content understanding by giving them an opportunity to apply their scientific understanding in the pursuit of research questions; by uncovering new scientific principles and refining their preexisting understandings, encouraging them to demand more knowledge (Edelson et al., 1999).

Scientific Inquiry and Teachers

Benzce and Hodson (1999) reported a common myth about scientific inquiry that is evident in science curricula which is “scientific inquiry is a simple, algorithmic procedure.” Such a conception of inquiry could lead to insufficient understanding and practice of scientific inquiry-based instruction. All definitions and strengths of the scientific inquiry approach shed light on the complex nature of inquiry-based practices.

First of all, inquiry-based learning demands activity and learning in authentic contexts (Edelson et al., 1999). It achieves this authenticity by engaging students in problem posing, problem solving, and persuading peers (Roth & Michelle, 1998). Lee, Greene, Odom, Schechter, and Slatta, (2004) identified ten stages of inquiry: content, developing the question, designing the experiment or study, defining and representing the problem, observing, exploring and generating strategies, organizing, analyzing, interpreting, and evaluating [data]. According to Bodzin (2005) and Brendzel (2005), however, inquiry in today's classrooms can take many different forms and encompass a range of activities. While some inquiry-based activities provide for observation, data collection, and analysis; others involve students in the design of open-ended activities based on either a teacher-posed question or a classroom discussion (Brendzel, 2005).

The National Research Council (1996, p. 25) established five essential features of classroom inquiry, which also formed the basis for the instrument developed in this study. These features are:

- Learners are engaged by scientifically oriented questions.
- Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
- Learners formulate explanations from evidence to address scientifically oriented questions.
- Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- Learners communicate and justify their proposed explanations.

Inquiry teaching requires students to exhibit certain skills. It engages students in the systematic approach of reasoning in which they are supposed to formulate and test scientific rules and laws (Looi, 1998); requires them to rely on their explanatory frameworks to develop research questions and hypothesis (Wichmann Gottdenker, Jonassen, & Milrad, 2003); and exercise a variety of skills, including formulating questions and hypotheses, observing, predicting, collecting and analyzing data, classifying, using logical and critical thinking to formulate conclusions, evaluate alternative explanations, and communicate their findings (Sherman & Sherman, 2004; Bodzin, 2005). However, research indicates that children have difficulties in conducting scientific investigations, data gathering, analysis, interpretation, and communication (Edelson et al., 1999). Edelson et al., (1999) listed some reasons, associated with required student skills, impeding the successful implementation of inquiry-based learning. They noted:

- When students are not sufficiently motivated they fail to participate in inquiry activities.
- If students are not able to master data collection and investigation techniques, they cannot conduct investigations that yield meaningful results.
- If students lack background knowledge and the opportunity to develop it, they will be unable to complete meaningful investigations.
- If they are unable to organize their work and manage an extended process, they cannot engage in open-ended inquiry.

Therefore, the role of teachers is crucial for successful enactment of inquiry approaches in science classrooms.

As outlined so far, inquiry is a broad concept. Thus, the meaning of such a concept when applied to classroom practice could become muddled and the integrity lost (Crawford, 2000). To overcome this challenge, teachers need strong content knowledge (Crawford, 2000), pedagogical content knowledge (Abd-el-Khalick et al., 2004), tools (Bodzin & Beerer, 2003), and assistance (McNall, 2004; Sherman & Sherman, 2004) to become well versed in inquiry-based instruction. Although the successful integration of inquiry in science classrooms require teaching skills such as guiding, challenging, and encouraging student learning (NRC, 1996); organizing materials, equipment, media, and technology (NRC, 1996); and a range of teaching strategies (Lee et al., 2004) quite different from typical didactic science instruction (Sandoval et al., 1999), research indicated that teachers typically found inquiry curricula to be difficult and time consuming to teach (White & Frederiksen, 1999). According to some studies, preservice science teachers graduated without conducting a single inquiry in their programs (Windschitl, 2003) and lacked an understanding of inquiry, skills, and experiences (Newman et al., 2004) as well as training and support (White & Frederiksen, 1998) to implement inquiry-oriented teaching. They also have very few operational models (Crawford, 1997) to guide them in the implementation of scientific inquiry-based instruction.

As highlighted above, the implementation of inquiry-based instruction demands a significant shift in what teachers are doing in a science lesson (Crawford, 2000; Bodzin & Beerer, 2003). The focus of much research has mainly been on student behaviors associated with inquiry instruction and lesser attention given to teacher actions (Carnes, 1997) and to their ability to make judgments about appropriate student experiences and evaluation in the learning context (Bencze & Hodson, 1999). However, Fullan (1982) underlined the importance of what teachers do and think for a successful implementation of educational change. It is certain that the behaviors and thoughts of teachers must be more explicitly studied (Crawford, 2000) because they influence (a) knowledge acquisition and interpretation, (b) define and select the task at hand, (c) interpret course content, and (d) determine assessment (Keys & Bryan, 2001). Keys and Bryan (2001) also noted teachers' beliefs about the nature of science, student learning, and their role affect how they plan, assess, and teach an accurate view of inquiry in the classroom.

The teaching of science is becoming more student-centered and requiring more from teachers in terms of classroom questioning and student involvement in discussions as well as facilitation and organization of learning using alternative teaching approaches. According to the

National Research Council (2004), the following list of teacher actions is required in an inquiry classroom:

- Providing experiences, materials, and sources of information for students to use directly.
- Showing the use of instruments or materials that students will need in their inquiry.
- Asking open and person-centered questions to elicit present understandings and how students are explaining what they find.
- Engaging students in suggesting how to test their ideas or answer their questions through investigation or finding evidence from secondary sources.
- Helping students with planning so that ideas are fairly tested where necessary.
- Listening to students' ideas and taking them seriously.
- Asking questions that encourage students to think about how to explain what they find.
- Creating opportunities for collaborative learning and dialogic talk.
- Scaffolding alternative ideas that may explain the evidence from their investigation.

The National Research Council (2000) supported the use of different strategies to develop the knowledge, understandings, and abilities described in the National Science Education content standards. Such an approach is not only inevitable but also desirable in order for teachers to implement inquiry in ways that match their own beliefs and teaching styles (Keys & Bryan, 2001).

In addition to the attributes of inquiry-based instruction stated above, discussion and verbal interactions with peers and teacher (Westbrook, 1997), argumentation (Zembal-Saul & Land, 2002; McDonald, 2004), relating information with prior knowledge and then integrating into larger knowledge structures (Myers & Botti, 1997), identifying a problem and making a reasoned judgment based on appropriate evidence (Lee at al., 2004), and learning from the process of making errors, revising, posing new questions, and retesting (Keys, 1997) are also important ways to enact inquiry in science classrooms. Schwab (1960, cited in NRC, 2000, p. 21), on the other hand, recommended teachers provide students with readings and reports about scientific research where students read about alternative explanations, different and conflicting experiments, and debates about the use of evidence.

Implementing inquiry is not an easy task. Westbrook (1997) stated it is more than a procedure or a method. Rather, “it is a process of investigating how or why or what and then making sense of the resultant findings” (p. 2). Therefore, direct teaching methods may fail in this process (Westbrook, 1997). Instead, students should be given both *freedom* and *privilege* where *freedom* allows students to choose content related to their interests, generate their own questions, invent methodologies, and make sense of data; and *privilege* involves learners with the ideas and practices of the scientific community and make these ideas meaningful at an individual level (Keys, 1997). However, this does not mean that teacher-control is not valued in inquiry instruction. Flick (1997) noted that skilled science teachers achieve inquiry-based learning in moderate to highly controlled conditions by explicitly teaching inquiry skills and allowing students to apply inquiry skills to authentic problems.

One way to achieve this is to use technology effectively in science classrooms. The section that follows describes the ways in which technology can be incorporated into classroom instruction, in general and science education, in particular.

Technology and Science Education

The last several decades have seen the rise of three significant educational issues: standards, the integration of technology, and teacher quality (Wenglinsky, 2005). Because of its influence in society, the integration of technology has gained people’s attention for its potential to contribute to classroom instruction. Houhgton (1997) contended that as computers and advanced telecommunications technologies revolutionize nearly every aspect of life, the attention should not be on whether technology should be incorporated into teaching and learning, but how to achieve it. Collins (1991) stated education cannot resist the technology movement because it has already transformed the world and the way education is conducted (Lou, Abrami, & d'Apollonia, 2001); shaped how people think, learn, and communicate (Gura & Percy, 2005); and changed the way people do science, handle personal affairs, and run businesses and the way schooling takes place (Carin & Bass, 2001). Collins (1991) listed eight possible shifts in instruction in schools due to the integration of technology into classrooms:

1. From whole-class to small-group instruction,
2. From lecture and recitation to coaching,
3. From working with better students to working with weaker students,
4. Toward more engaged students,
5. From assessment based on test performance to assessment based on products, progress, and effort,
6. From a competitive to a cooperative social culture,
7. From all students learning the same thing to different students learning different things,
8. From the primacy of verbal thinking to the integration of visual and verbal thinking.

However, technology is not a transformative power in and of itself (Pederson & Yerrick, 2000). While properly designed and implemented technologies can potentially improve learning (Kozma & Schank, 1998) and promote teaching for understanding (Nickerson, 1995), poorly designed and implemented technologies can hinder learning (Nickerson, 1995; Bransford et al., 1999). Researchers recommended technology should be used to increase and assist student learning (Kozma, 1991; Sheffler & Logan, 1999) and should go beyond superficial use (Cooper & Bull, 1997) by turning learning from simple assimilation into a process of active construction and supporting collaborative learning (Salomon, 1992).

A Nation at Risk, written by the U.S.A. Research, Inc in 1983, "sparked the movement of technology integration in schools for the purpose of producing more technologically literate workforce that is ready to compete in the 21st century world economy" (McNall, 2004, p.1). Subsequent reports continue to urge educators toward meeting this goal. In 2000, the U.S. Department of Education released a report "*eLearning: Putting a World-class Education at the Fingertips of All Children*" to develop strategies for the effective use of technologies in elementary and secondary education (U.S. Department of Education, 2000, p. 4). In this report, five national goals for technology were identified:

- All students and teachers will have access to information technology in their classrooms, schools, communities, and homes.
- All teachers will use technology effectively to help students achieve high academic standards.
- All students will have technology and information literacy skills.
- Research and evaluation will improve the next generation of technology applications for teaching and learning.
- Digital content and networked applications will transform teaching and learning.

Regardless of the call for the infusion of technology into the daily learning occurring in schools, the findings on the outcomes of technology use in schools produced controversial results. The National Center for Education Statistics (2002) reported no significant change in student achievement despite an increase in computers in schools. Kracjik, Marx, Blumenfeld, Soloway, & Fishman (2000), however, noted that although researchers do not have enough evidence on computers increasing achievement, many studies showed positive effects associated with computer aided instruction. Moreover, Pollard and Pollard (2004) cited two meta-analytic studies (Kulik, 1994 & Schater, 2001) in which results indicated technology-rich environments enabled students to learn more and faster, have more positive attitudes, and improved their achievement. Lou et al., (2001) conducted a meta-analysis and concluded when computer technologies were used for small group learning rather than individual learning, it produced more positive results in terms of learning. Pederson and Yerrick (2000), on the other hand, averred computers seem to only be used to support existing learning and teaching patterns.

Promising findings have been noted in other significant research studies. For example, Morgan (1996) stated that fourth and eight-grade students who used computers to play learning games and for simulation and models scored higher, on average, than others who did not. Berger, Lu, Belzer, & Voss (1994) reported higher thinking skills for secondary school students who were exposed to interactive video disk, computer-assisted instruction, and mastery-based learning. Another study (Spitulnik et al., 1998) indicated students who designed technological artifacts using hypermedia had better integrated understanding. It is also evident in the literature that when computer technologies were used for collaborative activity and designed for mindful engagement of students they created new opportunities for decision making, thinking, and constructing (Salomon, Perkins, & Globerson, 1991; Salomon, 1992). The results from the National Assessment of Educational Progress study (also known as the Nation’s Report Card) also revealed positive association between computer use and student performance when computers are used in a constructivist fashion (Wenglinsky, 2005).

Overall, findings mentioned above shed light on future research directions in the field. Bebell, Russell, & O’Dwyer (2004) suggested that despite the tendency to examine the effects of technology on student learning, effects of learning and understanding of how teachers and students are using technology should take higher consideration. Similarly, Lewis (1999) addressed the need for more evaluative studies that focus on attempts at integration. Pollard and Pollard (2004) organized a Delphi panel to examine the future of research in the field. The panel recommended that research efforts should focus on the role of technology in improving students’ problem solving abilities and helping them accomplish learning tasks rather than on scores on achievement tests. In addition, inservice and preservice teachers' use of technology has also been a high priority area in the field (Pollard & Pollard, 2004). Bebell et al., (2004) put that research on teachers' use of technology lacked a clear definition and stressed the importance of providing valid measures of technology use among teachers.

Technology and Learning

Duffy and Cunningham (1996) provided a rationale for using technology for learning. They suggested that learning occurs in context and is an active, social, and a reflective process. Such a rationale could provide teachers a framework when seeking out ways to effectively integrate technology into instruction. Technology has the potential to reinvigorate learning by increasing motivation; providing recontexualized and individualized instruction; improving writing; encouraging student publishing and research; and transforming the classrooms into a multiple intelligence-centered learning environment (Gura & Percy, 2005). Computers, for example, provide great interactivity and have the ability to become any media, to present information from many different perspectives, and to become reflective (Carin & Bass, 2001). Technologies can provide scaffolds and tools to enhance learning, give feedback (Bransford et al., 1999) and use multiple representations, modeling and visualization to enhance learning (Kozma, 1991; Morgan, 1996; Spitulnik et al., 1998; Dede, 2000; Flick & Bell, 2000; Gura & Percy, 2005). They also help build a community of learners by bridging teachers, students, and experts (Bransford et al., 1999; Dede, 2000). Another important use of technology in instruction is its ability to engage students in problem-rich environments to explore and solve (Bransford et al., 1999); develop math or science concepts as well as collaborative skills (Stables, 1997); deal with misconceptions (Cognition and Technology Group at Vanderbilt, 1992; Nickerson, 1995); and master more complex subjects via rich interactions using external resources (Dede, 2000). Technology tools are also essential in helping students generate and test hypotheses and build explanations of scientific phenomena (Spitulnik et al., 1998) and analyze, visualize, solve, investigate, and communicate information (Loveless et al., 2001; Rieser, Krajcik, Moje, & Marx, 2003; McNall, 2004).

In addition to these potential benefits of technologies, Hooper and Rieber (1995) noted three principles and their implications for using technology in the classroom: (a) effective learners actively process lesson content, (b) presenting information from multiple perspectives increases the durability of instruction, and (c) effective instruction should build upon students knowledge and experiences and be grounded in meaningful contexts. Therefore, technology tools should be used in ways to bridge the gaps between students and scientists, to provide meaningful problems to students, and to help students develop background knowledge and investigation techniques (Edelson et al., 1999).

Models of Technology Use

There are multiple methods for studying how technology is used in instruction. One model divides technology into two categories: *Effects with* and *effects of* technology. *Effects with* technology refers to changes that take place as the result of engagement in an intellectual partnership with a technology tool or peers; and *effects of* technology refers to long lasting changes that take place as a result of that intellectual partnership (Salomon et al., 1991; Salamon, 1998). For the purposes of this study, it is important to point out approaches to technology integration in science classrooms as the goal of the study is to develop an instrument that focuses on science teachers' perceptions and uses of technology in inquiry-oriented science classrooms. Carin and Bass (2001) interpreted the Information Society for Technology in Education (ISTE) technology standards considering how to connect educational technology and science education and categorized those standards into three areas: (a) standards related to *learning with technology* in which technology is used to enhance productivity, communications, research, problem solving, and decision making, (b) standards related to *learning from technology* in which computer-assisted instruction, tutorials, simulations, and multimedia presentations are used to enhance science learning, and (c) standards related to *learning about technology* in which learning how computing systems operate, learning how to use them in classroom settings, and considering societal implications of technology use are emphasized. The instrument developed in this study addressed all three of these standards to varying degrees.

Technology in Science Instruction

There is a strong support in the literature for using technology in science instruction. Flick and Bell (2000) highlighted this meaningful partnership between the two fields across most of the twentieth century. This partnership was also enforced by current reforms represented by institutions such as American Association for the Advancement of Science and National Research Council (Pederson & Yerrick, 2000). Such reforms encouraged integration of technology in science education to help students use scientific knowledge to predict, explain, and model phenomena (Spitulnik et al., 1998). In addition, McNall (2004) reported that the National Educational Technology Standards (NETS, ISTE) and the National Science Teachers Association (NSTA) recommended effective use of technology in science instruction to enrich the learning and teaching of science and to support inquiry. The impact of technology on science education challenged both science educators and science teachers and changed the ways each interact with students in their classrooms (Flick & Bell, 2000) and offered new opportunities to transform science instruction with inquiry projects that improve science, technology, and language literacy (Linn et al., 2004). By doing this, technology integration is considered to have an impact on connecting students to the designed world (NRC, 1996), empowering them to learn (Berger et al., 1994) and to become more active explorers of their environment (Carin & Bass, 2001). Lewis (1999) suggested educational technology to establish itself in relation to other subjects and noted that the field of educational technology has to understand the integration of technology to other subjects in the curriculum. The relationship between science education and technology integration discussed above pinpoints the importance of this perspective.

Technology and Inquiry

Although technology is a powerful tool for learning merely employing it does not produce the desired effects (Lou et al., 2001). Literature shows that as new technologies became available to educators, science teachers and educators struggled to find effective ways of using them (Linn, 1998) especially for the purpose of inquiry instruction. In addition, inquiry teaching is challenging because it requires strong background knowledge with regard to science content, inquiry-oriented instruction, pedagogy, and technology (Pedersen & Yerrick, 2000; Williams et al., 2004).

Spitulnik et al., (1998) pointed out that the new vision of science education has become engaging students in scientific inquiry activities and using technological tools to achieve this goal. Edelson et al., (1999) believed all of the fundamental properties of computing technologies, such as the ability to store and manipulate large quantities of information, the ability to permit interaction in a variety of audio and visual formats, the ability to perform complex computations, the support for communications, and the ability to give feedback to users offer benefits for inquiry-based learning. Flick and Bell (2000) noted that activities involving technology should make connections to student experiences and promote inquiry-based learning. Such learning demands new teaching methods and technology offers promising solutions (Linn et al., 2004). The contributions of inquiry-based learning and educational technology to each other are reciprocal. Namely, recent advances in cognitive science and educational technology (particularly computer simulations and modeling tools) set the stage for developing more effective approaches to the teaching of scientific inquiry (White & Frederiksen, 1998). Inquiry, on the other hand, contributed to the educational technology field because (a) it related fundamentally to the basic claims of the field, (b) it reminded us that educational technology is about learning and teaching, and (c) both inquiry and technology shared and conformed to conceptual frameworks such as situated cognition and constructivism that unite technology with other school subjects (Lewis, 1999). Carin and Bass (2001) contended that the notion of design in technology is parallel to science and, as identified by the National Science Education Standards, technological design facilitates scientific inquiry in defining a problem, designing an approach, implementing a solution, evaluating the solution, and communicating the problem, design, and solution to others.

McNall (2004) highlighted the capacity of educational technology tools to support inquiry learning in science by assisting students in visualizing abstract concepts and engaging them in rich experiences. According to Alagic et al., (2003), information technologies can play a special role in inquiry-based learning as the subject of instruction or as a tool for instruction. They noted that, when used in inquiry-oriented activities, technology is most often used (a) as a tool, (b) in the context of solving a problem, (c) to augment communication by expanding audiences, or (d) to broaden collection of representations. Similarly, Looi (1998) stated technology tools in the form of interactive learning environments could enrich learning (1) as instructive tools, (2) as constructive tools, (3) as communicative tools, and (4) as situating tools.

Literature provides several strategies regarding the successful integration of technology and inquiry-based instruction. Edelson et al., (1999) categorized these technologies as tools for modeling phenomena and processes from the real world (e.g., Model-It, Jackson, Stratford, Krajcik, & Soloway, 1996; ThinkerTools, White, 1993), visualizing and analyzing quantitative data (e.g., Tabletop, Hancock et al., 1992; GLOBE, Rock, Blackwell, Miller, & Hardison, 1997), exchanging data and ideas across distances (e.g., GLOBE, Rock et al., 1997; Kids as Global Scientists, Songer, 1995), structuring and supporting discussion (e.g., CoVis, Edelson et al., 1996; CSILE, Scarmadalia & Bereiter, 1994), and providing access to information in the form of digital collections and libraries (e.g., Knowledge Integration Environment, Linn, Bell, & Hsi, 1998).

Multiple Examples of Technology Used to Reach Goals of Science Inquiry

Although the literature pinpoints the potential contribution of technology to science education in general, and science inquiry in particular, there are not many examples of technologies designed to attain the goals of scientific inquiry. This section briefly introduces some of the well-known examples of technologies, such as the GLOBE, ThinkerTools and Model-It, used to expose students to scientific inquiry.

