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ELEMENTARY TEACHERS' KNOWLEDGE, ATTITUDE, AND PRACTICES

TOWARD TECHNOLOGY EDUCATION:

EFFECTS OF THE I³ PROJECT

A Dissertation

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirements for the Degree

Doctor of Education

Sandra E. Cavanaugh

Indiana University of Pennsylvania

August 2009

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Indiana University of Pennsylvania
The School of Graduate Studies and Research
Department of Professional Studies in Education

We hereby approve the dissertation of

Sandra E. Cavanaugh

Candidate for the degree of Doctor of Education

George R. Bieger, Ph. D., Chair
Professor of Education

James D. Hooks, Ph. D.
Professor, University Libraries

Mark Twiest, Ph. D.
Professor of Education

ACCEPTED

Michele Schwietz, Ph.D.
Assistant Dean for Research
The School of Graduate Studies and Research

Title: Elementary Teachers’ Knowledge, Attitude and Practices Toward Technology Education: Effects of the I³ Project

Author: Sandra E. Cavanaugh

Dissertation Chair: George R. Bieger, Ph. D.

Dissertation Committee Members: James D. Hooks, Ph. D.
Mark Twiest, Ph. D.

This study examined elementary school teachers’ perceptions of technology after participating in a field test, the I³ Project. The study explored and assessed how elementary teachers reported technology in terms of knowledge, attitude, and technology implementation in the classroom.

The results revealed that the technology experience, the I³ Project, had a strong positive impact on the teachers’ technological literacy, their pedagogical knowledge of technology, their confidence in teaching technology, and their incorporation of technology strategies in their classrooms. The teachers described appropriate definitions of technology and what it means to be technologically literate. They characterized technologically literate people as problem-solvers. Many used technology terms as they gave examples of problem-solving approaches. They also provided detailed accounts of teaching technology using components of the I³ units or their own developed units.

The data findings support the conclusion that teachers have been positively affected by their experience in the I³ Project, in terms of knowledge, attitude, and practices towards technology education. The data are supportive of the benefits of technology in the elementary curriculum. As the choice to include technology is made in more schools and classrooms, the impact on student

knowledge and competency will become increasingly evident. However, this will require continued work in areas of teacher preparation and professional development.

ACKNOWLEGEMENTS

I dedicate this final project to my family, who have patiently waited for me to finish. My mother, my children, my grandson and my husband- you have never stopped supporting me and giving me encouragement to continue.

Thank you Mom, Donnie and Missy, Chris, Matt and Kristen, Dylan and lastly- my husband, Donnie- I'm finally done!

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CHAPTER 1

THE PROBLEM

The purpose of education is to provide students with a diversified curriculum that presents a basic understanding of the world in which they live. While today's society is both democratic and technological, it is the technological component that is least emphasized. People spend more than 95% of their time interacting with the technological world (Cunningham, Lachapelle, & Lindgren-Streicher, 2006). Even so, very few comprehend how our designed world came about and how the products that we have developed function. Evidence shows that American adults and children have a poor understanding of what technology is (Rose & Dugger, 2002). In fact, Gallup polls in 2001 and 2004 reported two-thirds of the respondents cited computers as their first thoughts when hearing the word *technology*. Only one-third embraced the broader concept as the means of changing the natural world to satisfy our needs (ITEA, 2004). This misconception is attributed mainly because the majority of our nation's schools do not study the discipline of technology education.

As a society, a high priority has not been placed on technological literacy. Being able to use, manage, and understand technology is a literacy that all students need to become contributing members of society and live productive lives. If children are to be technologically literate, learning about technology must be a part of their education (International Technology Education Association [ITEA], 1996). More importantly, it must begin in a child's early school years

(Cunningham, Lachapelle, & Lindgren-Streicher, 2006; Foster & Kirkwood, 1997; ITEA, 2000, 1996; Pearson, & Young, T. [Eds.] 2002; Wright, 1999).

Introducing the discipline of technology at the elementary level can be challenging. In a curriculum that is already overloaded, implementation can face barriers such as teachers' interpretation of technological knowledge, confidence in and capability of teaching technology content, and ability to integrate technology content and concepts in the classroom. The literature is replete with rationales supporting the implementation of elementary technology education. However, there is almost no literature pertaining to professional development for elementary teachers that promotes understanding of technology content and concepts and supports teachers' efforts to implement technology into their classrooms.

This study examines teachers' perceptions of technology after participating in a technology curriculum field test, the I³ Project. Pronounced *i cubed*, it is short for Invention-Innovation and Inquiry- Units for Technological Literacy. The I³ Project is a compilation of ten instructional units created for students in grades 5 and 6 (Appendix A). The units were designed to provide professional support for teachers interested in technological literacy in education. This study sought to examine the link between participation in the I³ Project, and teachers' perceptions of knowledge, attitude, and practices towards technology education.

Problem Statement

The focus of this study is elementary school teachers' limited understanding of technology concepts and appropriate implementation of the same. The education of the vast majority of elementary school teachers did not include technology activities or information (Cunningham, et al., 2006). Elementary teachers' lack of technological exposure can translate to limited comprehension of technology in terms of pedagogical knowledge, ability to conceptualize technology in the learning environment, and ability to facilitate implementation within the current curriculum. Some elementary teachers likely include technological content and concepts in their curriculum; however, it is questionable whether this happens knowingly or unknowingly.

Educational policies call for students to have an understanding of technology and the rapidly changing world around them. Educating students to be technologically literate must be seen as a fundamental goal of the educational system (Business Roundtable [BR], 2005; Bybee & Kendall, 2006; ITEA, 2000; Pearson & Young, 2002; National Governors Association [NGA], 2007; Taskforce on the Future of American Innovation, 2005; US Dept. of Ed., 2002).

The Standards for Technological Literacy (STL) are clear about technology in the lower grades: "Technology is not an add-on subject in the primary grades. Rather, the study of technology is an integral part of the elementary curriculum" (ITEA, 2002, p.2). Technology instruction is interdisciplinary, a concept substantiated by research. Its relevancy lies in the premise that abstract concepts from multiple subjects are *blended* into practical applications in authentic ways. In addition, the activities or experiences comprising the technology curriculum are a collaboration of minds-on, hands-on challenges that are relevant to the world around us. The result is that children learn in ways that are exciting and more meaningful when actively engaged in the learning and the subject matter or content is combined in instruction rather than taught as separate subjects (ITEA, 2002, p.12). At a time when policymakers are calling for improved student achievement and ensuring the success of every child, providing educators with knowledge and skills needed to facilitate technology content successfully is necessary. Developing adequate professional materials and resources that educators believe will change their practice is crucial.

Purpose of the Study

This study addresses elementary school teachers' perceptions of technology after participating in a field test, the I³ Project. The purpose of this two-phase, mixed methods study is to acquire statistical quantitative results from a sample and then follow up with observations and interviews to refine and explain the results in more depth. In the first, quantitative phase of the study, a survey questionnaire collected from the elementary teacher I³ Project participants describes perceptions of knowledge, attitude, and practices towards technology education. In the second, qualitative phase, semi-structured interviews will be conducted to provide further understanding of the quantitative results. The reason for the explanatory follow-up is to help explain or build on initial quantitative results.

The findings of this investigation will provide focus and direction for future technology education professional development and curricular materials and resources in hopes of improving elementary teachers' technological literacy and ability to implement technology content and concepts in their current curriculum.

Questions Researched

The questions that guided the research included two primary questions with the following sub questions:

1. How did elementary teachers report perceptions of technology after implementing curricular units for the I^3 Project?
    a. In what way did participation in the I^3 Project affect elementary teachers' technological literacy?
    b. In what way did participation in the I^3 Project influence elementary teachers' pedagogical knowledge of technology?
2. How did elementary teachers report classroom practices after implementing curricular units for the I^3 Project?
    a. In what way did participation in the I^3 Project affect elementary teachers' confidence with technology content?
    b. To what extent did teachers implement technology content in the classroom after participation in the I^3 Project?

In order to answer these questions, a mixed methodology, organized by the type of quantitative and qualitative procedures was used to answer the above research questions. The use of a questionnaire and interviews compliment the statistical data in describing teachers' perceptions of technology.

Definition of Terms

I³ Project– the I³ Project was created to provide professional support for teachers interested in technological literacy in education particularly in elementary curriculum. I³ is short for Invention, Innovation, and Inquiry: Units for Technological Literacy, Grades 5–6. This ITEA project was funded by the National Science Foundation (NSF). It is so named because invention and innovation are the hallmarks of technological thinking and action. Each unit has standards-based content, suggested teaching approaches, and detailed learning activities including brainstorming, visualizing, testing, refining, and assessing technological designs (ITEA, 2008a).

Constructivism– asserts two main principles: 1) learners construct new understandings using what they already know. Learners come to learning situations with knowledge gained from previous experience, and that prior knowledge influences what new or modified knowledge they will construct from new learning experiences. 2) Learning is active rather than passive. Learners confront their understanding in light of what they encounter in the new learning situation. If what learners encounter is inconsistent with their current understanding, they can change their thinking to accommodate the new experience. Learners remain active throughout this process: they apply current understandings, note relevant elements in new learning experiences, judge the consistency of prior and emerging knowledge, and based on that judgment, they can modify knowledge (Hoover, 1996).

Technology— human innovation in action. Technology deals with the human-made world we live in and how people design and improve products and the environment (ITEA, 1996, 2000).

Technology Education— a problem-based learning curriculum that integrates math, science and technology principles. ITEA (2008b) describes six components of technological studies, as follows:

1. designing, developing, and utilizing technological systems
2. open-ended, problem-based design activities
3. cognitive, manipulative, and effective learning strategies
4. applying technological knowledge and processes to real world experiences
5. using up-to-date resources
6. working individually as well as in a team to solve problems

Technological literacy— a term applied to people who are able to use, manage and understand technology (ITEA, 1996). Technologically literate people are good at making decisions and solving problems in a variety of contexts. They understand what technology is, how it is created, how it shapes society, and how society shapes it.

Significance of the Study

Several documents and reports relating to technology education have emerged that serve as definition and attest to its value and necessity in a child's education. The Standards for Technological Literacy (STL) published in 2000, identifies what all students in grades K-12 should know and be able to do to achieve technological literacy. The current educational reform requires that students be assessed in technology through standardized testing. Members of various organizations, such as the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the National Academy of Engineering (NAE), have expressed the need for all people to have an understanding of technology to be productive citizens. Others recognize technology education as fundamental to achieving workforce competencies imperative to our global economy (Bybee, 2001; Bybee & Starkweather, 2006; National Research Council [NRC], 2006; National Governors Association [NGA], 2007).

To develop technological literacy in children, technology education must be a part of every student's education (International Technology Education Association [ITEA], 1996; Satchwell & Dugger, 1996). Furthermore, other authors have expressed the need to begin technology education in a child's early school years (Cunningham, Lachapelle, & Lindgren-Streicher, 2006; Foster & Kirkwood, 1997; ITEA, 1996, 2002, Wright, 1999). However, introducing the discipline of technology at the elementary level faces many obstacles, particularly among elementary teachers. The vast majority of elementary school teachers lack comprehension of technology in terms of pedagogical knowledge, ability to conceptualize technology in the learning environment, and ability to facilitate implementation within the current curriculum (Cunningham, et al., 2006).

This study was designed to explore and assess elementary teachers' perception of technology after participating in the I³ Project field test. The findings of this investigation will provide insight into elementary teachers' knowledge, attitudes, and practices of technology after participating in the I³ Project field test.

It is anticipated that the results of this study will be valuable in many forums, for example,

1) to those responsible for creating professional development experiences

2) to those responsible for developing curriculum, instructional materials, and/or resources in determining effective components that promote and support technological literacy in teachers

3) to school districts in selecting curriculum and strategies effective in improving student learning and achievement, while aligned with state and/or national technology standards

4) to teacher preparation institutes when considering course offerings and ways to bring awareness and support of technology to schools

Limitations of the Study

This study focused on elementary teachers' perceptions of technology after field-testing the I³ Project units. Factors that may affect the limitations of this study are 1) the small scale of the sample, which includes twenty of the twenty-five elementary education teachers who field-tested the I³ Project units 2) the accuracy and appropriateness of the units to promote and support technology, 3) time constraint, and 4) new concepts, 5) self-reporting.

This study examined only twenty elementary education teacher's interpretation and implementation of technology after field-testing technology education units for the I³ Project. The results of this study are only representative of the perceptions and opinions of this survey population. The accuracy and appropriateness of the units to advance technological literacy may be debatable.

The newness of the concepts to the teachers may have interfered with the intended conceptualization. Participants had only eight to ten days to complete the I^3 unit with their students. Even though traditional professional support experiences are much shorter, eight to ten days is a small amount of time to master understanding and implementation strategies. Teachers certified in technology education would have the entire scope of their college coursework to become experts in the field.

The data collection used in this study consists of a survey questionnaire, observations and interviews. Surveys and interviews are self-report measurement techniques designed to question people about themselves, their attitudes, and behaviors (Creswell, 2003). This type of measurement can be potential sources of unreliable answers. Respondents may exaggerate, they may be embarrassed to state their true response, or they may simply forget the true account.

Summary

The ultimate goal of schools is to prepare every child to live a productive life (Foster & Kirkwood, 1997). This means children must be provided with a diversified curriculum that presents a basic understanding of the world in which they live. The influence of technology over people's lives has dramatically increased. Even though people spend more than 95% of their time interacting with the technological world, few comprehend how our designed world came about and how the products we have developed function (Cunningham, Lachapelle, & Lindgren-Streicher, 2006).

Our society has not placed a high priority on technological literacy. Being able to use, manage, and understand technology is a literacy that all students need to become contributing members of society and live productive lives. If our children are to be technologically literate, learning about technology must be a part of their education. More importantly, it must begin in the early school years.

Introducing the discipline of technology at the elementary level is challenging. In a curriculum that is already overloaded, implementation faces barriers such as teachers' interpretation of technological knowledge, confidence in and capability of teaching technology content, and ability to integrate technology content and concepts in the classroom. These barriers exist largely because the education of the vast majority of elementary school teachers did not include technology activities or information (Cunningham, et al., 2006). Elementary teachers' lack of technological exposure can translate to limited comprehension of technology in terms of pedagogical knowledge, ability to conceptualize technology in the learning environment, and ability to facilitate implementation within the current curriculum.

Reform efforts will require change in traditional teaching methods and adaptation of curricula in ways that align with technology standards, fit seamlessly into an already overloaded curriculum, and ensure technological literacy. The literature is replete with rationales supporting the implementation of elementary technology education. However, there is almost no literature pertaining to professional development for elementary teachers that promotes understanding of technology content and concepts and supports teachers' efforts to implement technology into their classrooms.

This study examined teachers' perceptions of technology after participating in a technology curriculum field test, the I³ Project. This study sought to examine the link between participation in the I³ Project, and teachers' perceptions of knowledge, attitude, and practices towards technology education.

Chapter 1 describes the purpose of the study, providing a rationale for the guiding questions that provide focus and direction for the inquiry. Chapter 2 contains a review of relevant discourses including a conceptual meaning of technology, historical background of technology education, issues in elementary technology education, philosophical principles that guide elementary technology education, and reviews the literature on adult learning. Chapter 3 explains the research methodology used in this study. Specifically, information is provided regarding mixed methods research design, the sampling frame, and data collection procedures. It addresses the research methodology that frames this investigation and guides the research procedures. Chapter 4 presents the data analysis procedures and results. It includes a description of the sample, the quantitative data results and descriptive statistics, and the qualitative data results of observations and interviews.

Chapter 5 presents conclusions drawn from the data and discussions regarding the conclusions. Finally, implications for elementary teachers and future research are discussed, followed by a summary of the study.

CHAPTER 2

REVIEW OF THE LITERATURE

Technology has been evolving as a subject matter for centuries. As reported by Lewis & Zuga (2005), members of this field have made historical efforts to define the content in an effort to determine what should be taught in schools and how it should be delivered. From the first instances of early practices, confusion has existed in the content definition, its implementation, and in the name itself. The confusion has resulted from the fact that the terms and knowledge associated with technology continue to change with time. Viewpoints regarding the meaning of technology education, its historical background, content delivery, and its educational value for American children have persisted to be topics of research (Bennett, 1926, 1937; Brusic, 2003; Foster, 1994; Clark, 1989; Lewis & Zuga, 2005).

Several documents and reports relating to technology education have emerged that serve as definition and attest to its value and necessity in a child's education. The *Standards for Technological Literacy* (STL) published in 2000, identifies what all students in grades K-12 should know and be able to do to achieve technological literacy. The current educational reform requires students be assessed in technology. Members of various organizations, such as the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the National Academy of Engineering (NAE) have expressed the need for all people to have an understanding of technology to be productive citizens. Others recognize technology education as fundamental to achieving workforce competencies imperative to our global economy (Bybee, 2001; Bybee & Starkweather, 2006; National Research Council [NRC], 2006; National Governors Association [NGA], 2007).

Technology education stands to make a substantial contribution to American education. However, still existing is the problem of teachers (in fields other than technology) simply not knowing or understanding the meaning of technology and/or technology education, nor its goals and purposes. This phenomenon places educators, particularly elementary teachers, at a disadvantage. Current education reform efforts that include standards-based assessments will encompass technology content. This means teachers will be required to include technology content into the already over-loaded elementary curriculum. To attain the technological literacy needed for teachers to deliver effective implementation, change in teachers' practices must occur. School districts, administrators, principals, elementary education teachers, and ultimately, children, stand to benefit greatly with a conceptual understanding of its philosophical base, subject matter, and program implementation.

The goal of this study was to examine teachers' perceptions of technology after their participation in a technology education curriculum field test, the I³ Project. This study sought to examine the link between participation in the I³ Project, and teachers' perceptions of knowledge, attitude, and practices towards technology education.

This literature review will examine the following: a) conceptual meaning of technology, b) historical background of technology education, c) issues in elementary technology education, d) philosophical principles that guide elementary technology education, and e) adult learning theories.

The first section defines technology, explains what it means to be technologically literate, describes the differences between technological literacy and being technically competent, and discusses the evolving need for technological literacy in today's society. The second section examines the history of technology education encompassing the early beginnings of technology education, curricular development, the resurgence of elementary technology education, and the transitioning of industrial arts to technology education. The third section provides a framework of elementary technology education issues. It provides a contemporary view and rationale of technology education, examines the impacts of educational policy on technology education, and reviews elementary technology education both in the US and abroad. The fourth section discusses the philosophical principles that guide elementary technology education. The fifth section discusses adult learning. The final section is the summary that provides a connection of the topics in this literature review to this study as well as a closing transition to the next chapter, the methodology.

A Conceptual Meaning of Technology

Technology Defined

The misconception of technology is widespread. In fact, Gallup polls in 2003 and 2004 revealed that the public's perception of technology is confusing. Two-thirds of the respondents cited computers as their first thoughts when hearing the word *technology*. Only one-third embraced the broader concept as the means of changing the natural world to satisfy our needs (ITEA, 2004).

Defining technology is not a task answerable in a few words. It requires a sequence of understandings. First, technology is any artifact or product that is human-made. These products can be very simple, such as a paper clip, a vitamin, or a pair of shoes. They can also be complex, such as the space shuttle, an artificial limb, or the newest version of a cell phone. The second understanding is that technology is not just products. It is also the knowledge and processes needed to create and operate them, as well as the entire infrastructure necessary for the product development. Infrastructures can include management, workers, factories, marketing, etc. Consequently, “technology comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves” (Pearson & Young, 2002, p. 3).

ITEA simply states technology as “human innovation in action”; it deals with the human-made world we live in and how people design and improve products and the environment (1996 & 2000). This is similar to the definition provided in the National Science Education Standards, “…the goal of technology is to make modifications in the natural world to meet human needs” (NRC, 1996, p. 24). Comparable to these definitions, the American Association for the Advancement of Science (AAAS) *Benchmarks for Science Literacy* offers “in the broadest sense, technology extends our abilities to change the world; to cut, shape, or put together materials; to move things from one place to another; to reach further with our hands, voices, and senses" (1993, p.41). The National Publication of Engineering (NAE) and the National Research Council (NRC) in a publication prepared in 2002*, Technically Speaking: Why All Americans Need to Know More About Technology*, describes technology as "the processes by which humans modify nature to meet their needs and wants" (p.2). All of these definitions are synonymous, serving to reinforce each other (ITEA, 2003).

Technology enhances our comfort, communication, productivity, agriculture, medical care, safety, and more. We can create technological options to lessen, prevent, or eliminate threats to life, the environment, and to fulfill societal needs. However, the world is affected by problems that arise from both the natural world and the technological, human-made world. Examples of these include radiation, medication side effects, job elimination, decreased forestation, and global warming, to name a few. One might say that technology is two-fold; while technology is blamed for the degradation of the natural environment, others view it as a panacea to solve future problems. It is easy to see how technology has the ability to shape our future. It is essential that we prepare a more technologically literate society capable of understanding how technology affects our world and our existence with and around technology.

An aspect of technology often overlooked is its connection with science. Science and technology are commonly mentioned together, but technology is usually mentioned second. Some contend that technology is a secondary form of science, e.g. applied science, which can explain its subordinate stature (Gagel, 2006). Tiles and Oberdiek (1995) explain this debate as being rooted in a “conflict between utility and intellectual status” (p.74). They continue to say that the *scientific method* is used for problem solving in science for answering theoretically posed questions, but is also used outside science for answering practically posed questions. They imply this to be the reason much of public perception is that engineering and technology are sub-entities of science. With the close linkage of science and technology, Tiles and Oberdiek suggest a more appropriate terminology of *techno-science* rather than *applied science*. Regardless, science and technology function as two distinct forms of knowledge; science explains the natural world, technology modifies it (Pearson & Young, 2002; Gagel, 2006).

To strengthen this understanding, one might think of the instruments that scientists use, such as the microscope, scale, or spectrometer; these result from technology/engineering. The scientific concepts, such as the laws of motion, the relationship between electricity and magnetism, atomic power, and the DNA model have aided the improvement of the internal combustion engine, power transformers, nuclear power, and human gene therapy. The boundaries between these sophisticated efforts of scientists and engineers are blurred to the point that it becomes difficult to determine where science ends and technology begins. Hence, the two fields work side by side in extending knowledge (Massachusetts Department of Elementary and Secondary Education, 2008).

Technological Literacy

Based on the concept of technology described in the previous paragraphs, technological literacy can now be defined. In a general sense, technological literacy is a basic understanding of technology. The term applies to people who are able to use, manage and understand technology (ITEA, 1996). This person is good at making decisions and solving problems in a variety of contexts. They understand what technology is, how it is created, how it shapes society, and how society shapes it.

"Technological literacy encompasses three interdependent dimensions: knowledge, ways of thinking and acting, and capabilities" (Pearson & Young, 2002, p. 15). The knowledge dimension is related to other academic contents, e.g., science, mathematics, history, and/or language arts. In this way, technology integrates many other subjects currently taught separately. The thinking and acting dimension refers to ability to make appropriate decisions regarding democracy and civics. In other words, citizens should be able to participate, at some level, in decision-making about the use and development of technology. The capability dimension requires a hands-on, design and problem-solving orientation that is required in many jobs, in both technical and non-technical fields. Preparing students to be technologically literate means providing them "with the tools to participate intelligently and thoughtfully in the world around them" (Pearson & Young, 2002, p. 3).

Technological literacy vs. technical competence. Technological literacy and technical competence have separate meanings. Some people are very competent with certain skills or certain technologies, such as airplane pilots, intensive care nurses, or computer programmers. Their training in these technologies does not deem them technologically literate in the larger sense. In the same aspect, technological literacy includes a degree of hands-on ability; however, it does not necessarily correlate with a high level of practical, or technical, skill. Technical competency, therefore, is not necessarily associated with the characteristics of technological literacy (Garmire & Pearson, 2006).

Historical Background of Technology Education

Early Beginnings of Technology Education

As early as the existence of humans, people have taught each other how to make and do things to modify their existence and create new environments for themselves. In order to explain to another person about the skill or technique, a technology language had to be developed, then communicated. Teaching about technology occurred instinctively when humans first used tools. Apprenticeship may have been the first organized form of technology education. Apprenticeship programs for scribes in Egypt were documented around 2000 B.C. These programs consisted of two phases: basic knowledge transferred in a classroom setting and applied skills developed on the job (Roberts, 1971).

The first occurrences of technology education programs emerged in the 17th and 18th centuries. Practitioners realized a need for a more formal education of skills, other than apprenticeship. Manual arts in the forms of trade subjects and practical arts into colleges and institutions were proposed as the alternative. Bennett (1926) notes early forms back to Comenius, Rousseau, Pestolozzi, and Froebel, renowned educational philosophers and practitioners of the time.

John Amos Comenius, a 17th century educational writer, believed that education should be more than just filling children's heads with words, sentences and ideas from various authors. He emphasized the importance of understanding and involvement in the outer world. Holland (2004) remarks that Comenius saw value in using familiar pictures and objects in developing student language. He demonstrated this philosophy in his book *Orbis Pictus*, which was the first illustrated book for children. Furthermore, Comenius contended that children learned much from play. His belief that children's play paves the way for future demanding circumstances was the seed for Froebel's kindergarten. In this school, play was the instrument for education (Bennett, 1926).

In the 18th century, Swiss-French philosopher Jean-Jacques Rousseau also minimized the importance of book learning. Rousseau, a scholar whose ideas about education are present in modern educational theories today, recommended that a child's emotions be educated before his reason. He placed a high emphasis on learning by experience. His support of manual arts as a means of mental training marked the beginning of a new era of education (Bennett, 1926).

Rousseau's affirmation of manual arts served as a model for Johann Pestolozzi. He believed that educating a child meant integrating the hand, heart and head of a child. Pestolozzi's philosophy focused on arousing students' abilities to problem-solve and process information. He utilized his beliefs by developing the *object method* of instruction. Students were exposed to objects in their studies for stimulation of the senses (Wolf, 2000).

German educator Friedrich Froebel, another early pioneer of childhood educational reform, believed that every child possessed his full educational potential at birth and that an appropriate educational environment was necessary to promote growth and development in an optimal manner. Froebel's vision, according to Watson (1997), was to create an environment where children could play with others of their own age group and experience their first taste of independence. This new but small world, known as Kindergarten, laid the foundation for the framework of Froebel's philosophy of education that encompasses four basic components: a) free self-activity, b) creativity, c) social participation, and d) motor expression. Engaging children in play to stimulate learning follows Pestolozzi's view of using objects to incite reception, understanding, and reflection. The self-activity component, probably the most significant of Froebel's theoretical contributions, promotes growth from one educational plane to another (Dewey, 1938).

Early Beginnings of Curriculum Development

The approaches to teaching and learning from the aforementioned scholars became a catalyst for organizing and instructing technology techniques. Della Vos, Runkle, and Woodward would expand on these theories to perpetuate the initial selection and sequencing of technical content for instructional purposes. At the same time, the popularity of technology as a school subject was increasing for two reasons: 1) general education for all students, and 2) vocational education for students in preparation for jobs (Lewis & Zuga, 2005).

Della Vos was the director of the Imperial Technical School of Moscow. He centered manual arts instruction around completion of specific exercises, emphasizing skill development. His classrooms were divided into separate shops that included joinery, woodturning, blacksmithing, locksmithing, etc. (Bennett, 1937). Students engaged in graded learning exercises intended to teach fundamentals in a short period to a large number of students while developing a systematical acquirement of knowledge (Bennett, 1937). The exercises seldom resulted in a useful artifact. Rather, they were created as a means for students to receive value from its construction, promoting the basic skills needing to be developed. Della Vos attended the 1876 Philadelphia Centennial Exposition; his Russian exhibit is often credited as a defining moment in the history of vocational and industrial education (Barlow, 1967).

The Russian system was respected by many, but had a substantial impact on Calvin Woodward and William Runkle. As professors of engineering, both witnessed firsthand the advantages of having their students use wood to work out engineering problems. History states that Woodward and Runkle’s visit to the 1876 Philadelphia Centennial Exposition and subsequent observation of the Russian exhibit would influence the establishing of the first manual training Schools in America. Woodward would start the Manual Training School of Washington University in St. Louis and Runkle started the Massachusetts Institute of Technology (Bennett, 1937). Even in the early years of the development towards technology education, practitioners realized that engaging students through hands-on experiences was a method of instruction more enriching for the student.

While attributes of both schools drew upon the work of Della Vos, their philosophical approach regarding the value and purpose of studying technology was quite different. Woodward's purpose, according to Lewis and Zuga (2005), "was to educate all boys, regardless of career aspirations and Runkle's purpose was to educate mechanics with a better knowledge and grounding in the manual arts so that they could apply this knowledge and these skills to their jobs" (p.6). These differing pioneer efforts served as important precursors in thinking about the purpose of manual training. This difference in thinking has continued through time "because of the very nature of technology and the variety of roles and purposes that technological activity can serve" (Lewis & Zuga, 2005, p.6).

Modern viewpoints of technology parallel Woodward's view of manual training more so than Runkle's. After addressing an educational conference in England in 1885, Woodward was quoted as saying "My educational creed I put into six words: *Put the whole boy to school*" (quoted in Bennett, 1937, p.367). The study of manual arts was perceived to be a way to educate the whole student, emphasizing intellectual and social development along with the practical training of the hand and the eye. The intent was to prepare young men for the demands of actual life in a more complete manner than was done in the regular school. Students gained understanding through hands-on applications more so than through the abstract instruction of contents such as mathematics and others. Manual training, however, was not intended to teach a specific skill; rather, it was to be an enhancement to the traditional curriculum. Students would learn to use tools skillfully in drafting, metalworking, and woodworking thus gaining the ability to transfer this knowledge to almost any kind of tool or setting (Woodward, 1969). These descriptors of manual training were the beginning steps towards paving the path towards technology education as the intended perception today.

The years between 1880 and 1900 were years of remarkable development in manual training, securing it a permanent place in education. This time would reveal an increase and growing demand for manual training schools in America. While Woodward, Runkle, and others progressed in their visions and efforts to advance manual training, another notable event in the technology timeline was taking position. Educational sloyd, a form of tool instruction, came to America in the latter part of the 1880's. With origins in Denmark, Finland, and Sweden, sloyd began as a way to produce and sell products at home. Early supporters of sloyd, Uno Cygneaus and Otto Salomon, advocated the importance of sloyd to be part of the general education. As the demand increased, sloyd schools were established. Sloyd evolved from an economic basis to be a pedagogically organized and integral part of the elementary school course of instruction (Bennett, 1937).

Gustaf Larsson first taught sloyd to elementary teachers in Boston, 1888. The teaching practices soon extended to other states by Charles Kunou, Josef Sandberg, and Lars Erikson, all Scandinavian immigrants (Bennett, 1937). The name *educational sloyd* originated in Sweden from the sloyd knife, a carving knife that was used to shape the simplest garden tools, spoons, and hangers. As time progressed, sloyd became the term that referred to a much broader use and practice with tools. Sloyd education was different from manual training in that it was created for young children as activity-based instruction and taught by teachers as part of their general education. As a subject, sloyd was a series of graded exercises using wood, from simple to complex. The coursework always resulted in a useful object, something the student could take home. Sloyd had a significant impact on the development of manual training, manual arts, industrial arts, and technology education.

About this same period in history, Emily Huntington developed the first program of study to teach children housework duties. Huntington was the principal of the Wilson Industrial School for Girls in New York. Known for her practical work among the poor, she saw a need for a method to teach housekeeping to poor children. This new program would increase the supply of well-taught house-servants and provide income. She was inspired after visiting a kindergarten exhibit where she saw children playing with blocks while singing songs. She extended this idea of object teaching by designing classrooms with child-sized furnishings and writing songs the children liked to sing; housework became play. The success of this work promoted the creation of the Kitchen Garden Association in 1880. By 1884, interest in this organization had greatly increased. Hence, the Kitchen Garden Association was dissolved and the Industrial Education Association was formed. This new organization encompassed (Lewis & Zuga, 2005) “a more inclusive view of industrial education that included domestic economy as well as shop work for girls and boys” (p.7). Clearly, interest and support was growing about teaching industrial education.

Della Vos, Woodward, Runkle, and others shaped the initial curriculum and hands-on, problem-solving strategies to promote learning for technology education. As the twentieth century ascended, John Dewey, principally associated with progressive education, strongly advocated activity-based education in elementary schools. He believed that students should *do* to develop thinking and then think about what was done. This doing then thinking would stimulate learning. If students are doing to *do* and not problem solving, thinking would cease and boredom would develop and the intended knowledge would not occur (Campbell, 1995). Dewey's theory of cognitive growth and learning had a profound influence on industrial arts.

While Dewey led the movement for early efforts of technology education, the work of Gordon Bonser and Lois Mossman (colleagues with Dewey at Teachers College of Columbia University, New York City), would place it more prominently in the elementary curriculum. Industrial arts, the newly designated name, was the term for the school subject designed for all students in grades kindergarten through eight. Bonser and Mossman published one of the first texts for teachers about industrial arts entitled *Industrial Arts for Elementary Schools* (1923). Their classic definition, "industrial arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes" (p. 5) would redirect industrial arts away from activities and studies based on trade and skills training. Bonser & Mossman believed industrial arts was essential to every child's schooling. From their definition of how man changes the form of materials to increase value, they focused on human basic needs. Industrial arts was organized into the study of food, clothing, shelter, utensils, records, tools, and machines (Bennett, 1937; Brusic, 2003; Lewis & Zuga, 2005). Bonser & Mossman viewed industrial arts as *the most general subject of all* and being completely integrated with the rest of the school curriculum (Bonser and Mossman, 1923, p.74). Eighty-five years later, these are the intended precepts of technology education at all levels.

The contributions of Bonser & Mossman were significant in redefining industrial arts. However, as stated by Lewis & Zuga (2005), “practice and theory are often unrelated. Frequently, theory does not inform practice” (p.9). The definition described by Bonser & Mossman was not widely accepted. The perceptions of what and how to teach industrial arts encompassed a vast array of perspectives across the country. The evolving curriculum throughout the twentieth century resulted in numerous beliefs and ideas. Industrial arts became the accepted term, the definition of Bonser and Mossman became the standard, but the curriculum was oriented towards developing skills (Lewis & Zuga, 2005; Miller, 1979; Olson, 1963). For the next several decades, the study of industrial arts would continue as an industry-based curriculum.

Resurgence of Elementary Industrial Arts

Forty years passed and industrial arts as manual training instruction persisted as a curriculum based on industry. A positive effect, however, did surface during this time; elementary industrial arts gained in popularity. Brusic, (2003) noted several examples of growth that occurred in the late 1960s and 1970s: university teacher preparation courses, books specifically addressing teacher preparedness in elementary industrial arts, employment of industrial arts specialists intended to work with elementary teachers and students, and the establishment of the American Council for Elementary School Industrial Arts (ACESIA). ACESIA was an industrial arts publication dedicated to promoting elementary industrial arts, more recently named the Technology Education for Children Council (TECC). Elementary industrial arts became popular once more, but lack of agreement on whether it was a subject or a method of teaching slowed progress in the field for many more years.

Transitioning to Technology Education

Despite the new interest in elementary industrial arts, a state of agitation encompassed the field. Practitioners, frustrated with the outdated curriculum and that industrial arts was not representative of modern technology, began to re-evaluate the course content (Clark, 1989; Lewis & Zuga, 2005).This period of innovation and experimentation towards improvement in the study of industrial arts caused even more confusion in the field. In an attempt to synthesize these ideas, industrial arts supervisors from the state of West Virginia rallied curriculum specialists together to create a more coherent plan. The resulting document, *The Jackson's Mill Curriculum Theory,* became a national compromise. Its content was highly influenced by the work and ideas of Donald Maley (Maryland Plan, 1973); Edward Towers, Donald Lux, and Willis Ray (Industrial Arts Curriculum Project, 1966); and Paul Devore (1980) on his conceptualization for the study of technology (Lewis & Zuga, 2005). The focus was on society and the adaptive systems of manufacturing, construction, transportation, and communication. The Jackson’s Mill document revitalized the profession. In turn, the American Industrial Arts Association (AIAA) promoted technology and gave direction to the technology education curriculum. In 1986, the AIAA changed its name to the International Technology Education Association (Lewis & Zuga, 2005). The creation of the Jackson’s Mill document ended the controversy about the field and its content. In addition, it focused more broadly on technology instead of industry. This would be the keystone document setting the path towards additional documents and publications influencing current technology education.

Ten years later, another document entitled *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996), addressed the need for technological literacy for all. It provided a structure for the study of technology in terms of processes, knowledge, and context, discussed ways of teaching technology, and called for the implementation of educational reform to ensure technological literacy for all Americans. In 2000, ITEA, with funding from the National Science Foundation, created standards similar to the newer mathematics and science standards. This document, *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) specifies 20 standards and 100 benchmarks that define what all children in grades K-12 should know and be able to do in order to advance their technological literacy. Several companion documents reinforcing various aspects of technology education have since been published, including *Technology*

Starters: A Standards-Based Guide (ITEA, 2002) that provides content, activities, and resources for introducing technology content at the elementary level.

A Framework of Issues in Elementary Technology Education

Most people think of technology education as instructional technology, meaning the use of computers and software to enhance the curriculum (ITEA, 2004). Their understanding does not include the broader view of technology that is widely accepted by scientists, engineers, and technology education practitioners, which is the view presented in this study. Technology education helps children achieve the educational goals of the total curriculum. The active learning experiences develop students' perceptions of the world around them and help prepare them for life in a world defined by technology and innovation (ITEA, 1996, 2002).

A Contemporary View of Technology Education

Technology education in the United States is a relatively new subject, although its roots connect to the Industrial Arts movement of the twentieth century. There are, however, distinct differences between the two. Industrial arts is the development of tool-related skills while technology education is the development of problem-solving abilities. Wright, Israel, & Lauda describe technology as "…an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (1993, p. 4). The study of technology provides students with concepts and experiences necessary to learn about the human-made or technological world. Emphasis is placed on highlighting the relationship “among technologies and between technology and other school subjects, including science, mathematics, social studies, language arts, and other content areas” (ITEA, 2002, p.10). Students participate in open-ended, problem-based design activities that are applicable to real world situations. Students engage in minds-on, hands-on challenges either individually or in groups.

Presently, no consistent plan exists for organizing and teaching technology education across the states and school districts. Deliberation continues over which curriculum theory or organizing pattern best fits technology education (Pearson & Young, 2002; Zuga, 2005; Erekson & Shumway, 2006; Reed, 2007). Typically, organizing technology education as separate and distinct courses is the model for secondary schools. This approach, as pointed out by Erekson & Shumway (2006), is the basis for academic rationalism that identifies technology education as an academic discipline. Within the elementary school, a common theme of discussion is the lack of time available to include another subject in the already crowded curriculum. Some districts staff certified technology education teachers whose sole responsibility is to teach or provide support for elementary technology education; however, this circumstance is rare. It is more likely that the regular elementary teacher will be responsible for providing opportunities that integrate technology activities within the established curriculum. ITEA (2002) states that technology content is an integral part of the elementary curriculum that provides a theme or context for studying other subjects. While technology education training is not a part of regular elementary school teachers' education, with appropriate training, teachers can perform very well and excel at integrating technological concepts across the curriculum. The materials and resources required are minimal, with most supplies already typically used at elementary grade levels (ITEA-TfAAP, 1996).

Technology activities enable students to develop motor skills as well as exercise their cognitive abilities to solve problems. The experience helps them acquire knowledge of materials and technological processes, all the while increasing their interest (Foster & Kirkwood, 1997). When challenged with integrated technology education activities, von Eschenbach & Ragsdale (1989) wrote, "children are more attentive to their learning, achieve a deeper insight or meaning of the concepts, and are able to apply the information to realistic situations" (p. 225). The capabilities and knowledge children acquire while engaged in technology education activities are not found in traditional academic areas. In Foster's (1997) study, he described the benefits of technology education to children:

> ….provided rich contexts for the development of children's vocabulary, language use, and creative communication…provided dynamic environments for students to exercise process skills in mathematics and science…encouraged students to exercise complex thinking processes which are usually taught to older children. Problem-solving and creative thinking were especially evident…activities improved children's technological knowledge and capabilities. Children were encouraged to practice perceptual and motor skills for which they were developmentally

> ready, but which were not included in the traditional curriculum…provided authentic scenarios for children to practice and improve several social and life skills. These included engagement, responsibility, personal growth, and the ability to work with others. (pp. iii-iv)

A Rationale for Technology Education

Over the past century, humans have experienced unprecedented change in every aspect of life. Experts agree that technology is rapidly expanding on a daily basis. The influence of technology over people's lives has dramatically increased; however, society has not placed a high priority on technological literacy (Pearson & Young, 2002). Consequently, citizens are not equipped to make competent decisions or to think critically about technology. The importance of technological literacy is not a new concept: Twenty-five years ago, advisors to the National Science Board called for increased technological literacy:

> We must return to the basics, but the "basics" of the 21st century are not only reading, writing, and arithmetic. They include communication and higher problem-solving skills, and scientific and technological literacy—the thinking tools that allow us to understand the technological world around us. (CPEMST, 1983 as cited in Pearson & Young, 2002)

The evolving need for technological literacy. When Europeans first crossed the seas to explore the New World in the 1500s, they traveled in wind-powered ships, rode in horse-drawn wagons, and carried primitive weapons for hunting and protection. The technologies were simple and easy to comprehend. Although a skilled artisan probably built the ship, it did not take much to understand what a ship did, or how, and why. Furthermore, technologies were essentially the same three centuries later. A time traveler would have little difficulty adapting to devices and tools from the 1500s to the 1800s (Pearson & Young, 2002).

Moving forward another hundred years, a multitude of new technologies appeared that were intrinsically different from past technologies: steamships, the first airplane, the telegraph and telephone, the combustion engine, the first automobile, gasoline, medicines, and weapons. The citizens of this era became dependent upon these machines and tools, which in turn posed entirely new challenges. Nineteenth century citizens were compelled to adapt their competence, understanding, and use of technology in order to become contributing members of society (Pearson & Young, 2002).

Throughout the 20th century, the pattern of technological change continued. Advanced technologies and technological systems became an integral part of human lives. From where people live, to what people eat, jobs, how people travel and communicate, entertainment, and even national security are the result of and made possible by technology (Pearson & Young, 2002). The world we live in has been shaped by human action. Technologies have been created to lessen, prevent and eliminate threats to life, the environment, and to fulfill social needs. We live in a designed world—shaped and controlled primarily through the use of technology. Future generations will depend greatly on how we develop, use, assess and even restrict technology. In turn, that will depend greatly on how well we understand technology and the social, economical, cultural, and ecological systems within which we live (Rutherford & Ahlgren, 1990).

As our society becomes more dependent on technology, it becomes vitally important that everyone have a basic understanding of what technology is. Developing technological literacy requires effort, knowledge, and practice over time. Understanding technology and being aware of its societal and environmental impacts and consequences, is an outcome that develops subtly as students are associated with experiences of critical thinking and problem-solving activities (ITEA, 1996). Every child should begin to learn about technology at an early age. All students, regardless of their race, ethnic background, socioeconomic status, career aspirations, or disabilities, need to be able to make appropriate decisions to employ technology in their lives. Developing technological literacy means having a foundation of technology education beginning in the elementary years, continuing through high school, and beyond (Wright, 1999).

The heightened concern for technological literacy, the present mandates of educational policy and the numerous reports of America's failure to compete globally compound the need for technology education in our schools. Currently, the field of technology education appears to be in a unique position to make a substantial contribution towards American education.

The Impact of Educational Policy on Technology Education

The aftermath of *A Nation at Risk* (1983) brought forth the concept of standards as content in the classroom as well as administered assessments that were aligned with the standards. This effort was induced to create a more effective and coherent educational system that in turn would advance student learning and improve achievement. The current legislation of No Child Left Behind (NCLB) (2001) is increasing the pressure for accountability and assessment. National educational associations have created content standards for their curriculum areas. The National Science Education Standards (NSES) and the National Council of Teachers in Mathematics (NCTM) are two recognized content standards-based reforms. In 2000, ITEA published the *Standards for Technological Literacy* (STL). Similar in scope and intent to the NSES and NCTM standards, the STL was developed to bring more consistency and accountability to the varied technology education K-12 content in the US (Loveland, 2004). Additionally, the STL would continue the reform from industrial arts to an interdisciplinary and academic future (ITEA, 2000).