As a modeling tool, Model-It, developed by the University of Michigan, provided students with an open-ended task, where students were able to create their own models to represent some ecological phenomena. It focused on higher-level concepts and enabled students to ground their experience and prior knowledge, build representations, and couple actions, effects, and understanding (Jackson et al., 1996). This technology application supports the development of qualitative, verbal representations and provides simultaneous, linked textual-to-graphical representation of relationships. It also helps students connect their actions, the visual feedback provided, and their own mental representations of the phenomenon (Jackson et al., 1996). ThinkerTools, developed by White (1993), focused on learning how to construct causal models based on real-world phenomena rather than learning how to solve well-defined quantitative problems. In general, ThinkerTools supported strategies such as questioning, predicting, experimenting, modeling, and applying (White & Frederiksen, 1998). It also enabled students to develop conceptual models that embody the principles of Newtonian mechanics, and to apply their models in making predictions, solving problems, and generating explanations (White, 1993). The ThinkerTools environment was shown to be capable of changing students' views of aptitude for learning and understanding science (White & Frederiksen, 1998) and of enabling all students to improve their performance on various inquiry and physics measures (White & Frederiksen, 2000). It was also effective in reducing the performance gap between low and high achieving students (White & Frederiksen, 1998; 2000). Tabletop is a computer-based data analysis tool based on animated visual representations and enables students to solve real problems and to answer authentic questions (Hancock et al., 1992). Vignettes from clinical sessions of this study illustrated Tabletop stimulated students' interest and increased students' successful interactions with data creation and data analysis. Students became engaged in subtle and important questions in data design and data analysis and developed good discussions related to aggregate reasoning (Hancock et al., 1992). The GLOBE project (Global Learning and Observations to Benefit the Environment) is a worldwide, hands-on science program for primary and secondary school students. It creates a partnership between students, their teachers, and the scientific research community and introduces students to the process of doing real science and allows them to learn by doing (Rock et al., 1997). The students in the GLOBE project make scientific measurements in their local environments, report data through the Internet, publish and present their data on GLOBE, create visuals to present information and collaborate with peers and scientists. The Kids as Global Scientists (KGS) program uses communication features of the Internet to create a learning environment that enables students to solve real and complex problems associated with weather phenomena and supports reflective questioning, investigation, data collection, analysis, comparisons, predictions, and inquiry-based activities in which students act as reporters, participants, and providers and data and information (Songer, 1996). Findings indicated the effectiveness of authentic inquiry science (Lee & Songer, 2003) as well as significant content and inquiry gains (Songer, Lee, & Kam, 2002) associated with concepts in biodiversity and the design pattern, formulating scientific explanations from evidence (Songer & Wnek, 2003) and weather content knowledge (Mistler-Jackson & Songer, 2000). Results also showed a high positive attitude toward learning science (Kam & Songer, 1998; Mistler-Jackson & Songer, 2000). With regard to perception of difficulty of learning science, the results showed there was a statistically significant increase in the percentage of girls who perceived science as not difficult at all (Kam & Songer, 1998). In addition, a content analysis of the messages in the electronic discourse environment of the KGS program revealed that it enabled learners to build an electronic community of science learners and fostered student understanding through specific tasks, more student-student communication, socializations among participants, sharing personal experiences and scaffolding by experts (Lee & Songer, 1998). The CoVis (Learning Through Collaborative Visualization) project is founded on the premise that classroom science learning should resemble the open-ended, inquiry-based approach of science practice. The project enables teachers and students to learn science by doing in connection with communities of science and science educators (Gomez, Gordon, & Karlson, 1995). Computer-Supported Intentional Learning Environments (CSILE) are designed to support knowledge building in learning communities. Scarmadalia and Bereiter (1994) noted that CSILE was based on research on intentional learning, process aspects of expertise, and discourse in knowledge-building communities. It is also based on solving logistic problems that Scarmadalia and Bereiter thought have the greatest potential for educational technology. The Knowledge Integration Environment (KIE) is designed for using the Internet to enhance student understanding of science. It offers students science models that apply to problems they encounter in their everyday lives and engages them in personally relevant science projects (Linn et al., 1998). Linn et al., (1998) reported findings indicating significant gains in students' understanding of the nature of light, heat, and other scientific domains as well as in students' use of their new knowledge to interpret new problems. In addition to these technology examples, Edelson et al., (1999) targeted scientific visualization and developed visualization environments (The Climate Visualizer, The Radiation Budget Visualizer about global warning, The Greenhouse Effect Visualizer, and WorldWatcher) for the interpretation of relative weather data in order to support inquiry-based learning. The Inquiry Page is another web-based tool that provides its users a dynamic and flexible environment, which supports teaching and learning in diverse educational settings and facilitates real-world application of inquiry-based learning across subject areas. It engages learners in a learning cycle model based on Dewey's ideas and enables students to ask, investigate, create, discuss, and reflect (Bruce & Bishop, 2002; Comstock, Bruce, & Harnish, 2003). It is reported that the Inquiry Page tool was successful in fostering collaborative inquiry among students (Bruce & Bishop, 2002) and creating a community of learners including teachers and students in terms of inquiry learning (Benson & Bruce, 2001). Another web-based inquiry environment is called the Web-Based Inquiry Science Environment (WISE) where students design solutions to problems, generate predictions before conducting experiments, use scientific evidence to support theories or conclusions, debate contemporary science issues, and reconcile differences between new and prior science ideas (Williams et al., 2004). This free website is designed by the University of California at Berkeley. Some of the contemporary science issues studied on the website are earthquakes, malaria, genetically modifies foods, HIV, water quality and thermodynamics. A research study with 1100 sixth grade students indicated that WISE students were able to achieve a deeper understanding of the content knowledge and developed students’ model-based inquiry skills (Gobert, Slotta, Pallant, Nagy, & Targum, 2002).

Although there are numerous illustrations where technology have been created to assist the integration of science in classrooms to promote the goals of scientific inquiry, there is a need for instruments to assist science teachers and science educators to frame their work in using technology to promote the goals of scientific inquiry. Hence, this study will develop an instrument to begin providing this framework on which science teachers can base and evaluate their work.

Summary

The role of inquiry in science education has been strongly influenced by current reform reports or documents in the United States (Crawford, 1997; Flick, 1997; Abd-el-Khalick et al., 2004) such as the National Science Education Standards (NRC, 1996; 2000) and Benchmarks for Science Literacy (AAAS, 1993). In addition, the use of technological tools to enrich the learning and teaching of science and to support inquiry was recommended by National Science Teacher Association and outlined in National Educational Technology Standards of the International Society for Technology in Education (McNall, 2004). This review of the literature has attempted to establish a framework to develop an instrument that measures science teachers’ self-reported perceptions and uses of educational technologies to enact scientific inquiry in their classrooms. It was shown there is little research combining scientific inquiry and technology use by science teachers. This literature review indicates a need for more research into understanding teachers’ perceptions and uses of technological tools for science inquiry purposes.

CHAPTER 3
METHODOLOGY

This chapter provides an overview of the procedures that were used to conduct the study. It contains the research questions and a description of the participants, data collection, instrumentation, and data analysis techniques.

Introduction

This study is based on the premise that technology could enhance the quality of scientific inquiry-based instruction and attempts to answer the question of how science teachers use technology to attain the goals of scientific inquiry-based instruction. The instrument developed in this study can serve as a useful guide for science teachers in the integration of technology in scientific inquiry-based learning environments. For this purpose, the study investigated science teachers' self-reported perceptions about implementing scientific inquiry using technology and explored the degree to which they use technology for such a goal. This study also examined whether relationships existed, and the degree of these relationships, among a set of variables related to teachers' use of technology for inquiry purposes.

Research Questions

This study had two overarching research questions and five supporting questions. The main questions focused on how teachers use technology to implement the goals of scientific inquiry and the relationships between their self-reported perceptions and practices regarding this implementation. The supporting questions, however, articulated these relationships by addressing some teacher demographics and background/professional development variables as well as the level and frequency of their preparedness and use of certain inquiry tasks and technology tools. While the total scores obtained from the survey and the relationships between perception and practice items in the survey were utilized to help answer the overarching questions of the study, relationships obtained from supporting questions also contributed to answering these overarching questions. Through the creation of an instrument, the study addressed the following research questions:

Overarching Questions

1. How are teachers using technology to implement the goals of scientific inquiry in their classrooms?

2. What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry?

Supporting Questions

What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry in terms of:

- Teacher demographics and teacher background/professional development variables?
- How often do teachers support students to engage in certain inquiry skills in their science classrooms?
- How often do teachers use certain technology tools in their science classrooms?
- How prepared do teachers feel to support students to engage in certain inquiry skills in their science classrooms?
- How prepared do teachers feel to use certain technology tools in their science classrooms?

Technology in the SIT-TIPPS

In this study, technology referred to a range of devices and technological processes specifically used for teaching and learning purposes in K-12 settings. For the purposes of this study, the following devices, with examples, comprised the definition of technologies: Computers (desktop, laptop); presentation devices (such as video projectors, LCD panels); Smart Board/Promethean interactive boards; wireless communication devices (such as PDAs, student digital response systems); computer software (such as Word processors, desktop publishing, spreadsheets, presentation software, databases, simulations, educational games, graphing and data analysis software, video and picture editing software, etc.); graphing/scientific calculators;

Portable Global Positioning Systems (GPS); digital data collection devices (such as pH, pressure and temperature probes, digital microscopes, Navigator systems); videoconferencing, teleconferencing; Internet technologies (such as e-mail, websites, online databases, virtual field trips, online simulations and science games, Wikis, blogs, podcasts, videocasts, Google Earth and other Google tools, online learning communities); and data collection telecollaborative activities (such as Journey North, SCOPE, Amazing Space).

Data Collection

The researcher attempted to attract as many participants as possible to the study for a high turnout rate in order to run a successful factor analysis (at least ten times the number of items) and to have a representative sample. Because a random selection of participants is very difficult to achieve in such nationwide studies, the researcher attempted to reach as many science teachers as possible to have a wider representation from various states and social settings. For this purpose, middle and high school science teachers from various states in the U.S. were contacted by the following methods: (1) The researcher visited the official websites of public middle and high schools listed on the websites of Departments of Education in various states including Florida, Virginia, Kansas, Wisconsin, Connecticut, and Alabama and the city of San Diego. This method enabled the researcher to collect individual email addresses of over 4,000 science teachers. The selection criteria for these states were their geographical distributions in order to increase sample diversity. (2) The researcher contacted professional science teachers associations nationwide and statewide to have these organizations disseminate the invitational e-mail message to their members. This helped the researcher to reach an audience as representative as possible of the science teachers in the U.S. because, many of these statewide and nationwide organizations had access to teachers from different parts of the country. (3) Finally, the researcher also sent email messages to listservs (UFTScienceComm, middleschoolscience, HighSchoolScienceTeachers, science connection, astroed_news, and learningscienceconcepts) serving science teachers to which he had an online membership.

Data was collected online in the form of a web-based questionnaire (Appendix B). For this purpose, a professional web service, Survey Monkey, was used, which enabled the researcher to host the online survey, create email lists, collect data, and report basic statistics such as the number of responses for each individual item and frequencies. The researcher sent potential participants, directly or via listservs, an invitational e-mail message to inform them about the nature of the study and encourage their participation to complete the web-based questionnaire. The online version of the survey consisted of an interface including the IRB consent form (Appendix A), definition of technology, and the survey items. The participants were not able to access the survey unless they read the IRB consent form and agreed to participate in the study by clicking on the "Press here to start the Survey" button. An American Association for the Advancement of Science report titled *Ethical and legal aspects of human subject research on the Internet* (Frankel & Siang, 1999) and an American Psychological Association (APA) report titled *Psychological research online: Opportunities and challenges* (Kraut et al., 2003) recommended similar practices when getting informed consent from online participants.

Consent form informed all participants that participation in the study was voluntary, they had a right to withdraw from the study at any point without consequence, they may skip any question they did not wish to answer, and there were no anticipated risks, compensation, or other benefits for their participation in the study. It also provided information about how to contact the principal investigator, the supervisor, and the University of Florida Institutional Review Board (UF IRB) should they had any questions or concerns. Participants were encouraged to make a copy of the consent form for their own records as well as given the option to provide their email addresses if they want the researcher to send them a copy of it in an electronic format.

The online survey started with a question that asked whether a participant is a middle or high school science teacher in the U.S. This helped identify participants who were not among the target population of the study and thus, whose data was deleted from the data pool.

Over fifteen hundred people (1548) visited the link provided to them within the invitational email message. Of these visitors, 254 people (16.4%) responded “no” to the first question, which asked whether they are a middle or high school science teacher in the United States. Because these people were not among the targeted population, any data they provided was deleted from the database. On the other hand, 1294 people (83.6%) indicated that they were middle or high schools science teachers in the U.S. However, not all of these visitors were treated as participants. Although 715 of these science teachers (55.3%) provided valuable input and proceeded to the end of the survey, the rest of the visitors (517, 44.7%) did not submit any input and just seemed to explore the survey. These people either did not answer any of the survey items or responded to only a few questions in the beginning of the survey. Therefore, any visitor who did not answer any of the statements or responded to less than 40 statements (out of 120 statements plus demographics/teacher background questions) was neglected. Therefore, 715 science teachers comprised the sample of the study.

Instrumentation and Instrument Development Procedures

In the development of any instrument, the establishment of validity and reliability is crucial. Otherwise, the instrument will be ineffective. For this study, the researcher followed the guidelines set forth by Devellis (2003), Gable and Wolf (1993), and Mueller (1986) to establish validity and reliability for the SIT-TIPPS.

First, in order to achieve clarity (Devellis, 2003) in defining the construct this study intended to measure, the researcher made use of the extensive literature and theory related to the construct, established specificity, and was careful about what to include in the measure. This helped the researcher specify the goals of the instrument being developed (Mueller, 1986; Gable & Wolf, 1993; Devellis, 2003) and made sure the researcher had the same understanding of the instrument content as the respondents (Mueller, 1986). For this purpose, the researcher grounded the object of measurement in the substantive theories related to the phenomenon (Devellis, 2003). Therefore, in order to develop an instrument that measures science teachers' self-reported perceptions and uses of technology for scientific inquiry purposes, the researcher meshed the essential features of scientific inquiry described in the *National Science Education Standards* (NRC, 2000) with the extensive literature available on inquiry-based science instruction and the uses of technology in instruction (see Appendix C). This approach of following theoretically based conceptual definitions helped the researcher define appropriate operational definitions that lead to good content and construct validity of the measure (Gable & Wolf, 1993) as described in the sections that follow.

Specificity or generality of the construct is another factor contributing to the clarity of the construct being measured (Devellis, 2003). The SIT-TIPPS measured very specific behaviors regarding the use of technology for inquiry purposes in science classrooms. Moreover, the specified goals of the SIT-TIPPS were derived from theory and a well-done literature review guided the process of developing constructs that are distinct from other constructs and clearly written (see Appendix C).

Based on the purpose of the scale, the researcher constructed a large pool of behaviors (see Appendix C) that were later transformed into items and categorized under each of the five essential features of scientific inquiry described by the National Science Education Standards. These five features, which formed the basis for the development of the scale in this study, were meshed with technology related constructs and modified to reflect teacher perspective. For example, the first feature of scientific inquiry that reads “learner engages in scientifically oriented questions” were transformed into “teacher engages students in scientifically oriented questions.” Then, the researcher outlined specific behaviors based on the National Science Education Standards (2000) and the extensive literature review for each of the five teacher-oriented constructs. For instance, some of the behaviors identified for the first category were: “asking why and how questions”, “generating a need to know in students”, and “encouraging students to demand more knowledge.” Such behaviors then constituted the items of the scale. This process yielded a large item pool, which became candidates for eventual inclusion in the scale (Mueller, 1986; Devellis, 2003). All items making up the scale reflected the construct underlying them and were chosen cautiously to create a homogenous scale (Devellis, 2003).

This strategy is used to generate items in two different categories: Teacher perceptions and practices. Because another purpose of the study was to focus on teachers’ current practices of using technology for scientific inquiry purposes, as well as their self-reported perceptions of using technology for such purposes, the researcher created parallel items for both categories. For instance, one of the items in the first category (teacher engages students in scientifically oriented questions) took the form: “I integrate technology to enable students to conduct successful empirical investigations” in the “teacher practices” category, whereas in the “teacher perceptions” category it was expressed as “A science teacher should integrate technology to enable students to conduct successful empirical investigations.” The main objective for this strategy was to look at potential differences between teachers’ self-reported perceptions and actual practices regarding the use of technology for scientific inquiry purposes in their classrooms.

The internal consistency reliability of the scale is directly related to the number of items in a scale as well as how strongly the items correlate with one another, when all else is held equal (Mueller, 1986; Devellis, 2003). For this purpose, the researcher employed as large a pool of inquiry behaviors as possible and selected as many items as possible from this pool to have high internal consistency reliability. However, when determining the number of items in the scale, the researcher also took into consideration the suggestion that specific and tightly conceptualized objects can be measured by fewer items than the loosely defined and amorphous objects (Mueller, 1986). Therefore, the object of measurement in this study was kept specific and conceptualized according to a theoretical framework and the related literature.

In addition, during the construction of the items, the researcher attempted to avoid using items that are (a) ambiguous, (b) exceptionally lengthy, (c) difficult to read, (d) double-barreled (conveying two or more ideas), and (e) composed of multiple negatives (Devellis, 2003). In addition, the researcher also avoided the use of absolutes such as always and never. Feedback from the 6 content reviewers for the study (see page 65 for their credentials) was very useful at this process. In contrast to what Mueller (1986) suggested about using both positively and negatively worded items to prevent the problem of little variance in the scale, the researcher generated only positively worded items due to the length of the scale and to decrease the level of cognitive load for the participants. For the same reason, no additional items were included in the instrument to detect any flaws or problems influenced by other motivations or any measures of relevant constructs to contribute to the validity of the scale as suggested by Devellis (2003).

Likert scaling was used in the instrument because they are easy to construct, can be highly reliable, and have been successfully adapted to measure many different kinds of attitudes (Nunnaly, 1978). The statements in the scale were presented in a 5-point strongly agree/disagree format, because it is one of the most reliable one (Gable & Wolf, 1993, Mueller, 1986); yet these statements were fairly (though not extremely) strong to reflect true differences of opinion (Devellis, 2003). In addition to 5-point strongly agree/disagree format, the researcher also used a 4-point "not adequately prepared/very well prepared" format and a 5-point "never/almost all" type frequency format for Inquiry skills and technology tools sections of the survey (see survey in Appendix B). After a review of the items during the content-validity procedure, the scale was administered to a representative sample of more than 700 science teachers and item-analysis, alpha reliability, and factor analysis procedures followed to check for the validity and reliability of the scale being constructed.

Content Validation Process:

The next step in the instrument development procedure was to have the item pool reviewed by experts who are knowledgeable in inquiry-based science instruction and instructional technology. This validation strategy was utilized to maximize the content validity of the instrument by confirming or invalidating the definition of the constructs the study intended to measure as well as evaluating the items' clarity and conciseness (Devellis, 2003). For this purpose, the researcher contacted one expert on educational technology to provide insight into technology related aspects of the scale. Five other experts in science education, as well as in integrating technology into science classrooms, comprised the content validation team. The researcher provided the content validators with the working definitions of the constructs including what is meant by technology in the study, and then asked them to rate each item with respect to its relevance to the construct (1 being "completely irrelevant, 2 being "somewhat relevant", and 3 being "highly relevant") as it has been defined (Devellis, 2003) and with respect to its predetermined category of one of the five essential features of scientific inquiry used in this study. The content validators were also asked to indicate how certain they felt about their agreement of the item to the construct (1 being "completely unsure", 2 being "unsure", 3 being "pretty sure", and 4 being "very sure"). Each content validator, rated the 50 items in the scale and provided feedback on the contents of the "inquiry skills" and "technology tools" sections of the instrument.

The experts who participated in the content validation of the scale were:

- Dr. Collen Swain, Educational Technology, School of Teaching and Learning at the University of Florida (educational technology expert who provided feedback on technology related content)
- Dr. Tom Dana, Science Education, School of Teaching and Learning at the University of Florida (content validator)
- Dr. Rose Pringle, Science Education, School of Teaching and Learning at the University of Florida (content validator)
- Dr. Troy Sadler, Science Education, School of Teaching and Learning at the University of Florida (content validator)
- Dr. Karen Irving, Science Education, School of Teaching and Learning at the Ohio State University (content validator)
- Dr. Dina Mayne, South Effingham High School in Georgia, Chemistry Teacher (content validator).

Before administering the instrument to the study sample, the researcher calculated the percent agreement among the content validators on whether they agreed with the researcher-assigned categories to items as well as the average level of certainty and relevance across validators. Any item whose percent agreement was below 80 percent was deemed "problematic" and subjected to either revision or deletion. Whether it is more than 80 percent or not, an average certainty score of less than 3.0 (out of 4.0) and an average relevance score of less than 2.0 (out of

3.0) were selected as additional criteria to determine whether an item needed revision or deletion from the scale. Moreover, the content validators also provided feedback regarding the demographic information/teacher background segment and the “inquiry skills” and “technology tools” segments of the instrument that aimed to collect information on the extent science teachers use certain inquiry skills and technology tools in their classrooms as well as how well prepared they feel about these skills and technology tools. Based on the calculations, the researcher found out that 10 items (5 perception and 5 practice items that were parallel to each other) had percent agreement scores of less than 80 percent. Then, based on feedback from two experts, some of these items have been revised to fit into the category that is intended to represent the item and/or to make them more relevant, understandable, and concise. In addition, content validators’ written comments on some of the statements were also used to make such revisions. For instance, the item that read “I integrate technology to improve students’ abilities to describe scientific theories, rules, laws, and events” was revised into “I integrate technology to improve students’ skills to check their results against existing scientific knowledge.” No other item needed revision or deletion based solely on relevance and/or certainty level scores because of above cutoff scores (above 2.0 for relevance and above 3.0 for certainty categories).

After the content validation process was completed, the researcher designed the online version of the scale and then posted it. The 715 science teachers completed the survey, which was as large enough to eliminate subject variance (Devellis, 2003) and to successfully run the item-analysis, reliability, correlation, and factor analysis procedures (Gable & Wolf, 1993). This is in concert with the criteria that suggested having 6-10 times as many people as there are statements on the instrument (Gable & Wolf, 1993) or at least five subjects per item (Nunnaly, 1978) as the minimum number of items that can be tolerated.

Once the scale was administered to a large and representative sample, the researcher tested the performance of items to identify effective functioning. The analysis of the set of items at this step was (a) factor analysis: to determine the number of latent variables underlying an item set and explain the variation among the items (Devellis, 2003; Gable & Wolf, 1993), (b) item analysis: to generate response frequencies, percentages, means, and standard deviations as well as to identify items to delete from the instrument, and (c) reliability analysis: to indicate the scale's quality.

A detailed dissemination of the results of these analyses is presented in Chapter 4. As a summary, the factor analysis results supported a two-factor solution: teachers' practices of scientific inquiry using technology and their perceptions of such use. In addition, results provided support for construct validity of the instrument. The Cronbach's alpha reliability value of .980 for the overall scale (.976 for perceptions factor and .974 for practices factor) indicated high internal consistency reliability.

Statistical Techniques Used to Answer Study Research Questions

The researcher made use of a variety of statistical methods to answer the overarching and the supporting questions. Before beginning to answer the research questions, the reliability and item analysis and exploratory and confirmatory factor analyses were used to determine the reliability and validity of the SIT-TIPPS instrument. This process was essential in answering the research questions as all of the overarching and supporting questions depended on the quality of the scale. The data obtained through teachers' self-reported responses to the components of the SIT-TIPPS instrument were then analyzed using a variety of statistical methods to answer the study research questions. The additional methods used were descriptive statistics (e.g., frequencies), correlations, multiple regressions, t-tests, and ANOVAs. Interpretations from all of these methods contributed to the explanation of the first overarching question. For the second overarching question, the correlations between the 25 items constituting the teachers' self-reported perceptions factor and the 25 items constituting the teachers' self-reported practices factor were calculated. Multiple regression method was also used to answer this question because models indicated that these two factors were dependent on each other. To investigate the effect of teacher demographics and teacher background/teacher professional development variables on teachers' perceptions and practices for using technology to enact scientific inquiry, descriptive statistics, multiple regression, correlations, t-tests, and ANOVAs were used. For example, in order to explore the relationship between gender and teachers' classroom practices, the researcher calculated the correlation between the two variables and a t-test was conducted. In addition, gender was used as an exploratory variable in a multiple regression model where the teacher practices factor was used a dependent variable. The last four supporting research questions were represented in the SIT-TIPPS with certain number of items (see Appendix B). Nine items were used to measure how well prepared teachers' felt to support students to engage in certain inquiry skills and how often they use these inquiry skills in their classrooms. Twenty-six items were employed to answer how well prepared teachers' felt to use certain technology tools/applications and how often they used these tools in their classrooms. In order to answer these four supporting questions, the researcher used frequency reports, correlations, and multiple regression models.

According to the criteria set forth by Cohen (1988) for psychological research, a correlation coefficient ranging between .10 and .30 was considered small; values between .30 and .50 were considered medium; and values between .50 and 1.0 were considered large. In this study, this criterion was used as a guideline to interpret the correlation coefficients.

Item Analysis and Reliability

The Scientific Inquiry with Technology-Teacher Perceptions and Practices (SIT-TPPS) Scale developed as part of this study demonstrated high internal consistency (see Table 3-1). The overall reliability of the scale (including 50 items dealing with perceptions and practices) was .980. Internal consistency reliabilities for its components were .976 (Teachers' Perceptions), .974 (Teachers' Practices), .924 (level of inquiry skills), .886 (frequency of use of inquiry skills), .932 (level of use of technology tools), and .915 (frequency of use of technology tools).

Table 3-2 reports item analysis results for each individual item including 50 items that measures teachers' self-reported perceptions and practices of using technology to attain the goals of scientific inquiry in science classrooms. The statistics show that no item should be deleted and all of the items contributed well to the reliability of the scale.

Factor Analyses

Sample Size

Factor analytic research requires large samples (Guadagnoli & Velicer, 1988) and the number of subjects needed to undertake a factor analysis of an instrument depends on the number of items that are initially included in the instrument. There is, however, very little agreement among the researchers regarding sample size in factor analysis (Pett, et al., 2003). In deciding how many subjects to be used in this study, the researcher relied on a rule of thumb, called the subjects-to-variables (STV) ratio (Bryant & Yarnold, 1995, p. 100). Bryant and Yarnold (1995, p. 100) and Nunnally (1978) explained that for the results to be reliable and to replicate if the analysis is repeated using an independent sample, the minimum number of observations in one's sample should be at least five times the number of variables. Other researchers suggested more conservative numbers (Gable & Wolf, 1993; Pett, Lackey, & Sullivan, 2003, p.148). Some researchers suggested rules in terms of the number of subjects required. According to Comrey and Lee (1992, p.217), 300 subjects were accepted as “good” and 500 subjects as “very good.” Tabachnick and Fidell (2001, p. 588), on the other hand, recommended at least 300 cases for factor analysis. Based on these criteria, the researcher administered the instrument resulting in data from 715 science teachers. Because the STV ratio is 715/50, or 14.3, the sample size was sufficiently large by the reliability criterion (Bryant & Yarnold, 1995, p.100).

The researcher was also careful about the nature of the sample selected. Although selection of the science teachers for the study was mainly based on convenience, this practice is not deemed problematic (Fabrigar, Wegener, MacCallum, & Strahan, 1999) unless the sample is overly homogeneous and its selection is related to measured variables (Fabrigar et al., 1999). Such a practice was reported to result in low estimates of factor loadings and correlations among factors (Comrey & Lee, 1992). To prevent this from happening, the researcher collected over 5,000 email addresses from various states, contacted over 40 national science teachers associations and joined listservs in order to get a sample as large and representative as possible.

Exploratory Factor Analysis

This section describes the objective for selecting the preferred method of extraction and rotation for factor analysis.

In this study, principal factor analysis (PFA) method was preferred to the commonly used principal components analysis as suggested by Costelllo and Osborne (2005). PCA is only a data reduction method (Costelllo & Osborne, 2005) and does not differentiate between common and unique variance as factor analysis does (Fabrigar et al., 1999). It was suggested that when the purpose of the study is to identify latent variables which are contributing to the common variance in a set of measured variables, PFA is the preferred method of extraction (Fabrigar et al., 1999). Fabrigar et al., (1999) suggested although principal components with varimax rotation and the

Kaiser criterion are the norm, they are not optimal, particularly when data do not meet assumptions, as is often the case in the social sciences. Based on an analysis of the related literature, Fabrigar et al., (1999) favored the use of a true factor analysis extraction method (they preferred maximum likelihood), oblique rotation (such as direct oblimin), and use of scree plots plus multiple test runs to determine the number of meaningful factors in a data set in order to get optimal results (i.e., results that will generalize to other samples and that reflect the nature of the population).

In this study, principal axis factoring method was preferred to maximum likelihood (ML), as one of ML's assumptions is multivariate normality (Fabrigar et al., 1999). A preliminary analysis of the data in this study did not indicate normally distributed data. Therefore, principal factors methods were preferred as they did not require any distributional assumptions (Fabrigar et al., 1999).

As for the method to identify how many factors to retain, the researcher used the Kaiser criterion of eigenvalues of greater than 1.0 (Fabrigar et al., 1999; Pett et al., 2003) and parallel analysis (Fabrigar et al., 1999).

As for the rotation method, oblique rotation method was preferred over orthogonal solutions because the latent variables in the study demonstrated evidence of correlation with each other (see Table 3-10 & Table 3-15). Oblique methods allow the factors to correlate (Costelllo & Osborne, 2005) and produce a better estimate of the true factors and a better simple structure than will an orthogonal rotation (Fabrigar et al., 1999). Promax rotation method was chosen to achieve this objective.

In addition to using principal axis factoring with promax rotation, the researcher made use of additional statistics provided in SPSS software to identify any severe multicollinearity (an assumption of factor analysis) and to determine whether data is appropriate for undertaking an exploratory factor analysis. Although mild multicollinearity is not a problem for factor analysis (Field, 2005), the determinant, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test of sphericity were also used to understand whether the data were appropriate to run exploratory factor analysis in the first place.

Table 3-5 presents the KMO measure of sampling adequacy and Barlett's test of sphericity. The value for KMO was .975 and significance level for Barlett's test of sphericity was .000 (<.001). It was suggested in the literature that with a KMO value over .5 and a significant value for Barlett's test ascertain that it would be judicious to proceed with factor analysis (Pett et al., 2003, p.78). All three statistics suggested that the sample size was sufficient relative to the number of items in the scale and the correlations among the individual items were strong enough to suggest that the correlation matrix was factorable (Pett et al., 2003, p.78).

After this step, the researcher ran parallel analysis to get a better sense of how many factors to extract from the factor analysis. As shown in Table 3-3, the results suggested a 6-factor model. However, a principal axis factoring method with promax rotation in SPSS extracted 5 factors. Because the scale developed in this study was based on a 5-category model (based on literature review and National Science Education Standards, 2000), the researcher decided to go with the 5-factor model. However, a preliminary evaluation of this model based on communalities, total variance explained, pattern matrix, and structure matrix (Tables 3-6 through 3-9, respectively) did not produce interpretable factors considering the nature of the items in the scale. Communalities of items ranged from .604 to .766, suggesting that a high percentage of variance in a given item was explained by all five factors. Moreover, Table 3-7 illustrated that the five factors extracted were able to explain 69.4% of the variance. As shown in pattern (Table

3-8) and structure matrices (Table 3-9), 19 items loaded on the first item and 22 items loaded on the second item. Only 9 items loaded on two other factors (6 on factor 3; 3 on factor 4). None of the items loaded on the fifth factor. Because the items were originally constructed based on five essential features of scientific inquiry proposed by the National Science Education Standards (2000), as illustrated in Table 3-4, the researcher concluded that a five factor solution was not statistically supported by the data and that the five essential features of scientific inquiry outlined in the National Science Education Standards was indeed a conceptual categorization rather than a data-driven theoretical one.

Therefore the researcher ran a two-factor model using principal axis method with promax rotation considering the fact that the items in the scale were constructed in terms of teacher perceptions and practices (see Table 3-4 for the breakdown of items into these two categories). That is, statements starting with “I integrate” constituted the “practices” items, whereas statements starting with “A science teacher” constituted the “perceptions items.

A new factor analysis that was limited to a two-factor extraction (see Table 3-10 through Table 3-15) was able to separate items measuring perceptions from items measuring practices. The correlation between the two factors was .629 (Table 3-15) and this two-factor solution was able to explain 61% of the total variation (Table 3-12). Communalities of individual items ranged between .368 and .752 (Table 3-11). Although some of these communalities seemed lower than the ones produced in the five-factor model, they were kept due to these items’ high values of interpretability and their contributions to a well-defined factor (either teacher perceptions or teacher practices). A careful evaluation of values reported both in the pattern and the structure matrices together demonstrated a perfect distribution of items into categories coded as teacher perceptions and teacher practices are outlined in Table 3-4.

Hence, this study and the SIT-TIPPS instrument support 2 factors – perceptions and practices. During the instrument development process, the researcher found that although National Research Council (1996) reports 5 psychological factors in the attainments of teaching scientific inquiry in the National Science Education Standards, these five factors are not statistical factors. Models showed that creating the SIT-TIPPS with two factors, perceptions and practices, created a better model for measuring teachers' self-reported perceptions and practices regarding the use of technology to enact scientific inquiry.

Multiple Regression

A multiple regression analysis was conducted to examine the degree of association between various outcome variables and exploratory variables. Four regression models were tested using the stepwise regression method with SPSS 13.0. For the first two models, the outcome variables were the teachers' perceptions and practices regarding the use of technology for scientific inquiry purposes. The exploratory variables for these models were the level of preparedness for using inquiry skills; the frequency of using inquiry skills in instruction; the level of preparedness for using technology tools; the frequency of using technology tools in instruction; gender; race/ethnicity; years of teaching experience; number of grades taught; the level of grades taught (high numbers meaning that a particular teacher taught higher grades ranging from 6th grade to 12th grade and higher); number of science courses taught; number of computers in class; the presence of a computer lab; number of computers in computer lab; number of science labs; the presence of a science lab in classroom; and previous educational technology training.

The other two regression equations tested smaller models in which two of the exploratory variables in the previous two models (the frequency of using inquiry skills in instruction and the frequency of using technology tools in instruction) served as outcome variables separately in one of the two models. These models, then, investigated the influence of some of the exploratory variables (included in the first two models) on both of these two outcome variables separately.

Overall, no multicollinearity problem was observed among the variables because the variance inflation factor (VIF) values in all six models was less than 2.0, which indicated that collinearity was not a problem (Miles & Shevlin, 2001).

The first regression model consisted of 16 exploratory variables and the outcome variable: “Teachers’ self-reported perceptions regarding the use of technology for scientific inquiry purposes.” Table 3-16 indicates the unstandardized regression coefficients (*b*), the standardized regression coefficients (β), the observed t-values (*t*), and the p-values (*p*).

The second regression model consisted of 16 exploratory variables and the outcome variable: “Teachers’ practices regarding the use of technology for scientific inquiry purposes.” Table 3-17 reports the unstandardized regression coefficients (*b*), the standardized regression coefficients (β), the observed t-values (*t*), and the p-values (*p*) for the model.

The third regression model consisted of 5 exploratory variables (the level of preparedness for using inquiry skills, years of experience, total number of grades taught, the level of grades taught, and the number of science courses taught) and the outcome variable: “Frequency of using scientific inquiry skills in instruction.” Table 3-18 reports the unstandardized regression coefficients (*b*), the standardized regression coefficients (β), the observed t-values (*t*), and the p-values (*p*) for this model.

The fourth regression model consisted of 8 exploratory variables (the level of preparedness for using technology tools, years of experience, total number of grades taught, the level of grades taught, and the number of science courses taught, the number of computers in classroom, the number of computers in computer lab, and previous educational technology training) and the outcome variable: “Frequency of using technology tools in instruction.” Table 3-19 reports the unstandardized regression coefficients (*b*), the standardized regression coefficients (β), the observed t-values (*t*), and the p-values (*p*) for this model.

Summary

Chapter 3 described the methods used to develop the SIT-TIPPS instrument as well as to investigate the research questions of the study. The results of these analyses are described in Chapter 4.

Table 3-1. Descriptive statistics and reliability index of the SIT-TIPPS instrument

Components	N	Minimum	Maximum	Mean	Std. Dev.	Reliability
Perceptions	588	25	125	106.1	15.0	.976
Practices	595	25	125	98.5	17.7	.974
Inquiry skills-Level	616	9	36	29.4	5.4	.924
Inquiry skills-Frequency	606	9	45	32.5	5.8	.886
Technology tools-Level	562	26	104	72.1	15.3	.932
Technology tools-Frequency	530	29	130	63.5	16.3	.915
Overall (Perceptions & Practices items)						.980

Table 3-2. Item analysis results

Item Number	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	200.82	823.47	.627	.980
2	200.39	829.42	.603	.980
3	200.48	825.74	.637	.980
4	200.68	823.87	.592	.980
5	200.87	819.95	.639	.980
6	200.70	822.94	.684	.980
7	200.76	821.06	.684	.980
8	200.43	828.29	.583	.980
9	200.94	815.90	.718	.980
10	200.93	815.82	.735	.979
11	200.85	818.44	.744	.979
12	200.62	822.11	.747	.979
13	200.39	829.07	.637	.980
14	200.86	818.36	.745	.979
15	200.91	815.48	.710	.980
16	200.39	829.31	.618	.980
17	201.37	815.46	.648	.980
18	201.18	814.88	.665	.980
19	201.01	815.69	.733	.979
20	200.66	823.73	.675	.980
21	200.52	825.24	.719	.980
22	201.16	816.30	.689	.980
23	200.62	822.70	.727	.980
24	200.86	817.21	.710	.980
25	201.21	814.29	.699	.980
26	200.70	820.51	.680	.980
27	200.65	823.23	.642	.980
28	200.75	817.35	.743	.979
29	200.45	825.35	.688	.980
30	200.66	820.98	.731	.980
31	201.01	815.60	.757	.979
32	200.62	822.74	.739	.980
33	200.68	821.85	.645	.980
34	200.67	820.54	.753	.979
35	200.70	820.12	.756	.979
36	200.66	820.26	.746	.979
37	200.94	812.66	.798	.979
38	200.73	821.28	.651	.980
39	200.66	820.33	.753	.979
40	200.63	823.40	.708	.980
41	200.75	818.76	.659	.980

Table 3-2. Continued.

42	200.88	820.53	.679	.980
43	200.75	820.96	.715	.980
44	200.71	818.37	.753	.979
45	200.99	814.85	.724	.980
46	200.85	815.38	.752	.979
47	200.76	819.81	.713	.980
48	200.91	814.19	.777	.979
49	200.64	822.03	.719	.980
50	200.78	818.75	.726	.980

Table 3-3. Parallel analysis: PAF/common factor analysis & random normal data generation (N=557, Nvariables=50)

Root	Raw Data	Means	Percentile
1.000000	25.372641	.731735	.799033
2.000000	5.327737	.662761	.702616
3.000000	1.960368	.614535	.656174
4.000000	1.419856	.576870	.618403
5.000000	.827231	.537975	.572217
6.000000	.628507	.506394	.540146
7.000000	.462105	.475422	.507302
8.000000	.428912	.444682	.480694
9.000000	.381882	.415302	.441793

Table 3-4. Breakdown of 50 items into categories and related factors

Category	Perception factor	Practice factor
Teacher engages students in scientifically oriented questions	3, 21, 26,29,30	1, 4, 5, 28, 46
Teacher encourages students to give priority to evidence	2, 8, 13, 16, 44	19, 27, 33, 38, 41
Teacher helps students formulate explanations from evidence to address scientifically oriented questions	12, 20, 32, 35, 36, 40, 49	7, 10, 11, 15, 24, 37, 45
Teacher helps students connect explanations to scientific knowledge	23, 34, 39, 50	9, 14, 25, 48
Teacher encourages students to communicate and justify their proposed explanations	6, 42, 43, 47	17, 18, 22, 31

Table 3-5. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.975
Bartlett's Test of Sphericity	Approx. Chi-Square	28979.831
	df	1225
	Sig.	.000

Table 3-6. Communalities

Item number	Initial	Extraction
1	.651	.604
2	.725	.705
3	.772	.775
4	.683	.666
5	.671	.615
6	.682	.650
7	.702	.696
8	.713	.631
9	.750	.708
10	.747	.700
11	.719	.649
12	.767	.702
13	.720	.665
14	.709	.655
15	.706	.620
16	.708	.683
17	.667	.647
18	.696	.612
19	.747	.673
20	.659	.632
21	.751	.742
22	.686	.608
23	.732	.660
24	.713	.662
25	.677	.625
26	.701	.655
27	.684	.636
28	.748	.723
29	.715	.684
30	.741	.708
31	.783	.720
32	.777	.749
33	.772	.760
34	.801	.759
35	.805	.763
36	.821	.763
37	.806	.766
38	.762	.700
39	.818	.756
40	.762	.674
41	.764	.716
42	.775	.736
43	.821	.749

Table 3-6. Continued.

44	.807	.753
45	.699	.644
46	.794	.740
47	.799	.751
48	.773	.747
49	.805	.750
50	.757	.713

Extraction method: Principal Axis Factoring.

Table 3-7. Total variance explained: PAF with promax rotation

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	25.627	51.254	51.254	25.325	50.651	50.651	20.559
2	5.579	11.157	62.412	5.280	10.559	61.210	20.207
3	2.236	4.472	66.884	1.921	3.842	65.052	13.474
4	1.688	3.377	70.261	1.386	2.773	67.825	7.593
5	1.108	2.216	72.476	.786	1.571	69.397	.846
6	.894	1.789	74.265				
7	.727	1.453	75.718				
8	.685	1.369	77.088				
9	.646	1.293	78.381				
10	.571	1.143	79.523				

Extraction method: Principal Axis Factoring. [a] When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 3-8. Pattern matrix

Item number	Factor 1	2	3	4	5
1	-.150	.392	.568	.027	-.028
2	.221	-.207	.713	.207	.085
3	.274	-.213	.768	.121	.063
4	-.162	.322	.698	-.084	.188
5	-.222	.505	.359	.279	-.080
6	.428	-.059	.451	.127	-.108
7	-.022	.380	.617	-.128	.087
8	.123	-.074	.446	.483	-.056
9	-.059	.593	.409	-.072	-.125
10	-.051	.625	.335	-.002	-.123
11	.031	.698	.117	.049	.009
12	.673	.033	.078	.197	-.045
13	.324	.033	.091	.556	.078
14	.037	.694	.074	.107	.093
15	.059	.743	.034	-.029	.040
16	.332	.005	.055	.607	.011
17	.112	.736	-.037	-.119	-.286
18	.151	.714	-.018	-.147	-.185
19	.061	.797	-.053	.044	-.049
20	.688	-.010	.028	.178	-.133
21	.596	.034	-.037	.437	-.015
22	.150	.751	-.086	-.071	-.089
23	.703	.038	.067	.108	.019
24	.084	.723	.058	-.077	.227
25	.180	.687	.061	-.198	-.062
26	.780	-.049	.064	.045	.068
27	-.037	.671	.135	-.024	.338
28	.117	.651	.132	-.047	.323
29	.667	-.022	.126	.107	.292
30	.635	.079	-.047	.330	-.066
31	.125	.828	-.074	-.042	.002
32	.835	.003	.054	-.013	.099
33	-.246	.824	-.092	.408	.057
34	.820	.019	.095	-.040	-.011
35	.844	.057	-.003	-.004	-.004
36	.836	.021	-.039	.106	.053
37	.145	.791	-.107	.114	.100
38	-.190	.788	-.069	.352	.074
39	.819	.024	-.006	.094	.016
40	.797	.034	.016	-.011	.059
41	-.180	.806	-.098	.361	.032
42	.839	.084	-.098	-.054	-.242

Table 3-8. Continued.

43	.865	.029	-.028	-.037	-.122
44	.824	.075	-.028	.031	-.058
45	.097	.755	-.087	.088	-.090
46	.040	.830	-.131	.169	.077
47	.901	.034	-.060	-.065	-.011
48	.181	.777	.000	-.121	.146
49	.842	.015	.018	-.036	.202
50	.820	.172	-.087	-.115	.104

Extraction method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
Rotation converged in 7 iterations.