Nearly every state has developed technology standards; however, they are not always identified as such nor do they align with the STL. For example, Alabama has standards titled Technology Education Standards; however, they reflect the study of computers and software. Alabama's standards most consistent with the STL are found in the Career/Technical Education Standards, yet their science standards reflect technology concepts as well. Minnesota refers to its standards as Trades and Industry Technology Standards. In Georgia, Nebraska, and Pennsylvania, technology standards are infused in the science standards.

According to Rogers (2006), a survey of the education websites of 50 states and the District of Columbia reports that only three states- Massachusetts, New York, and Kentucky- have any type of assessment of technology education. Rogers does not identify the date of this survey or give reference to it. Since the date of the survey is unknown, it is possible that other states have initiated assessment in technology education. This is reasonable to assume since this researcher resides in the state of Pennsylvania and standardized tests in science and technology were administered to students in grades 4, 7, and 11 in 2008. Students and schools will receive reports for the assessment; however, the results will not be included in district and school AYP calculations. Up-to-date research is critically needed in all areas of technology education, as evidenced by the previous statements.

Elementary Technology Education Initiatives in the United States

Similar to the inconsistency of the standards, elementary technology education programs across the US are inconsistent as well. The lack of unity relating to the name and the standards hampers the recognition of many technology education programs. Since little research exists relating to elementary technology education (Zuga, 1996; Foster & Wright, 2001) researchers are at a disadvantage in communicating its presence and benefits. Some states appear to be more prevalent in terms of elementary technology education than others. For instance, implementation of elementary technology education programs or concepts is clearly observable in websites, reports, or articles pertaining to the states of Delaware, Florida, Kentucky, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Virginia, and Wisconsin. In contrast, it is difficult to discover the degree of interest in elementary technology education in a great deal of the remaining states. It also must be mentioned that program implementation may vary from school district to school district within the state. In Pennsylvania, some districts have dedicated elementary technology education programs taught by certified technology education teachers while others exclude it from the curriculum altogether.

Some states have developed, or are in the process of developing, curriculum and/or resource materials to provide support for teachers and promote technological literacy in students. The Boston Museum of Science (Massachusetts) through its Engineering is Elementary (EiE) Project is creating a curriculum that integrates engineering and technology concepts and skills with elementary science topics. It is research-based, standards-based, and classroom-tested. Design challenges encourage children to apply their knowledge of science, engineering, and problem solving skills, while designing, creating, and improving possible solutions (Cunningham, 2008). EiE also provides professional development workshops and Teacher Educator Institutes. Virginia's Children's Engineering Council (CEC) develops design and technology instructional material, and provides local, regional and statewide inservice opportunities for educators at grades K-5. Additionally, a Children's Engineering Convention is held annually. Since 2003, the Pennsylvania Department of

Education has conducted a Governor's Institute for Technology Education that includes elementary strands. On the national level, ITEA recently completed its I³ Project. I³ is short for Invention, Innovation, and Inquiry: Units for Technological Literacy. Developed for grades 5–6, each unit has standards-based content, suggested teaching approaches, and detailed learning activities including brainstorming, visualizing, testing, refining, and assessing technological designs. Students learn how inventions, innovations, and systems are created and how technology becomes part of people's lives (ITEA, 2008a).

It is rare to find a school district in the US that hires dedicated elementary technology education teachers. If a technology curriculum is addressed, quite often it is the choice of the regular classroom teacher. In addition, the undertaking comes with little or no support for training, curriculum, and materials/equipment (Brusic, 2003). In the case when elementary schools do staff technology education teachers, support and funding is likely available for supplies and professional development. This situation, Brusic (2003) expresses, is the exception, not the rule.

Technology Education Initiatives Abroad

Over the last fifteen years, technology education has progressed as an area of study in many countries around the world (Anning, 1994; McLaren, 1997; Fleer, 2000; Fox-Turnbull, W., 2006; Bungum, 2006). During this time, a significant amount of research has taken place supporting this new curriculum and the technological learning of both teachers and students. Initially, technology education was directed toward secondary students, however recent studies reveal more countries are including elementary technology education in their core curriculum as well.

As technology education becomes internationalized, concerns and debates extend national and cultural borders; ideas and innovations are being exchanged and transferred (Bungum, 2006). Different countries describe technology education using different terms, such as technics, design and technology, technology education, and technological education. The universal goal, regardless of the term, is to help students become technologically literate.

Rasinen (2003) analyzed the technology education curriculum of six countries in order to establish a theoretical basis for Finland's new technology education curriculum. The countries included were Australia, England, France, The Netherlands, Sweden, and the United States. He utilized Madaus & Kelleghan's six components of curriculum to guide his study: 1) content, 2) general objectives, 3) specific objectives, 4) curriculum material, 5) transaction, and 6) results. The study was not meant to compare but rather to synthesize theory and practice. The findings are summarized in the following paragraphs.

Australia. Technology is one of the eight subject areas studied in schools by both boys and girls, mandatory in years 1-10. Upper secondary programs are more specialized and focus on further education. It is divided into four content areas called strands: designing, making and appraising; information; materials; and systems. The rationale for implementation is that people face technology everyday, therefore they must learn about it. The national goal reflects the current emerging economic and social needs of the nation. Students develop skills in analyzing and problem solving, information processing and computing, scientific and technological literacy, understanding of and concern for a balanced development of the global environment, and a capacity to exercise good judgment in matters of morality, ethics, and social justice.

The study of technology is both integrated and interdisciplinary. Students become more innovative, knowledgeable, skillful, adaptable, and enterprising. Technology programs can be structured and delivered either as separate programs, or combined with other areas of learning. Regular elementary teachers, sometimes in association with specialists or resource people, teach elementary students. At the secondary level, different areas of study include agriculture, computing/information technology, home economics, media, and industrial arts, manual arts, and design and technology.

England. England's National Curriculum was revised in 2000. The curriculum is called design and technology education. Required study is divided into four Key Stages. Key Stage One (grades 1-2, ages 5-7) and Key Stage Two (grades 3-6, ages 8-11) concentrate on English, mathematics, science, design and technology, information and communication technology (ICT), history, geography, art and music, and physical education. In Key Stage Three (grades 7-9, ages 11-14) and Key Stage Four (grades 10-11, ages 14-16), citizenship and modern languages are added, with one required language.

The rationale for instruction is to prepare students to participate in tomorrow's rapidly changing technologies. Students learn to think and intervene creatively, to improve quality of life as well as become autonomous and creative problem solvers both as individuals and as team members. Through needs, desires and opportunities, they develop ideas in order to design and make products and systems. Emphasis is placed on evaluating the effects and impacts of present and past design and technology. With each higher Key Stage, the objectives become more demanding.

Technology is a core subject studied by both boys and girls, and is integrated where convenient, such as the arts, science, or mathematics. Upon passing a national examination, a General Certificate of Education is issued.

France. Technology education is mandatory for the four years of junior secondary level (ages 11-15). There is a specific curriculum for each of the levels. At the time of the study, a specific plan was not in place for elementary levels.

The aim of technology education is to clarify the interconnections among work, products, and human needs, and identify the societal and cultural effects of technology. Through concrete situations, students learn about technical systems, correct use of the language of the discipline, design methods, problem solving, safe use of equipment and control systems, etc. Both boys and girls study technology in time ranges of 90 to 120 minutes per week. In primary schools, facilitated by regular primary school teachers, students learn about simple machines, electricity, energy production, and production in general. Secondary schools include production, marketing, needs analysis, professions in production and service and CAD/CAM.

The Netherlands. Implementation for The Netherlands Technology Action Plan was completed in 1997 for primary students (ages 4-11). The purpose was to stimulate attention to technology within and outside the primary school with emphasis on thinking and doing. All students attend the comprehensive school “Basisvorming” until the age of 15 or 16. Technology is studied at three different perspectives: technology and society, technical products and systems, and designing and making products.

The purpose of the technology education curriculum is to enable students to be familiar with aspects of technology dealing with culture, society and technical abilities, use, manage and understand technology and its relationship with society and natural sciences, design and develop solutions for human needs, safe use of technologies, and explore abilities and interests in technologies. Both boys and girls study technology. At the primary level, it is integrated with crafts, arts, and natural sciences. At the secondary level, it is a separate subject but is integrated with mathematics, science, and social studies.

Sweden. The equivalent to technology education in Sweden is “Teknik” (technic). The goal of technology education, according to the 1994 national curriculum, is to develop in students an understanding of technics, particularly, the impact of technology on production, society, physical environment and living conditions. Students are expected to achieve basic technical competence that results from understanding technical development, historical perspective, and reflecting on solutions to technical problems. Additionally, emphasis is placed on ability to analyze and value human beings teamwork in the context of society, technics, and nature, and effects on the environment. Ethics and values are also addressed.

The primary objectives for studying technology in Sweden are to study the historical development of technical culture, and the effects on people, society and nature. Additionally, students will examine and evaluate the choices of different technologies on people, society and nature, update technical knowledge of the structure and use of technics for practical solutions, and develop a positive interest in technics and confidence in self-ability to solve technical problems. Technics is studied by both boys and girls and is be integrated with history, science, and social studies.

Rasinen (2003) points out that at the time of this study, the countries he analyzed were at different stages of technology education development. He stated that the curriculum planning, the planning process, and the structure of the curriculum differ from one country to another; therefore, a single model cannot be applied to each country. He concludes that, although the studied countries are widely separated geographically each with distinct cultures, “there are several similar features in their curricular objectives, methods, and content” (p. 45).

The analysis (Rasinen, 2003) clearly reveals that technological literacy is a universal goal. Common ambitions include ”understanding the role of science and technology in society, the balance between technology and the environment, the development of technological literacy, and the development of skills, such as planning, making, evaluating, social/moral/ethical thinking, innovativeness, awareness, flexibility, and entrepreneurship" (p.45). The methods identified focus on engaging students in planning, analyzing, inventing, innovating, making, and evaluating. Content in terms of significance, Rasinen writes, is as broad as it is long. It includes technology systems and structures, professions in technology and industry, safety practices, ergonomics, and design. The list continues to identify construction techniques, assessment practices, history of technology, problem-solving strategies, and examining the relationship between society and nature.

Program implementation also varies from country to country. At the elementary level, most elementary technology education is integrated with other subjects and is mainly taught by regular classroom teachers. This allows for easier integration with other subjects. However, in England, technology education has been practiced for several years; elementary technology education is a separate subject. At the secondary level, technology education studies are taught by specialized subject teachers, with a high recommendation to integrate the curriculum with other subjects.

It is interesting to examine the extent to which technology has evolved from country to country. Since technology education is a fairly new subject, the standards of teaching vary widely, ranging from England's highly developed program to those less developed in other countries (Rasinen, 2003). The existence of elementary programs in other countries is particularly informing. Technology education in the United States has existed for a number of years, yet there are very few programs at the elementary level. It is clear, Rasinen writes, there are still many obstacles that must be overcome in the United States before the intended curriculum can be fully realized (2003).

Philosophical Principles of Elementary Technology Education

Constructivism

A technology curriculum supports a constructivist approach. The term refers to the idea that learners construct knowledge for themselves. In this view, each learner constructs meaning, individually (and socially), as he or she learns. The focus is on knowledge construction, not knowledge reproduction. This means that we must recognize that there is no such thing as knowledge *out there* independent of the knower, but only knowledge we construct for ourselves as we learn (Hein, 1991). If we accept this view, then we are adhering to the learning theories of Dewey, Piaget, Vygotsky, Bruner, and others. Several principles of learning, based on relevant research, are recognized as components of constructivist theory, all predicated on the belief that learning consists of individuals' constructed meanings that are used to interpret objects and events.

Guiding principles of constructivism. Much of the literature on constructivism expresses similar principles of the constructivist theory. Learning takes time; it is not immediate. For meaningful learning, ideas need revisited, pondered about, toyed with, and used. Learning is not acquired in a few minutes; rather it is invented and reinvented as the child constantly reacts with the world around him. Children, to use Piaget's formulation, think and reason differently at different periods in their lives. A child first experiences new events; the existing thought adapts and changes to accommodate the new information, and then a balance is established between the child and the environment (ITEA, 2002).

Learning is an active process in which the learner uses sensory input and constructs meaning from it. The theme of active learning has emerged from Dewey's (1916) argument that in order for children to learn, they need to do something that engages them with the world. *Learning by doing* as also emphasized by Piaget, focuses on authentic tasks or *concrete operations* that involve the participation of the learner. Learning is more significant when children are allowed to experiment with a variety of materials and situations rather than passively hear a lecture (ITEA, 2002).

Children learn to learn as they learn. The learning consists of both constructing meaning and constructing systems of meaning. Each meaning constructed enables better understanding of other meanings that fit similar patterns.

The crucial action of constructing meaning happens in the mind. According to research from cognitive science, learning activities (especially for children) must engage the mind as well as the hands. Dewey (1933) called this reflective activity. By thinking thoughtfully before taking action, the child more clearly understands what he/she is about to act upon. The act is converted into intelligent action, not merely appetitive, blind and impulsive (Archambault, 1974).

Learning involves language: the language we use influences learning. As contended by Vygotsky (1962), words are a central component in the development of thought. Consequently, language and learning are inextricably linked.

Learning is a social activity. Learning is inherently connected with associations with others such as teachers, peers, and family. This is the major theme of Vygotsky's theoretical framework: social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) states: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological) (p57).

Learning is contextual: Children do not learn isolated facts and theories. Children learn in relationship to what else they know, what they believe, there prejudices and there fears. This reflects Bruner's (1983) assertion that learners construct new ideas based on their current level of knowledge. Each new concept builds upon what is already known allowing the learner to go beyond the information given to discover key principles by themselves.

Multiple Intelligences

In addition to constructivism, a technology education environment employs the development of multiple intelligences. In 1983, Howard Gardner, professor of education at Harvard University, developed the theory of multiple intelligences. His research involved observing many children in American schools; the findings revealed that children possess various strengths and weaknesses. Gardner categorized these differences as *Intelligences.* He theorized that the blendings of intelligences are as varied as the faces and personalities of the individuals themselves. Gardner identified the following nine intelligences:

1) linguistic intelligence (word smart), 2) logical-mathematical intelligence (number smart), 3) spatial intelligence (picture smart), 4) bodily-kinesthetic intelligence (body smart), 5) musical intelligence (music smart),

6) interpersonal intelligence (people smart), 7) intrapersonal intelligence (self-smart), 8) naturalist intelligence (nature smart), and 9) existential (life smart).

Gardner observed that schools and culture focus mainly on linguistic and logical-mathematical intelligence. He advocates that equal attention should be given to those with gifts in the other intelligences. Unfortunately, the children with these gifts are often deprived of recognition for them in schools. Many end up being labeled learning disabled, ADD (attention deficit disorder), or simply underachievers (Armstrong, 2000).

The theory of multiple intelligences proposes that it is more important to examine *how* children think than *what* they think about. Considering Gardner's ideas and research, it seems only logical that teachers transform their classrooms and present lessons that engage students in a wide variety of ways that address different interests with varied rates of instruction and multiple degrees of complexity (ITEA, 2002).

Differentiated instruction. Differentiated instruction is an approach to teaching that supports the view of multiple intelligences. Carol Tomlinson (*Differentiated Classrooms,* 1999) in her effort to define Gardner's ideas in practice, affirms the need to accept students as they are. Taking into account the wide diversity of students, she suggests that teachers need to be flexible in their approach to teaching, and adjust the curriculum and presentation of information to students instead of expecting students to modify themselves. Tomlinson (1999) suggests three areas that teachers manage to maximize each student's growth and individual success. These areas are

1) Content – *what* is to be learned
2) Process – *activities* used to help students make sense out of essential ideas
3) Products – *vehicles* through which students demonstrate and extend what they learned

The learning model presented by Tomlinson (1999) is clearly child-centered and aligned with constructivist and multiple intelligence theories (ITEA, 2002). The practical approach ensures an effective curriculum, learning environment, and educational experience.

The principles generated by social and cognitive scientists that apply to constructivism and multiple intelligences emphasize a child-centered philosophy. Renowned epistemologists identify teaching both the hand and the mind to recognize the learning abilities of all students as key to meaningful learning. Teaching methods such as lectures, demonstrations, and programmed instruction do not fit with most theories about teaching and learning (Dewey, 1938; Piaget, 1963; Bruner, 1986; Gardner, 1983; Vygotsky,1962; Tomlinson, 1999; ITEA, 2002).

A technology curriculum reflects the characteristics of constructivist and multiple intelligences theories. The cognitive and psychomotor activities of technology studies promote a learning environment that enables individual talents, skills, and abilities to shine (ITEA, 2002).

Global Competitiveness and Technology Education

The United States has been recognized as a world leader for decades. Americans are the inventors and innovators responsible for developing the technologies that drive the economy forward. As expressed in the Business Roundtable (BR) (2005) report, Americans first conquered flight, pioneered the first mass production assembly lines, discovered vaccines for numerous diseases, and first set foot on the moon. The leadership history Americans have enjoyed is the result of well-trained people and a steady stream of scientific and technical innovations they produce (NRC, 2006). American citizens have become so accustomed to being in the leadership position, our inability to maintain this status is being overlooked. What we have taken for granted is now being challenged by other nations. As they progress in knowledge, they are embracing opportunities to prioritize their status as top players in the world marketplace.

Since 1983, with the release of *A Nation at Risk,* Americans have known that students in the US were performing poorly when compared to students of other industrialized nations, and that as a nation, America was falling behind. If current trends continue, more than 90% of all scientists and engineers will be living in Asia by the year 2010. Currently, more than 50% of all engineering doctoral degrees awarded by US engineering colleges are to foreign nationals (*Tapping America's Potential: The Education for Innovation Initiative, 2005*). More than twenty-five years has passed since the publication of *A Nation at Risk,* and although there have been numerous reform efforts, very little has changed with respect to our nation's performance in preparing our young people to meet the challenges of a global economy. According to scores on the National Assessment of Educational Progress (NAEP, 2005), US students still fail to rank among the top nations.

The national problem American is facing calls for improvement in the overall quality and results of the entire U.S. education system, pre-K through 16 (BR, 2005). Today's global economy requires a workforce with specific knowledge and skills (NAEP, 2005; Bush, 2006; NGA, 2007). The profile of this workforce includes problem-solvers, inventors, and innovators who are self-reliant and can think critically. Key factors for developing these skills are strengthening the competencies of science, technology, engineering, and mathematics (STEM) in every K-12 student (BR, 2005; NGA*,* 2007).

In a 2006 presentation directed to the Aerospace States Association, Dr. Kendall N. Starkweather, Executive Director/CEO of the ITEA addressed the importance of a STEM education and the need for adjustment to our educational system. He expressed that a nation's future and prosperity coincide with its ability to invent and innovate in a technological society. Creating the next generation of thinkers requires an educational environment that promotes expertise not only in science and math, but also technology, innovation, design, and engineering (Starkweather, 2006). The educational content base that creates this environment is technology education. The study of technology has a uniqueness all its own. Technology education is the curriculum where invention and innovation happen while at the same time utilizing science and mathematics principles (STL, 2002; Starkweather, 2006).

Numerous reports and authors have expressed the need for technological literacy for all Americans. Additionally, these reports and authors recommend that children begin learning about technology in the early school years (ITEA, 2000/2002; Foster & Wright, 1996; Kirkwood, 2000; Minton & Minton, 1987; Pearson & Young, 2002). The present today is very different from the past of yesteryear. In turn, the future will be equally compelling. The emergence of such changes demands new expectations for students and as a result, new expectations in the educational process. To maintain our country’s competitiveness, we must focus on cultivating the next generation technologist, innovator, designer and engineer (Starkweather, 2006).

Adult Learning Theories/Experiential Learning Theory

This literature review would not be complete without discussion about how adults learn, since the participants in this study were challenged to implement material unfamiliar to them, and in a sense, learn about it. Participants in this study had little to no background of or training with technology education content or concepts, therefore, the process of implementing the technology units became a learning experience for the teachers.

All learners have certain needs and requirements, and adults are no different. Typically, adult learning theories have included the basic concepts of behavioral change and experience. From this, specific theories and concepts emerged that were built around the idea of change in behavior (Merriam and

Caffarella, 1999). This thought proposal introduced more complexities “such as whether one needs to perform in order for learning to have occurred or whether all human behavior is learned” (Merriam and Caffarella, 1999, p.249).

Andragogy

Malcolm Knowles, considered by some to be the founding father of adult learning, popularized the concept of andragogy. Andragogy is the art and science of helping adults learn. Andragogy first appeared when Alexander Kapp, a German teacher, used it to describe Plato’s educational theory (Knowles, Holton, and Swanson, 1998). Appearing again in 1921, a German scientist, Eugen Rosenstock, asserted, “adult education required special teachers, special methods, and a special philosophy” (Knowles, Holton, and Swanson, 1998). In 1968, Dusan Savicevic, a Yugoslavian adult educator, discussed andragogy for the first time in the United States. Knowles, after hearing the term, developed an interest in andragogy and wrote an article, published in *Adult Leadership*, entitled *Androgogy, Not Pedagogy*. Despite his initial misspelling of the word andragogy, Knowles soon became known as the principle expert on adragogy, even though others have addressed the concept or discussed its facilitation in adult learning.

Knowles, Holton, and Swanson (1998) discuss six assumptions about adult learners that reflect a humanist view of learners and their potential growth. Following are definitions of those assumptions:

1. Need to Know- Adults need to know why it is important to learn something. Unlike the pedagogical model where it is assumed student’s will learn because it

is presented to them, adults need to see a benefit of the learning. They are used to understanding what they do in life.

2. Self-Concept- As a person matures, their self-concept moves from dependency to self-directness. Adult learners want to take responsibility of their own learning. Knowles argues that people who take the initiative in learning-learn more things, learn better, and better retain what is learned more so than people waiting to be taught. Knowles (1975, p.14) contends, “They enter into learning more purposefully and with greater motivation.”

3. Experience- Life experiences can be a continuous reservoir of resources for learning. These experiences can provide an additional knowledge base for learning. Connections to life experiences can provide relevancy to the topic being learned.