Table 3-9. Structure matrix

Item number	Factor 1	2	3	4	5
1	.387	.632	.714	.282	-.053
2	.570	.376	.781	.463	.055
3	.618	.402	.835	.412	.021
4	.360	.591	.750	.204	.146
5	.361	.671	.612	.471	-.069
6	.691	.467	.699	.409	-.134
7	.474	.667	.768	.198	.043
8	.510	.398	.634	.647	-.045
9	.467	.762	.688	.223	-.150
10	.479	.780	.658	.282	-.137
11	.499	.796	.534	.328	.010
12	.810	.513	.530	.486	-.048
13	.601	.445	.463	.727	.113
14	.500	.791	.507	.380	.101
15	.476	.784	.464	.251	.039
16	.596	.418	.437	.754	.051
17	.460	.737	.407	.127	-.292
18	.485	.739	.421	.123	-.196
19	.491	.816	.437	.307	-.039
20	.768	.444	.462	.434	-.135
21	.761	.487	.450	.661	.011
22	.495	.763	.392	.197	-.088
23	.801	.499	.504	.411	.009
24	.481	.778	.464	.230	.219
25	.520	.755	.477	.110	-.082
26	.803	.433	.472	.352	.050
27	.391	.719	.457	.254	.333
28	.524	.775	.521	.281	.313
29	.758	.454	.495	.420	.278
30	.780	.512	.454	.576	-.050
31	.527	.842	.436	.252	.005
32	.859	.492	.500	.331	.076
33	.314	.771	.359	.559	.108
34	.867	.512	.539	.307	-.039
35	.872	.521	.486	.334	-.023
36	.865	.497	.458	.422	.045
37	.566	.851	.440	.401	.117
38	.340	.760	.373	.521	.117
39	.864	.505	.483	.412	.006
40	.818	.480	.461	.313	.039
41	.350	.771	.366	.527	.077
42	.817	.475	.401	.240	-.260

Table 3-9. Continued.

43	.855	.480	.454	.282	-.144
44	.863	.525	.475	.354	-.073
45	.503	.788	.416	.335	-.075
46	.491	.836	.399	.420	.103
47	.863	.478	.428	.268	-.033
48	.562	.838	.479	.214	.136
49	.842	.480	.461	.312	.179
50	.822	.541	.410	.233	.082

Extraction method: Principal Axis Factoring.
Rotation method: Promax with Kaiser Normalization.

Table 3-10. Factor correlation matrix

Factor	1	2	3	4	5
1	1.000	.554	.544	.380	-.023
2	.554	1.000	.552	.327	.006
3	.544	.552	1.000	.327	-.058
4	.380	.327	.327	1.000	.085
5	-.023	.006	-.058	.085	1.000

Extraction method: Principal Axis Factoring.
Rotation method: Promax with Kaiser Normalization.

Table 3-11. Communalities

Item number	Initial	Extraction
1	.651	.456
2	.725	.412
3	.772	.464
4	.683	.412
5	.671	.504
6	.682	.541
7	.702	.511
8	.713	.368
9	.750	.608
10	.747	.638
11	.719	.652
12	.767	.694
13	.720	.456
14	.709	.651
15	.706	.612
16	.708	.441
17	.667	.494
18	.696	.508
19	.747	.651
20	.659	.609
21	.751	.639
22	.686	.551
23	.732	.663
24	.713	.607
25	.677	.550
26	.701	.651
27	.684	.537
28	.748	.628
29	.715	.600
30	.741	.653
31	.783	.684
32	.777	.730
33	.772	.621
34	.801	.741
35	.805	.746
36	.821	.752
37	.806	.726
38	.762	.600
39	.818	.752
40	.762	.659
41	.764	.611
42	.775	.620
43	.821	.701

Table 3-11. Continued.

44	.807	.734
45	.699	.608
46	.794	.691
47	.799	.707
48	.773	.692
49	.805	.692
50	.757	.638

Extraction method: Principal Axis Factoring.

Table 3-12. Total variance explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	25.627	51.254	51.254	25.250	50.500	50.500	21.826
2	5.579	11.157	62.412	5.213	10.425	60.925	21.234
3	2.236	4.472	66.884				
4	1.688	3.377	70.261				
5	1.108	2.216	72.476				
6	.894	1.789	74.265				
7	.727	1.453	75.718				
8	.685	1.369	77.088				
9	.646	1.293	78.381				

Extraction method: Principal Axis Factoring. [a] When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 3-13. Pattern matrix

	Factor[a]	
Item number	1	2
1	.047	.644
2	.563	.116
3	.603	.115
4	.035	.619
5	-.008	.715
6	.661	.111
7	.131	.625
8	.478	.178
9	.036	.756
10	.040	.773
11	.051	.774
12	.805	.045
13	.572	.148
14	.061	.767
15	.015	.772
16	.591	.109
17	.033	.681
18	.064	.671
19	.017	.796
20	.800	-.031
21	.768	.049
22	.059	.704
23	.793	.032
24	.024	.764
25	.096	.678
26	.849	-.070
27	-.051	.764
28	.099	.727
29	.759	.024
30	.766	.064
31	.038	.803
32	.873	-.030
33	-.168	.883
34	.867	-.009
35	.868	-.007
36	.890	-.037
37	.105	.782
38	-.126	.848
39	.882	-.023
40	.821	-.015
41	-.121	.852
42	.810	-.038

Table 3-13. Continued.

43	.873	-.059
44	.854	.004
45	.065	.738
46	.010	.825
47	.881	-.066
48	.088	.774
49	.849	-.027
50	.751	.072

Extraction method: Principal Axis Factoring.
Rotation method: Promax with Kaiser Normalization. [a] Rotation converged in 3 iterations.

Table 3-14. Structure matrix

Item number	Factor 1	Factor 2
1	.453	.674
2	.636	.470
3	.675	.494
4	.424	.641
5	.442	.710
6	.731	.527
7	.524	.708
8	.590	.479
9	.512	.779
10	.526	.798
11	.538	.807
12	.833	.551
13	.665	.508
14	.544	.806
15	.501	.782
16	.659	.480
17	.462	.702
18	.486	.711
19	.518	.807
20	.780	.472
21	.799	.532
22	.501	.741
23	.814	.531
24	.505	.779
25	.522	.738
26	.805	.464
27	.429	.731
28	.556	.789
29	.774	.501
30	.807	.546
31	.543	.826
32	.854	.519
33	.388	.777
34	.861	.536
35	.864	.540
36	.867	.523
37	.597	.848
38	.407	.768
39	.867	.532
40	.812	.501
41	.415	.776
42	.787	.472

Table 3-14. Continued.

43	.836	.490
44	.856	.541
45	.529	.778
46	.529	.831
47	.839	.488
48	.575	.829
49	.831	.507
50	.796	.545

Extraction method: Principal Axis Factoring.
Rotation method: Promax with Kaiser Normalization.

Table 3-15. Factor correlation matrix

Factor	1	2
1	1.000	.629
2	.629	1.000

Extraction method: Principal Axis Factoring.
Rotation method: Promax with Kaiser Normalization

Table 3-16. Regression analysis summary for teachers' perceptions factor

Variable	b	β	t-values	p-values
Constant	73.43		14.57	.000*
Inquiry skills-frequency	.619	.232	4.15	.000*
Technology tools-level	.181	.180	3.22	.001*

Note. R^2 = .119 (n = 514, p = .000)
*p< .05.

Table 3-17. Regression analysis summary for teachers' practices factor

Variable	b	β	t-values	p-values
Constant	38.97		7.86	.000*
Inquiry skills-frequency	1.202	.401	7.99	.000*
Technology tools-level	.171	.151	2.58	.010*
Technology tools-frequency	.155	.150	2.54	.012*

Note. R^2 = .331 (n = 462, p = .000)
*p< .05.

Table 3-18. Regression analysis summary for frequency of using inquiry skills

Variable	b	β	t-values	p-values
Constant	16.70		14.25	.000*
Inquiry skills-level	.532	.502	13.62	.000*

Note. R^2 = .252 (n = 553, p = .000)
*p< .05.

Table 3-19. Regression analysis summary for frequency of using technology tools

Variable	b	β	t-values	p-values
Constant	1.09		.339	.735
Technology tools-level	.681	.630	17.50	.000*
Years of experience	.261	.153	4.28	.000*
Previous ed tech training	2.33	.151	4.21	.000*
Number of computers in classroom	.232	.104	2.99	.003*
Number of computers in computer lab	.117	.103	2.95	.003*

Note. R^2 = .499 (n = 428, p = .000)
*p< .05.

CHAPTER 4
PRESENTATION AND ANALYSIS OF DATA

This study developed an instrument, the SIT-TIPPS, that examined middle and high school science teachers' self-reported perceptions and practices of using technology for scientific inquiry purposes in their classrooms. After a review of the relevant literature, specific variables were identified to construct the survey and included in the analysis to answer the research questions. These variables included teachers' self-reported perceptions and practices of using technology to attain the goals of scientific inquiry, level and frequency of integrating certain inquiry skills and technology tools in science classrooms, gender, race/ethnicity, years of teaching experience, grades taught, science courses taught, access to computers, computer labs, and science labs, and time period in which educational technology courses had been taken. This chapter will present the analysis of data used to answer the study research questions.

Study Research Questions

Overarching Questions

1. How are teachers using technology to implement the goals of scientific inquiry in their classrooms?

2. What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry?

Supporting Questions

What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry in terms of:

- Teacher demographics and teacher background/professional development variables?

- How often do teachers support students to engage in certain inquiry skills in their science classrooms?

- How often do teachers use certain technology tools in their science classrooms?

- How prepared do teachers feel to support students to engage in certain inquiry skills in their science classrooms?
- How prepared do teachers feel to use certain technology tools in their science classrooms?

Demographic Reporting of the Sample

In order to provide a thorough description of the middle and high school teachers and the context in which they teach, the demographic responses for study data will be presented.

Demographic Characteristics

As noted in chapter 3, a total of 715 science teachers' self-reported responses comprised the data for this study. Of the 598 respondents (83.6%) who reported their gender, 207 (34.6%) were males and 391 (65.4%) were females (Table 4-1). Of the 590 participants (82.5%) who reported their racial/ethnic identity, 479 (81.2%) were White, 34 (5.8%) were Black, 27 (4.6%) were Multiracial, 26 (4.4%) were Hispanic, 20 (3.4%) were Asian, and 4 (.7%) were American Indian (Table 4-2).

Virginia and Florida were the two states with the highest number of participants (Table 4-3). One hundred and sixty five (27.5%) participants were from Virginia and 156 were from Florida (26%). The third highest participation was from Kansas with 50 participants (8.3%).

Teaching Experience

The survey included open-ended statements to collect pertinent information from science teachers regarding their years of science teaching experience (Table 4-4), grade levels (Table 4-5) and science courses (Table 4-6) taught, and certification areas. Because the range of responses science teachers provided on their certification areas was very wide, it is not reported by category. Therefore, the researcher made the assumption the information provided about the science courses taught was an indication of areas in which they were certified.

The number of years served (Table 4-4) as a science teacher ranged from 0 to 44 years with a mean of 13.5 years (n=583). Of the 583 teachers who responded, 244 (41.9%) fell in the 1 to 9-year range; 187 (32.1%) fell in the 10 to 19-year range; 99 (17.0%) fell in the 20 to 29-year range; 49 (8.4%) fell in the 30 to 39-year range; and 4 (.7%) fell in the 40 to 44-year range.

Results indicated that 171 teachers (23.9%) taught grade 6; 238 (33.3%) taught grade 7; 252 (35.2%) taught grade 8; 345 (48.3%) taught grade 9; 360 (50.3%) taught grade 10; 378 (52.9%) taught grade 11; 371 (51.9%) taught grade 12; and 130 (18.2%) taught grades over 12 (Table 4-5). Seventy-one teachers (9.9%) taught only one grade level; 82 (11.5%) taught two grade levels; 124 (17.3%) taught three grade levels; 149 (20.8%) taught four grade levels; 79 (11.0%) taught five grade levels; 39 (5.5%) taught six grade levels; 35 (4.9%) taught seven grade levels; and 21 (2.9%) taught eight grade levels (Table 4-5).

On the survey, when asked about what science courses they taught, science teachers reported a variety of course names which the researcher then categorized these responses into five categories: Life sciences, earth sciences, physical/general sciences, physics, and chemistry. The results showed that 364 teachers (50.9%) taught life science; 283 (39.6%) taught earth science; 369 (51.6%) taught physical/general sciences; 142 (19.9%) taught physics; and 194 (27.1%) taught chemistry (Table 4-6). One hundred and sixty seven (23.4%) teachers taught only one course; 195 (27.3%) taught two courses; 161 (22.5%)

taught three courses; 58 (8.1%) taught four courses; and 16 (2.2%) taught 5 courses (Table 4-6).

Computer Access and Knowledge

Computer Access

The demographics/teacher background section of the SIT-TIPPS instrument also asked for information about whether science teachers had computers in their classrooms and the number of computers, whether they had access to computer labs and the number of computers in these labs, the number of science labs at their schools, whether they had a science lab in their classrooms, and whether they had anyone available at their schools to provide technology support.

The results indicated that 592 out of 599 teachers (98.8%) had computers in their classrooms. The number of computers in their classrooms ranged from 1 to 37 with a mean of 6.12 and a standard deviation of 7.63. Many teachers (36.1%) who specified the number of computers in their classrooms (n = 590) had 1 computer in their classrooms. The cumulative percentage calculations indicated that 80.3% of the teachers had 1 to 9 computers in their classrooms (see Table 4-12).

When asked if teachers had access to computer labs, 550 out of 590 teachers (93.2%) indicated that they had access to computer labs. Responses from those who specified the number of computers in computer labs (n = 544) showed that the number of computers in computer labs ranged from 2 to 200 (including all computer labs at their schools) with a mean of 28.22 and a standard deviation of 12.91.

Science teachers were also asked to report the number of science labs to which they have access. According to the results, science teachers had access to an average of 2.44 science labs with a standard deviation of 3.72. Of the 514 teachers who responded, 62.8%

reported having access to 1 science lab; 12.5% had 2 labs; 9.7% had 3 labs; and 4.9% had 4 labs. This shows that cumulatively 89.9% of science teachers had 1 to 4 science labs at their schools. The researcher also asked if the participants had a science lab in their classrooms. Of the 594 teachers who responded, 72.7% indicated that they had a science lab within their classrooms.

When asked about if they had anyone available at their school to provide them with technology support, 93.9% of the teachers reported having someone available to them for receiving technology support when needed. This indicates that schools are providing teachers with at least some limited technical support on a daily basis.

Source of Computer Knowledge

The researcher asked science teachers to indicate whether they took educational technology classes in high school, undergraduate school, graduate school, or in-service or continuing education courses.

As shown in Table 4-13, the majority of the science teachers (92.3%) reported receiving educational technology classes during in-service training or continuing education courses. More teachers reported taking educational technology classes in graduate school (54.4%) than receiving it in undergraduate school (47.3%). Only 28.3% of the science teachers took educational technology classes in high school. Because teachers were able to select more than one option to report at what stage in their career they took educational technology courses, the researcher attempted a new calculation to see in how many of these levels (high school, undergraduate school, graduate school, and in-service or continuing education) a particular science teacher reported taking educational technology classes. Results indicated that 187 teachers (26.2%) took educational technology classes at only one of these levels; 204 (28.5%) at two levels; 122 (17.1%) at three levels; and 66 (9.2%) at all of the four levels.

Answering Research Question 1

This research question was answered by exploring supporting questions 2 and 3. Regarding the statements dealing with teachers' frequency of use of the inquiry skills and technology tools in instruction, teachers rated their use based on a 5-point Likert scale in this order: Never; rarely (e.g., a few times a year); sometimes (e.g., once or twice a month); often (e.g., once or twice a week); and almost or all science lessons.

The results on the frequency of use of these inquiry skills (Table 4-7) indicated that supporting students to explain cause-effect relationships (M = 4.0, 28.2%) and supporting students to discuss scientific explanations/ideas/models with others (M = 3.88, 28.2%) were the two highest rated skills by the teachers. Approximately twenty-eight percent of the science teachers reported that they integrate these skills in most or all science lessons. Supporting students to conduct experiments (M = 3.70, 11.5%) and to collect, organize, and analyze data (M = 3.78, 12.6%) were also among the highest rated skills. Over 12.5% of the teachers reported integrating them in almost or all science lessons.

The results showed the inquiry skills with the lowest mean scores were: to support students to identify their own misconceptions of science content (M = 3.10), to find biases and flaws in their scientific explanations (M = 3.10), to test scientific explanations against current scientific knowledge (M = 3.12), and to critique experiments (M = 3.17). About 21% of teachers reported that they felt either not adequately prepared or somewhat prepared to implement these skills in their instruction. Regarding the frequency with which they integrated these skills in their lessons, the results were almost parallel. Having the options "never", "rarely" (e.g., a few times a year), and "sometimes" (e.g., once or twice a month) treated as “low integration” of inquiry skills in instruction, critiquing experiments was the least integrated skill (M = 3.20). Of the 624 teachers who rated this skill, 59.2% selected the never, rarely, and sometimes options. The other two lowest rated skills in this category were testing scientific explanations against current scientific knowledge (M = 3.31) and finding biases or flaws in scientific explanations (M = 3.39) with 56.5% selecting never, rarely, and sometimes options for the former and 53.5% selecting the same options for the latter.

When asked about how often they used technology tools (Table 4-8). Teachers’ responses showed that word processing (M = 4.16), which was the tool they felt more prepared to use, was again the most used technology tool in lessons. About 47% of the teachers reported they used word processing in most or all science lessons. The other highly rated technologies from high to low were presentation devices (M = 4.12, 45.6%); presentation software (M = 3.86, 38.1%); Internet searches (M = 3.67, 25.4%); and email (M = 3.52, 34.7%) (Table 4-8).

The least frequently used technologies by science teachers were from lowest to highest were videoconferencing, teleconferencing (M = 1.29); portable Global Positioning Systems (M = 1.44); blogs (M = 1.45); data collection, telecollaborative activities (M = 1.50); video editing (M = 1.54); wikis (M = 1.56); podcasts, videocasts (M = 1.63); wireless communication devices (M = 1.69); image/picture editing (M = 2.00); and virtual experiences (M = 2.16). When “never” and “rarely” (e.g, a few times a year) options were considered a “non-use”, 93.1% of teachers reported almost never using videoconferencing, teleconferencing in their instruction. The percentages were 89.7% for portable Global Positioning Systems; 88.1% for blogs; 87.5% for data collection, telecollaborative activities; 86.7% for video editing; 84.7% for wikis; 82.6% for podcasts, videocasts; 80.4% for wireless communication devices; 69.7% for image/picture editing; and 65.9% for virtual experiences.

Answering Research Question 2

As mentioned in the methodology section, frequencies, correlations, multiple regression models, t-tests, and ANOVAs were used to determine the relationship between teachers' perceptions and practices of using technology tools/applications for scientific inquiry purposes. This research question used teachers' self-reported responses from supporting questions 4 and 5 along with data from research questions 1.

Level of Use of Inquiry Skills and Technology Tools

Regarding the statements dealing with teachers' level of preparedness, science teachers rated their level of inquiry skills and technology tools based on a 4-point Likert scale ranging from not adequately prepared to very well prepared (i.e., "1", not adequately prepared; "2", somewhat prepared; "3", fairly well prepared; and "4", very well prepared).

When asked about how well prepared they felt about supporting students to achieve certain inquiry tasks, science teachers felt "very well prepared" in supporting students to collect, organize, and analyze data ($M = 3.51$, 58.7%), explain cause-effect relationships ($M = 3.42$, 52.1%), and conduct experiments ($M = 3.41$, 53.4%). The rest of the inquiry skills produced lower mean scores and percentages (see Table 4-9).

Regarding science teachers self-reported level of preparedness in using certain technology tools, the results of the study indicated that (Table 4-10) science teachers felt more prepared to use (from highest to lowest) word processing ($M = 3.85$); e-mail ($M = 3.80$); Internet searches ($M = 3.70$); presentation software ($M = 3.69$); spreadsheets ($M =$

3.56); and presentation devices (M = 3.55). This equated to 87% of the teachers feeling very well prepared to use word processing in their classrooms; 84.4% to use email; 75.6% to use Internet searches; 68.1% to use spreadsheet; and 67.5% to use presentation devices.

On the other hand, teachers felt less prepared for using certain technologies in their classrooms. Using the options “not adequately prepared” and “somewhat prepared” considered together, teachers rated (from lowest to highest) low on data collection telecollaborative activities (M = 1.85, 75.6%); videoconferencing, teleconferencing (M = 1.86, 74.5%); portable Global Positioning Systems (M = 2.00, 69.7); video editing (M = 2.00, 69.3%); podcasts, videocasts (M = 2.10, 65.6%); blogs (M = 2.13, 64.8%); wikis (M = 2.13, 63.3%); wireless communication devices (M = 2.16, 63.3%); Smart Board/Promethean interactive boards (M = 2.34, 56.2%); and webpage design (M = 2.37, 56.4%).

Correlational Analysis

Correlations were computed among the teachers’ self-reported perceptions and practices, teachers’ level of preparedness in using certain scientific inquiry skills and technology in their classrooms, the frequency of use of these inquiry skills and technology tools during instruction, number of years of experience teaching science, total number of grades taught, the level of grades taught (high numbers meaning that a particular teacher taught higher grades ranging from 6th grade to 12th grade and higher), the number of computers in classroom and computer labs, and the total number of educational opportunities (high school, undergraduate school, graduate school, and/or in-service training or continuing education) in which they received educational technology training. Table 4-11 reports the Pearson Product-Moment Correlation coefficients and level of significance among the aforementioned variables. Some of the correlations will not be discussed in the chapter because they do not offer a practical interpretation. Only the correlations that appear in bold will be reported and interpreted throughout this text.

Teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes in science classrooms were positively correlated with: Teacher's practices of using technology for scientific inquiry purposes in their own classrooms (r= .649, p<.001); the level of preparedness for using certain inquiry skills (r= .225, p<.001); the frequency of using certain inquiry skills (r= .267, p<.001); the level of preparedness for using certain technology tools in instruction (r= .233, p<.001); the frequency of using certain technology tools in instruction (r= .189, p<.001); and the total number of educational levels in which they received educational technology training (r= .136, p= .001).

Teacher's practices of using technology for scientific inquiry purposes in their own classrooms were positively correlated with: Teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes (r= .649, p<.001); the level of preparedness for using certain inquiry skills (r= .283, p<.001); the frequency of using certain inquiry skills (r= .456, p<.001); the level of preparedness for using certain technology tools in instruction (r= .384, p<.001); the frequency of using certain technology tools in instruction (r= .443, p<.001); the number of computers in class (r= .109, p= .010); the number of computers in computer lab (r= .136, p= .002); and the total number of educational levels in which they received educational technology training (r= .157, p= .001).

The level of preparedness for using certain inquiry skills was significantly correlated with: Teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes (r= .225, p<.001); teachers' practices regarding the use of technology for scientific inquiry purposes (r= .283, p<.001); the frequency of using certain inquiry skills (r= .522, p<.001); the level of preparedness for using certain technology tools in instruction (r= .448, p<.001); the frequency of using certain technology tools in instruction (r= .275, p<.001); total number of grades taught (r= .151, p<.001); and the level of grades taught (r= .144, p<.001).

The frequency of using certain inquiry skills variable was positively correlated with: Teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes (r= .267, p<.001); teachers' practices regarding the use of technology for scientific inquiry purposes (r= .456, p<.001); the level of preparedness for using certain inquiry skills (r= .522, p<.001); the level of preparedness for using certain technology tools in instruction (r= .423, p<.001); the frequency of using certain technology tools in instruction (r= .450, p<.001); and the number of computers in computer lab (r= .088, p= .043).

The level of preparedness for using certain technology tools in instruction variable was positively correlated with: Teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes (r= .233, p<.001); teachers' practices regarding the use of technology for scientific inquiry purposes (r= .384, p<.05); the level of preparedness for using certain inquiry skills (r= .448, p<.001); the frequency of using certain inquiry skills (r= .423, p<.001); the frequency of using certain technology tools in instruction (r= .671, p<.001); total number of grades taught (r= .118, p= .005); the level of grades taught (r= .121, p= .004); and the total number of educational levels in which they received educational technology training (r= .249, p= .001). It was, however, negatively correlated with the number of years of teaching experience (r= -.177, p<.001).

The frequency of using certain technology tools in instruction variable was positively correlated with: Teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes (r= .189, p<.001); teachers' practices regarding the use of technology for scientific inquiry purposes (r= .443, p<.05); the level of preparedness for using certain inquiry skills (r= .275, p<.001); the frequency of using certain inquiry skills (r= .450, p<.001); the level of preparedness for using certain technology tools in instruction (r= .671, p<.001); the total number of grades taught (r= .112, p= .010); the level of grades taught (r= .120, p= .006); the number of computers in class (r= .136, p= .002); the number of computers in computer lab (r= .180, p<.001); and the total number of educational levels in which they received educational technology training (r= .262, p<.001).

The number of years of teaching experience was positively correlated with the total number of grades taught (r= .226, p<.001), but negatively correlated with the level of preparedness for using certain technology tools in instruction (r= -.177, p<.001) and the total number of educational levels in which they received educational technology training (r= -.193, p<.001).

Finally, the level of grades taught was significantly correlated with: The level of preparedness for using certain inquiry skills (r= .144, p<.001); the level of preparedness for using certain technology tools in instruction (r= .121, p=.004); the frequency of using certain technology tools in instruction (r= .120, p=.006); the total number of educational levels in which they received educational technology training (r= .321, p<.001).

Multiple Regression

Four regression models were tested using the stepwise regression method in order to examine the degree of association between various outcome variables and exploratory variables. Results provided additional insight into understanding the relationships between demographic variables, teachers' comfort levels in using scientific inquiry and technologies, and their level of integration of these skills and technologies.

Results from the first model showed that R^2 of .119 was statistically significant, F (2,333) = 22.442, p<.001. This model indicated that two exploratory variables (frequency of using inquiry skills and level of preparedness for using technology tools) were jointly associated with about 12% of the variance in teachers' self-reported perceptions regarding the use of technology for inquiry purposes. No other variable was significant at the p<.05 level. Although the influence of these two exploratory variables on the outcome variable was small (12%), this observation indicated that as science teachers' frequency of using inquiry skills in instruction and the level of their preparedness for using technology tools in instruction get higher, it is likely that their perceptions regarding the use of technology for scientific inquiry purposes get higher as well.

The second model showed that R^2 of .331 was statistically significant, F (3,330) = 54.437, p<.001. This model indicated that three exploratory variables (frequency of using inquiry skills, level of preparedness for using technology tools, and frequency of using technology tools in instruction) were jointly associated with about 33% of the variance in teachers' practices regarding the use of technology for inquiry purposes in their own classrooms. No other variable was significant at the p<.05 level. This result showed that as science teachers’ frequency of using inquiry skills in instruction, the level of their preparedness for using technology tools in instruction, and the frequency of using technology tools in their classrooms get higher, it is likely that their practices regarding the use of technology for scientific inquiry purposes get higher as well.

The third model showed that R^2 of .252 was statistically significant, F (1,551) = 185.63, $p<.001$. This model indicated that only one exploratory variable (level of preparedness for using inquiry skills in instruction) was associated with about 25% of the variance in teachers’ frequency of using scientific inquiry skills in their classrooms. No other variable was significant at the $p<.05$ level. This result showed that as science teachers’ level of preparedness for using inquiry get higher, it is likely that their frequency of using certain scientific inquiry skills in instruction get higher as well.

The fourth model showed that R^2 of .499 was statistically significant, F (5,422) = 84.07, $p<.001$. This model indicated that 5 exploratory variables (level of preparedness for using inquiry skills in instruction, years of experience, previous educational technology training, the number of computers in classroom, and the number of computers in computer lab) were associated with about 50% of the variance in teachers’ frequency of using technology tools in their classrooms. No other variable was significant at the $p<.05$ level. This result showed that as science teachers’ level of preparedness for using technology tools in classroom, their teaching experiences, the level of educational technology training they received at various stages during their career (high school, undergraduate school, graduate school, and in-service training or continuing education), the number of computers in their classrooms, and the number of computers in computer labs they have access to get higher, it is likely that their frequency of using technology tools in instruction get higher as well.

It can be concluded that the results from the multiple regression analysis models indicate a certain degree of association between some of the demographic variables, teachers' self-reported perceptions and practices regarding the use of scientific inquiry using technology, and their comfort levels with and uses of inquiry skills and technologies. The results obtained from the four models contribute to answering the second research question that addresses the relationship between teachers' perceptions and practices as well as the supporting questions of the study.

Further Analyses

Some of the variables used in the study enabled the researcher to test for significant differences between group means. The researcher conducted T-tests and ANOVAs to study the differences between the subsets of certain variables. Using the subsets of gender, presence of science lab in classroom, and presence of computer lab in school, significant differences were tested using a T-test with respect to teachers' self-reported perceptions and practices regarding the use of technology for scientific inquiry purposes; teacher's level of preparedness for using inquiry skills and technology tools in instruction; and teachers' frequency of using inquiry skills and technology tools in their classrooms. An alpha level of .05 was used for all statistical tests. For the ANOVA tests, a different set of variables (teachers' years of teaching experiences in a categorized format, the number of different types of science lessons taught, race/ethnicity, and state) were tested for significant group differences with respect to the six variables previously mentioned.

Due to large volume of subsets of the data used in T-test and ANOVA statistics, only significant results were reported in Tables 4-14, 4-15, 4-16, and 4-17. Cohen's *d* for significant t-test results and partial eta-squared (η^2) for significant ANOVA results were also computed to report effect sizes.

The independent-samples t-test analysis indicated that there was not any differences between males (n=207) and females (n=391) in terms of teachers' self-reported perceptions (t=-.363, df=558, p=.717, two-tailed) and practices (t=-.083, df=560, p=.934, two-tailed) regarding the use of technology for scientific inquiry purposes; teacher's level of preparedness for using inquiry skills (t=-.089, df=584, p=.373, two-tailed) and technology tools in instruction (t=.146, df=577, p=.884, two-tailed); and teachers' frequency of using inquiry skills (t=-.200, df=543, p=.845, two-tailed) and technology tools in their classrooms (t=.161, df=518, p=.872, two-tailed).

To test whether there were significant differences in terms of having (or not) a science lab in the classroom, four variables were studied: Teachers' self-reported perceptions and practices regarding the use of technology for scientific inquiry purposes; teacher's level of preparedness for using technology tools in instruction; and teachers' frequency of using technology tools in their classrooms.

Results showed that teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes did not differ significantly based on whether there was a science lab in their classrooms (t=-1.520, df=554, p=.129, two-tailed). This means that teachers who have a science lab in their classrooms did not differ significantly from those who do not on their perceptions regarding the use of technology for scientific inquiry purposes in instruction. They did, however, have significantly higher means with regard to teachers' practices factor (t=2.250, df=556, p=.025, two-tailed, Cohen's d=.22); teacher's level of preparedness for using technology tools in instruction (t=2.003, df=541, p=.046, two-tailed, Cohen's d=.19); and teachers' frequency of using technology tools in their classrooms (t=2.744, df=517, p=.006, two-tailed, Cohen's d=.27).

Teachers who had a computer lab in their schools scored significantly higher than those who did not on teacher's level of preparedness for using technology tools in instruction (t=2.749, df=537, p=.006, two-tailed, Cohen's d=.39) and teachers' frequency of using technology tools in their classrooms (t=2.103, df=513, p=.036, two-tailed, Cohen's d=.47). Both groups of science teachers did not differ significantly on teachers' perceptions (t=.140, df=552, p=.888, two-tailed) and practices (t=1.342, df=554, p=.180, two-tailed) factors. All of the Cohen's d effect sizes reported were less than .50, which indicated small effect sizes for significant t-test results, based on criteria suggested by Cohen (1988, p.25).

The effect of race/ethnicity was not statistically significant for teachers' self-reported perceptions regarding the use of technology for scientific inquiry purposes, F(5, 547)=1.468, p=.198; teacher's level of preparedness for using technology tools in instruction, F(5, 533)=1.945, p=.085; teachers' frequency of using inquiry skills, F(5, 565)=1.264, p=.278; and teachers' frequency of using technology tools in their classrooms, F(5, 508)=1.745, p=.123. However, with an alpha level .05, the effect of race/ethnicity was statistically significant for teachers' practices regarding the use of technology for scientific inquiry purposes, F(5, 548)=2.653, p=.022, η^2=.024, and teacher's level of preparedness for using inquiry skills in instruction, F(5, 572)=3.016, p=.011, η^2=.026.

A post hoc Tukey test was conducted to determine which race/ethnicity categories indicated significant differences. Results indicated that although the overall F value for teachers' practices factor was significant at the .05 level, none of the race/ethnicity categories showed statistical difference among each other. For teacher's level of preparedness for using inquiry skills, however, results demonstrated that Hispanic (Mean=32.31, SD=3.93) teachers had significantly higher scores than their Asian counterparts (Mean=26.95, SD=6.96), $p=.009$, SE=1.57.

The effect of the number of different types of science lessons taught was not statistically significant for teachers' self-reported perceptions, $F(5, 582)=1.600$, $p=.158$, and practices, $F(5, 589)=2.145$, $p=.059$, regarding the use of technology for scientific inquiry purposes; teacher's level of preparedness for using inquiry skills in instruction, $F(5, 610)=1.125$, $p=.346$; teachers' frequency of using inquiry skills, $F(5, 600)=1.244$, $p=.287$; teacher's level of preparedness for using technology tools, $F(5, 556)=1.745$, $p=.123$; and teachers' frequency of using technology tools in their classrooms, $F(5, 524)=.818$, $p=.537$.

In order to investigate if teachers from different states had significant differences with each other in terms of variables discussed above, the researcher selected only six states (Connecticut, Florida, Kansas, Michigan, Virginia, Wisconsin) from which more than 29 science teachers participated in the study. The effect of state where science teachers were teaching at the time of the study was not statistically significant for teachers' perceptions, $F(5, 438)=1.628$, $p=.151$, and practices, $F(5, 433)=1.203$, $p=.307$, regarding the use of technology for scientific inquiry purposes; teacher's level of preparedness for using inquiry skills in instruction, $F(5, 449)=2.047$, $p=.071$; teacher's level of preparedness for using technology tools, $F(5, 415)=1.065$, $p=.379$; and teachers' frequency of using technology tools in their classrooms, $F(5, 396)=1.550$, $p=.173$.

Only teachers' frequency of using inquiry skills was significant at the .05 level, $F(5, 445)=3.168$, $p=.008$, $\eta^2=.034$. A post hoc Tukey test was conducted to determine if teachers teaching in various states had significant differences among them in terms of six variables listed above. Results indicated significant difference between only those teachers who taught in Florida and Kansas. Science teachers from Florida (Mean=33.66, SD=5.32) had significantly higher scores than those who teach in Kansas (Mean=30.29, SD=5.04), $p=.004$, SE=.93.

The effect of years of science teaching experience was not statistically significant with teachers' perceptions, $F(4, 543)=.693$, $p=.597$, and practices, $F(4, 545)=.615$, $p=.652$, regarding the use of technology for scientific inquiry purposes; teacher's level of preparedness for using inquiry skills in instruction, $F(4, 566)=1.777$, $p=.132$; teachers' frequency of using inquiry skills, $F(4, 559)=2.129$, $p=.076$; and teachers' frequency of using technology tools in their classrooms, $F(4, 504)=.251$, $p=.909$. With an alpha level .05, the effect of years of science teaching experience was statistically significant for teacher's level of preparedness for using technology tools, $F(4, 528)=4.167$, $p=.002$, $\eta^2=.031$. A post hoc Tukey test was used to determine which experience categories indicated statistically significant mean scores. According to the results, science teachers who have 1 to 9 years of experience (Mean=74.88, SD=14.89) had significantly higher mean scores than those who taught science for 20 to 29 years, (Mean=69.47, SD=14.97), $p=.034$, SE=1.88, as well as those who taught science for 30 to 39 years, (Mean=67.67, SD=15.33), $p=.034$, SE=2.26. These results demonstrated that those science teachers who are new in the field and less than 10 years of experience with respect to those who have 20 to 39 years of experience reported higher level of preparedness for using technology tools in instruction. All of the partial eta-squared values to report effect sizes were less than .06, which indicated small effect sizes for significant ANOVAs, based on criteria suggested by Cohen (1988, p.285).

A Summary of Results in terms of Study Research Questions

The researcher made use of a variety of methods to answer the overarching and the supporting questions. First of all, reliability and item analysis and exploratory and confirmatory factor analyses were used to determine the reliability and validity of the SIT-TIPPS instrument. This process was essential in answering the research questions as all of the overarching and supporting questions depended on the quality of the scale. The data obtained through teachers' responses to the components of the SIT-TIPPS instrument were analyzed using a variety of statistical methods to answer the research questions of the study. The SIT-TIPPS indicated high reliability (see Table 3-1 & 3-2) and good content and construct validities based on expert judgment and factor analysis results.

The additional methods used to answer the study's questions were descriptive statistics (e.g., frequencies), correlations, multiple regressions, t-tests, and ANOVAs. Interpretations from all of these methods contributed to the explanation of the first overarching question, which dealt with how science teachers are using technology to implement the goals of scientific inquiry in their classrooms. It can be concluded that science teachers who scored high in the SIT-TIPPS instrument used technology tools/applications to engage students in scientifically oriented questions; to encourage students to give priority to evidence in responding to questions; to enable students to formulate explanations from evidence; to enable students to connect explanations to scientific knowledge; and to encourage students to communicate and justify their explanations. The data provided by the SIT-TIPPS instrument provides an in-depth snapshot to describe how the five essential features of scientific inquiry as presented in the National Science Education Standards (1996) are being used by middle and high school science teachers.

For the second overarching question, the correlations between the 25 items constituting the teachers' perceptions factor and the 25 items constituting the teachers' practices factor were calculated. Multiple regression method was used as well to answer this question because models indicated that these two factors were dependent on each other. Correlation analysis indicated a positive significant correlation between teachers' perceptions and practices regarding the use of technology for scientific inquiry purposes.

The first supporting question investigated the effect of teacher demographics and teacher background/teacher professional development variables on teachers' self-reported perceptions and practices for using technology to enact scientific inquiry. For this purpose, descriptive statistics, multiple regressions, correlations, t-tests, and ANOVAs were used. In general, the results in this category indicated that as science teachers get more years of teaching experience, get exposed to educational technology training at different stages during their career, and get access to more computers in their classrooms and computer labs, they are more likely to use technology tools in their classrooms. Teachers' gender, race/ethnicity, state in which science teachers are teaching, and the number of different types of science courses a science teacher taught did not have any significant effect on their perceptions and practices regarding the use of technology for scientific inquiry purposes.

The last four supporting questions enabled the researcher to explore the second overarching research question. Nine items from the SIT-TIPPS were used to measure how well prepared teachers' feel to support students to engage in certain inquiry skills and how often they use these inquiry skills in their classrooms. Twenty-six items were employed to answer how well prepared teachers' feel to use certain technology tools/applications and how often they use these tools/applications in their classrooms. In order to answer these four supporting questions, the researcher used frequency reports, correlations, and multiple regression models. In general, results in this category showed science teachers felt very well prepared in supporting students to collect, organize, and analyze data; explain cause-effect relationships; and conduct experiments. However, they felt less comfortable in supporting students to identify their own misconceptions of science content; find biases and flaws in their scientific explanations; test scientific explanations against current scientific knowledge; and critique experiments. In terms of how frequently these skills are integrated into science classrooms, teachers seemed to more frequently support students to explain cause-effect relationships; to discuss scientific explanations/ideas/models with others, conduct experiments; and to collect, organize, and analyze data. However, they less frequently support students to find biases and flaws in scientific explanations; to test scientific explanations against current scientific knowledge; and to critique experiments.

In addition, teachers' frequency of using inquiry skills and their level of preparedness for using technology tools are jointly associated with about 12% of the variance in teachers' self-reported perceptions regarding the use of technology for inquiry purposes. About 33% of the variance in teachers' practices regarding the use of technology for scientific inquiry purposes was explained by how frequently teachers used inquiry skills and technology tools in instruction and how well prepared they feel to use technology tools. The extent to which science teachers felt better prepared to use scientific inquiry skills was associated with about 25% of the variance in how frequently they use these skills in instruction. Moreover, results also indicated that as science teachers feel more prepared to use technology tools in their lessons, get more years of teaching experience, get exposed to educational training at different stages during their career, get access to more computers in their classrooms and computer labs, they will more likely to use technology tools in their science courses.

Table 4-1. Participant characteristics based on gender (n=598)

Gender	n	%
Male	207	34.6
Female	391	65.4

Table 4-2. Participant characteristics based on race/ethnicity (n=590)

Race/Ethnicity	n	%
American Indian	4	.7
Asian	20	3.4
Black	34	5.8
Hispanic	26	4.4
White	479	81.2
Multiracial	27	4.6

Table 4-3. Distribution of participants based on states (n=601)

States	n	%
AL	16	2.7
AZ	3	.5
CA	15	2.5
CT	30	5.0
FL	156	26.0
GA	6	1.0
HI	9	1.5
IL	6	1.0
IN	1	.2
IA	13	2.2
KS	50	8.3
KY	1	.2
LA	1	.2
MD	2	.3
MA	2	.3
MI	36	6.0
MN	1	.2
MO	6	1.0
MT	1	.2
NE	1	.2
NH	6	1.0
NJ	3	.5
NM	7	1.2
NY	5	.8
NC	6	1.0
OH	5	.8
OK	1	.2
PA	1	.2
SC	6	1.0
TN	1	.2
TX	5	.8
VA	165	27.5
WA	2	.3
WV	1	.2
WI	29	4.8
WY	1	.2
DC	1	.2

Table 4-4. Number of years of teaching experience: Categorized (n=583)

Categories	n	%
1-9	244	41.9
10-19	187	32.1
20-29	99	17.0
30-39	49	8.4
40-44	4	.7

Table 4-5. Grade levels taught by science teachers (n=715)

Characteristics	n	%
Grade levels taught		
6	171	23.9
7	238	33.3
8	252	35.2
9	345	48.3
10	360	50.3
11	378	52.9
12	371	51.9
Over 12	130	18.2
Total number of grades taught		
1	71	9.9
2	82	11.5
3	124	17.3
4	149	20.8
5	79	11.0
6	39	5.5
7	35	4.9
8	21	2.9

Table 4-6. Courses taught by science teachers (n=715)

Characteristics	n	%
Course name		
Life Sciences	364	50.9
Earth Sciences	283	39.6
Physical/General Sciences	369	51.6
Physics	142	19.9
Chemistry	194	27.1
Total number of courses taught		
1	167	23.4
2	195	27.3
3	161	22.5
4	58	8.1
5	16	2.2

Table 4-7. Science teachers' frequency of use of scientific inquiry skills

	Never	Rarely	Sometimes	Often	Almost or All Lessons			
To support students to:	1	2	3	4	5	n	M	S.D.
1. Ask researchable questions	1.0	9.6	33.2	41.4	14.8	623	3.59	.89
2. Conduct experiments	.5	4.4	31.5	52.3	11.5	620	3.70	.75
3. Collect, organize, analyze data	.5	3.7	25.6	57.6	12.6	620	3.78	.73
4. Identify their own misconceptions of science content	1.1	10.1	32.8	37.4	18.6	625	3.62	.94
5. Explain cause-effect relationships	.3	2.9	21.2	47.4	28.2	624	4.00	.80
6. Test scientific explanations against current scientific knowledge	3.2	14.9	38.4	34.7	8.8	623	3.31.	.94
7. Find biases or flaws in their scientific explanations	2.6	15.2	35.7	33.9	12.6	625	3.39	.97
8. Discuss scientific explanations/ideas/models with others	1.3	6.6	23.2	40.7	28.2	624	3.88	.94
9. Critique experiments	3.4	21.2	34.6	33.8	7.1	622	3.20	.96