4. Readiness to Learn- When adults take on a new learning experience, they usually know what goal they want to attain. Knowles (1980, p. 44) explains, adults are ready to learn “when they experience a need to learn it in order to cope more satisfyingly with real-life tasks or problems.”

5. Orientation to Learning- As adults mature, they become problem-centered in their orientation to learning. They need to see that what they are learning will be applicable and valuable to their work or other responsibilities. Their learning shifts from one of subject-centered to one of problem centered.

6. Motivation to Learn- Knowles (1984) contends that motivation becomes more internal than external as adults mature. Self-esteem, increased job satisfaction, and quality of life become important incentives for adults to learn.

Each of the characteristics identified support the assumptions about how adults learn. It is not clear in the literature whether adragogy is a theory, a set of assumptions about learning, or a model of teaching (Hartree, 1984). Nonetheless, Knowles introduced a “set of well-grounded principles of good practice” about adult learning (Brookfield, 1986, p.98).

Experiential Learning Theory

The name *experiential learning* emphasizes the central role that experience plays in the learning process, which also distinguishes it from other learning theories. The term *experiential* therefore, differentiates it from other learning theories, such as cognitive, which emphasizes cognition over affect, and behavioral learning theories that emphasize stimulus and response.

Kolb (1984) defines experiential learning theory as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience.” Experiential learning concentrates on the learning process for the individual. The theory is learner-centered with the premise that individuals learn best by experience. It is often described as “learning by doing” where the learner is directly involved with what is being studied instead of just thinking and talking about what is being studied. A simple example of experiential learning is visiting a museum of history and learning by observing the various exhibits, as opposed to reading about history from books. The discoveries are learned with firsthand knowledge instead of just reading about historical artifacts or events.

Kolb and his associate Robert Fry (Kolb & Fry, 1975) created the experiential learning circle out of four elements: concrete experience, observation and reflection, the formation of abstract concepts, and testing in new situations.

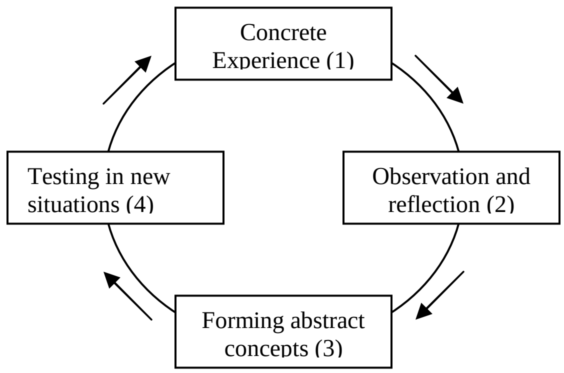

Figure 1. Model of the experiential learning process (Kolb, 1984).

The learning circle (Kolb & Fry, 1975) can begin at any one of the four points and should be viewed as a continuous spiral. However, the learning process is suggested to begin at the first step with a person doing a particular action then observing the effect of the action in the situation. The second step is to understand the effect of the particular instance to ascertain what a similar effect might be if the same action was taken under similar circumstances. The third step would be to understand the general principle that the instance falls under. Once the general principle is understood, the last step is to apply the acquired learning to a new circumstance. If learning has taken place, the process can be depicted as a circular movement. One might gather from the stages or phases identified in Kolb's "recurring circle" (Kolb (1984) that teachers immersed in implementing new material, actually doing or performing an activity of some kind, would be experiencing *experiential learning*.

Summary

As the literature reveals, technology education, in its broadest definition, is the oldest discipline among all the school subjects. The survival of primitive society and their development of hand skills contributed to the refinement of civilization (Phillips, 1985). Early practitioners and philosophers realized the importance of learning by experience. Centuries passed, and the idea of hands-on, minds-on learning to promote knowledge continued to increase. Technological knowledge, as described by Herschbach (1995), “arises from and is embedded in, human activity” (p.2).

Currently, an abundance of misconceptions exist about the role of the field of elementary technology education. However, the literature contends that education about and with technology is essential for all children (ITEA, 1996, 2000, 2002; Satchwell & Dugger, 1996; Foster & Kirkwood, 1997; Wright, 1999; Pearson & Young, 2002; Cunningham, Lachapelle, & Lindgren-Streicher, 2006). The consensus, along with the mandated legislature of educational policy, both here and abroad, is a clear directive for the inclusion of elementary technology education in every school.

Technology education is a program of study for all students. It employs the principles of constructivism and multiple intelligences generated by social and cognitive scientists that emphasize a child-centered philosophy. Renowned epistemologists identify teaching both the hand and the mind to recognizing the learning abilities of all students as key to meaningful learning.

This literature review surfaced many elementary technology education programs abroad; however, information on programs in the United States was scant. Furthermore, studies that probe elementary teacher's technological literacy and ability to implement technology concepts are almost non-existent, suggesting a need for more technology education professional development for teachers.

This study examined the impact of a professional development experience, the I³ Project, on elementary teacher's level of technological literacy and confidence and capability to implement the appropriate concepts and understandings in the classroom. The I³ Project is a compilation of technology education instructional units created for students in grades 5 and 6, designed to provide professional support for teachers interested in technological literacy in education. The units promote constructivism, whereas learners construct new understandings using what they already know through minds-on, hands-on activities.

Chapter 3 will address the research methodology that frames this mixed methods study and guides the research procedures. A description of the research method and design, sampling frame, and data collection procedures are presented. The instrument that was used in the study and the data analysis process are also discussed.

CHAPTER 3

DESIGN AND METHODOLOGY

This chapter will address the research methodology that frames this investigation and guides the research procedures. A description of the research method and design, sampling frame, and data collection procedures are presented. The instrument that was used in the study and the data analysis process are also discussed.

Research Method and Design

This mixed methods study combined the paradigms of quantitative and qualitative research to ensure maximum insight and understanding to characterize teacher attitudes and outcomes of a technology education field-testing experience. The researcher believed that a mixed methods design was necessary to best address the research problem.

The mixed methods design of this study consists of two distinct phases: quantitative followed by qualitative (Creswell, Plano Clark, Gutmann, & Hanson, 2003). In the first phase, the researcher collected and analyzed the quantitative data. The second phase consisted of collecting and analyzing the qualitative data to help explain, or elaborate on, the quantitative results in the first phase. The second, qualitative, phase built on the first, quantitative, phase, and both phases were connected in the intermediate stage in the study. The rationale for this approach is that quantitative data and their resultant analysis provide a general understanding of the research problem. The qualitative data and their analysis refine and clarify the quantitative results by examining participants' views in more depth (Rossman & Wilson, 1985; Tashakkori & Teddlie, 1998; Creswell, 2003).

Mixed Methods Research

Traditionally, researchers choose either quantitative or qualitative research designs to investigate their research problem. Quantitative research follows a systematic process of defining a principle. When gathering, analyzing, and interpreting quantitative data, the researcher can remain detached and objective. Quantitative research is deductive; in other words, it tests theory. In addition, results of quantitative designs can frequently be generalized; assumptions or statements can be made about the results. Perhaps the most obvious aspect of quantitative research is that it uses data that are structured in the form of numbers or that can be easily converted into numbers.

In contrast, qualitative research consists of data collected through a variety of means such as interviews, notes, documents, observation, videotape, and written descriptions by subjects. Analysis begins when the first data are collected and continues to guide decisions related to further data collection. Typically, the words or images of the data are aggregated into categories of information in order to present the diversity of ideas gathered during data collection. The outcome of analysis is a theoretical statement that addresses the research question. Descriptive statistics are used to validate the statement, commonly by examples of the data, which often are direct quotes from the subjects. In this study, qualitative data were collected two ways; through open-ended questions asked during interviews and classroom observation.

For years, researchers have integrated quantitative and qualitative data in the same studies. However, blending both quantitative and qualitative data as a distinct research design in the same studies has emerged only recently in the past few decades (Creswell & Plano Clark, 2007).

The mixed method approach combines quantitative and qualitative research techniques, methods, approaches, concepts, or language into a single study (Johnson & Onwuegbuzie, 2004). Blending quantitative and qualitative forms of data together (Creswell and Plano Clark, 2007) provides the researcher with a better understanding of the problem than if either dataset had been used alone. Creswell and Plano Clark (2007) offer the following definition of mixed methods research:

> Mixed methods research is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process. As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. (p. 5)

Johnson and Onwuegbuzie (2004) contend the goal of mixed methods research is to draw from the strengths and weaknesses of both quantitative and qualitative approaches, not replace them. Advocates of mixed methods research view this approach as the third research paradigm that can help bridge the dissension between quantitative and qualitative research (Creswell & Plano Clark, 2007; Johnson and Onwuegbuzie, 2004; Onwuegbuzie & Leech, 2004).

Mixing the data. Some researchers concur that mixing quantitative and qualitative datasets can provide a better understanding of research problems than either approach alone (Creswell & Plano Clark, 2007). However, simply collecting and analyzing quantitative and qualitative data are not sufficient; they need to be mixed in some way so as they form a more cohesive picture of the problem than they do in solitude. There are three ways, according to Creswell & Plano Clark (2007), that mixing data can occur: "merging or converging the two datasets by actually bringing them together, connecting the two datasets by having one build on the other, or embedding one dataset within the other so that one type of data provides a supportive role for the other dataset" (p.7).

Creswell & Plano Clark (2007) report several advantages of mixed methods research. They are: 1) provides strengths that offset weaknesses of each type, 2) provides more comprehensive evidence, 3) helps answer questions that cannot be answered by quantitative or qualitative approaches alone, 4) encourages collaboration between quantitative or qualitative researchers, 5) encourages the use of multiple worldviews or paradigms, and 6) practicality, using both numbers and words.

Both quantitative and qualitative data are necessary for a complete analysis of research problems, according to Creswell & Plano Clark (2007). Multiple forms of evidence are needed to document, inform, and report a complete analysis of the research problem. In the evolution of research methodologies, mixed methods research is called the "third methodological movement" (Tashakkori and Teddlie, 2003, p. ix).

The explanatory design. There are four major types of mixed methods design: 1) the Triangulation Design, 2) the Embedded Design, 3) the Explanatory Design, and 4) the Exploratory Design (Creswell & Plano Clark, 2007). Each design has different features, with variants within each type. This study utilized a variant of the Explanatory Design, the follow-up model. The use of two qualitative data sources, interviews and observation, added a triangulation element to help validate the findings.

The Explanatory Design follow-up model is a two-phased, mixed methods design with the purpose of using qualitative data to help explain or build upon the quantitative results (Creswell et al., 2003). The aim of this design is to use the qualitative data to explain significant (or non-significant) results, outlier results, or surprising results (Morse, 1991, as cited in Creswell & Plano Clark, 2007).

A researcher uses the follow-up explanations model (Appendix B) when qualitative data is needed to explain or expand on the quantitative data. Specifically, when the researcher identifies certain quantitative data that needs additional explanation, such as statistical differences among groups, radical levels of scoring, or unexpected results, the researcher then collects qualitative data from participants best able to explain these findings (Creswell & Plano Clark, 2007). The emphasis is primarily on the quantitative findings. This model is considered the most straightforward of the mixed methods designs. The two-phase structure allows the researcher to conduct the two methods separately, collecting only one type of data at a time. This allows single researchers to conduct this type of design, as opposed to requiring a research team to carry out the study. The final report can be written in two phases, providing a clear description to the reader. The strong quantitative orientation of the design appeals to quantitative researchers.

Even though this design is straightforward, challenges to using this approach also exist. More time is needed to implement the two phases. The researcher must choose whether to use the same individuals for both phases, to use individuals from the same sample for both phases, or choose participants from the same population for both phases. The researcher cannot decide which quantitative results need further explanation until after the quantitative phase is complete.

In this study, the quantitative data were collected in the first stage. The principle investigator used the data collection and results to determine what results needed to be explained in more detail. In the final stage, qualitative data were collected through observations and interviews. The results of this stage helped build on the results of the first stage.

Sampling Frame/Sample Size

The sample for this study was recruited from the population of 25 teachers who field-tested the I³ Project Units. A complete consensus of the 25 teachers was the original target. After informally investigating the accuracy of the contact information of the proposed participants, it was discovered that three of the teachers had retired and two had taken other positions. No contact information was available for these teachers.

A cover letter (Appendix C) and the survey questionnaire (Appendix D) were distributed electronically to the remaining 20 teachers. The cover letter explained the nature and purpose of the research as well as an invitation to participate. All 20 teachers returned the questionnaire and became the sample.

The participants resided in various states: Florida, North Dakota, Pennsylvania, Texas, Virginia, and Wisconsin. In terms of gender, 3 of the participants were male; the remaining 17 were female.

I³ Project Description

The I³ Project, Invention-Innovation and Inquiry, was created to provide professional support for teachers interested in technological literacy in education targeting the elementary curriculum. It was supported, in part, by the National Science Foundation and was implemented by the International Technology Education Association and California University of Pennsylvania.

The I³ Project consists of 10 curricular units developed to promote technological literacy for students in grades 5 and 6 (Appendix A). Each unit was written to be *self-contained* in so much that the teacher would not need special training to conduct the unit. The units were expected to take 8 to 10 days to complete in sessions of 40-50 minutes. Each unit was field tested by five teachers; however, some teachers field-tested more than one unit. The teachers did not receive any direct professional development to aid in the implementation of the units in order to examine the units' ability to stand on its own.

Field test participants were located through various means: IDEA Garden listserve, CTTE (Council on Technology Teacher Education) listserve, TrendScout (ITEA electronic publication), state supervisors, elementary members of ITEA, writers and experts involved in the project, and ITEA-CATTS (Center to Advance the Teaching of Technology & Science) members. To be selected as a field participant, interested teachers were required to have certain credentials: a bachelors or advanced degree in education; be certified to teach elementary school, middle school science, or technology education; have a minimum three years teaching experience; and agree to a telephone interview or site visits (Appendix E).

Data Collection Procedures

A cover letter and the questionnaire were distributed to each of the potential respondents, through the use of StudentVoice®.com, a web-based survey company. Additionally, the researcher interviewed participants and observed two classrooms. The purpose of the study was explained with assurance of complete anonymity.

The small population of this study necessitated a mixed-methodological approach. The design of the study consisted of two distinct phases: quantitative followed by qualitative (Creswell et al., 2003). Three research instruments were combined for triangulation in the study, namely the questionnaire (quantitative), the classroom observations, and the follow-up interviews (qualitative). The triangulation design provided in-depth understanding and added richness to secure validity of the findings.

Phase One

The questionnaire for the quantitative phase included likert-type questions partially derived from an established questionnaire (validated at conception by colleague review). Permission to adapt the established questionnaire was obtained from the authors (Appendices F and G). This questionnaire was used in a study to survey elementary school teachers who were recent graduates and had some technology education training. In addition, the principle investigator of this study developed additional items for the questionnaire. The adapted questionnaire was field tested by teachers in the principle investigators' school district to establish validity regarding content and construct, then revised by the author as needed.

The questionnaire collected background information from the participants as well as assessed the extent in which the I³ Project influenced their perception of technology education and classroom practices. It was sectioned into four parts: 1) Technological Literacy, 2) Pedagogical Knowledge, 3) Confidence, and 4) Implementation.

Phase Two

The second phase of data collection consisted of developing follow-up interview questions pertaining to certain quantitative data that needed additional explanation (Appendix H). Upon completion and review of the preliminary, quantitative analysis, the principle investigator determined which quantitative results needed to be further explained and developed interview questions accordingly. The participants agreeing to be phone interviewed and determined to be most able to answer the questions needing additional explanation, were contacted. A time was established, convenient with them, to conduct the recorded interview. The principle investigator conducted the interviews then analyzed the qualitative data to help explain, or elaborate on, the quantitative results in the first phase.

The classroom observations were conducted during the same time period the interviews were conducted. The observations were carried out in the classrooms of two of the teachers. Teacher selection was based on willingness to participate and accessibility to the principle investigator.

The second phase built on the first phase, and both phases were connected in the intermediate stage in the study. The rationale for this approach is that quantitative data and their resultant analysis provide a general understanding of the research problem. The qualitative data and their analysis refine and clarify the quantitative results by examining participants' views in more depth (Rossman & Wilson, 1985; Tashakkori & Teddlie, 1998; Creswell, 2003). The findings of the qualitative data are represented in the form of interpretive commentaries and stories.

Summary

The research method and design, sampling frame, and data collection procedures have been presented in this chapter. In addition, the instrument that was used in the study and the data analysis process have been discussed as well. Chapter 4 presents the data analysis procedures and results. The sections will include the quantitative data results of the survey questionnaire and the qualitative data results of the observations and interviews.

CHAPTER 4

DATA AND ANALYSIS

The purpose of this chapter is to present the data analysis procedures and results. The organization of this chapter reflects the mixed methodology used in this study. The data were collected through administration of a survey questionnaire, interviews with participants and classroom observations. The sections included are as follows: a) results and analysis of quantitative data, b) results and analysis of qualitative data, and c) summary of the results. The study explored how elementary teachers' reported technology in terms of knowledge, attitude, and classroom practices.

This study was designed to answer the following research questions:

1. How did elementary teachers report perceptions of technology after implementing curricular units for the I³ Project?

    a. In what way did participation in the I³ Project affect elementary teachers' technological literacy?

    b. In what way did participation in the I³ Project influence elementary teachers' pedagogical knowledge of technology?

2. How did elementary teachers report classroom practices after implementing curricular units for the I³ Project?

    a. In what way did participation in the I³ Project affect elementary teachers' confidence with technology content?

    b. To what extent did teachers implement technology content in the classroom after participation in the I³ Project?

This study collected and analyzed both quantitative and qualitative data to answer the research questions. Quantitative data were collected utilizing questions that directly related to each of the sub questions of the study, using a 5-point Likert scale rating. A Likert scale was used to determine the strength of respondents' answers about their perception of technology. Additionally, Likert scales are easy to employ and understand for both the respondent and the researcher. The findings are presented descriptively.

Qualitative data were collected through observations and interviews. Two of the interviews were conducted face- to- face and the remaining ten were conducted by telephone. All interviews were tape recorded, transcribed, systematically coded, and then categorized. The observations are presented in story form; the interviews are presented in the form of interpretive commentaries.

Results and Analysis of Quantitative Data

The survey questionnaire was distributed electronically to all of the teachers who participated in the field test for the I^3 Project and could be contacted. The original number of participants was 25; however, three had retired leaving no contact information, and two could not be located. A total of 20 teachers completed and returned the survey; 85% (n= 17) were female and 15% were male (n=3). The sample consisted of elementary school teachers who participated in a field test, the I^3 Project. The I^3 Project is a compilation of 10 curricular units created for students in grades 5 and 6. The units were designed to provide professional support for teachers interested in technological literacy in education.

The survey questionnaire was comprised of two sections. Section I consisted of items related to demographic information. Section II consisted of items related to teachers' perceptions of technology in terms of technological literacy, pedagogical knowledge, confidence, and implementation.

Demographics of the Sample

Respondents were asked to indicate the extent of their agreement with the 24 statements (SA= strongly agree, A=agree, N= neutral, D=disagree, SD= strongly disagree). Table 1 indicates the demographics of the sample.

Table 1

Demographics of the Sample

Variable	*N*	Percentage
Gender		
Male	3	15
Female	17	85
Race[a]		
White	18	94.74
Other	1	5.26
Highest degree earned		
Bachelor's	7	35
Master's	13	65
Total number of years teaching		
8-10	4	20
11-15	3	15
16-20	7	35
21-34	3	15
35-50	3	15

[a]Note. One respondent chose not to answer this question.

The majority of the respondents were female (85%) and indicated white as their race (95%). Sixty-five percent (*n*=13) have a master's degree and the remaining 35% (*n*=7) have a bachelor's degree. The number of years teaching was widely dispersed ranging from a minimum of 8 years of teaching experience to a maximum of 50 years of teaching experience.

When asked about familiarity with technology education prior to the I³ Project field test experience (Item 9), 65% (n=13) of the respondents indicated they were familiar and 35% (n=7) indicated no familiarity.

When asked to identify the level of familiarity of technology education prior to the I³ Project field test experience (Item 10), only 13 of the total 20 participants responded. This raised concern about the accuracy of answers in item 9. Eleven noted some experience with technology education, one indicated only a vague understanding of it, and one indicated they were an experienced elementary technology education teacher. A subsequent interview revealed this person's experience was equal to that of a regular elementary teacher. It is interesting to note that all respondents answered item 9, but only 13 respondents answered item 10 (see Table 2).

Table 2

Level of Familiarity of Technology Education

Variable	*N*	Percentage
9. Were you familiar with technology education prior to participation in I³ Project?		
Yes	13	65
No	7	35
10. Level of familiarity with technology education prior to participation in I³ Project		
Vague understanding	1	7.69
Some experience	11	84.64
Experienced elementary technology education teacher	1	7.69

Descriptive Statistics

The 26 survey items on the questionnaire were categorized under terms that reflect the research questions. Therefore, the results of the survey items are sorted by categories that relate to the research questions:

Question 1a-Technological Literacy

Question 1b- Pedagogical Knowledge

Question 2a- Confidence

Question 2b- Implementation

Data analysis for research question 1a- Technological literacy. Research question 1a: In what way did participation in the I^3 Project affect elementary teachers' technological literacy?

Table 3 shows the combined results of this section, focusing on I^3 Project field test participants' perceptions of technology in terms of technological literacy. Specific items in this section were selected and defined further by explanation.

Table 3

Combined Results for Research Question 1a- Technological Literacy

Technological Literacy In what way did participation in the I³ Project affect elementary teachers' technological literacy?	Strongly Agree[a]	Agree	Neutral	Disagree	Strongly Disagree
8. It is important to understand the technological world around us.	16 (80)	4 (20)			
9. I have a better understanding of basic technological and engineering concepts and terms such as systems, constraints and trade-offs.	7 (35)	9 (45)	2 (10)	2 (10)	
10. I have an increased awareness of how technology shapes human history and people shape technology.	8 (40)	9 (45)	3 (15)		
11. I gained understanding that all technologies involve some risk that can be anticipated and some that cannot.	4 (20)	14 (70)	2 (10)		
12. I have difficulty understanding basic technological and engineering concepts.	3 (15)	2 (10)	2 (10)	10 (50)	3 (15)
13. I have a better understanding of how technology reflects the values and culture of society.	9 (45)	5 (25)	4 (20)	1 (5)	1 (5)

[a] Note. Numbers in the cells represent *n* (%)

Table 4 shows the results from item 8- It is important to understand the technological world around us. The majority of the responses (n=16) were strongly agree; the remaining indicated agree (n=4).