Table 4-8. Science teachers' frequency of use of technology tools

	Never	Rarely	Sometimes	Often	Almost or all lessons			
	1	2	3	4	5	n	M	S.D.
1. Presentation devices (such as video projectors, LCD panels)	2.5	5.4	15.1	31.4	45.6	609	4.12	1.1
2. Smart Board/Promethean interactive boards	53.0	13.4	7.0	11.1	15.4	610	2.23	1.5
3. Wireless communication devices (e.g., PDAs, student digital response systems)	62.3	18.1	10.7	5.8	3.1	608	1.69	1.1
4. Graphing/scientific calculators	30.6	16.8	20.1	19.1	13.3	607	2.68	1.4
5. Portable Global Positioning Systems (GPS)	69.9	19.8	7.6	1.8	1.0	607	1.44	.79
6. Digital data collection devices (e.g., pH, pressure and temperature probes, digital microscopes, Navigator systems)	22.8	26.1	30.2	15.8	5.1	609	2.54	1.2
7. Videoconferencing, teleconferencing	81.3	11.8	3.9	2.0	1.0	611	1.29	.72
8. Word processing (e.g., Word)	1.6	4.9	16.6	29.7	47.1	609	4.16	.98
9. Spreadsheets (e.g., Excel)	7.9	14.5	28.9	30.7	17.9	605	3.36	1.2
10. Presentation software (e.g., Power Point)	3.5	11.4	18.6	28.5	38.1	607	3.86	1.1
11. Database software	31.0	23.7	23.5	13.7	8.1	604	2.44	1.3
12. Educational games	20.5	27.1	32.8	14.0	5.6	609	2.57	1.1
13. Virtual experiences (e.g., Google Earth and Starry Night, a virtual planetarium)	33.2	32.7	21.9	9.4	2.8	608	2.16	1.1
14. Graphing and data analysis software	26.0	22.7	30.3	15.1	5.8	603	2.52	1.2
15. Video editing	64.1	22.6	9.6	2.6	1.0	605	1.54	.85
16. Image/picture editing	45.9	23.8	18.6	7.5	4.2	601	2.00	1.2
17. E-mail	15.2	10.4	16.4	23.4	34.7	599	3.52	1.4
18. Webpage design	51.5	21.9	12.1	8.6	5.8	602	1.95	1.2
19. Accessing online databases	23.7	28.0	26.8	14.9	6.6	604	2.53	1.2
20. Internet searches	2.7	10.6	29.4	32.0	25.4	603	3.67	1.1
21. Online simulations	14.0	22.3	36.1	18.8	8.8	601	2.86	1.1
22. Online science games	28.2	27.0	29.7	10.1	5.0	603	2.37	1.1
23. Wikis	68.1	16.6	9.0	4.3	2.0	598	1.56	.97
24. Blogs	74.1	14.0	6.5	4.0	1.5	602	1.45	.89
25. Podcasts, videocasts	62.8	19.8	11.5	3.3	2.5	600	1.63	.98
26. Data collection telecollaborative activities (e.g., Journey North, SCOPE, Amazing Space)	691.	18.4	7.4	3.8	1.3	598	1.50	.89

Table 4-9. Science teachers' level of preparedness of scientific inquiry skills

To support students to:	Not adequately prepared 1	Somewhat prepared 2	Fairly well prepared 3	Very well prepared 4	n	M	S.D.
1. Ask researchable questions	2.4	11.5	44.0	42.1	627	3.26	.75
2. Conduct experiments	1.4	9.1	36.0	53.4	625	3.41	.72
3. Collect, organize, analyze data	1.3	5.4	34.6	58.7	625	3.51	.66
4. Identify their own misconceptions of science content	2.6	17.9	46.3	33.2	626	3.10	.78
5. Explain cause-effect relationships	1.3	7.5	39.1	52.1	626	3.42	.69
6. Test scientific explanations against current scientific knowledge	2.2	18.7	43.9	35.1	626	3.12	.78
7. Find biases or flaws in their scientific explanations	4.0	18.4	41.6	36.0	625	3.10	.83
8. Discuss scientific explanations/ideas/models with others	2.4	9.1	40.7	47.8	627	3.34	.74
9. Critique experiments	4.3	15.7	38.2	41.8	624	3.17	.85

Table 4-10. Science teachers' level of preparedness of using technology tools

	Not adequately prepared	Somewhat prepared	Fairly well prepared	Very well prepared			
	1	2	3	4	n	M	S.D.
1. Presentation devices (such as video projectors, LCD panels)	3.1	6.7	22.7	67.5	616	3.55	.75
2. Smart Board/Promethean interactive boards	33.3	22.9	20.3	23.4	615	2.34	1.2
3. Wireless communication devices (such as PDAs, student digital response systems)	37.9	25.4	19.7	16.9	614	2.16	1.1
4. Graphing/scientific calculators	18.7	25.3	26.3	29.7	616	2.67	1.1
5. Portable Global Positioning Systems (GPS)	42.9	26.8	17.5	12.9	613	2.00	1.1
6. Digital data collection devices (such as pH, pressure and temperature probes, digital microscopes, Navigator systems)	12.2	22.2	29.3	36.3	617	2.90	1.0
7. Videoconferencing, teleconferencing	48.5	26.0	17.1	8.5	615	1.86	.99
8. Word processing (e.g., Word)	.7	1.6	10.1	87.6	614	3.85	.45
9. Spreadsheets (e.g., Excel)	2.1	7.5	22.3	68.1	614	3.56	.72
10. Presentation software (e.g., Power Point)	1.6	4.9	16.2	77.3	617	3.69	.64
11. Database software	11.4	18.8	28.6	41.2	616	3.00	1.0
12. Educational games	7.9	19.1	31.8	41.2	611	3.06	.96
13. Virtual experiences (such as Google Earth and Starry Night, a virtual planetarium)	14.1	27.8	28.3	29.8	615	2.74	1.0
14. Graphing and data analysis software	12.7	27.6	28.1	31.6	613	2.79	1.0
15. Video editing	42.1	27.2	18.9	11.7	613	2.00	1.0
16. Image/picture editing	20.6	28.1	25.8	25.5	612	2.56	1.1
17. E-mail	1.1	2.4	12.1	84.4	614	3.80	.53
18. Webpage design	27.2	29.2	23.5	20.2	614	2.37	1.1
19. Accessing online databases	9.8	21.2	30.1	38.9	614	2.98	1.0
20. Internet searches	1.0	3.6	19.9	75.6	614	3.70	.59
21. Online simulations	6.4	15.5	29.8	48.4	614	3.20	.92
22. Online science games	10.0	17.6	30.3	42.1	608	3.04	1.0
23. Wikis	40.3	23.0	19.6	17.1	608	2.13	1.1
24. Blogs	38.0	26.8	19.3	15.9	611	2.13	1.1
25. Podcasts, videocasts	37.3	28.3	21.2	13.2	612	2.10	1.1
26. Data collection telecollaborative activities (e.g., Journey North, SCOPE, Amazing Space)	48.9	26.7	15.5	9.0	614	1.85	.99

Table 4-11. Pearson Product-Moment Correlation between variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12
Perceptions	1	**.649****	**.225****	**.267****	**.233****	**.189****	-.019	.087**	.077	-.006	.084	**.136****
Practices		1	**.283****	**.456****	**.384***	**.443***	.359	.024	.011	**.109***	**.136****	**.157****
Inquiry skills-level			1	**.522****	**.448****	**.275****	.078	**.151****	**.144****	.007	.062	.042
Inquiry skills-frequency				1	**.423****	**.450****	.064	.065	.050	.070	**.088***	.069
Technology tools-level					1	**.671****	**-.177****	**.118****	**.121****	.061	.117**	**.249****
Technology tools-frequency						1	.014	**.112****	**.120****	**.136****	**.180****	**.262****
Years of experience							1	**.226****	.202**	.110**	.035	**-.193****
Number of grades taught								1	.982**	-.041	.107*	.343**
Grade level									1	-.022	.087*	**.321****
Number of computers in class										1	.045	-.013
Number of computers in computer lab											1	-.120**
Previous ed tech training												1

Note. **p<.05, **p<.001 (2-tailed)*

Table 4-12. The number of computers in classrooms

Number of Computers	n	%	Cumulative %
1	213	36.1	36.1
2	86	14.6	50.7
3	38	6.4	57.1
4	29	4.9	62
5	32	5.4	67.5
6	14	2.4	69.8
7	27	4.6	74.4
8	20	3.4	77.8
9	15	2.5	80.3

Table 4-13. Percent of teachers reporting taking educational technology classes

	n	%	Total
Level of educational technology training			
High school	152	28.3	538
Undergraduate school	261	47.3	552
Graduate school	288	54.4	529
In-service training or continuing education courses	568	92.3	568
Frequency of educational technology training			
1	187	26.2	
2	204	28.5	
3	122	17.1	
4	66	9.2	

Table 4-14. T-test results for subscales based on presence of science lab in classroom

Subscale vs. lab presence	N	Mean	SD	*t*	df	*P*	Cohen's d
Practices							
Lab present	409	99.83	16.79	2.25*	556	.025	.22
Lab not-present	149	96.13	18.17				
Technology tools-level							
Lab present	395	72.90	14.76	2.00*	541	.046	.19
Lab not-present	148	70.00	15.86				
Technology tools-frequency							
Lab present	377	64.65	16.39	2.74*	517	.006	.27
Lab not-present	142	60.25	15.95				

* p< .05, two-tailed

Table 4-15. T-test results for subscales based on presence of computer lab in school

Subscale vs. lab presence	N	Mean	SD	*t*	df	*P*	Cohen's d
Technology tools-level							
Lab present	502	72.73	14.91	2.75*	537	.006	.47
Lab not-present	37	65.73	15.57				
Technology tools-frequency							
Lab present	479	63.79	16.47	2.10*	513	.036	.39
Lab not-present	36	57.86	13.90				

* p< .05, two-tailed

Table 4-16. ANOVA results between subscales and selected variables

Source	df (between)	df (within)	*F*	η^2	*P*
Ethnicity x Inquiry skills-level	5	572	3.016	.026	.011*
Experience-categorized x Technology tools-level	4	528	4.167	.031	.002*
State x Inquiry skills-frequency	5	445	3.168	.034	.008*

* p< .05

Table 4-17. Summary of Post Hoc (Tukey) ANOVA results for significant differences

Source	N	Mean	SD	SE	*P*
Ethnicity x Inquiry skills-level					
Asian	19	26.95	6.96	1.60	
Hispanic	26	32.31	3.93	.77	
Asian x Hispanic				1.57	.009*
Experience-categorized x Technology tools-level					
1-9	224	74.88	14.89	.99	
20-29	85	69.47	14.97	1.62	
30-39	46	67.67	15.33	2.26	
1-9 x 20-29				1.88	.034*
1-9 x 30-39				2.39	.023*
State x Inquiry skills-frequency					
FL	151	33.66	5.32	.43	
KS	48	30.29	5.04	.72	
FL x KS				.93	.004*

* p< .05

CHAPTER 5
FINDINGS, CONCLUSIONS, IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

There have been many efforts throughout the history of science education to improve teaching and learning in elementary and secondary schools (Abrams, 1998). The National Research Council and American Association for the Advancement of Science have contributed to efforts by publishing reports such as the National Science Education Standards (1996), Science for All Americans (1990), and Benchmarks for Science Literacy (1993) that emphasized student learning, the nature of science, science literacy, and scientific inquiry. Despite these efforts, the current science curriculum in the United States and many other countries has failed to prepare students for the kinds of experiences they will need to become successful science learners (Linn et al., 2004).

Scientific inquiry has been an overarching goal of science education (AAAS, 1993; NRC, 1996; Flick, 1997; Crawford, 1997; Edelson, et al., 1999) and a central strategy for teaching science (NRC, 1996) for decades. Although there are certain instructional methods and strategies that help teachers implement scientific inquiry in their classrooms, the use of technology can also play a significant role in meeting the goals of scientific inquiry. According to the National Research Council (1996), a goal for using educational technology in the classroom is to identify effective ways to use technology tools for higher-order thinking that mesh with the assumptions of scientific inquiry.

When it comes to technology integration, teachers play a key role (Scheffler & Logan, 1999). Yet, research indicates teachers lack good instructional frameworks for effective implementation of technology into the curriculum (Bitner & Bitner, 2002). In addition to that, there is little literature available on answering the question of how science teachers use technology to succeed in enacting the goals of scientific inquiry. There is clearly a need to understand how science teachers use technology as they strive to attain the goals of scientific inquiry in their classrooms and to provide teachers with a framework for using technology in scientific inquiry-based instruction.

This study, which is based on the premise technology could enhance the quality of scientific inquiry-based instruction, attempted to answer the question of how science teachers use technology to attain the goals of scientific inquiry-based instruction through the development of an instrument about scientific inquiry and the use of technology for that purpose. It was an attempt to address an essential topic both in science education and educational technology. Through the creation of an instrument, the SIT-TIPPS, the study addressed the following research questions:

Overarching Questions

1. How are teachers using technology to implement the goals of scientific inquiry in their classrooms?
2. What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry?

Supporting Questions

What are the relationships between teachers' self-reported perceptions and practices regarding the use of technology to attain the goals of scientific inquiry in terms of:

- Teacher demographics and teacher background/professional development variables?
- How often do teachers support students to engage in certain inquiry skills in their science classrooms?
- How often do teachers use certain technology tools in their science classrooms?
- How prepared do teachers feel to support students to engage in certain inquiry skills in their science classrooms?
- How prepared do teachers feel to use certain technology tools in their science classrooms?

The SIT-TIPPS Instrument

One of the main purposes of this study was to validate and develop an instrument called the Scientific Inquiry with Technology-Teachers' Perceptions and Practices Scale (SIT-TIPPS). The theoretical framework and extensive literature base of the items as well as experts' agreement on the contents of the items contributed to the content validity of the instrument. In addition, a successful two-factor solution using exploratory factor analysis provided support for the construct validity of the SIT-TIPPS. Therefore, the SIT-TIPPS instrument could be used to identify middle and high school science teachers' self-reported perceptions and practices regarding the use of technology to enact scientific inquiry in their classrooms and to explore to what extent science teachers feel comfortable to use certain scientific inquiry skills and technology tools in their lessons. This is important in assessing the needs of science teachers in terms of professional development and designing effective preservice and inservice training programs.

One of the initial expectations of the researcher when generating the item pool for the SIT-TIPPS was to observe a five-factor solution after factor analysis. This was because the first attempt by the researcher to generate the SIT-TIPPS items based on the five essential features of scientific inquiry as described in the National Science Education Standards (NRC, 1996). The factors are: Teachers engage students in scientifically oriented questions; enable students to give priority to evidence in responding to questions; encourage students to formulate explanations from evidence; enable learners to connect explanations to scientific knowledge; and encourage learners to communicate and justify explanations. The factor analysis procedure did not produce a five-factor solution as expected. Instead, it produced a two-factor solution in the form of perceptions and practices. Although all of the items in the scale, measuring either perceptions or practices of science teachers regarding the use of technology to attain the goals of scientific inquiry, were generated based on these five features of scientific inquiry and their contents were verified by five content experts, the inability of factor analysis to yield five factors might indicate that science teachers' opinions and perspectives regarding these five components are not distinctive. Although the National Science Education Standards (NRC, 1996) reports five psychological factors in the attainments of teaching scientific inquiry, this study provided evidence that these five factors are not statistical factors. Creating the SIT-TIPPS with two factors, perception and practice, created a better model for understanding science teachers' perceptions and practices regarding the use technology to attain the goals of scientific inquiry in instruction.

Summary of Findings

The results of the study demonstrated that the SIT-TIPPS is a useful tool in analyzing self-reported current practice of middle and high school science teachers regarding the use of technology for scientific inquiry purposes and in furthering the discussion on how science teachers can use technology to attain the goals of scientific inquiry. It measured middle and high school science teachers' self-reported perceptions and practices regarding the use of technology in attaining the goals of scientific inquiry. In doing so, it connected theory and research from two fields, science education and educational technology, which can result in a change of daily practice in science classroom. Even though there are some instruments targeting scientific inquiry in science education literature (Bodzin & Beerer, 2003; Brandon & Taum, 2005), an instrument specifically targeting scientific inquiry in science classrooms where technology is used is an area of need in both fields. The instrument developed in this study and the research questions it attempted to answer is a contribution to this body of literature and the fields of science education and educational technology.

This study had two overarching research questions and five supporting questions. The main questions focused on how teachers use technology to implement the goals of scientific inquiry and the relationships between their self-reported perceptions and practices regarding this implementation. The supporting questions articulated these relationships by addressing some teacher demographics and background/professional development variables as well as the level and frequency of their preparedness and use of certain inquiry tasks and technology tools. While the total scores obtained from the SIT-TIPPS and the relationships between perception and practice items were utilized to help answer the overarching questions of the study, relationships obtained from supporting questions also contributed to answering these overarching questions. Conclusions were drawn from the results of the study in relation to these questions.

Characteristics of Science Teachers

A national sample of middle and high school science teachers was targeted to participate in the study. About 65% of the science teachers were females and the majority (81.2%) were white. This profile of science teachers parallels that of another large-scale national study called the National Survey of Science and Mathematics Education (Weiss et al., 2001; Smith et al., 2002) in which about 2500 middle and high school science teachers were surveyed from 1977 to 2000. In this survey, about 64% of the science teachers (grades 5-12) were females and about 81 percent were white. This similarity in profiles in terms of gender and race/ethnicity might indicate a continuing trend among middle and high school science teachers in the U.S. since 1977. In that respect, this study might be a good contribution to the data from 1977 to 2000 by demonstrating a similar trend in 2008.

Demographic findings also indicate that the more experienced science teachers get the more grades (6 through 12 and above) they tend to teach. However, teachers with less teaching experience (or younger for that matter) seem to receive more educational technology training at more levels of various educational settings and in-service/continuing education and seem to feel more prepared to use technology tools in instruction.

Data also showed that the level of grades taught significantly correlates with the total number of educational levels in which teachers received educational technology training. Hence, it appears that teachers who teach more grade levels receive more educational technology training. The level of grade taught positively correlates with the level of preparedness for using inquiry skills, the level of using technology tools, and frequency of using technology tools in instruction. This means that teachers who teach higher-level grades indicate a higher level of preparedness and frequency for using inquiry skills and technology tools in their lessons. This could be reflective of the potential differences in preservice and inservice experiences at the middle school and high school level. This finding is in line with the results of the 2000 National Survey of Mathematics and Science Education study (Weiss, et al., 2001), which indicated higher percentages of high school science teachers feeling very well qualified to teach science processing skills.

A Snapshot of Science Teachers' Scientific Inquiry and Technology Skills

Study results gave a clear picture of science teachers' strengths and areas in which improvements are needed in the areas of scientific inquiry and technology integration. Table 5-1 and Table 5-2 list teachers' weaknesses and strengths in terms of their self-reported comfort levels and actual practices in using inquiry skills and technology tools/applications in instruction.

Middle and high school science teachers that participated in this study do feel prepared to support students in "traditional" aspects of scientific inquiry. However, in areas which might challenge content knowledge, such as identifying misconceptions of science content, there is great discomfort. When looking at the tasks listed in the weakness column of Table 5-1, a concern of science content is clear. This results in students not engaging in scientific inquiry tasks that challenge and expand their content knowledge.

Regarding middle and high school science teachers' self-reported comfort levels and integration of technology tools/applications in instruction, it is obvious to see that science teachers feel very comfortable using common forms of technologies such as word processing, Internet searches, and spreadsheets. However, they exhibit low comfort level and integration when it comes to "uncommon" and "new" forms of technologies such as data collection telecollaborative activities, portable Global Positioning Systems, and Internet 2.0 applications. The technologies listed in the weakness column of Table 5-2 designate essential tools and applications that lend themselves to higher-order thinking in classrooms. Hence, the inadequacy of science teachers' abilities to utilize tools such as these point out an area of concern because it results in students not benefiting from the transformative and challenging power of these tools to investigate scientific principles and concepts.

Source of Computer Knowledge

Science teachers' responses to whether they received educational technology training during high school, undergraduate school, graduate school, or in-service/continuing education yielded interesting results. The majority of the science teachers (92.3%) reported receiving educational technology classes during in-service training and continuing education. This indicates the importance of in-service training provided to science teachers regarding the use of instructional technologies in classrooms. More educational technology training was received by science teachers in graduate school than during undergraduate education. Because of teachers' multiple responses to select a level where they received educational technology training, it was interesting to see the percentage of teachers who reported having training at certain number of levels. Although nearly 92% reported getting educational technology training at a various level during their careers, these findings indicate a low infusion of educational technology training throughout the career path of a science teacher.

Additional Demographic Findings

Although previous research indicated more male teacher use of computers in classrooms (Becker, 1994; Chiero, 1997), this study found no differences between male and female science teachers. According to the results of this study, there is no difference between male and female science teachers in terms of their perceptions and practices regarding the use of technology for scientific inquiry purposes; how prepared they feel to use inquiry skills and technology tools in instruction; and how often they used inquiry skills and technology tools during lessons.

Having a computer lab at school also plays an important role for science teachers. Teachers who have a computer lab in their schools scored significantly higher than those who did not on how well prepared they feel to use technology tools and how frequently they use these tools in instruction. Both groups, on the other hand, do not differ in terms of their perceptions and practices regarding the use of technology for scientific inquiry purposes.

Teachers’ race/ethnicity does not produce significant results for teachers’ self-reported perceptions and practices in using technology for inquiry purposes, their level of preparedness for using technology tools, and how often they use inquiry skills and technology tools in instruction. It is, however, significant for how they practice the use of technology for scientific inquiry skills in classroom as well as for how well prepared they feel to use inquiry skills in instruction. Though significant, post hoc ANOVA test did not produce any group differences between race/ethnicity categories. The only significant mean difference was between Hispanic and Asian teachers in terms of how well prepared they feel to use inquiry skills. Results indicate Hispanic teachers feel more prepared to use scientific inquiry skills in instruction than their Asian counterparts.

The results were not very different for the state in which science teachers are teaching based on the variables listed above. Only teachers from Florida and Kansas (among Connecticut, Florida, Kansas, Michigan, Virginia, Wisconsin) differ significantly in terms of how frequently they use scientific inquiry skills in instruction. Florida teachers use scientific inquiry skills more in their lessons than Kansas teachers. An overview of the science education standards of both states reveals Florida science education standards seem to provide more detailed benchmarks to assist teachers in instruction. However, a more thorough analysis of the standards in two states are needed to make comparisons and to identify the impact of content standards in both states on teachers' implementation of inquiry skills in their classrooms.

Science teachers' years of teaching experiences are significant for how confident they feel to use technology tools in their classrooms. According to the results, science teachers who have 1 to 9 years of teaching experience reports higher level of confidence in using technology tools in their lessons than those who have 20 to 29 years of experience and 30 to 39 years of experience. This demonstrates science teachers who are relatively new and have less than 10 years of experience in the field feel more prepared to use technology tools in their lessons than their more experienced counterparts (between 20-39 years of experience). Interestingly, the group of science teachers who have less than 10 years of experience does not demonstrate a significant difference with those who have 10 to 19 years of teaching experience.

Study Implications

The SIT-TIPPS instrument developed in this study could be used to identify middle and high school science teachers' self-reported perceptions and practices regarding the use of technology to enact scientific inquiry in their classrooms and to explore to what extent science teachers feel comfortable to use certain scientific inquiry skills and technology tools in their lessons. It also enables one to look at the existence and the degree of relationship among this set of variables.

The findings of the study have implications that could help researchers, educators, science teachers and administrators identify how technology is being used by middle and high school science teachers as well as how well prepared they feel to use scientific inquiry skills and technology tools during instruction. It also provides information about science teachers' self-reported perceptions and practices of using technology to attain the goals of scientific inquiry as set forth by the National Science Education Standards (NRC, 1996) and discussed extensively by researchers in the field.

Moreover, the SIT-TIPPS instrument could effectively be used as an evaluation tool for curriculum. For instance, the integration of an exemplary science curriculum such as the Foundational Approaches in Science Teaching (FAST) that potentially lends itself to students using the scientific inquiry process could be evaluated using the components of SIT-TIPPS instrument. The experiments and activities employed by a FAST teacher could be evaluated in terms of the use of inquiry skills and technology tools/applications addressed in the SIT-TIPPS. For example, using the SIT-TIPPS one can easily determine the degree to which a FAST teacher enables students to critique experiments found in FAST or to test their explanations from the FAST activities against current scientific knowledge. The SIT-TIPPS could enable researchers to analyze the state of integration of scientific inquiry and technology not only at the classroom level, but also at the school and district level. The way the SIT-TIPPS instrument was developed dovetails with the essential features of scientific inquiry that has been an overarching goal in the science education field (NRC, 1996; Flick, 1997; Crawford, 1997; Edelson et al., 1999) along with the manner in which technology plays a significant role in meeting the goals of scientific inquiry. This approach can help researchers from both science education and educational technology fields analyze how science teachers perceive such a complex form of instruction and how often they try to implement such practices in their lessons. The findings from such studies could shed light on school level and district level analysis of the state of scientific inquiry implementation from teachers' perspective and then could lead to district level policy and professional development for science teachers. For example, the finding that illustrates science teachers' inadequacy to use interactive whiteboards, which many districts purchase these days, highlights the importance of knowing this fact in order to provide professional development to enable teachers to support students' learning through presentations, demonstrations, and more.

In this respect, another important aspect of the curricular evaluative ability of the SIT-TIPPS instrument is its emphasis on teachers' role. When it comes to technology teachers play a key role (Scheffer & Logan, 1999). Yet, research indicates teachers lack solid instructional frameworks for effective implementation of technology into the curriculum (Bitner & Bitner, 2002). The SIT-TIPPS with its emphasis on teachers' perceptions and practices, and the way it meshes the essential features of scientific inquiry skills and use of technology tools can be used by researchers, teacher educators, and administrators to analyze teacher behaviors and practices with respect to technology use to achieve scientific inquiry.

The SIT-TIPPS can also be a useful tool in teaching preservice science teachers and helping them understand the complex nature of scientific inquiry and how technology can be used to facilitate its successful implementation. According to some studies, preservice science teachers graduated without conducting a single inquiry in their programs (Windschitl, 2003) and lacked understanding of inquiry, skills, and experiences (Newman et al., 2004) as well as training and support (White & Frederiksen, 1998) to implement inquiry-oriented teaching. They also have very few operational models (Crawford, 1997) that they could use during inquiry instruction. The instrument developed in this study has the potential to support preservice science teachers to better understand what inquiry skills are expected of students and how technology can contribute to the fulfillment of these expectations. For instance, one of the scientific inquiry skills to which students are to be exposed and acquire knowledge about is addressing misconceptions of science content. Presentation devices and reliable Internet-based applications could help students identify and overcome their own misconceptions. As noted in the study findings, when preservice teachers are exposed to such a detailed approach, they can develop a better understanding of the inquiry skills expected from students and understand ways technology contribute to its achievement. The findings of the study point out that even inservice science teachers' perceptions and actual classroom practices for using technology in a science inquiry oriented classroom differ. A more structured scientific inquiry education/training using technology in colleges and schools of education designed according to the National Science Education Standards for scientific inquiry might help close this gap for preservice and inservice science teachers.

The study highlights areas where professional development activities for science teachers could focus. For instance, the findings that indicate science teachers' low comfort levels and uses of inquiry skills such as supporting students to critique experiments and finding biases/flaws in their reasoning are salient for professional development designers. In terms of technology, teachers' low comfort levels in and uses of new and/or uncommon forms of technology tools/applications are also worth paying attention. Teachers are comfortable with technology tools that have been around for a long time such as email. The same teachers, on the other hand, report low a comfort level and integration when it comes to a relatively newer or unfamiliar forms of technology tools such as using Internet 2.0 tools. These technology tools exhibit high potential to facilitate scientific inquiry in classrooms with the help of technology. These results indicate the need to train science teachers to be able to use these technology tools and to show them how these technologies could bring about change in their teaching practices toward better integration of technology to attain the goals of scientific inquiry.

Professional development activities and preservice teacher education programs should concentrate more on increasing science teachers' familiarities with these new and unfamiliar forms of technologies while continuing to encourage the use of most commonly used technologies. As study findings indicate, when science teachers get more prepared to use technology for scientific inquiry purposes they tend to use it more often in their classrooms for the same purposes. If science teachers' familiarity with these technology tools increase, they will be more likely to appreciate the potential these technology tools carry for their instruction. Another finding of the study indicates almost all of the classrooms have at least one computer in them. This tells us that the limited use of these computer tools could be affected by teachers' inability to use them effectively. Yet, if the computers that are available in classrooms are lacking the technical requirements to run these programs/applications efficiently, it might also contribute to teaches' inability to use these tools/applications in their classrooms.

The findings also have implications for school districts, community colleges, colleges and schools of education, researchers, practitioners, administrators or even politicians who have the responsibility to provide training to science teachers or make decisions on their behalf. The components of the SIT-TIPPS instrument could be used by professors and trainers to help preservice and inservice science teachers identify what they are missing in their recent knowledge base and skills related to scientific inquiry and technology, and then focus their training/education on these missing areas. One tangible product of such an understanding, for example, would be to teach science teachers how to use data collection telecollaborative activities and how to integrate them to support students to develop hypotheses, collect/organize/analyze data, make judgments, and critique findings with peers. As this study indicates such uses are missing in our classrooms.

As the findings of this study also indicates, science teachers' comfort levels with and exposure to inquiry skills and technology tools/applications matter. Improving scientific inquiry and technology skills could be achieved by exposing teachers to these skills, technology tools, and strategies on a regular basis. They need to observe successful implementation examples and practice these skills before they complete their initial teacher preparation program. For inservice teachers, this translates to new policies in the form of mandatory scientific inquiry and technology professional development programs/trainings. As this study illustrates, the higher the comfort level science teachers have with inquiry skills and technology tools, the more they use these skills and technologies in their classrooms. This could be done by providing teachers the opportunity to shadow teachers effectively enacting the goals of scientific inquiry with technology. Obviously, resources are also important to achieve these objectives. The study's findings show the relationship between computer access and integration. Therefore, schools and districts should invest more money, time, and energy on technology along with the professional development that is required to familiarize teachers with their effective use in the classroom.

This implication is also supported by research. Recent studies on science teachers and inquiry suggest that professional development programs help science teachers develop inquiry-based skills and applications in the classroom (Wee, Shepardson, Fast, & Harbor, 2007). According to new evidence in the literature on the nature of professional development programs, it is suggested that such programs should enable teachers to experience the benefits of scientific inquiry-based practices as learners through inquiry-based activities (Spector, Burkett, & Leard, 2007) and should focus on student learning and learning difficulties encountered by students (Lotter, Harwood, & Bonner, 2006) in an inquiry atmosphere. In this respect, the content of the SIT-TIPPS instrument addresses all of these aspects of professional development. This is because it interprets essential features of scientific inquiry from a students' perspective and encourages teachers to look from the same perspective. The way it details the components of scientific inquiry is a very useful tool for assessing areas where students are having (or could have) difficulties or inquiry activities should target in the first place. As suggested in the recent empirical studies mentioned above, the use of this approach could open new doors to alternative and effective professional development programs for inservice science teachers and methods courses for preservice science teachers.

Possibilities for Future Research

Although the researcher was able to attract 715 science teachers nationwide to participate in the survey and collected enough data to run factor analyses reliably, a larger sample size would have produced more generalizable information. In addition, the researcher did not make any attempt to differentiate between middle and high school science teachers when interpreting the results or developing and validating the SIT-TIPPS instrument. A more homogeneous sample could have been produced different results.

Participation rate from various states were not equal. Some of the states were represented in the study with more participants. Because socio-economic structures, beliefs and culture are engraved in the educational life of different states (or even within a state) findings might exhibit differences in teachers' perceptions and practices regarding the use of technology and scientific inquiry in science lessons, a different sample structure and state-wide representation might have resulted in a different response pattern. This might pinpoint an area of further investigation regarding the use of the SIT-TIPPS instrument.

As mentioned above, although teachers report high percentage of computer presence within their classrooms and/or in computer labs, no attempt was made to determine the quality of this technology infrastructure.

As is true with all new instruments, additional research is needed to support the validity and reliability of the instrument developed in this dissertation study. A randomly chosen, larger and more representative sample might produce different results.

Conclusion

Literature indicates scientific inquiry is one of the major goals of science curriculum and science teachers play a key role in achieving this goal as well as in implementing technology to support the objectives of scientific inquiry-based instruction. The instrument developed in this study, the SIT-TIPPS, contributes to this body of literature by indicating how well prepared teachers self-report their ability to use scientific inquiry skills and technology tools in their classrooms and how often they use them. Results indicate science teachers are below the satisfactory level in terms of implementing some of the essential features of scientific inquiry skills and integrating some new generation of technology tools during science lessons. The results of the study highlight areas in which preservice science teachers and inservice science teachers need training and professional development. The researcher contends that if science teachers' lack certain inquiry skills this would cause their students to lack the same skills. Therefore, these results should be alarming to those who are in charge of shaping the policies, initial teacher preparation programs, and professional development activities for future science teachers.

Results also indicate the importance of providing more educational technology training to teachers continuously throughout their career. The more training they receive the more likely they tend to use these technologies in their classrooms and, thus, more often they use these technologies to facilitate scientific inquiry.

In summary, the SIT-TIPPS instrument can be a highly effective tool for science educators, teachers, researchers, administrators, and policy makers to diagnose problems associated with science teachers' perceptions and practices regarding the use of technology tools/applications to attain the goals of scientific inquiry and to elucidate the factors contributing to their low comfort levels with the uses of inquiry skills and technology tools in science classrooms. Instruments that specifically targeting technology use for scientific inquiry purposes are limited in number. Therefore, this study makes a very valuable contribution to this body of literature by developing and validating the SIT-TIPPS instrument, which is capable of answering a wide range of questions dealing with science teachers' perceptions and actual classroom practices regarding the use of technology for scientific inquiry purposes.

Table 5-1. Teachers' self-reported strengths and weaknesses in scientific inquiry.

	Strengths (from highest to lowest)	Weaknesses (from lowest to highest)
Level of preparedness to support students to:	Collect, organize, and analyze data	Identify their own misconceptions of science content
	Explain cause-effect relationships	Find biases and flaws in their scientific explanations
	Conduct experiments	Test scientific explanations against current scientific knowledge Critique experiments
Frequency of integration of skills to support students to:	Explain cause-effect relationships	Find biases and flaws in their scientific explanations
	Discuss scientific explanations/ideas/models with others	Test scientific explanations against current scientific knowledge
	Conduct experiments Collect, organize, and analyze data	Critique experiments

Table 5-2. Teachers' strengths and weaknesses in technology tools/applications.

	Strengths (from highest to lowest)	Weaknesses (from lowest to highest)
Level of preparedness to support students to:	Word processing, Email, Internet searches, presentation software, spreadsheets, presentation devices	Data collection telecollaborative activities, videoconferencing, teleconferencing, portable Global Positioning Systems, video editing, podcasts/videocasts, blogs, wikis, wireless communication devices, Smart Board/Promethean interactive boards, webpage design
Frequency of integration of skills to support students to:	Word processing, presentation devices, presentation software, Internet searches, Email	Videoconferencing, teleconferencing, portable Global Positioning Systems, blogs, data collection telecollaborative activities, videoediting, wikis, podcasts/videocasts, wireless communication devices, image/picture editing, virtual experiences

APPENDIX A
RESEARCH STUDY INFORMED CONSENT FORM

<table>
<tr><td colspan="2">UFIRB 02 – Social & Behavioral Research
Protocol Submission</td></tr>
<tr><td colspan="2">Title of Protocol: Development and Validation of Scientific Inquiry with Technology - Teacher Practices and Perceptions Scale (SIT-TPPS)</td></tr>
<tr><td>1. Principal Investigator:. Ugur Baslanti</td><td>UFID #: 8735-6150</td></tr>
<tr><td>Degree / Title:
Doctoral Candidate in Educational Technology
Department:
School of Teaching and Learning</td><td>Mailing Address:
323 University Vllg S. #1 Gainesville, FL 32603

Email Address & Telephone Number:
baslanti@ufl.edu & (352) 846-5282</td></tr>
<tr><td>Co-Investigator(s): -</td><td>UFID#: -</td></tr>
<tr><td>Supervisor:
Dr. Colleen Swain</td><td>UFID#: N/A</td></tr>
<tr><td>Degree / Title:
Associate Professor & Graduate Coordinator

Department:
School of Teaching and Learning</td><td>Mailing Address:
PO Box 117048 School of Teaching & Learning
University of Florida, Gainesville, FL 32611

Email Address & Telephone Number:
(352) 392-9191, ext. 264</td></tr>
<tr><td colspan="2">Date of Proposed Research: From Oct 15, 2007 to August 1, 2008.</td></tr>
<tr><td colspan="2">Source of Funding (A copy of the grant proposal must be submitted with this protocol if funding is involved):
None.</td></tr>
<tr><td colspan="2">Scientific Purpose of the Study:

The purpose of this study is to develop and validate a survey that focuses on scientific inquiry in science classrooms where technology is used. It is an attempt to address an essential topic both in science education and educational technology. Even though there are some instruments targeting scientific inquiry in science education literature, an instrument specifically targeting scientific inquiry using technology is an area of need in both fields. Such an instrument will be helpful in analyzing the current practice in schools and colleges of education and in furthering the discussion on how science teachers can use technology to attain the goals of scientific inquiry. For this purpose, this study intends to develop a quantitative instrument that measures teachers' perceptions and practices regarding the use of technology in attaining the goals of scientific inquiry. It connects theory and research from two fields; science education and educational technology, which can result in a change of daily practice in science classroom.</td></tr>
<tr><td colspan="2">Describe the Research Methodology in Non-Technical Language: (Explain what will be done with or to the research participant.)

The researcher will contact middle and high school level science teachers nationwide via email or through national and statewide professional teacher organizations to participate in the study by filling</td></tr>
</table>

out the online version of the survey, which will be situated in a fire-walled server at the College of Education. Some of the participants who live within a reasonable distance to the researcher may be contacted in their schools and invited to fill out a paper based version of the survey. In either case, the participants will be given a consent form before they take the survey. In the online version, the participants will be directed to the online survey from an independent URL, which holds the consent form. Participants will be directed to the survey after they read the consent form and click on ‘Press here to start the survey” button. Participants will not be able to access the contents of the survey without submitting their consent. All data will be stored in a fire-walled server at the College of Education. Only the researcher and the supervisors will have access to data. The survey will also include a section that presents the operational definition of technology as it relates to the study; and a section that asks participants to complete demographics as well as a professional background (teaching experience etc.) information. Please see attached form.	
Describe Potential Benefits and Anticipated Risks: (*If risk of physical, psychological or economic harm may be involved, describe the steps taken to protect participant.)* There are no known benefits or risks involved on the participant’s behalf.	
Describe How Participant(s) Will Be Recruited, the Number and AGE of the Participants, and Proposed Compensation: Approximately 500 science teachers at the middle and high school level nationwide will be recruited through the use of electronic mailing as well as personal contacts. The researcher will also contact some professional teacher organizations to email an invitation note out to their members. All participants will be at or over eighteen years old. The participants will not be compensated for participation in the study.	
Describe the Informed Consent Process. Include a Copy of the Informed Consent Document: The informed consent will be presented to the participants on their computer screen prior to participating in the study and they can print or save the page for their information if they would like to do so. These consent forms will be secured in a fire-walled server at the College of Education. Please see attached form. If the participants wish to complete the paper version of the survey, the paper version of the informed consent form will be presented to the participants before they agree to participate in the study. The signed consent forms will be collected by the researcher and secured in a safe place. Please see attached form.	
Principal Investigator(s) Signature:	**Supervisor Signature:**
Department Chair/Center Director Signature:	**Date:**

INFORMED CONSENT FORM (Online Version)

Dear Science Teacher,

My name is Ugur Baslanti, and I am a graduate student from the School of Teaching and Learning at the University of Florida. I would like to invite you to participate in an online study that focuses on scientific inquiry in science classrooms where technology is used. For this purpose, this study intends to develop a quantitative instrument that measures teachers' perceptions and practices regarding the use of technology in attaining the goals of scientific inquiry. Such an instrument will be helpful in analyzing the current practice in schools and colleges of education and in furthering the discussion on how science teachers can use technology to attain the goals of scientific inquiry.

The procedure will entail the completion of a short demographic page and a short survey. It will take approximately 25 minutes to complete the survey.

Participation in this project is completely voluntary. You do not have to answer any questions you do not wish to answer, and you are free to withdraw your consent and to discontinue your participation at any time without any consequences. Your identity will be kept confidential to the extent provided by law.

There are no risks or direct benefits from your participation in this study apart from reflecting on your experience. You will not be compensated in any form for your participation in this study. The measure will be kept secure and only accessible to Ugur Baslanti and his advisors, Dr. Colleen Swain and Dr. Tom Dana. You will not be associated with your responses, which will be kept secure. Data will be removed from the server as soon as practicable. Data will not be shared and it will be stored on a highly secure and firewalled server, which can only be accessed by the research investigator via password-protected file transfer protocols.

This study has been approved by the University of Florida Institutional Review Board (IRB). For questions or concerns about your rights as a research participant, contact the UFIRB office, P.O. Box 112250, University of Florida, Gainesville, FL 32611-2250. Phone: (352) 392-0433.

If you have any questions about this research project, please contact Ugur Baslanti, baslanti@ufl.edu or Dr. Colleen Swain, Room (352) 392-9191 x 264.

I have read the procedure described above and by clicking the below link, I am voluntarily agreeing to participate in the survey study, and that I have received a copy of this description electronically.

Press Here To Start The Survey

INFORMED CONSENT FORM (Paper Version)

Dear Science Teacher,

My name is Ugur Baslanti, and I am a graduate student from the School of Teaching and Learning at the University of Florida. I would like to invite you to participate in a study that focuses on scientific inquiry in science classrooms where technology is used. For this purpose, this study intends to develop a quantitative instrument that measures teachers' perceptions and practices regarding the use of technology in attaining the goals of scientific inquiry. Such an instrument will be helpful in analyzing the current practice in schools and colleges of education and in furthering the discussion on how science teachers can use technology to attain the goals of scientific inquiry.

The procedure will entail the completion of a short demographic page and a short survey. <u>It will take approximately 25 minutes to complete the survey.</u>

Participation in this project is completely voluntary. You do not have to answer any questions you do not wish to answer, and you are free to withdraw your consent and to discontinue your participation at any time without any consequences. <u>Your identity will be kept confidential to the extent provided by law</u>.

There are no risks or direct benefits from your participation in this study apart from reflecting on your experience. You will not be compensated in any form for your participation in this study. Data will be accessible only to Ugur Baslanti and his advisors, Dr. Colleen Swain and Dr. Tom Dana and stored in a safe place at the College of Education.

<u>This study has been approved by the University of Florida Institutional Review Board (IRB).</u> For questions or concerns about your rights as a research participant, contact the UFIRB office, P.O. Box 112250, University of Florida, Gainesville, FL 32611-2250. Phone: (352) 392-0433.

If you have any questions about this research project, please contact Ugur Baslanti, baslanti@ufl.edu or Dr. Colleen Swain, Room (352) 392-9191 x 264.

APPENDIX B
SURVEY INSTRUMENT

Scientific Inquiry with Technology Teacher Perceptions and Practices Survey (SIT-TPPS)

Ugur Baslanti
School of Teaching & Learning
University of Florida
baslanti@ufl.edu

Definition of Technology

In this study, technology refers to a range of devices and technological processes specifically used for teaching and learning purposes in K-12 settings.