Understanding the technological world is a fundamental component of technological literacy. Understanding what technology is, how it is created, how it shapes society, and how society shapes technology is critical to informed citizenship. Individuals benefit greatly from a higher level of technological literacy (ITEA, 1996). Technologically literate people are better prepared to make well-informed decisions on matters of health and economic well-being and individual and community prosperity (ITEA, 1996). In order to prepare technologically literate citizens, learning about technology must be part of a child's early educational experience. Hence, the teacher must be technologically literate to facilitate technology content successfully. All of the teachers strongly agreed or agreed that it is important to understand the technological world around us (see Table 4).

Table 4

Importance of Understanding the Technological World

8. It is important to understand the technological world around us.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	16 80%	4 20%			

Items 9 and 12 are worded similarly, with the exception of item 12 excluding the words *terms such as systems, constraints, and tradeoffs*. Additionally, item 12 is stated negatively. Both items indicate positive results of teachers having a better understanding of basic technological and engineering concepts (Table 5).

Table 5 shows the results from item 9- I have a better understanding of basic technological and engineering concepts and terms such as systems, constraints, and tradeoffs.

Thirty-five percent (n=7) strongly agreed with this question, 45% (n=9) agreed, 10% were neutral (n=2), and 10% (n=2) disagreed.

Results from Item #12- I have difficulty understanding basic technological and engineering concepts.

Fifteen percent (n= 3) of the respondents strongly disagreed with this question, 50% disagreed (n=50), 20% (n=2) indicated neutral, 20% (n=2) indicated agree, and 15% (n=3) strongly agreed.

Understanding what technology is and how technologies are created, are qualities that technologically literate people possess. Today's citizens require not only skills to use products and ability to identify and remedy malfunctions, but also must understand and appreciate that technological development is the result of creative, problem-solving processes that incorporate characteristics from engineers, artists, designers, etc. (Pearson& Young [Eds.], 2002). Although items 9 and 12 are stated differently, the respondents answered similarly. In item 9, 75% percent indicated they have a better understanding of basic technological and engineering concepts and in item 12, 65% indicated the same.

Table 5

Understanding of Technological Concepts

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9. I have a better understanding of basic technological and engineering concepts and terms such as systems, constraints and trade-offs.	7	9	2	2	
	35%	45%	10%	10%	
12. I have difficulty understanding basic technological and engineering concepts.	3	2	2	10	3
	15%	10%	10%	50%	15%

Table 6 shows the results from item 10- I have an increased awareness of how technology shapes human history and people shape technology. To this item, 40% of the respondents (*n*=8) indicated strongly agree, 45% (*n*=9) indicated agree, and 15% (*n*=3) were neutral.

In the broadest of words, technology is any modification of the natural world made to fulfill human needs and desires (ITEA, 2002). Although people tend to focus on the most recent technologies, for example computers, cell phones, and the newest version of vehicles, the technological world has been built on advancements of prior developments. Each new development leads to additional potential technological developments often at an accelerated pace. For some people this is confusing. For others, they embrace the technological change, realizing the new technologies will make their lives easier. This understanding is a trait of technological literacy. The results of this question indicate most of the teachers gained awareness of how technology shapes human history and people shape technology (see Table 6).

Table 6

Awareness of How Technology Shapes History and People Shape Technology

10. I have an increased awareness of how technology shapes human history and people shape technology.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	8 40%	9 45%	3 15%		

Data analysis for research question 1b- Pedagogical knowledge.

Research question 1b: In what way did participation in the I³ Project influence elementary teachers' pedagogical knowledge of technology?

Table 7 shows the combined results of this section, focusing on I³ Project field test participants' pedagogical knowledge of technology. Specific items in this section were selected and defined further by explanation.

Table 7

Combined Results for Research Question 1b-Pedagogical Knowledge

Pedagogical Knowledge In what way did participation in the I³ Project influence elementary teachers' pedagogical knowledge of technology?	Strongly Agree [a]	Agree	Neutral	Disagree	Strongly Disagree
14. I am confused about the relationship between technology and other subjects.	1 (5)			9 (45)	10 (50)
15. I acquired greater understanding of fundamental concepts in technology.	4 (20)	11 (55)	3 (15)	2 (10)	
16. Technology can be a way to help teach science, math, and other subjects.	15 (75)	5 (25)			
17. I understand the relationship between science, technology and engineering.	11 (55)	6 (30)	3 (15)		
18. I better understand how teaching problem-solving can be done successfully.	15 (75)	5 (25)			
19. I learned about innovative ways to use ordinary materials and tools in my classroom.	13 (65)	5 (25)	2 (10)		

[a]Note. Numbers in the cells represent *n* (%)

Table 8 shows the results from item 14- I am confused about the relationship between technology and other subjects.

When asked this question, 50% of the respondents (n= 10) strongly disagreed, 45% (n= 9) disagreed, and 5% (n=1) strongly agreed.

Technology has interdisciplinary linkages with science, math, language arts, and many other subjects. All fields of study can be enhanced by integrating technological concepts (ITEA, 1996). Research supports the premise that students gain more meaning and relevancy of abstract concepts when they are combined with other subjects (ITEA, 2002). Integrating technology content into other subject areas contributes to a more positive attitude and perception about learning. The results of this question clearly indicate that teachers realize the relationship between technology and other subjects (see Table 8).

Table 8

Confused About Relationship Between Technology and Other Subjects

14. I am confused about the relationship between technology and other subjects.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	1			9	10
	5%			45%	50%

Table 9 shows the results from item 16- Technology can be a way to help teach science, math, and other subjects. All of the respondents either strongly agreed (n=15) or agreed (n=5) to this question.

A technology curriculum offers a framework for integration with other subjects, like science, math, language arts, etc. The concept is interdisciplinary with the curriculum comprising of minds-on, hands-on challenges that are relevant to the real world. The result is that children learn in ways that are exciting and more meaningful when they are actively engaged in the learning and the subject matter is combined in instruction rather than taught as separate subjects (ITEA, 2002, p.12). The result of this question substantiates that the respondents agree that technology can help teach science, math, and other subjects (see Table 9).

Table 9

Technology as a Way to Help Teach Science, Math, and Other Subjects

16. Technology can be a way to help teach science, math, and other subjects.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	15	5			
	75%	25%			

Table 10 shows the results from item 18- I better understand how teaching problem- solving can be done successfully. All of the respondents either strongly agreed (n=15) or agreed (n=5) to this question.

"Problem solving is the foundation of a young child's learning" (ITEA, 2002, p.15). A technology curriculum facilitates problem-solving activities and promotes life-long learning strategies. Through exploring, experimenting, trying out ideas, and finally solving a problem, children make learning meaningful. Constructing knowledge is a natural part of the process of problem-solving/engineering. When children discover or invent for themselves, they learn. This is exactly what occurs when engaged in technological studies. Children are asked to "do" engineering within the context of their development level, intelligence, interests, and skill level (ITEA, 2002, p.15). The results of this question indicate that all the teachers agreed they better understood how problem solving can be taught (see Table 10).

Table 10

Understanding of Teaching Problem-Solving

18. I better understand how teaching problem-solving can be done successfully.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	15 75%	5 25%			

Table 11 shows the results from item 19- I learned about innovative ways to use ordinary materials and tools in my classroom. The majority of respondents, 65% (n=13) strongly agreed to this question, 25% (n=5) agreed, and 10% (n=2) chose neutral. Technological studies offer interesting ways of challenging students to learn. Engaging them in the design of products, systems, and environments delivers active learning that children need and enjoy. Technology activities should explore the relationship of technology to humans, societies, or the environment (ITEA, 1996, p. 36). The resources are minimal; often including ordinary classroom materials typically used at that grade level and/or recycled items that students can bring in from home or other sources. The results of this item indicate a strong agreement that teachers have learned innovative ways to use ordinary materials and tools in their classroom (see Table 11).

Table 11

Innovative Ways to Use Materials and Tools

19. I learned about innovative ways to use ordinary materials and tools in my classroom.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	13 65%	5 25%	2 10%		

Data analysis for research question 2a- Confidence. Research question 2a: In what way did participation in the I³ Project affect elementary teachers' confidence with technology content?

Table 12 shows the combined results of this section, focusing on I³ Project field test participants' confidence with technology content. Specific items in this section were selected and defined further by explanation.

Table 12

Combined Results for Research Question 2a- Confidence

Confidence In what way did participation in the I³ Project affect elementary teachers' confidence with technology content?	Strongly Agree [a]	Agree	Neutral	Disagree	Strongly Disagree
20. I need more training in elementary technology education in order to implement it effectively.	4 (20)	4 (20)	4 (20)	6 (30)	2 (10)
21. I feel confident with my ability to teach about technology.	5 (25)	9 (45)	4(20)	2 (10)	
22. I feel capable and comfortable using the problem- solving approach in technology education.	9 (45)	7 (35)	4 (20)		
23. I don't feel capable of developing new technology activities for my students.		3 (15)	4 (20)	6 (30)	7 (35)
24. I gained a greater appreciation of the difficulties some students encounter when learning science or technology.	6 (30)	10 (50)	3 (15)	1 (5)	
25. I feel prepared to develop new technology activities for my students.	9 (45)	2 (10)	6 (30)	3 (15)	

[a] Note. Numbers in the cells represent *n* (%)

Results from Items 20 & 21 are examined in parallel. Table 13 shows the results from item 20 and 21. In item 20, twenty percent (n=4) of the respondents strongly agreed, 20% (n=20) agreed, 20% (n=4) chose neutral, 30% (n=6) disagreed, and 10% (n=2) strongly agreed.

In item 21, twenty-five percent (n=5) of the respondents strongly agreed, 45% percent (n=9) agreed, 20% (n=4) chose neutral, and 10% (n=2) disagreed.

Item's 20 and 21 were similar questions that were expressed oppositely. It is interesting to note that item 20 had responses across the scale with an equal number of strongly agree /agree (n=8) and disagree/ strongly disagree (n=8); 4 chose neutral. However, item 21 revealed 14 responses for strongly agree/agree and only 2 responses for disagree; 4 chose neutral. Item 20 notes respondents were evenly split (40% and 50%) over whether they needed additional training in elementary technology education in order to implement it effectively. Responses for item 21 indicate that 65% (n=14) of the respondents feel confident with their ability to teach about technology. The responses of these two questions evoke an undetermined result (see Table 13).

Table 13

Training in Elementary Technology Education

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
20. I need more training in elementary technology education in order to implement it effectively.	4	4	4	6	2
	20%	20%	20%	30%	10%
21. I feel confident with my ability to teach about technology.	5	9	4	2	
	25%	45%	20%	10%	

Table 14 shows the results from item 22- I feel capable and comfortable using the problem-solving approach in technology education. Forty-five percent of the teachers (n=9) responded strongly agree, 35% (n= 7) responded agree, and 20% (n=4) chose neutral.

Technological activities emphasize using creative problem-solving skills to address a variety of anticipated problems. The regular elementary curriculum offers many opportunities to include strategies that allow students to become problem solvers. Problem solving encourages children to be active participants in their learning, but is a skill that must be learned and practiced. The teacher's role becomes one of facilitator providing opportunities that promote problem-solving skills. The majority of the teachers (n=16) indicated they feel capable and comfortable using the problem- solving approach in their classroom (see Table 14).

Table 14

Capability and Comfort Using Problem-Solving Approaches

22. I feel capable and comfortable using the problem-solving approach in technology education.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	9 45%	7 35%	4 20%		

Items 23 and 25 are items that ask similar understandings. The items, stated oppositely, were included in this manner to check validity of the response.

In item 23- I don't feel capable of developing new technology activities for my students, fifteen percent (n=3) agreed, 20% (n=4) were neutral, 30% (n=6) disagreed, and 35% (n=7) strongly disagreed.

In item 25- I feel prepared to develop new technology activities for my students. Forty-five percent (n=9) strongly agreed, 10% (n=2) agreed, 30% (n=6) chose neutral, and 15% (n= 3) disagreed.

The responses were similar. The results show that most of the teachers feel prepared to develop new technology activities (see Table 15).

Table 15

Developing New Technology Activities

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
23. I don't feel capable of developing new technology activities for my students.		3	4	6	7
		15%	20%	30%	35%
25. I feel prepared to develop new technology activities for my students.	9	2	6	3	
	45	10%	30%	15%	

Data analysis for research question 2b- Implementation. Research question 2b: To what extent did teachers implement technology content in the classroom after participation in the I³ Project?

Table 16 shows the combined results of this section, focusing on I³ Project field test participants' implementation of technology content in the classroom. Specific items in this section were selected and further defined by explanation.

Table 16

Combined Results for Research Question 2b- Implementation

Implementation To what extent did teachers implement technology content in the classroom after participation in the I³ Project?	Strongly Agree[a]	Agree	Neutral	Disagree	Strongly Disagree
26. I see a significant benefit of implementing technology activities.	14 (70)	4 (20)	2 (10)		
27. I now use my knowledge of technology in many ways as a teacher.	6 (30)	10 (50)	3 (15)	1 (5)	
28. I seldom engage my students in technological activities.			3 (15)	13 (65)	4 (20)
29. Knowing how to implement technology content has become a necessary skill for me.	5 (25)	9 (45)	6 (30)		
30. I engage students in manipulative, problem-solving activities on a periodic basis when they conveniently and/or appropriately fit in with my curriculum.	10 (50)	7 (35)	3 (15)		
31. I feel capable and comfortable using tools, materials, and processes in my classroom.	10 (50)	7 (35)	3 (15)		

[a]Note. Numbers in the cells represent *n* (%)

Table 17 shows the Results from item 26- I see a significant benefit of implementing technology activities. Seventy percent of respondents (n=14) strongly agreed, 20% (n= 4) agreed, and 10% (n=2) chose neutral.

Technology activities are designed to help students achieve the educational goals of the total elementary curriculum. Students develop perception and knowledge of technology, psychomotor skills, and provide a basis for understanding the interrelationship of technology, society, and the environment (ITEA, 1996, p. 36).

The majority of respondents strongly agreed or agreed to seeing a significant benefit of implementing technology activities (see Table 17).

Table 17

Benefits of Implementing Technology Activities

26. I see a significant benefit of implementing technology activities.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	14	4	2		
	70	20%	10%		

Table 18 shows the results from item 30- I engage students in manipulative, problem-solving activities on a periodic basis when they conveniently and/or appropriately fit in with my curriculum. Fifty percent of respondents (n=10) strongly agreed, 35% (n=7) agreed; three chose neutral.

Including technology activities in the elementary curriculum can be challenging. In a curriculum that is already overloaded, and with the demands of current educational policy, it can be difficult to find the time to facilitate technology content. Teachers must be creative, efficient in time management, and believe in the value and benefits of including any particular content. The majority of teachers (n=17) agreed that they engage their students in technology activities when convenient or appropriate (see Table 18).

Table 18

Engage Students in Manipulative, Problem-Solving Activities

30. I engage students in manipulative, problem-solving activities on a periodic basis when they conveniently and/or appropriately fit in with my curriculum.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	10	7	3		
	50%	35%	15%		

Table 19 shows the result from item 31- I feel capable and comfortable using tools, materials, and processes in my classroom. Fifty percent of respondents (*n*=10) strongly agreed, 35% percent (*n*=7) agreed; three chose neutral. The responses of this question reflect the result of item 30, engaging students in technology curriculum.

Technology can and should be taught in a regular classroom by the regular elementary teacher, unless the school district has a dedicated, staffed technology education teacher. Initially, elementary teachers believe they are not qualified, but with appropriate experience and training, these teachers can perform well and excel at integrating technological concepts (ITEA, 1996) (see Table 19).

Table 19

Capable and Comfortable Using Tools, Materials, and Processes

31. I feel capable and comfortable using tools, materials, and processes in my classroom.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Teachers (n=20)	10 50%	7 35%	3 15%		

Summary of Quantitative Data

The quantitative data from the survey questionnaire provided a starting point from which qualitative data were collected using observations and interviews. The results of the quantitative probe led the researcher to generate qualitative data to provide insights into teacher’s knowledge, attitude, and practices towards technology education. The qualitative results and analysis are discussed in the next section.

Results and Analysis of Qualitative Data

The results of the quantitative probe led the researcher to generate qualitative data to provide insights into teacher's knowledge, attitude, and practices towards technology education. In the light of this interpretive study, data generation and analysis led to examining teachers' perceptions in terms of technological literacy, pedagogical knowledge of technology, confidence with technology content, and implementation of technology in the classroom. Findings related to the qualitative data are reported below in two parts: researcher's stories with interpretive commentaries, and interview accounts.

Observations in Story Form

The following section describes the observations in story form. They are followed by interpretive commentary to help place them in context with the questionnaire and interviews. The stories attempt to represent teachers' perceptions by extracting themes that were familiar over a number of interviews with the teachers. The emerging themes were a) technological literacy, b) technological strategies, and c) implementing technology experiences.

Story 1- A 5th grade science class. It was almost 9 AM; the 5th grade students would be arriving soon. I surveyed the room to find the least noticeable place to conduct my observation. The room was full, literally. Every inch of space was occupied. Several filing cabinets lined the back wall, placed along-side bookcases and game-laden shelves and containers of supplies. A small door was barely noticeable; I assumed it led to a bathroom. More shelves with more books and supplies were located beneath the windows on another wall. An overhead projector was set up near the front of the room, appearing as though it was in a permanent location. A student desk and computer sat to the right of the board and the teacher's desk sat to the left of the board. A coat closet took up much of the space on the other wall. Its door wallpapered with student's school pictures; some from the present, some obviously from the past. A small sink and counter was tucked in the far back corner of this wall. This area seemed the most accessible, so, chair in place, notebook in hand, I settled in to begin the observation.

The teacher greets the students as they trickle into the room. They know the routine. Remove coats, hang them in the closet, and get books from the closet. The environment is chaotic: students talking, handing in papers, asking questions. After a few minutes, the teacher quiets the class, takes role and lunch count and then selects a student to take this information to the office.

The teacher requests that students put all papers away and get ready to begin science. Students follow her directions, she turns on the overhead and the engineering design process appears on the white board. She proceeds to tell them they will continue working on their game board. Their excitement is obvious in their sounds of affirmation and attentiveness to the teacher. The teacher requests students to move to their groups and she hands each group stapled packets of paper that I later found out to be design briefs for the lesson. The teacher, pointing to the design process on the board, provides a short review of previously work. She tells the students the first step is to *define the problem*. Several students raise their hand as if they know she wants them to explain what this means. The teacher selects a student; the student announces that they had to design a game board for a fictitious company called Happy Land Toy Company. The teacher points to the second step, *thinking and planning*. She asks them to explain some of the first things they needed to do for this step. One boy said his group talked about what they wanted on the board. They thought about other games, like Life and Monopoly, to help give them ideas. The teacher probed for more information, asking what the main things were that needed to be on the board. Several hands fly up; the teacher chooses a girl to answer. She said they needed to write directions, or else the game would not be able to be played right. Another student adds that it needs to be colorful, and still another adds that it had to be made for kids who were 5 to 10 years old. Other students refer to the amount of players the game is allowed to have. More discussion leads to dimensions and what two-dimensional and three-dimensional means.

The teacher asks what step of the design process the students were on presently. Again, many hands rise. A boy confirms their group is at the stage of developing and this is where they make the game and the directions.

The teacher proceeded to ask what the final step was in the design process. A girl answered that it is presenting their game. She said they were going to display their game boards at a parent night in a few weeks.

The teacher praises students on the review comments and explains that they can use the rest of the time on step three, developing their game boards. Students immediately open their design briefs and begin talking in their groups. Students use the remaining class time working on their game boards. The teacher moves around the room, checking each group's progress, answering questions, and confirming ideas. She glances at her watch; I can see her reluctance to end the class. The students are engrossed in their work. She calls for their attention and asks them to gather their materials and turn in their design briefs. Reluctantly, the students begin cleaning up and the class end.

Interpretive commentary for Story 1. The story illustrates the implementation of a technology education activity in a regular elementary teachers' 5th grade science class. It describes a lesson in which the teacher facilitates one of the I^3 Project units.

Most of the teachers interviewed stated that implementing the units helped them to understand what technology is and why it is important to understand the technological world. According to the majority of teachers interviewed, their perception of technology changed from viewing technology as computers, electronics, etc, to that of critical thinking skills and problem-solving challenges.

The story describes a teacher using fundamental concepts of technology in a lesson. Although interviews revealed many of the teachers acquired greater understanding of technological concepts, one teacher interviewed still associated computers and smart boards with technology concepts.

Many of the interviewed teachers expressed that they now understand how technology concepts can be taught in any subject. Interviews indicated that teachers realized a relationship between science, technology, and engineering. In addition, many stated that technology activities can easily be accomplished with materials they already have in their classrooms.

The story also describes the teacher's confidence in teaching technology concepts; particularly, using the problem-solving approach. Several of the teachers interviewed agreed that problem solving should play a large role in students' learning. Several admitted to keeping the illustration of the engineering design process hanging in their classrooms and pointing it out to students when they are involved in problem-solving challenges. Most indicated that their experience with the I^3 Project gave them more confidence to develop new technology activities for their students.

Finally, the story describes a teacher implementing technology activities in a science class. Although most of the teachers interviewed acknowledged implementing technology content, concepts, and strategies in their classrooms, many stated they did not always have time to implement the whole unit. They did state, however, that particular parts of the units could be used to incorporate many of the concepts in other lessons or subject areas. Of those teachers, most said they felt it is important to provide opportunities for students to be involved technological activities.

Story 1 describes an exemplary model for implementing technology education in a regular elementary classroom. The teacher was able to implement the I^3 Unit into her daily curriculum schedule almost void of barriers.

Story 2 describes a different circumstance. The teacher no longer teaches the grade level she did when she originally field-tested the I^3 units. This story develops a model of technological implementation constrained with barriers.

Story 2- A 1st grade class. The classroom echoes learning. Colorful arrangements of letters and numbers splatter the walls. Several bookcases stand against the back wall. A myriad of art supplies including crayons, markers, scissors, and paper fill another shelf. A huge map of the United States covers the whiteboard on the front wall. Three large, c-shaped desks take up the center space of the room, each a different color. Three small children sit at two of the tables and four at the third.

I sat at the student computer desk against the far wall, trying to be as inconspicuous as one might hope to be in a class full of inquisitive five and six year olds. The lesson had already begun. Four children were standing at the front of the class uttering strange sounds. I had never observed a first grade class, so I wasn't sure what the children were doing. As seconds passed, I realized they were enunciating the sounds of letters in a word. These first grade students were learning the first steps of reading! One at a time, in order, each girl and boy take turns making the sounds of the letters. Then each child names the letter, and in unison, the group speaks the word, lake. The teacher pleasantly commends the students and invites the last group to take their turn at enunciation. As this group complies, most of the students listen and watch. One little girl rests her head on her desk, still watching, and another is looking at me, with innocent wondering. The students finish, and the teacher asks them to clear their desks and put away their study books.

The teacher begins to recap a story, something about cars across America. I assume she is referencing a story from a prior lesson. She focuses on the map attached to the board, and asks the students, “Where did the girl in the story live?”

A few students call out, “Pleasant Grove, Kansas.” The teacher smiles, nods, and says yes. Then, “Where do we live”? She called on a little girl with long dark hair. The girl walks up to the map, points to Pennsylvania and says Pennsylvania; then sits back down.

The teacher glances around the room and says, “Where at in Pennsylvania?” The children call out the name of their town. The teacher replies with, “In the big country of?” And all of the students reply- “USA.”

The teacher explains that everyone is going to get a map of the United States. She places maps and a box of crayons at each table.

> I’m putting you into groups. I want you to try to go from (their town) to the state of Washington. Your task is to try to figure out the shortest way to get there, in books. Pretend like each state is a book and figure out how many books you need to go through to get to Washington. One state equals one book. But here’s the catch, all the states (books) have to touch each other. How many books does it take to get to Washington?

She explains that only one of the maps in the group will be colored in. The other maps are for each student to look at as they figure out the problem. One of the boys asks, “How do we move a car when we don’t have a car?” The teacher ignores the comment but repeats the directions for the activity and tells the child to try to figure out what is the best and shortest way to go. I notice some students begin coloring as soon as they get their maps. The teacher, noticing also, begins clapping her hands, in a rhythmic beat. As soon as she does this, the students stop what they are doing and repeat the clapping pattern. Clap, clap- clap, clap, clap. This is her way of getting their attention. With the student's eyes on her, she reinforces the instructions, but has to repeat the clapping another time. It seemed the students now understand their task, and she begins walking around to each table to check on their progress.

One child complains that another group is copying off them. Another child declares they find eight (meaning it took eight states or books to get to Washington). The teacher once again reminds students not to color until they are sure they found the fastest way. At her remark, one little boy begins to cry. He thinks she is reprimanding him. The teacher comforts him and tells him this is supposed to be a fun activity, and there is no need to cry; he stops and he rubs his eyes.

At another table, two girls are arguing over what a different group has concluded. The teacher settles the conflict explaining they should be working together, not fighting. Trying to keep the students on task, the teacher reminds them again to make sure they look at all the ways to go, trying to find the shortest distance. The little boy, who had been crying before, begins crying again. When asked why, he says he can't understand how to count the shortest distance. At this point, the teacher says they are ready to share the solution.

The teacher calls two students to come up to the map and point out their shortest way to Washington. After the group points out their way, she calls on two more groups to do the same. All three groups have the same number of states (books) but chose different states to go through to get to Washington. The teacher uses this opportunity to explain to the students that there is not always just one solution, but many solutions to get to the same place, to solve the same problem. She tells them she wants them to try every possibility and not stop at the first try. Then she told them they all did an excellent job. She continues saying that problems can have different answers, and it's okay if everyone's answer is not the same. She concludes the lesson by commending their excellent work.

Interpretive commentary for Story 2. Besides the differences in grade levels of the two observations, other more subtle differences discussed below could be explained only after interviews with the teachers: curriculum integration, pressures experienced by teachers, and educational aims.

The story describes the teachers' battle to fit technology concepts into a classroom where the curriculum focuses on one aspect. In this observation, the curriculum focus is reading; in other cases (as stated by the interviews), it is specific curriculum driven by educational policy. Interviews with teachers indicated standardized tests could be a major barrier on how, when, and even if, technology is integrated into subject matter. Some of the interviewed teachers stated they had difficulty finding the time to include technology content in the schedule. Many expressed the best time as being at the end of a lesson, with leftover time, or at the end of the year, when testing is over.

The story also illustrates the pressure teachers are under (educational policy) for students to perform well on standardized tests. The nature of the required testing and consequential results allows very little diversion from the tested content. The teacher in this observation stated that her foremost role as a first grade teacher was to teach the students how to read. Other interviewed teachers also indicated that teaching is constrained to the aspects of the tested curriculum. Although most teachers agreed the constrained curriculum takes precedence, they indicated their experience in the I^3 Project, using technology strategies, has prompted them to revisit their teaching approaches. According to interviews, they have learned to introduce new content in ways that promote critical thinking and include problem-solving activities.

The story describes the educational aims the teacher has for her students. The teacher implemented a problem-solving activity connecting it to a reading activity. According to teachers interviewed, being able to implement technology strategies into various subjects is an essential component of teaching. Through interviews, teachers indicated that using problem-solving strategies promoted student's understanding of concepts that might otherwise be difficult to cultivate. The interviewed teachers indicated a new willingness and ability to develop lessons in ways that include technology strategies thereby promoting student understanding, and at the same time, making learning fun.

The classrooms described in the stories presented in this section, have different learning environments. The first story describes a teacher implementing a technology unit from the I^3 Project. The second story describes a teacher integrating a technology strategy within a reading lesson.

If the stories and interviews are to be considered typical of teachers who field-tested the I^3 Project units, then they can be used to help explain differences and similarities in knowledge, attitude, and practices toward technology.

Both stories indicate teachers gained understanding of technology, and its importance to the world around us. Additionally, the stories and interviews describe teachers using technology strategies in the classroom. This translates to understanding fundamental concepts of technology and realizing that technology can be taught in any subject. The stories and interviews indicated most teachers feel confident teaching technology and have better understanding of teaching problem-solving techniques. Finally, the stories and interviews reveal most teachers now include technology content and strategies in their curriculum schedule.

Interviews

Teacher responses in the interviews were subjected to content analysis, systematic coding, and categorization. After using an iterative process, three main themes emerged: a) technological literacy, b) technological strategies, and c) implementing technology experiences. Each of these themes are discussed and supported by direct quotes from the teachers.

Technological literacy. The teachers stated their understanding of what it means to be technologically literate. They expressed their understanding in numerous ways. For example, Lynn said,

> I didn't really understand what technology was until this I^3 thing, but now I do. And I think it's really just being able to live- kind of smartly- in the world

> we live in. I can look at products and examine them- per say, and ask questions about them and can make a good decision about whether I want it or not. I also look at things, say, when some things break, and I try to fix them, sometimes I can, sometimes I can't. So I kind of try to problem solve as a way to do things.

John had similar thoughts. Both appear to agree on the characteristics of a technologically literate person. He stated,

> If a person is technologically literate, they have a lot of common sense. They have the where-with-all to realize they have to take steps to try to solve the problem they might have. It might be as simple as fixing a toaster. I look more at it as if it's an ability, what kids used to get from their parents, when they did a lot of things for themselves. …for me a technology person is not someone who sits at a computer, it's somebody who problem solves.

George also confirmed the thoughts of Lynn and John, "It's being able to understand how things work, what they're made of, how they were developed, and the evolution of ideas."

Elsie suggested it means being aware of the differences between instructional technology and technology education.

"A technologically literate person is aware of the many definitions of the word and being comfortable with the use and adaptation of technology on a daily basis. " She expressed her responsibility as an educator as " preparing children to be technologically literate citizens so they can function in a global society."

Lisa commented on the types of things a student would be demonstrating if they were considered to be technologically literate. She said,

> They would have the ability to work through the engineering design process, the steps to achieve whatever challenge is put in front of them. It's creating something that's not there, you know what I mean, giving them a challenge, then being able to create what is needed.

Many of the teachers commented on their perception of technology. Marilyn said,

> My perception has definitely changed, before I did this (I^3 Project) I thought it was mostly computers and using the overhead or using electronic equipment, and now I believe it's more problem solving, critical thinking skills, and things like that.

Lynn also talked about her perception of technology,

> Okay, well, my view has definitely changed. Especially with respect to the umm, idea that, umm, technology education is not just about computers or teaching kids how to use computers or some other technological device. I think technology can include those kinds of things, I think that's a part of it, but there's so much more. What this really did for me was to make me realize that I can teach in ways that make students look at the world around them and they feel like they are learning, umm, things that are, I guess I would say, more worthwhile, like this means something to them. Like I said before, I ask better questions, and can kind of get "into" things a little deeper, if you know what I mean. I think I'm making the students like learning a little better, at least it seems like that, because they are

always so excited when we do these challenges. So, doing the I^3 has been refreshing to me as a teacher, kind of revitalizing.

Technology strategies. Technology education activities and challenges require that teachers have abilities to effectively facilitate certain techniques or strategies as ways to enhance or promote learning. Technology strategies, particularly the engineering design process, were noted consistently throughout the interviews.

The teachers expressed an eagerness to talk about their understanding of technology strategies and how they used them in their classes. Lisa said, “Technology strategies, I would say, it’s working through the engineering design process, the steps to achieve whatever is in front of you.” In general, the teachers perceived the engineering design process to be the main concept of technology strategies.

Lynn said,

> Technology strategies, well, this means, how we do things, how things are done. It’s like going from step to step to do something, to accomplish something. It is the actual processes of problem solving, being able to imagine it, what it will look like, what it’s supposed to be or do, and then doing what needs done to get it done. … it’s called the design process, engineering design process, it is a set of steps kids have to go through to find the solution to whatever it is they are doing.

John also stated,

I'm talking about the engineering design process- I think that's a great process. If I've taken anything away from that whole unit- I still have those (posters) plastered all over my science lab, 'cause I think that's a really good way to look at a problem and how it can be fixed.

> I think it's really given me a new avenue to approach teaching and also use, you know, much better, I should say. Like I said, I still go back to the engineering design process, I think it's a good thing, I think it's really good that they (students) know that whole process.

Karen confirmed her understanding of technology strategies as "using step-by-step planning and organizing to help solve some sort of problem, problem solving to reach an end goal."

Lisa exclaimed,

> I did tech just a little bit ago with my students; this class had never seen it before. And when they first saw it, they were scared to death. But they did it, and they were excited and now they keep coming to me every day and ask, can we do this again, are we gonna do tech again? And they are excited to learn. I also believe that they learn more than they realize they are learning. There are so many processes they go through that I can't teach them with usual teaching, such as problem solving. Such as working with someone who doesn't necessarily agree with you and stating your point and why you want to do that. Umm, even applying some of the

> things we've learned, some of the things we did in our tech, we are now doing in science, and they say, oh, we already know how to do this!

Elsie contended that implementing the I^3 Units allowed her to teach her students "…how to apply their knowledge and skills to real life experiences." She explained that she integrates subject areas into thematic units that help student see the relationship between the contents. "Knowledge of technology is learned by the students when they are able to use various tools and materials to design, construct, innovate, and solve problems."

Implementing technology experiences. Integration of technology experiences surfaced often during the interviews. Three teachers stated they were still using the I^3 units while others use only parts of them. For example, George uses one of the units in its entirety in place of a science kit.

> The main thing in the unit is students using the engineering design process- that helps them visualize what they're doing. It's not just rote learning all the time. It gives them a path to follow and they can see the way to go to find the solution.

Marilyn uses a unit when she is teaching energy.

> We recently studied energy, and we used the I^3 unit to guide the lesson. The unit took a lot of time, but watching the kids struggle through a problem, design, idea, and then watch them figure it out one way or another, it's worth it!

Lynn also stated,

> Well, I still use the I^3 units, or at least parts of them, whenever I can, we have so much to do, especially with the state tests, there isn't always time, but I do fit in bits and pieces here and there, even if I can't do the whole unit. Like in my science class, I have a lot of, umm lessons, that just kind of end, you know, when we're done, so I a lot of times will ask my students things like, what can we do different to come up with a solution that might do this, or this, so it may not be a whole lesson that has technology in it, but I just add little kind of fragments that makes them think beyond what the original goal of that lesson was.

Most all teachers stated they have developed new technology opportunities for students, integrating technology across the curriculum.

Karen said,

> My partner and I use a lot of the ideas that we have regarding technology together. Umm, we do a toothpick bridge, we talk about structure, we talk about stress, we talk about tension, and in math class, they have to build a, they have to come up with a plan, and then they build it, and uh, obviously we break it. Now, we don't use the format from the TSA stuff, or anything like that, it's my own design as far as that goes.
>
> We do rockets, hot air balloons, and I do a bunch of different things- I have a couple of different types of cars that they will build and they have to go through a process of how it works, like a hydrogen car engine, and

> then learn the technology behind it before they actually can build it and things like that.

Lisa explained how she integrates technology,

> Reading, we were reading a story, and I turned it into a tech project. A boy had his lunch stolen, and he was talking about a little trap he made and put it in his lunch box, and so we worked on how we could do that. We didn't really do that, but we planned it out, we laid it out, made plans. So you can incorporate tech into everything.

Lynn gave her account of integrating technology,

> In social studies, we learn about United States history, and the kids learn about the early settlements and about early hunting tools and things that the farmers farmed with, so I always do a comparison to what they used then and what we use now, and umm, I have them design a tool of something the way they think it might have looked like way back then, then they have to talk about what they designed, why they designed it that way or why they think it looked that way, and they really enjoy it.

Becky alluded to her experiences,

> In my experience, I was able to do problem solving. … after this (I^3 unit) they were less hesitant about doing something like this in other areas. Well, minimally, I extended the concepts into the math program. It obviously didn't have anything to do with invention, or anything, but it was an attempt to get the students to explore, you know, like, I would lead students from information that I knew, I would lead them, without telling

them and have them find out for themselves. For example, in arithmetic series or something, I would say to them well, put this down, what do you see, and let them do different ways of coming to conclusions.

George added a final comment,

> I^3 validated a lot of beliefs I have as an educator. Children need an outlet for their curiosity and a testing ground for their ideas. Integrating across the curriculum has been a plus to try and reach the multiple benchmarks I'm to teach to. Unfortunately, this type of learning takes time, materials, and know how, characteristics that not all educators possess or value. I^3 changed the way I teach!

Summary

In this study, the combination of multiple research methods helped examine teachers' perceptions of technology after implementing technology units in their classroom. The quantitative data from the survey questionnaire provided a starting point from which qualitative data were collected using observations and interviews. The results of the quantitative probe led the researcher to generate qualitative data to provide insights into teacher's knowledge, attitude, and practices towards technology education.

Although the descriptive analysis of the quantitative data established validity of the questionnaire, the researcher also wanted to determine if the teachers had interpreted the items of the questionnaire consistently and had reasons for their responses. Using qualitative data put the researcher in a better position to interpret the quantitative data more accurately and understand teachers' perceptions and feelings about particular aspects of their I^3 Project experience. During that process, the researcher identified strong points and pitfalls associated with the experience. One limitation that emerged through the teacher interviews was that, despite the answers indicated on the questionnaire, some teachers still reflected a misunderstanding of technology regarding computers and electronics as a major component of the concept of technology.

The teacher anecdotes were generally consistent with teachers' perceptions as described in the questionnaire. Therefore, the questionnaire appeared to provide a basis for measuring teachers' knowledge, attitude, and practices towards technology education.

The questionnaire also provided a basis for which to examine similarities and differences in teachers' knowledge, attitude, and practices from the teacher perspective. The researcher found that where differences were identified, teacher observations and interviews provided a plausible explanation, suggesting further support for the validity of the questionnaire. Including the observation and interview data was vital for making sense of the questionnaire results.

Chapter 4 analyzed the quantitative and qualitative data from the survey questionnaire, observations, and interviews. Chapter 5 presents conclusions drawn from the data and discussions regarding the conclusions. Finally, implications for elementary teachers and future research are discussed, followed by a summary of the study.

CHAPTER 5

CONCLUSION AND DISCUSSION

The primary focus of this study was to address perceptions of knowledge, attitude, and practices of elementary school teachers, regarding technology education, because of participating in a field test, the I³ Project. This study was designed to answer the following research questions:

1. How did elementary teachers report perceptions of technology after implementing curricular units for the I³ Project?

   a. In what way did participation in the I³ Project affect elementary teachers' technological literacy?

   b. In what way did participation in the I³ Project influence elementary teachers' pedagogical knowledge of technology?

2. How did teachers report classroom practices after implementing curricular units for the I³ Project?

   a. In what way did participation in the I³ Project affect elementary teachers' confidence with technology content?

   b. To what extent did teachers implement technology content in the classroom after participation in the I³ Project?

The present study has highlighted the importance of introducing the discipline of technology at the elementary level. The study was distinctive because it used multiple data sources and triangulation to document and confirm interpretations of the data. Quantitative data provided a starting point from which qualitative observations and interviews were gathered to gain greater understanding and insight of teachers' knowledge, attitude, and practices of technology education.

The quantitative data, collected using a survey questionnaire, was comprised of two sections. Section I consisted of items related to demographic information. Section II consisted of items related to teachers' perception of technology in terms of 1) technological literacy, 2) pedagogical knowledge, 3) confidence, and 4) implementation. These terms or categories reflect the essential ideas of the research questions.

This chapter is organized around each of the four categories described above to provide a framework for discussion. Conclusions generated from the quantitative analyses of the survey questionnaire along with the results of the qualitative analyses of the observations and interviews are presented. The findings from the mixed methodology converge in the conclusions and discussion. Finally, implications for elementary teachers and future research are discussed, followed by a summary.

Conclusions

Technological Literacy

In general, technological literacy is a basic sense of technology. Technologically literate people are able to use, manage, and understand technology, can make good decisions, and can solve problems in a variety of contexts. They understand what technology is, how it is created, how it shapes society, and how society shapes it (ITEA, 1996).

The initial quantitative data collected indicated teachers' knowledge and attitude relating to technology were positively affected after their participation in the I^3 Project. Participation in the I^3 field-testing appeared to promote understanding of technological concepts and terms, as well as increase their awareness of how technology shapes human history and people shape technology. The majority of teachers indicated they gained understanding that technologies involve some risks that can be anticipated and some that cannot. Additionally, many indicated they have a better understanding of how technology reflects the values and culture of society.

The qualitative analysis revealed more in-depth aspects of participants' experiences. As mentioned in the introduction of Chapter 2, misconceptions of technology are widespread. From the first instances of early practices, educators have been confused about the definition of technology, what the content of technology entails and how a technology curriculum should be implemented in educational settings. Even the name itself, has changed over time.

The interviews confirmed that teachers had prior misconceptions of what technology is. Teachers remarked their "before" understanding to be that of computers, software or electronics. After implementing the I^3 units, they revised their understanding to that of human made artifacts and the design and processes needed to create them. Their involvement in I^3 appeared to transform their way of thinking that technology dealt with computers to the broader concept of how humans change the natural world to satisfy their needs (ITEA, 2004).

One teacher described her new understanding of technology as the things people make and the way they make them, to make human life easier. In numerous explanations, the teachers related their thoughts of what it means to be technologically literate. They discussed design and processes, and knowing how all things work together.

Nine teachers stated characteristics that technologically literate people possess. For example, one teacher said characteristics include being problem solvers, and being able to live smartly in the world. Another stated having skills to use products and being able to fix them when they break. The implied consensus among the teachers was that all citizens, children included, need to become technologically literate in order to participate fully in the technological world.

In contrast, the conversations included erroneous responses. In particular, one teacher repeatedly referenced technology as computers, etc., even after continued probing from the researcher. However, in later statements, she reported problem solving as a major component of technology.

Additionally, two other teachers alluded to technology as electrical components. The researcher found this interesting because these same teachers had indicated accurate definitions of technology on the quantitative survey questionnaire. These findings indicate some teachers still had misconceptions of technology, even after implementing the I^3 units.

Regardless, 17 out of 20 teachers indicated positive consequences in terms of technological literacy because of their experience in the I^3 Project.

Pedagogical Knowledge

A technology curriculum offers a framework for integration with other subjects, like science, math, language arts, etc. The concept is interdisciplinary with the curriculum comprising of minds-on, hands-on challenges that are relevant to the real world.

Additionally, a technology curriculum facilitates problem-solving activities and promotes life-long learning strategies. Through exploring, experimenting, trying out ideas, and finally solving a problem, children make learning meaningful. Constructing knowledge is a natural part of the process of problem-solving/engineering. Engaging them in the design of products, systems, and environments delivers active learning that children need and enjoy.

The preliminary findings of the quantitative data reveal teachers have a greater understanding of fundamental concepts in technology. All 20 teachers believed technology can be a way to help teach other subjects. All 20 teachers also indicated a better understanding of how to teach problem solving. All but two said they learned innovative ways to use ordinary materials and tools in the classroom.

The qualitative data made an important contribution to the interpretation of these findings. The researcher found that every interviewed teacher exhibited knowledge of teaching technology. They gave examples of using technology strategies, either alone, or in other subjects. They used terms like critical thinking and problem solving. One teacher stated that implementing the I^3 units has taught her how to help students apply their own knowledge and skills to real life experiences using technology activities. Other teachers elaborated further by identifying additional ways they taught technology, not just using the I^3 units. All ten teachers interviewed related integrating technology in math, science, and/or reading.

The teachers expressed the ease of which technology can be integrated into other subjects, like science, math, or reading. They pointed out technology activities into other curriculum helps teach problem-solving skills in ways that students enjoy, sometimes not even realizing they are learning. Teachers talked about technology strategies as being cross- curricular, giving students more opportunities for creativity, especially for children who are not ‘book smart’.

Several conversations translated to greater understanding of problem-solving techniques. One teacher stated teaching problem solving strategies comes easily now, after their I^3 experience. Teachers recognized the engineering design process as a major component of technology strategies.