For the purposes of this study, the following devices, with examples, comprise the definition of technologies:

- Computers (desktop, laptop)
- Presentation devices (such as video projectors, LCD panels)
- Smart Board/Promethean interactive boards
- Wireless communication devices (such as PDAs, phones, digital response systems)
- Computer software (such as Word processors, desktop publishing, spreadsheets, presentation software, databases, simulations, games, graphing and data analysis software, video and picture editing software, etc.)
- Graphing/scientific calculators
- Portable Global Positioning Systems (GPS)
- Digital data collection devices (such as pH, pressure and temperature probes, digital microscope, Navigator systems)
- Videoconferencing, teleconferencing
- Internet technologies (such as e-mail, websites, online databases, virtual field trips, online simulations and games, Wikis, blogs, podcasts, videocasts, Google Earth and other Google tools, online learning communities)
- Data collection telecollaborative activities (such as Journey North, SCOPE, Amazing Space)
- Learning management systems (such as WebCT, Blackboard)

Scientific Inquiry with Technology Teacher Perceptions and Practices Survey (SIT-TPPS)

		Indicate how well prepared you currently feel to do each of the following in your science classroom with or without technology				Indicate how often the following happens in your science instruction				
	To support students to:	Not adequately prepared	Somewhat prepared	Fairly well prepared	Very well prepared	Never	Rarely (e.g.,a few times a year)	Sometimes (e.g.,once or twice a month)	Often (e.g.,once or twice a week)	Almost or all science lessons
Inquiry Skills										
1	Ask researchable questions	1	2	3	4	1	2	3	4	5
2	Conduct experiments	1	2	3	4	1	2	3	4	5
3	Collect, organize, analyze data	1	2	3	4	1	2	3	4	5
4	Identify their own misconceptions of science content	1	2	3	4	1	2	3	4	5
5	Explain cause-effect relationships	1	2	3	4	1	2	3	4	5
6	Test scientific explanations against current scientific knowledge	1	2	3	4	1	2	3	4	5
7	Find biases or flaws in their scientific explanations	1	2	3	4	1	2	3	4	5
8	Discuss scientific explanations/ideas/models with others	1	2	3	4	1	2	3	4	5
9	Critique experiments	1	2	3	4	1	2	3	4	5

		Indicate how well prepared you currently feel to use each of the following in your science classroom				Indicate how often you use the following in your science instruction				
		Not adequately prepared	Somewhat prepared	Fairly well prepared	Very well prepared	Never	Rarely (e.g.,a few times a year)	Sometimes (e.g.,once or twice a month)	Often (e.g.,once or twice a week)	Almost or all science lessons
Technology tools										
1	Presentation devices (such as video projectors, LCD panels)	1	2	3	4	1	2	3	4	5
2	Smart Board/Promethean interactive boards	1	2	3	4	1	2	3	4	5
3	Wireless communication devices (such as PDAs, student digital response systems)	1	2	3	4	1	2	3	4	5
4	Graphing/scientific calculators	1	2	3	4	1	2	3	4	5
5	Portable Global Positioning Systems (GPS)	1	2	3	4	1	2	3	4	5
6	Digital data collection devices (such as pH, pressure and temperature probes, digital microscopes, Navigator systems)	1	2	3	4	1	2	3	4	5
7	Videoconferencing, teleconferencing	1	2	3	4	1	2	3	4	5
8	Word processing (e.g., Word)	1	2	3	4	1	2	3	4	5
9	Spreadsheets (e.g., Excel)	1	2	3	4	1	2	3	4	5
10	Presentation software (e.g., Power Point)	1	2	3	4	1	2	3	4	5
11	Database software	1	2	3	4	1	2	3	4	5
12	Educational games	1	2	3	4	1	2	3	4	5

		Indicate how well prepared you currently feel to use each of the following in your science classroom				Indicate how often you use the following in your science instruction				
		Not adequately prepared	Somewhat prepared	Fairly well prepared	Very well prepared	Never	Rarely (e.g.,a few times a year)	Sometimes (e.g.,once or twice a month)	Often (e.g.,once or twice a week)	Almost or all science lessons
13	Virtual experiences (such as Google Earth and Starry Night, a virtual planetarium)	1	2	3	4	1	2	3	4	5
14	Graphing and data analysis software	1	2	3	4	1	2	3	4	5
15	Video editing	1	2	3	4	1	2	3	4	5
16	Image/picture editing	1	2	3	4	1	2	3	4	5
17	E-mail	1	2	3	4	1	2	3	4	5
18	Webpage design	1	2	3	4	1	2	3	4	5
19	Accessing online databases	1	2	3	4	1	2	3	4	5
20	Internet searches	1	2	3	4	1	2	3	4	5
21	Online simulations	1	2	3	4	1	2	3	4	5
22	Online science games	1	2	3	4	1	2	3	4	5
23	Wikis	1	2	3	4	1	2	3	4	5
24	Blogs	1	2	3	4	1	2	3	4	5
25	Podcasts, videocasts	1	2	3	4	1	2	3	4	5
26	Data collection telecollaborative activities (e.g., Journey North, SCOPE, Amazing Space)	1	2	3	4	1	2	3	4	5

	Please indicate your level of agreement with the following statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I integrate technology to enable students to ask scientifically oriented questions.	1	2	3	4	5
2	A science teacher should integrate technology to enable students to obtain evidence from various sources.	1	2	3	4	5
3	A science teacher should integrate technology to stimulate students to inquire about scientific phenomena.	1	2	3	4	5
4	I integrate technology to involve students in authentic/real world scientific issues.	1	2	3	4	5
5	I integrate technology to enable students to conduct successful empirical investigations.	1	2	3	4	5
6	A science teacher should integrate technology to enable students to evaluate their proposed explanations based on evidence and scientific knowledge.	1	2	3	4	5
7	I integrate technology to enable students to relate new concepts/ideas with their prior knowledge.	1	2	3	4	5
8	A science teacher should integrate technology to facilitate students’ collection, organization, and analysis of scientific data.	1	2	3	4	5
9	I integrate technology to encourage students to compare the ideas they have developed as a result of classroom inquiry against scientific facts.	1	2	3	4	5
10	I integrate technology to enable students to formulate explanations and coherent arguments to address scientifically oriented questions.	1	2	3	4	5
11	I integrate technology to enable students to make reasoned judgments based on scientific evidence.	1	2	3	4	5
12	A science teacher should integrate technology to enable students to formulate explanations of experimental and observational evidence.	1	2	3	4	5
13	A science teacher should integrate technology to enable students to use technology as instruments to make scientific observations.	1	2	3	4	5

	Please indicate your level of agreement with the following statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
14	I integrate technology to enable students to evaluate scientific explanations.	1	2	3	4	5
15	I integrate technology to improve students' skills to check their results against existing scientific knowledge.	1	2	3	4	5
16	A science teacher should integrate technology to enable students to use technology as instruments to collect data for conducting scientific experiments.	1	2	3	4	5
17	I integrate technology to enable students to critique experiments with others.	1	2	3	4	5
18	I integrate technology to enable students to discuss their scientific explanations/ideas/models with others.	1	2	3	4	5
19	I integrate technology to stimulate my students' skills to develop hypotheses based on their own observations and measurements of scientific phenomena.	1	2	3	4	5
20	A science teacher should integrate technology to develop students' knowledge and understanding of scientific ideas based on data collected from students.	1	2	3	4	5
21	A science teacher should integrate technology to encourage students to gather and use data to develop explanations for scientific phenomena.	1	2	3	4	5
22	I integrate technology to encourage students to justify their scientific arguments with others.	1	2	3	4	5
23	A science teacher should integrate technology to enable students to make connections between their results and existing scientific knowledge.	1	2	3	4	5
24	I integrate technology to enable students to identify and overcome their misconceptions of science content covered.	1	2	3	4	5
25	I integrate technology to enable students to find biases or flaws in the reasoning connecting scientific evidence and explanations.	1	2	3	4	5

	Please indicate your level of agreement with the following statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
26	A science teacher should integrate technology to enable students to ask scientifically oriented questions.	1	2	3	4	5
27	I integrate technology to enable students to obtain evidence from various sources.	1	2	3	4	5
28	I integrate technology to stimulate students to inquire about scientific phenomena.	1	2	3	4	5
29	A science teacher should integrate technology to involve students in authentic/real world scientific issues.	1	2	3	4	5
30	A science teacher should integrate technology to enable students to conduct successful empirical investigations.	1	2	3	4	5
31	I integrate technology to enable students to evaluate their proposed explanations based on evidence and scientific knowledge.	1	2	3	4	5
32	A science teacher should integrate technology to enable students to relate new concepts/ideas with their prior knowledge.	1	2	3	4	5
33	I integrate technology to facilitate students' collection, organization, and analysis of scientific data.	1	2	3	4	5
34	A science teacher should integrate technology to encourage students to compare the ideas they have developed as a result of classroom inquiry against scientific facts.	1	2	3	4	5
35	A science teacher should integrate technology to enable students to formulate explanations and coherent arguments to address scientifically oriented questions.	1	2	3	4	5
36	A science teacher should integrate technology to enable students to make reasoned judgments based on scientific evidence.	1	2	3	4	5
37	I integrate technology to enable students to formulate explanations of experimental and observational evidence.	1	2	3	4	5
38	I integrate technology to enable students to use technology as instruments to make scientific observations.	1	2	3	4	5

	Please indicate your level of agreement with the following statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
39	A science teacher should integrate technology to enable students to evaluate scientific explanations.	1	2	3	4	5
40	A science teacher should integrate technology to improve students' skills to check their results against existing scientific knowledge.	1	2	3	4	5
41	I integrate technology to enable students to use technology as instruments to collect data for conducting scientific experiments.	1	2	3	4	5
42	A science teacher should integrate technology to enable students to critique experiments with others.	1	2	3	4	5
43	A science teacher should integrate technology to enable students to discuss their scientific explanations/ideas/models with others.	1	2	3	4	5
44	A science teacher should integrate technology to stimulate students' skills to develop hypotheses based on their own observations and measurements of scientific phenomena.	1	2	3	4	5
45	I integrate technology to develop students' knowledge and understanding of scientific ideas based on data collected from students.	1	2	3	4	5
46	I integrate technology to encourage students to gather and use data to develop explanations for scientific phenomena.	1	2	3	4	5
47	A science teacher should integrate technology to encourage students to justify their scientific arguments with others.	1	2	3	4	5
48	I integrate technology to enable students to make connections between their results and existing scientific knowledge.	1	2	3	4	5
49	A science teacher should integrate technology to enable students to identify and overcome their misconceptions of science content covered.	1	2	3	4	5
50	A science teacher should integrate technology to enable students to find biases or flaws in the reasoning connecting scientific evidence and explanations.	1	2	3	4	5

APPENDIX C

LITERATURE BASE USED TO DEVELOP THE ITEM POOL

Table C-1. Definition and skills table of the essential features of scientific inquiry for the development of the instrument {NRC (2000). Inquiry and the National Science Education Standards: A guide for teaching and learning. Washington, DC: National Academy Press}

1. Teacher engages students in scientifically oriented questions

A question robust and fruitful enough to drive an inquiry generates a "need to know" in students, stimulating additional questions of "how" and "why" a phenomenon occurs. The initial question may originate from the learner, the teacher, the instructional materials, the Web, some other source, or some combination. The teacher plays a critical role in guiding the identification of questions, particularly when they come from students. Fruitful inquiries evolve from questions that are meaningful and relevant to students, but they also must be able to be answered by students' observations and scientific knowledge they obtain from reliable sources. The knowledge and procedures students use to answer the questions must be accessible and manageable, as well as appropriate to the students' developmental level. Skillful teachers help students focus their questions so that they can experience both interesting and productive investigations (NRC, 2000, p. 24).

Teacher and student skills & questions to consider – Derived from NRC (2000):
Lending to empirical investigation
Leading to gathering and using data to develop explanations for scientific phenomena
Asking why and how questions
Generating a need to know in students, stimulating additional questions of how and why a phenomenon occurs
Stimulate interest in science
Generate/ask questions that center on objects, organisms, and events in the natural world
Questions connect to the science concepts described in the content standards, guide the identification of questions, help students focus their questions so that they can experience both interesting and productive investigations

Addendum from the literature:
Seeking information from experts
Seeking for information/researching conjectures
Planning/designing/conducting empirical investigations
Encouraging students to demand more knowledge
Developing an appreciation of how we know
Posing real world questions/dealing with authentic problems
Engaging students in identifying/diagnosing problems/defining and representing a problem

2. Teacher encourages students to give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions

Students use evidence to develop explanations for scientific phenomena. They observe plants, animal, and rocks, and carefully describe their characteristics. They take measurements of temperature, distances, and time, and carefully record them. They observe chemical reactions and moon phases and chart their progress. Or they obtain evidence from their teacher, instructional materials, the Web, or elsewhere, to "fuel" their inquiries (NRC, 2000, p. 26).

Teacher and student skills & questions to consider - Derived from NRC (2000):
The use of empirical evidence as the basis for explanations about how the natural world works
Getting accurate data from observations of phenomena
Obtaining evidence from observations and measurements taken in natural settings such as oceans, or in contrived settings such as labs
Using senses, instruments
Gather data over a wide range of naturally occurring conditions and over a long enough period of time so that they can infer what the influence of different factors might be
The accuracy of the evidence gathered is verified by checking measurements, repeating the observations, or gathering different kinds of data related to the same phenomenon
The evidence is subject to questioning and further investigation
Students use evidence to develop explanations for scientific phenomena
Students observe plants, animals, and rocks, and carefully describe their characteristics
Taking measurements of temperature, distances, and time, and carefully record them
Students obtain evidence from their teachers, instructional materials, the web, to fuel their inquiry

Addendum from the literature:
Making observations
Reviewing what is already known in light of experimental evidence
Using tools to gather, analyze, and interpret data
Predicting, collecting, and analyzing data
Dealing with data
Developing hypotheses
Designing experiment or study
Observing, exploring, and generating strategies

3. Teacher helps students formulate explanations from evidence to address scientifically oriented questions

Explanations are ways to learn about what is unfamiliar by relating what is observed to what is already known. So, explanations go beyond current knowledge and propose some new understanding. For science, this means building upon the existing knowledge base. For students, this means building new ideas upon their current understandings. In both cases, the result is proposed new knowledge. For example, students may use observational and other evidence to propose an explanation for the phases of the moon; for why plants die under certain conditions and thrive in others; and for the relationship of diet to health (NRC, 2000, p. 26).

Teacher and student skills & questions to consider - Derived from NRC (2000):
Emphasizes the path from evidence to explanation rather than the criteria for and characteristics of the evidence.
Scientific explanations are based on reason. They provide causes for effects and establish relationships based on evidence and logical argument. They must be consistent with experimental and observational evidence about nature, they respect rules of evidence, are open to criticism, and require the use of various cognitive processes generally associated with science e.g. classification, analysis, inference, and prediction, and general processes such as critical reasoning and logic. Explanations are ways to learn about what is unfamiliar by relating what is observed to what is already known. So, explanations go beyond current knowledge and propose some new understanding. Building upon the existing knowledge base; building new ideas upon their current understandings: The result is proposed knowledge. (e.g.) students may use observational and other evidence to propose an explanation for the phases of the moon; for why plants die under certain conditions and thrive in others; relationship of diet to health

Addendum from the literature:
Forming coherent arguments
The activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world
Developing epistemological understanding about the nature of science and the development of scientific knowledge
Developing a broader understanding of science
Constructing/formulating explanations
Formulating and testing scientific rules and laws
Interpreting, evaluating
Students describe objects and events
Drawing inferences
Using logical & critical thinking to formulate conclusions
Identifying one’s own assumptions
Improving students’ critical reasoning and problem solving skills
Enabling students to develop their own ideas by building connections between their existing ideas and new ideas
Uncovering new scientific principles and refining their preexisting understandings
Relating information with prior knowledge and then integrating into larger knowledge structures
Making a reasoned judgment based on appropriate evidence
Dealing with misconceptions

4. Teacher helps students connect explanations to scientific knowledge. Teachers help students evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding

Alternative explanations may be reviewed as students engage in dialogues, compare results, or check their results with those proposed by the teacher or instructional materials. An essential component of this characteristic is ensuring that students make the connection between their results and scientific knowledge appropriate to their level of development. That is, student explanations should ultimately be consistent with currently accepted scientific knowledge (NRC, 2000, p. 27).

Teacher and student skills & questions to consider - Derived from NRC (2000):
Evaluation and possible elimination or revision of explanations is one feature that distinguishes scientific from other forms of inquiry and subsequent explanations
Does the evidence support the proposed explanation?
Does the explanation adequately answer the questions?
Are there any apparent biases or flaws in the reasoning connecting evidence and explanation?
Can other reasonable explanations be derived from the evidence?
Alternative explanations may be reviewed as students engage in dialogues, compare results, or check their results with these proposed by the teacher or instructional materials
Students make the connections between their results and scientific knowledge appropriate to their level of development. That is, student explanations should ultimately be consistent with currently accepted scientific knowledge

Addendum from the literature:
Students test their explanations against current scientific knowledge
Proposing answers, explanations, and predictions
Distinguishing alternatives
Evaluating/Considering alternative explanations
Building theories

5. Teacher encourages students to communicate and justify their proposed explanations

Having students share their explanations provides others the opportunity to ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations. Sharing explanations can bring into question or fortify the connections students have made among the evidence, existing scientific knowledge, and their proposed explanations. As a result, students can resolve contradictions and solidify an empirically based argument (NRC, 2000, p. 27).

Teacher and student skills & questions to consider - Derived from NRC (2000):

Having students share their explanations provides others the opportunity to ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations
Sharing explanations can bring into question or fortify the connections students have made among the evidence, existing scientific knowledge, and their proposed explanations. As a result, students can resolve contradictions and solidify an empirically based argument

Addendum from the literature:
Communicating the results, findings, and ideas
Critiquing experiments
Debating with peers
Communicating and defending hypotheses, models, and explanations
Persuading peers
Argumentation

Table C-2. Essential features of scientific inquiry for the development of the instrument. (1) Teacher engages students in scientifically oriented questions. (2) Teacher encourages students to give priority to evidence. (3) Teacher helps students formulate explanations from evidence to address scientifically oriented questions. (4) Teacher helps students connect explanations to scientific knowledge. (5) Teacher encourages students to communicate and justify their proposed explanations

1	**2**	**3**	**4**	**5**
posing (real world) questions (NRC, 1996; Crawford, 2000; Roth & Michelle, 1998; Keys, 1997)	making observations (NRC, 1996; Brendzel, 2005; Sherman & Sherman, 2004; Bodzin, 2005)	the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 1996)	proposing answers, explanations, and predictions (NRC, 1996)	communicating the results, findings (their ideas) (NRC, 1996; Sherman & Sherman, 2004; Bodzin, 2005).
developing question, defining and representing problem (Lee et al., 2004)	reviewing what is already known in light of experimental evidence (NRC, 1996)	forming coherent arguments (Linn et al., 2004)	distinguishing alternatives (Linn et al., 2004)	critiquing experiments (Linn et al., 2004)
examining books and other sources of information to see what is already known (NRC, 1996)	using tools to gather, analyze, and interpret data (NRC, 1996; Brendzel, 2005; Keys, 1997)	develop epistemological understandings about the nature of science and the development of scientific knowledge (Abd-el-Khalick et al., 2004)	test those explanations against current scientific knowledge (NRC, 1996)	debating with peers (Linn et al., (2004)
seeking information from experts (Linn et al., 2004)	developing hypothesis (Wichmann et al., 2003; Crawford, 2000; Sherman & Sherman, 2004; Bodzin, 2005)	formulating explanations (Abd-el-Khalick et al., 2004; Keys, 1997)	considering alternative explanations (NRC, 1996; Schwab, 1960, cited in NRC, 2000, p.21)	communicating, and defending hypothesis, models, and explanations (Abd-el-Khalick et al., 2004)
researching conjectures (Linn et al., 2004)	dealing with data (Crawford, 2000)	using logical and critical thinking to formulate conclusions (Sherman & Sherman, 2004; Bodzin, 2005)	building theories (Crawford, 2000)	persuading peers (Roth & Michelle, 1998)
searching for information (Linn et al., 2004)	predicting, collecting and analyzing data (Sherman & Sherman, 2004; Bodzin, 2005)	formulate and test scientific rules and laws (Looi, 1998)	evaluate alternative explanations (Sherman & Sherman, 2004; Bodzin, 2005).	discussion-verbal interactions with peers and teacher-(Westbrook, 1997)
planning (designing and conducting) investigations (NRC, 1996; Linn et al., 2004; Abd-el-Khalick et al., 2004); Crawford, 2000; Keys (1997)	designing experiment or study (Lee et al., 2004)	an understanding of the nature of science (Sherman & Sherman (2004)		argumentation (Zembal-Saul & Land, 2002; McDonald, 2004),

Table C-2. Continued.

engaging students in the intentional process of diagnosing problems (Linn et al., 2004; Lee et al., 2004)	observing, exploring and generating strategies, organizing, analyzing (Lee et al., 2004)	interpreting, and evaluating (Lee et al., 2004)		debates about the use of evidence (Schwab, 1960, cited in NRC, 2000, p.21)
relevant inquiry skills such as identifying problems (Abd-el-Khalick et al., 2004)	interdisciplinary contexts (Myers & Botti, 1997)	developing a broader understanding of science (Bodzin, 2005)		
generating research questions, (Abd-el-Khalick et al., 2004)		students describe objects and events (NRC, 1996)		
engaging in inquiry helps students develop an appreciation of “how we know” (Sherman & Sherman, 2004)		construct explanations (NRC, 1996)		
encouraging them to demand more knowledge (Edelson et al., 1999)		identifying assumptions (NRC, 1996)		
applying their scientific understanding in the pursuit of research questions (Edelson et al., 1999)		use critical and logical thinking, (NRC, 1996)		
authentic problems (Flick, 1997)		improves their critical reasoning and problem solving skills (Bodzin, 2005)		
		enables students to develop their own ideas by building connections between their existing ideas and new ideas (Berge & Slotta, 2005)		
		drawing inferences (Crawford, 2000)		

Table C-2. Continued.

uncovering new scientific principles and refining their preexisting understandings (Edelson et al., 1999)

relating information with prior knowledge and then integrating into larger knowledge structures (Myers & Botti, 1997)

making a reasoned judgment based on appropriate evidence (Lee at al., 2004)

deal with misconceptions (Cognition and Technology Group at Vanderbilt, 1992; Nickerson, 1995)

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BIOGRAPHICAL SKETCH

Ugur Baslanti was born in Istanbul, Turkey, in 1975. He received his Bachelor of Science degree in chemistry education and his Master of Science degree in secondary school science and mathematics education with an emphasis on gifted education from Bogazici University in Istanbul. He worked as a teaching and research assistant at this university for three years, but also taught chemistry, physics, and mathematics part-time in a private educational institution. In 2002 and 2004 he taught chemistry in a summer program for the gifted organized by the Center for Talented Youth at the Johns Hopkins University.

He started working toward his doctorate degree in educational technology in the School of Teaching and Learning at the University of Florida in 2002. During his doctoral studies Ugur taught Instructional Technology Lab and Technology Integrated in Mathematics Curriculum to undergraduate and graduate pre-service teachers for two years and served as a research assistant on a variety of educational grants including Preparing Tomorrow's Teachers to Use Technology (PT3) and Classroom Connectivity. His areas of interest are gifted underachievers, teacher education, and the integration of technology into mathematics and science instruction.