Often in the conversations, teachers talked of having their students work through the engineering design process, giving them a challenge, and following steps to solve the challenge. One teacher explained the design process as how we do things, how things are done. She elaborated saying that “solving a problem is being able to imagine what it will look like, what it’s supposed to be or do, and then doing what needs done to get it done.” Teachers stated they learned how to allow students to work through problems on their own, and even if they failed, they still learned from that failure.

The qualitative findings revealed a few of the teachers previously used problem-solving strategies before they field-tested the I^3 units. Specifically, three teachers who taught science related the similarities of the engineering design process to the scientific method. They did note, however, that there were definite differences, such as the scientific method involves hypothesizing, and the engineering design process involves brainstorming. The scientific method ends with a definition conclusion, and the engineering design process can have multiple solutions. Five of the interviewed teachers delightedly stated they may have been doing forms of technology all along, but never knew it!

Confidence

Technological activities emphasize using creative problem-solving skills to address a variety of anticipated problems. The regular elementary curriculum offers many opportunities to include strategies that allow students to become problem solvers. Problem solving encourages children to be active participants in their learning, but is a skill that must be learned and practiced. The teacher's role becomes one of facilitator providing opportunities that promote problem-solving skills.

The quantitative data revealed 16 of the teachers indicated confidence and capability with technology concepts and using problem-solving techniques, with four choosing neutral. However, it is interesting that eight teachers said they needed more training in elementary education, eight said they did not need more training and four were neutral on the item.

The qualitative analysis revealed further explanation of teachers' confidence levels. Teachers described numerous examples of implementing technology activities. A teacher's confidence increases each time a similar lesson is implemented. Teachers are more confident about their knowledge and capabilities with each lesson taught.

The researcher found that teachers became affluent in problem-solving techniques. Teachers' conversations circulated around classroom accounts of using problem solving strategies and the engineering design process. They were proud to tell the researcher how they developed, how they integrated, and how they succeeded in using technology strategies.

One teacher recalled her initial thoughts of participating in the I^3 Project field-testing. She remembered feeling afraid to use the technology concepts. Once she started teaching using the concepts, she stated it became easy because it made so much sense. She exclaimed it has changed her teaching techniques, and she now uses technology strategies every chance she gets.

In contrast, three of the interviewed teachers stated needing more training. Teachers still teaching the same grade level or close to that grade level had no difficulty in executing technology strategies. However, one teacher, in particular, was transferred to a lower grade; she remarked having trouble developing technology strategies for her students age, and that units that pertained more to that grade level would be a big help. Professional development for technology education at various grade levels would be beneficial to teachers.

Implementation

Technology activities are designed to help students achieve the educational goals of the total elementary curriculum. Including technology activities in the elementary curriculum can be challenging. In a curriculum that is already overloaded, and with the demands of current educational policy, it can be difficult to find the time to facilitate technology content. Teachers must be creative, efficient in time management, and believe in the value and benefits of including any particular content.

The quantitative data identified the extent teacher's implemented technology in their classrooms. Sixteen teachers acknowledged implementing technology activities either on a periodic basis or when they appropriately fit in with their curriculum. Eighteen teachers agreed that implementing technology activities has significant benefits and indicated knowing how to implement technology was important to them. Sixteen teachers agreed they feel comfortable and capable using tools, materials, and processes in the classroom.

The qualitative data illuminated these findings. Technology can and should be taught in a regular classroom by the regular elementary teacher, unless the school district has a dedicated, staffed, technology education teacher.

The I^3 Project promoted instruction of technology content. Teachers were eager to discuss their accounts of technology activities and challenges. Five of the 10 teachers interviewed still use the I^3 units, and nine said they have developed their own lessons, which they adapted to fit particular needs. Tales of implementing technology, and using problem-solving strategies encompassed the conversations.

Teachers continuously spoke of the benefits of utilizing technology activities. Their explanation can be categorized two ways: benefits as teachers and benefits for students. For teachers, they learned new approaches to problem solving, using the engineering design process. One teacher said, “Engaging the kids in problem-solving is the biggest value.” Another called teaching technology “teaching real knowledge; concepts students can use for the rest of their life.” Still another remarked she learned how to ask better questions in ways that make students think.

Of the many benefits mentioned for students, problem-solving abilities surfaced most often. Other things were socialization skills, working cooperatively, student creativity, and kids having fun while they are learning. Another stated technology activities allows students to shine who normally would not in a traditional classroom.

The qualitative analysis revealed barriers to implementing technology activities. Nine teachers stated time was an issue. “We have so much to do, especially with the state tests; there isn’t always time to fit it in.” Some stated because of the state tests, they are only able to integrate bits and pieces of technology strategies.

Ten of the 10 interviewed teachers stated that at the onset of the I^3 experience, they felt unqualified and afraid of not understanding the content and concepts. Field-testing the I^3 units has given them new understandings of technology and taught them new approaches to student learning.

The analysis of the finding of this mixed method study indicate positive effects of teachers' knowledge, attitude, and practices towards technology education.

Implications for Elementary Teachers

Imagine curriculum developers, schools, and policy makers, all working together to create environments that advocate the study of technology and support teacher and student growth in technological literacy and the study of technology. Imagine curriculum materials and resources provided to empower teachers to educate and students to learn. Imagine professional development providing learning opportunities to enhance pedagogical knowledge and higher education institutes supporting teacher preparation in technology.

Making technological literacy a reality for all requires a strong system of support for teachers from professional development, curriculum developers, school districts, and teacher preparation institutes.

The study of technology is seldom a part of the elementary curriculum. This fact is highlighted throughout the literature review. If technology education is to be recognized as an important implementation to promote technological literacy for all students, guiding principles must support the visions of national education reforms and national and state standards that require all students to study technology from Kindergarten through Grade 12.

Elementary teachers must be adequately prepared to teach technology content and concepts. Recommendations for ways to support elementary teachers' integration of technology into classrooms, such as professional development that provides technology experiences, development of technology materials, technology workshops, or marketing the study of elementary technology education, all have the potential to foster technological literacy and effective technology instruction techniques. Since technological literacy is imperative for all individuals (ITEA, 1996, 2003; Pearson & Young [Eds.] 2003), teachers need to be able to educate students about technology. Therefore, teachers must be technologically literate as well as have knowledge and capabilities consistent with teaching technology (ITEA, 2003).

This study has implications for teacher learning, curriculum developers, school districts, and teacher preparation institutes. This section of Chapter 5 will look at each of the aforementioned areas and offer recommendations on how to better prepare elementary teachers in the discipline of technology.

Teacher Learning

The participants in this study did not receive training to aid in the implementation of the I^3 units. Part of the evaluation of the units (conducted by I^3 evaluators) was to determine the ability of the units to stand on their own. In other words, the units were developed in a manner that an elementary teacher would not require background knowledge in technology in order to implement them. As the teachers implemented the units, they had to make meaning of the technology material so that they in turn could effectively teach it to their students.

Teachers attained knowledge of technology by their experience of implementing the units.

The literature review, in Chapter 2, (Adult Learning Theories/Experiential Learning Theory) describes adult learners as having needs and requirements different from children. Andragogy is a set of assumptions about how adults learn. Experiential learning, a theory defined by Kolb (1984) concentrates on the learning process of the individual, centering on the premise that individuals learn best by experience. The learner is directly involved with what is being studied, often described as “learning by doing.”

Following are expanded definitions of adragogy assumptions combined with experiential learning elements that are relevant to the topic of this study. Together, they provide insight into elementary teachers’ perceptions of technology education and support the conclusions of this study.

The learner’s need to know. Adults need to know why it is important to learn something. Unlike the pedagogical model where it is assumed student’s will learn because it is expected, adults need to see a benefit of the learning. They are used to understanding what they do in life. This may have been accomplished even before teachers engaged in implementing the units. Teachers reading articles, reports, or administration may have addressed the importance of integrating technology into the elementary curriculum. Certainly, the facilitators of the I^3 field-testing project explained the need and necessity of elementary students learning problem-solving and critical thinking strategies that reflect world instances.

The learner's self-concept. As a person matures, that person's self-concept moves from dependency to self-directness. Adult learners want to take responsibility of their own learning; they need to be free to direct themselves. Teachers were actively involved in the learning process as they served as facilitators of the I^3 units. Specifically, through their experience, they acquired perspectives about the topics and assumed responsibility for presenting that information to their students.

The role of the learner's experience. Life experiences can be a continuous reservoir of resources for learning. These experiences can provide an additional knowledge base for learning. Connections to life experiences can provide relevancy to the topic being learned. The teachers participating in this study were immersed in the implementation of the I^3 units. They were able to draw from previous knowledge and experiences (as revealed in the data collection) to form a more cohesive understanding of technology content and concepts.

A student's readiness to learn. When adults take on a new learning experience, they usually know what goal they want to attain. Knowles (1980, p. 44) explains, adults are ready to learn "when they experience a need to learn it in order to cope more satisfyingly with real-life tasks or problems." It is important that learning be concrete and relate to the learner's needs and future goals. Teachers reported the need for their students to learn problem-solving concepts as opposed to rote learning. The learning experience for the teacher facilitated the learning process for the student. Teacher and student gained knowledge simultaneously.

The student's orientation to learning. As adults mature, they become problem-centered in their orientation to learning. They need to see that what they are learning will be applicable and valuable to their work or other responsibilities. Their learning shifts from one of subject-centered to one of problem centered. Technology education utilizes a problem-solving approach towards learning. As teachers employed the techniques of problem-solving using real-life challenges, they acquired a better understanding of technology approaches and were able to transfer that knowledge to their students and to other content areas.

Student's motivation to learn. Knowles (1984) contends that motivation becomes more internal than external as adults mature. Self-esteem, increased job satisfaction, and quality of life become important incentives for adults to learn. The action of implementing the I^3 units promoted teachers' knowledge of new learning strategies, as reported in the data results. Teachers reported they acquired new attitudes about teaching while learning how to integrate effective technology strategies. They also talked about enjoying the process of implementing the units, which can translate to feeling capable and comfortable with the content and concepts.

Teachers in this study acquired specific knowledge of technology content and concepts, and reported the benefits of their *learning by experience* in the results of the data collection. Their learning was fostered by the very nature of the field-testing; teachers unfamiliar with technology curriculum were expected to facilitate technology content in their classrooms. This study confirms that immersion or active involvement in an experience can promote better understanding of new knowledge. Experiential learning is a method of learning that might well be considered for future professional development in elementary technology education.

Curriculum Developers

If the study of technology is to be effective, instructional materials must be appropriate and current. Curriculum materials can directly affect what teachers will teach, how they teach it, and the learning experiences that students can have. Elementary teachers, for the most part, will be new to technology education. As mentioned in Chapter 2 under the section of A Contemporary View of Technology Education, most teachers have not had prior experiences with technology, whether in preservice coursework or inservice programs. Teachers will need detailed support for teaching the curriculum.

Different types of resources can play an integral role in increasing teachers' understanding of technology. Support materials can be in the form of printed materials, like textbooks and monographs, or can be in the form of Web-based curricula. In the case of the latter, however, many educational facilities may not have Internet connections to the Web. Additionally, many teachers may not feel experienced to appropriately access and use online resources. As well, scheduling technology instances in the loaded elementary curriculum may appear inconceivable to teachers, therefore, the materials and resources must be applicable and effective.

Support materials for teaching the curriculum should provide grade-level content knowledge. Materials that target specific grades according to teachers' teaching assignments appears to be effective in helping teachers teach the curriculum, as observed in this study. Development of grade- level materials should be an important consideration.

School Districts

Teaching materials intended to promote technological literacy must be aligned with state and/or national technology standards. The literature review, under the section The Impact of Educational Policy on Technology Education highlights the mandates of the present educational policy regarding technology assessment in schools. For example, Pennsylvania has already begun standardized assessments in technology. As schools districts are pressured in areas of accountability and assessment, teachers only have time to teach with materials that align to the goals of the standards and the district.

Chapter 2, under the section A Contemporary View of Technology Education contends technology is interdisciplinary, meaning it can be integrated within subject contents. Technology curriculum materials for elementary grades can serve as catalysts for learning other content more deeply. As expressed in Chapter 2, under A Framework of Issues in Technology Education, educating children using technology approaches helps children achieve the educational goals of the total curriculum. Technology education activities can be integrated with related concepts from other disciplines, such as science, math, social studies, or the humanities. The design and structure of materials and resources must reflect an interdisciplinary vision, as cited by ITEA and described in Chapter 2 under the section of A Contemporary View of Technology Education.

At present, there is no consistency in how technology is taught or organized throughout school districts in the United States. In Chapter 2, under the section of A Contemporary View of Technology Education, ITEA (2002) states that technology content is an integral part of the elementary curriculum that provides a theme or context for studying other subjects. Even though technology education training is not a traditional part of en elementary teacher's education, teachers can learn and excel at integrating technological concepts across the curriculum. This statement is justified from the population of teachers in the findings of this study. School districts must recognize the importance of technological literacy and begin providing professional development opportunities for elementary teachers.

In Chapter 2, under the section Elementary Technology Education Initiatives in the United States, only a handful of states have been identified as having developed specific materials or resources to provide support for elementary teachers. Even though resources and programs are scarce, the reports of benefits supporting teachers are plentiful. In particular, the state of Massachusetts developed a project called Engineering is Elementary. This project is referenced in Chapter 2 under the section Elementary Technology Education Initiatives in the United States. Its goal is to integrate engineering and technology concepts with elementary science topics. In addition to increasing student concepts and skills in technology and engineering, it also aimed to help elementary educators enhance their knowledge and pedagogy through professional development workshops. The outcomes of the professional development related positive, meaningful learning experiences for teachers. Positive learning experiences can help teachers effectively infuse intended concepts into their own classrooms. More professional development experiences, such as just described, would be deeply beneficial in promoting elementary teachers' understanding of technology and how it should be taught.

Teacher Preparation Programs

Management personnel, such as school administrators, principals, supervisors, superintendents, and others, must recognize and support technological literacy and the study of technology. As asserted in Chapter 2 under the section A Framework of Issues in Elementary Technology Education section, most people misinterpret technology education, generally viewing it as instructional technology. This holds true among management personnel as well; levels of technological understanding vary between individuals. Lack of understanding technology may very well translate to lack of technology integration; hence, teachers may never be afforded opportunities to teach technology and observe its value. To aid in this remedy, higher education institutes can market and promote the study of technology. University advisory committees can be helpful in this process by developing relationships with management personnel in order to promote technology programs and technological literacy as essential components of education. An example of this might be forming groups of three or four technology education specialists that would attend school board or administrative meetings in order to initiate technology awareness and provide assistance for technology implementation plans. Additionally, these specialists could conduct inservice trainings either at schools or in the university settings to promote technology.

Technology workshops, provided by university or college technology experts can inform teachers about technology and provide them with strategies for implementing technology in the classroom. In Chapter 2, under the section Elementary Technology Education Initiatives in the United States, the Pennsylvania Department of Education conducts Governor's Institutes. The institutes are weeklong workshops specifically tailored to elementary, middle, or high school teachers to develop and promote technological literacy. With no cost to the teacher, the workshops include minds-on, hands-on instruction in which teachers learn from their own practice. It would be beneficial for other states to look at professional develop experiences such as this one and consider designing similar programs for their educators.

Technology education is mandated as a school subject in several countries, aside from the United States. As mentioned in Chapter 2, under the section, Technology Activities Abroad, a significant amount of research has taken place that supports a technology curriculum and the learning that is cultivated by both teachers and students. Specifically, research has emerged that examines elementary teachers' perceptions of technology and technology education (Jones & Moreland, 2004; McRobbie, Ginns, & Stein, 2000; Rasinen, 2003).

Similar to the United States, other countries report elementary school teachers have limited perceptions of technology that can adversely affect their ability and confidence to teach technology in the classroom.

In Australia, teaching elementary technology education is a relatively new event occurring in the last five to ten years. Very few practicing teachers have any exposure to teaching technology. The findings from one particular study (McRobbie, Ginns, & Stein, 2000) revealed teachers learned best when engaged in hands-on design projects. Teachers became more cognizant of things like materials, systems, etc. The learning experiences, which consisted of structured and open-ended activities, helped teachers develop awareness for ways of teaching technology in classroom settings.

In a New Zealand study (Jones & Moreland, 2004), circumstances again pertained to teachers' unfamiliarity of elementary technology education.
The discussion focused on attaining technological knowledge through socio-cultural approaches. The framework of this three-year study focused on teachers' attention on the conceptual, procedural, societal, and technical aspects of student learning in technology. The study suggested teachers moved from using general concepts about technology to more specific concepts within different technological areas. Although the studies from Australia and New Zealand are different, the implications for teachers attaining understanding of technology content and concepts through professional development seems apparent.
Education has become internationalized (Bungum, 2006); the trends, debates, and concerns "exceed national and cultural borders, and ideas and innovations are being exchanged and transferred." It may be advantageous for Americans to examine ways that curriculum programs are developed and realized in the schools of other nations.

The thought of teaching technology with inclusion in elementary classrooms can be daunting. Most elementary teachers have never seen or experienced technology in an elementary classroom, nor have they taught it to students. These thoughts were translated in teachers' interviews within this study. Many stated having fears of implementing the curriculum due to the unfamiliarity with the content and concepts. An effective technology experience, such as was ascertained in this study, can unleash fears and instill feelings of confidence and capabilities towards, and about, technology within teachers.

Technology experiences and professional development are necessary steps to introducing technology in elementary classrooms. However, they shouldn't be the only strategies. If technology is to infiltrate elementary classrooms, effective curriculum materials must be developed, school district must support technology integration, and teacher preparation programs must include technology courses.

Technology is a new discipline for elementary teachers. Teachers need time and opportunities to try technology activities and techniques. As this study illustrated, professional development programs and resources can help elementary teachers expand and improve their knowledge, attitude, and practices towards technology education.

Implications for Future Research

Classroom elementary teachers are the most important factors to getting technology implemented in schools. There is clearly a need for research that documents the advantages of technology experiences and professional development that helps mitigate teachers' misconceptions while fostering technology concepts.

More studies that examine elementary teachers' issues, particularly in the areas of implementing technology content and concepts, would have the potential to shed light on ways that enhance teachers' understandings of technology concepts and pedagogies. It would also be advantageous to involve larger samples of elementary teachers, as well as teachers of different grade levels.

Additionally, the results of this study strengthen the need for longitudinal studies that follow elementary teachers who had participated in technology experiences. Documenting the perceptions of these teachers and teaching approaches would be valuable to those responsible for developing technology curriculum, instructional materials, or resources. These studies would also provide evidence of effective components that promote technological literacy in teachers, thus increasing teachers' ability to facilitate technological literacy in students. Finally, factors that facilitate or inhibit implementation of technology content or concepts in the classroom may be discovered as well.

Summary

Several documents and reports relating to technology education have emerged that serve as definition and attest to the value and necessity of technology in a child's education. Many authors have expressed the need to begin technology education in a child's early school years (Cunningham, Lachapelle, & Lindgren-Streicher, 2006; Foster & Kirkwood, 1997; ITEA, 1996, 2002, Wright, 1999). To implement technology content into elementary classrooms, teachers will require knowledge of technology content and concepts. Additionally, they need to feel confident and capable using technology approaches.

This study examined elementary school teachers' perceptions of technology after participating in a field test, the I^3 Project. The study explored and assessed how elementary teachers' reported technology in terms of knowledge, attitude, and classroom practices.

The researcher found that the technology experience, the I^3 Project, had a strong positive impact on the teachers' technological literacy, their pedagogical knowledge of technology, their confidence in teaching technology, and their incorporation of technology strategies in their classrooms. The teachers described appropriate definitions of technology and what it means to be technologically literate. They characterized technologically literate people as problem-solvers. Many used technology terms as they gave examples of problem-solving approaches. They also provided detailed accounts of teaching technology using components of the I^3 units or their own developed units.

The data findings support the conclusion that teachers have been positively affected by their experience in the I^3 Project, in terms of knowledge, attitude, and practices. The data are supportive of the benefits of technology in the elementary curriculum. As the choice to include technology is made in more schools and classrooms, the impact on student knowledge and competency will become increasingly evident. However, this will require continued work in areas of teacher preparation and professional development.

Change in education can be slow, as evidenced in the history of technology education. The movement of elementary technology education is steadily growing. Fortunately, the movement is taking place in a time of emphasized standardized testing and increased accountability on the part of teachers and schools. No single learning approach is likely to be the “cure-all” to the educational system. Quite possibly, however, and with determination and perseverance, inclusion of technology strategies, may be viewed as an additional effective approach to increase learning.

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Appendix A
I^3 Units

Invention-Innovation-Inquiry
A National Science Foundation Project
I^3 Unit Summaries and Learning Goals

Innovation: Inches, Feet and Hands
Summary Of Unit
This unit is about innovation, measurement, and anthropometrics, which is the study of the size of human form. Students will be using an engineering design process to design and develop an improved product that is used by the human hand. They will be studying the sizes of the human hand and using these measurements to estimate sizes of various objects. They will also be improving their measurement ability through various activities.
Learning Goals
Students will:

1) Demonstrate an understanding of basic design concepts as they relate to measurement and human form.
2) Explain and demonstrate how an engineering design process can be used to improve technological devices.
3) Describe limitations for a given device or design.
4) Realize that with innovation, technological devices can be improved in many different ways.

Invention: The Invention Crusade
Summary Of Unit
This unit will help students in Grades 5 and 6 to explore the process of developing an idea into an invention. Students are asked to invent and construct a working model or prototype of a gadget that will help a small child to do a household task. The culminating event is a "Kids Better Living Home Show" where the young inventors will explain their ideas behind their gadget and give other elementary students an opportunity to try the new inventions.
Learning Goals
Students will:

1) Explain and demonstrate how ideas can become inventions by using an engineering design process.
2) Recognize that products are invented to meet specific needs and wants.
3) Describe the general characteristics of famous inventors and their inventions.
4) Document their inventive thinking with sketches and notations, in an Inventor's Journal.

Manufacturing: The Fudgeville Crisis
Summary Of Unit
Students will explore and identify how the process and preservation of food has changed over time and will see how raw materials can be processed into fudge. Throughout the unit students will be divided into four different teams and each team will become a different company. Each company will experiment with how material can be formed to keep a desired shape, how food can be packaged to keep it fresh, and the importance of cleanliness in a food

production environment. As a culminating activity, each team will mass-produce and package their fudge for a fudge festival.

Learning Goals

Students will:

1) Analyze the causes of change in food quality over time.
2) Design a package that can extend the freshness of a food product.
3) Design a production system for a food product and use it to produce shaped fudge.
4) Recognize the importance of following and maintaining cleanliness when handling food products.

Construction: Buildings and Beams

Summary Of Unit

In this unit students act as structural engineers. The students will design and construct at least two laminated paper beams. They will explore forces that act on structures and discover that the strength of a beam varies with height, shape, and thickness. Lastly, they will test, evaluate, and revise their beams using feedback from testing to refine their designs.

Learning Goals

Students will:

1) Describe forces that act on structures.
2) Explain how the size and shape of a beam will affect the ability to resist loads.
3) Calculate the efficiency of a constructed beam.
4) Design, construct, and test a variety of beams to determine which can support the most weight.

Transportation: Across the United States

Summary Of Unit

In this unit students will explore transportation technology by understanding transportation environments (land, water, air, and space) and transportation systems. They will be able to experience how ideas for inventions and innovations are modeled and recognize how transportation has played an important role in the development of the United States.

Learning Goals

Students will:

1) Explain the significance of transportation in the westward expansion of the United States.
2) Describe how inventions and innovations in technology can be modeled.
3) Recognize that transportation systems are comprised of several subsystems.
4) Design, construct, and test a prototype of a transportation vehicle by following the Engineering Design Process.

Communication: From Print to Radio

Summary Of Unit

Few things have changed our world as drastically as communication technologies, such as the telephone and television. They have changed our homes, our workplaces, and our buying choices. Designing, creating, and producing commercials will show students how to work within the communications environment to create a unique and appealing commercial, or advertisement, to promote school spirit.

In this unit students will explore communication processes and mediums by designing, developing, and implementing different types of commercial projects promoting school spirit. In teams of three or four, students will create an advertising firm. Each team will create an identity for their firm and meet their school's advertising needs in order to encourage students to support their school and show school spirit.

<u>Learning Goals</u>

Students will:

1) Describe how to assess the design of technological products by asking good questions.
2) Explain the concepts of risks, benefits, and trade-offs.
3) Use the findings of an inquiry process to design and produce an improved school bag by following an engineering design process.

Power and Energy: The Wizards of Willing Wind

<u>Summary of Unit</u>

This unit presents an alternative form of energy that is both available and inexhaustible. Students will construct a device that will capture wind energy and convert it into mechanical energy. The students will also design and build a structure that will support their wind energy device. The students will research and compare the energy cycles of the most common resources used to produce electricity in an attempt to gain an understanding of how those systems work. The students will also examine the ways energy is used for technological devices in their home.

<u>Learning Goals</u>

Students will:

1) Explain how energy is created, transmitted, and utilized in a home.
2) Describe benefits and drawbacks of utilizing renewable energy.
3) Design and develop a device that will harness wind and convert it into mechanical energy.

Inquiry: The Ultimate School Bag

<u>Summary of Unit:</u>

In this unit the students assume the role of design engineers for a company called Sensible School Supplies. They will use inquiry skills to investigate and evaluate the school bags they currently use and apply what they discover to design and construct a model of their version of the ultimate school bag. The students will then present their school bag designs to students from other classes.

<u>Learning Goals:</u>

Students will:

1) Learn to assess the design of technological products and systems.
2) Understand the concepts of risk, benefits, and trade-offs.
3) Use the findings of an inquiry process to design and produce an improved product by following an engineering design process.
4) Recognize the widespread use of technology in our society.

Technological Systems: Creating Mechanical Motion

<u>Summary of Unit:</u>

In this unit, students will explore simple machines and linkage mechanisms. After seeing what these can accomplish, students will be challenged to design a toy that uses both to create movement. Since everyone thinks of toys and games as fun, this is an ideal medium for learning. As students turn their ideas into models, learning occurs. Students will design, build, test and make improvements to their designs.

<u>Learning Goals:</u>

Students will:

1) Explain mechanical linkage function and movement.
2) Explain how the Engineering Design Process is used when creating mechanical devices.
3) Recognize that simple machines can be used with linkage mechanisms to create a mechanical system.

Design: Toying with Technology

<u>Summary of Unit:</u>

This unit will show students how they take an idea from brainstorming to sketching to prototyping. Students will see how creative designs, unique logos, vivid color schemes, and celebrity endorsements can affect how many people may buy, sell, and play with board games. Students will explore two-dimensional (2-D) and three-dimensional (3-D) visualization processes and mediums by designing, developing, and building a board game. Students will design and create a game for the Happyland Toy Company, a fictitious board game company.

<u>Learning Goals:</u>

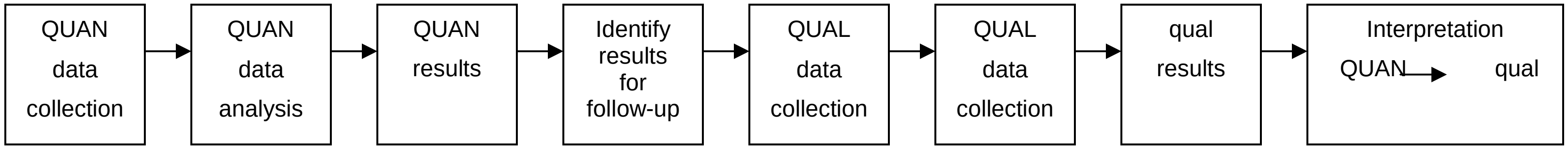
Students will:

1) Describe and demonstrate how visualization and drawing techniques are used to document ideas using two- and three-dimensional representations.
2) Explain how the engineering design process may be used to develop a new product such as a game.
3) Recognize that effective marketing techniques can increase product success.

Appendix B

Mixed Methods Explanatory Design

Explanatory Design: Follow-up Explanations Model (Quan emphasized)



Appendix C

Cover Letter

Dear I³ Participant,

I am a doctoral candidate at Indiana University of Pennsylvania. As a requirement for completion of my doctorate degree, I am working on a dissertation entitled “Elementary Teachers’ Knowledge, Attitude, and Practices towards Technology Education: Effects of Implementing Curricular Units for the I³ Project”. The study will require input from teachers who have implemented I³ Units in their classroom. I would be very grateful if you could take a few minutes to respond to the questionnaire.

The study will examine the change elementary school teachers experienced as a result of field testing units for the I³ Project. This mixed method study is designed to explore and assess how teachers’ perception of technology changed in terms of their role as elementary teachers after field testing the I³ Units. The findings of this investigation will provide focus and direction for future technology education professional programs, materials, and resources in hopes of improving elementary teachers’ technological literacy and ability to implement technology content and concepts in their current curriculum. It is hoped that this research will: 1) reveal how participation in the I³ Project increased elementary teachers’ technological literacy, 2) reveal how participation in the I³ Project increased elementary teachers’ pedagogical knowledge of technology, 3) reveal how participation in the I³ Project increased elementary teachers’ confidence with technology content, and 4) reveal the extent that elementary teachers implement technology content in the classroom.

You are eligible to participate in this study because you participated in field testing curriculum units for the I³ Project. The Indiana University of Pennsylvania supports the practice of protection for human subjects participating in research. There are no known risks associated with this research. Your participation is voluntary. There is no penalty for not participating. You are free to withdraw at any time without adverse actions. If you choose to withdraw, simply call me or send me an email at the phone number or email address which I have provided for your convenience at the end of this letter. Your name will not be associated with any results and your response will be coded to ensure anonymity. Confidentiality will be maintained throughout. Participation or non-participation in this study will not adversely affect you in any way.

The questionnaire will take approximately twenty to thirty minutes of your time. In addition, you will be asked if you are willing to participate in a brief interview; simply answer by checking yes or no in the appropriate box. All of your responses on the questionnaire and interview (if you agree) will be kept confidential. No one, except myself and my faculty sponsor, Dr. George Bieger, will have access to the data. All data will be kept in a locked file cabinet in my home office for at least three years in compliance with federal regulations. When analyzing and presenting the data, all data will be coded and participants will be identified with a pseudonym in order to protect your anonymity.

By completing and submitting this questionnaire, you are indicating your consent to participate in the study. Please note that e-mail is not 100% secure, so it is possible that someone intercepting your e-mail will have access to your questionnaire responses. Please remember to clear your browser’s cache and page history after you submit the questionnaire in order to protect your privacy.

Your expediency in completing and submitting the questionnaire will be greatly appreciated. The questionnaire should be returned to me by December 30, 2008. If you are interested in receiving a summary of the results of this study, please check the appropriate box on the questionnaire.

Please accept my sincere thank you in advance for your cooperation in this study.

Appendix C (continued)

Sincerely,

Sandra Cavanaugh	Dr. George Bieger, Faculty Sponsor
Indiana University of Pennsylvania	Indiana University of Pennsylvania
265 Krepps Lane	114 Davis Hall, 520 S. 11th Street
East Millsboro, PA 15433	Indiana, PA 15705
Phone: 724-785-2860	Phone: 724-357-3285
s.e.cavanaugh@iup.edu	grbieger@iup.edu

Appendix D

Survey Questionnaire

I^3 Project Survey Questionnaire

Elementary Teachers' Perception of Technology Education Questionnaire

Thank you in advance for participating in this study. The purpose of this study is to report elementary school teacher's perceptions of technology education because of participating in a field test of the curriculum materials for the I^3 Project. Any information you submit will be held in the strictest confidence. Should you have any further questions about the study, please contact Sandra Cavanaugh (D. Ed candidate) at s.e.cavanaugh@iup.edu or 724-785-2860.

SECTION I

Contact information

Name		Address
Phone	Email	

Background Information- Please mark an "X" in the appropriate spot.

1. Gender

☐ Female	☐ Male

2. With which racial or ethnic group do you primarily identify? (optional)

☐ White	☐ Black	☐ Hispanic	☐ Other

3. Highest degree earned:

☐ Certificate	☐ Associate's	☐ Bachelor's	☐ Master's	☐ Doctorate

4. Years and Level

Year completed highest degree: __________	Total number of years teaching: __________
Level of current certification you hold: ____	

5. Were you familiar with elementary technology education prior to your participation in the I^3 Project?

☐ Yes	☐ No

6. If yes, please identify your level of familiarity with elementary technology education prior to your participation in the I^3 Project.

☐	I had heard of elementary technology education, but only had a vague understanding of it.
☐	I was aware of elementary technology education, but I had not used it in a classroom.
☐	I had some experience with elementary technology education.
☐	I am an experienced elementary technology education teacher.

7. Please identify the factor that most affected your involvement in the I^3 Project.

☐ Attended a presentation, workshop, or other in-service meeting	☐ An administrator encouraged me to get involved
☐ Observed other teacher(s) and liked what I saw	☐ Learned about it by reading educational materials
☐ Invitation to get involved	☐ Other (please specify)

Appendix D

Survey Questionnaire (continued)

SECTION II- Questions referring to the ways in which the I³ Project impacted your perceptions of technology education and classroom practices.

To what extent, if any, do you feel you experienced each of the following types of learning as a result of your participation in the I³ Project field test? *(Place an "X" in the appropriate box).*

SA = Strongly Agree	A = Agree	N = Neutral	D = Disagree	SD = Strongly Disagree

	SA A N D SD
Technological literacy	
8. It is important to understand the technological world around us.	☐ ☐ ☐ ☐ ☐
9. I have a better understanding of basic technological and engineering concepts and terms such as systems, constraints and trade-offs.	☐ ☐ ☐ ☐ ☐
10. I have an increased awareness of how technology shapes human history and people shape technology.	☐ ☐ ☐ ☐ ☐
11. I gained understanding that all technologies involve some risk that can be anticipated and some that cannot.	☐ ☐ ☐ ☐ ☐
12. I have difficulty understanding basic technological and engineering concepts.	☐ ☐ ☐ ☐ ☐
13. I have a better understanding of how technology reflects the values and culture of society.	☐ ☐ ☐ ☐ ☐
Pedagogical Knowledge	
14. I am confused about the relationship between technology and other subjects.	☐ ☐ ☐ ☐ ☐
15. I acquired greater understanding of fundamental concepts in technology.	☐ ☐ ☐ ☐ ☐
16. Technology can be a way to help teach science, math, and other subjects.	☐ ☐ ☐ ☐ ☐
17. I understand the relationship between science, technology and engineering.	☐ ☐ ☐ ☐ ☐
18. I better understand how teaching problem-solving can be done successfully.	☐ ☐ ☐ ☐ ☐
19. I learned about innovative ways to use ordinary materials and tools in my classroom.	☐ ☐ ☐ ☐ ☐
Confidence	
20.I need more training in elementary technology education in order to implement it effectively.	☐ ☐ ☐ ☐ ☐
21. I feel confident with my ability to teach about technology.	☐ ☐ ☐ ☐ ☐
22. I feel capable and comfortable using the problem-solving approach in technology education.	☐ ☐ ☐ ☐ ☐
23. I don't feel capable of developing new technology activities for my students.	
24. I gained a greater appreciation of the difficulties some students encounter when learning science or technology.	☐ ☐ ☐ ☐ ☐
25. I feel prepared to develop new technology activities for my students.	☐ ☐ ☐ ☐ ☐

Appendix D
Survey Questionnaire (continued)

Implementation	
26. I see a significant benefit of implementing technology activities.	☐ ☐ ☐ ☐ ☐
27. I now use my knowledge of technology in many ways as a teacher.	☐ ☐ ☐ ☐ ☐
28. I seldom engage my students in technological activities.	☐ ☐ ☐ ☐ ☐
29. Knowing how to implement technology content has become a necessary skill for me.	☐ ☐ ☐ ☐ ☐
30. I engage students in manipulative, problem-solving activities on a periodic basis when they conveniently and/or appropriately fit in with my curriculum.	☐ ☐ ☐ ☐ ☐
31. I feel capable and comfortable using tools, materials, and processes in my classroom.	☐ ☐ ☐ ☐ ☐

☐ Check the box if you are willing to participate in a phone interview

☐ Check the box if you would like the survey results emailed to you.

Thank you for your time!

Appendix E

I^3 Unit Field-testing and Teacher Selection

Field Testing

During the field-testing phase there was at least 5 sites for each unit. The units' effectiveness and value, as well as the usability was evaluated. It is important to note that there was not any direct professional development given to the participants since each of the units were to stand on their own. Web support was available later in the project when the units were complete.

Unit Testing Participants Solicitation

To locate field test participants, information was sent to the following:

1. IDEA Garden listserve
2. CTTE listserve
3. TrendScout (ITEA electronic publication)
4. State supervisors
5. Elementary members of ITEA
6. Writers and Experts currently in project
7. ITEA-CATTS members
8. NSTA listserve (possibly)
9. NASA listserve (possibly)

Selection of Pilot and Field Test Participants

To become a pilot or field test participant, the following items needed to have been satisfied.

1. Bachelors or advanced degree in education.
2. Certified to teach elementary school, middle school science, or technology education
3. Complete unit and return feedback forms by established date each semester.
4. Minimum 3 years teaching experience
5. Permission of school administrator
6. Willingness to conduct telephone interview and/or site visit
7. Varied school settings including rural, urban, and suburban

NOTE: Since the first round of pilot-testing focused on the accuracy of the content and processes, preference was given to teachers with some experience and/or training in technology education. Subsequent field test sites did not require these prerequisite skills. Once a site was selected, the following occurred:

1. Congratulations letter sent to teacher and school administrator. Letter required school administrator to return signed form to allow the school to participate.
2. Unit was mailed to field test participant
3. Evaluation forms were emailed (or mailed if necessary) to participants.
4. Telephone interview
5. Unit returned with sample of student work, summary evaluation, and receipts for subsistence reimbursement for school ($50 maximum)

Appendix F

Permission to use survey- Brusic

IUP I-Mail - Message from InBox Folder

Reply | Reply All | Forward | Delete | Close Unread | Unflag | Add Address | Folders | Compose | Rules | Settings | Log Out | Help

Next Unread | Back To Folder | Copy To | Move To | Print

From: "Sharon Brusic" <Sharon.Brusic@millersville.edu>
Subject: ESTE Survey
Date: Fri, 12 Oct 2007 09:53:38 -0400
To: "Sandra Eileen Cavanaugh" <s.e.cavanaugh@iup.edu>
Cc: "Kirkwood, James J." <JJKIRKWOOD@bsu.edu>

Headers

Decode

Hi Sandy,

It's good to hear from you. I'm glad to know that you are moving forward on your dissertation. It's a huge undertaking and I completely understand your need to stay focused on that right now. So...no apologies needed about the article. I'll tap you soon enough!

I'm pleased that you have interest in using the survey that Jim and I developed -- or parts of it. I wish I had published my research in the form of an article. I keep saying that I'm going to replicate the study in PA, but I cannot find the time to do it. The only thing I did was to deliver an ITEA presentation about it.

Attached you will find four items of interest:

1. My ITEA presentation slides reporting my results
2. MY ITEA presentation paper as distributed to conference session attendees
3. My version of the survey in PDF format
4. My version of the survey in Word format

Since the survey was developed by Jim and I, you should gain permission from both of us. Jim's version of the survey is a little different than mine because he used a slightly different population. So, you will want to borrow his version as well and decide what changes you will need. Just be sure to credit the source somewhere on the instrument and in your dissertation. I am copying this message to Jim so he is aware of my support. His email is JJKIRKWOOD@bsu.edu so you can also contact him directly.

Best of luck to you on your research, Sandy! If there's anything I can do to help, please don't hesitate to ask. This is an area of research that I have a great deal of interest in!

Best,
Sharon

~ ~

Sharon A. Brusic
Dept. of Industry & Technology
Millersville University

~ ~

-----Original Message-----
From: Sandra Eileen Cavanaugh [[illegible]]
Sent: Thursday, October 11, 2007 7:05 PM
To: Sharon Brusic

Permission to use survey- Brusic (continued)

Subject: article

Hi Sharon, how is your semester going? Things are still hectic with me but probably will stay that way until I get my degree. I know I promised you an article- I am embarrassed that I have not fulfilled that promise. One day- I will.

I am researching information regarding my dissertation. I ran across an article that was written by James J.Kirkwood entitled "The Status of Technology Education in Elementary Schools as Reported by Beginning Teachers" (2000). You had created the survey that was used.
My topic pertains to the perceptions of elem ed teachers towards TE after participating in a prof. dev. workshop- namely GITE and I3-. My study will be a mixed-method study. I plan to use a survey as well as interviews. Alot of the questions in your survey will be questions I can use. In the article- it was suggested that this survey be used to do additional research. Can I use the survey?-
I will need to adapt it somewhat. I didn't know if I needed permission from you or Kirkwood.If Kirkwood, do you know how I can get in touch with him? Hope you can help-
Sandy

Open File

Attachment: ITEA.Presentation.03.01.FINAL.pdf (98K)

Open File

Attachment: ESTE Survey (05.15.00).pdf (193K)

Open File

Attachment: ESTE ITEA PresentationPaper.FINAL.pdf (22K)

Open File

Attachment: RevisedElemSurvey05.15.00.doc (1394K)

Reply | Reply All | Forward | Delete | Close Unread | Unflag | Add Address | Folders | Compose | Rules | Settings | Log Out | Help

Next Unread | Back To Folder | Print

A service of the Technology Services Center
Last updated: 03/13/2004 by jbr

Appendix G

Permission to use survey- Kirkwood

IUP I-Mail: Message from InBox Folder

Reply | Reply All | Forward | Delete | Close Unread | Unflag | Add Address | Folders | Compose | Rules | Settings | Log Out | Help

Next Unread | Back To Folder | Copy To | Move To | Print

From: "KIRKWOOD, JAMES J" <JJKIRKWOOD@bsu.edu>
Subject: RE: survey permission request
Date: Fri, 12 Oct 2007 18:15:09 -0400
To: "Sandra Eileen Cavanaugh" <s.e.cavanaugh@iup.edu>

Headers

Decode

Sandy,

I'm honored!

Do you have the instrument I used, or do I need to search for it?

Good luck with the study. Let me know your progress and your final report. I have wanted to do a follow-up just to see if the new curriculum, devised by the el ed department, has any benefit for children learning technolgy.

The problem with the 2000 study, and will be even more difficult if I do a study with recent graduates is communicating what we mean by ESTE, or whatever we want to call it. Trouble is, naming it anything creates a whole new paradigm for the respondents. If you solve this problem, let me know. I re-read my article's discussion and remember the equivocating I had to do to try to make some meaningful interpretations of the data. It's evident that I was tentative in my writing.

Jim Kirkwood

-----Original Message-----
From: Sandra Eileen Cavanaugh [mailto:s.e.cavanaugh@iup.edu]
Sent: Fri 10/12/2007 4:09 PM
To: KIRKWOOD, JAMES J
Subject: survey permission request

Hello Dr. Kirkwood,
I am a doctoral candidate at IUP. I am certified in TE and currently teach at Canon McMillan School District, (PA) at the elementary level grades 5/6. I am beginning my dissertation- my topic pertains to pedagogical TE knowledge of reg. elem. teachers after they ahve participated in a TE workshop- namely GITE. You had written an article in 2000- "The Status of Technology Education in Elementary Schools as Reported by Beginning Teachers". I found it extremely interesting and also similar to what I will be doing with my study. However, I will also be adding a qualitative aspect to it. I have had the opportunity to meet Sharon Brusic a few months back and was delighted to talk with her about her experiences in elem. tech ed. I am requesting your permission to use the survey in your article-perhaps with modification. I will be happy to give you a summation of my study upon request if you should desire, when complete.

Appendix H

Qualitative Interview Questions

Interview questions

1. What do you think it means to be “technologically literate”?

2. What might some characteristics of a technologically literate person be or include?

3. Describe how “technologically literate” you are

4. Summarize your understanding of technological knowledge.

5. Summarize your understanding of technological processes.

6. Describe what an elementary technology education ‘student’ experience might look like.

7. Describe a time –or two- when you have challenged your students to use technological processes.

8. How often do you engage your students in hands-on, problem-solving activities?

9. How has your view of technology been affected because of your I^3 Project field-testing experience?