Spring 2009

Technological Literacy in K–12 Teacher Preparation: A Review of Course Requirements at Accredited Education Institutions

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TECHNOLOGICAL LITERACY IN K-12 TEACHER PREPARATION:

A REVIEW OF COURSE REQUIREMENTS AT ACCREDITED EDUCATION INSTITUTIONS

by

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Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirement for the Degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

OCCUPATIONAL AND TECHNICAL STUDIES CONCENTRATION

OLD DOMINION UNIVERSITY
May 2009

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ABSTRACT

TECHNOLOGICAL LITERACY IN K-12 TEACHER PREPARATION:
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Roger Allan Skophammer
Old Dominion University, 2009
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The goal of this study was to determine to what extent, technological literacy courses were required in K-12 teacher education. The study was limited to initial teacher education programs that are accredited by the National Council for Accreditation of Teacher Education and Teacher Education Accreditation Council. Out of 697 accredited programs in the United States, a random sample of 248 programs was created. A document review of the appropriate course catalogs for initial teacher preparation was conducted. The document review identified general education requirements and options for technological literacy courses, as well as requirements and options for these courses for the education majors included in the study. Finally, the study looked at differences between the K-12 education majors of elementary education, English, social studies, mathematics, and science concerning technological literacy course requirements.

For this study, technological literacy was defined using the International Technology Education Association's *Standards for Technological Literacy* as "the ability to use, manage, assess, and understand technology" (ITEA, 2000/2002/2007, p. 9). This definition of literacy is broader than the technology literacy associated with computer use

and instructional technology as well as courses limited to the history or philosophy of technology.

A general conclusion is that there is very little exposure to technological literacy courses for prospective K-12 teachers. This may be due in part to the confusion between instructional technology literacy and technological literacy. Though 1/3 of the sample provided opportunities for technological literacy courses in general education, only four institutions required these courses. Thirty-two of the 248 institutions had requirements for technological literacy courses in teacher education programs. These requirements were primarily limited to elementary education and secondary science education majors. The study found that the requirement for technological literacy courses that focused on technology education instructional methods had large increases for elementary majors compared to earlier studies.

This dissertation is dedicated to the students.

Their enthusiasm for learning is my motivation.

ACKNOWLEDGMENTS

This research project is the culmination of many instructors' time and energy. I would like to express my gratitude to all those that helped prepare me to complete this project. Special thanks go to Dr. Phil Reed, committee chair and mentor, whose enthusiasm and guidance greatly contributed to the success of this project. Thanks to Dr. John Ritz for sharing your knowledge and insights, and for your expectations for quality work. Thanks to Dr. Dan Dickerson for serving on the committee and for input concerning teacher education outside of technology education.

My family and friends have contributed to the success of this project. I give a special thank you to my daughter, Elise, for her support and understanding, and to Roger (Sr.), for his support and editing assistance. Finally, I wish to thank Kate, my wife, for her editing help and support as well as her willingness to learn about technological literacy. Kate, thank you for sharing this journey.

Roger Allan Skophammer

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CHAPTER I

INTRODUCTION

The increasing rate of technological change in the United States requires a technologically literate populace that can think critically and make informed decisions about technological developments. According to *Technologically Speaking: Why All Americans Need to Know More about Technology* (Pearson & Young, 2002), "The argument for technological literacy is fundamentally about providing citizens with the tools to participate fully and confidently in the world around them" (p. 12). K-12 education should play a key role in developing technological literacy in students. The International Technology Education Association (ITEA) and the National Academy of Engineering (NAE), along with other organizations, have called for a larger involvement in K-12 education for the development of technological literacy in our students (ITEA, 1996; Pearson & Young, 2002).

There has been a lot of activity concerning computer literacy in K-12 education; however, computer technologies constitute a very narrow definition of technology. A broader definition of technology was required for the development of technological literacy. The ITEA (2000) defines technology as "the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants" (p. 2). This broad definition suggested that the development of "technological literacy will require early and regular contact with technology in the school setting" (Pearson & Young, 2002, p. 53). Yet the study of technology was required in K-12

This dissertation follows the requirements of *the Publication Manual of the American Psychological Association 5th Edition* education in only 14 states (Pearson & Young, 2002). Technology education courses were generally offered as electives and are often seen as career or technical preparatory classes (Pearson & Young, 2002). In addition, technology education teachers made up only about 40,000 (2.4%) of the 1.7 million teachers in the United States, with many technology education positions going unfilled annually (Pearson &Young, 2002). A broad range of academic subjects encompasses technological literacy; therefore, development of technological literacy for K-12 students necessitated that all K-12 teachers develop a level of technological competency. According to the NAE and National Research Council in *Technically Speaking*, "the integration of technology content into other subject areas, such as science, mathematics, social studies, English, and art could greatly boost technological literacy" (Pearson &Young, 2002, p. 55). Pearson and Young (2002) go on to assert that "schools of education spend virtually no time developing technological literacy in those who will eventually stand in front of the classroom" (p. 55). The purpose of this study was to develop a better understanding of the development of technological literacy in pre-service K-12 teacher education in the U.S.A.

Research Problem

The problem examined in this study was to determine to what extent technological literacy courses were required for K-12 teacher education programs at accredited teacher preparation institutions in the United States. In this study, the researcher will differentiate course requirements based on the different education majors for elementary education and secondary education for English, social studies, mathematics, and science. The study examined what aspects of technological literacy were included in course content for those programs requiring technological literacy coursework.

Research Questions

To guide this study the following research questions were developed:

1. Are technological literacy courses a part of general education requirements for K-12 education majors at 4-year, accredited institutions?
2. Are technological literacy courses used to fulfill program requirements for K-12 education majors at 4-year, accredited institutions?
3. Do the required technological literacy courses focus on the development of broad technological literacy awareness or is the focus on learning how to use instructional methods similar to those used in technology education activities?
4. What, if any, are the differences in K-12 education majors in requirements for technological literacy courses?

Background and Significance

For this study, a distinction was made between technological literacy as defined by the ITEA and technology literacy as defined by the International Society for Technology in Education (ISTE). Technology literacy is concerned with student literacy in computer and information technologies as well as teacher abilities to use computer and information technologies for instruction (ISTE, n.d.). Technological literacy is concerned with the preparation of students for a technological world. "Broadly speaking technology is how people modify the natural world to suit their own purposes. From the Greek word *techne*, meaning art or artifice or craft, technology literally means the act of making or crafting, but more generally refers to the diverse collection of processes and technology and knowledge that people used to extend human abilities and to satisfy human needs and wants" (ITEA, 2002 p. 2). In reference to Research Question 3, "broad technological literacy awareness" includes this definition as well as the relationship between technology, the sciences, and society.

Instructional methods that utilize technology education activities (Research Question 3) generally involve the design and development of a product, physical or virtual, as a means to improve learning of the subject content (Foster, 1995). These activities promote problem-solving skills essential in a complex society (Schwaller, 1995). The activities teach the design process, but may or may not address additional technological literacy content.

The need for a technologically literate populace has been broadly recognized, and programs that promote the development of technological literacy have been supported by several organizations. The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) provided grant funding in 1994 to the International Technology Education Association (ITEA) to promote technological literacy through the Technology for All Americans Project (TfAAP) (ITEA, 1996). The focus of TfAAP was the development of standards and practices for promoting technological literacy in K-12 education. A key publication in the project was *Standards for Technological Literacy* (STL) (ITEA, 2000/2002/2007). The importance of technological literacy was reflected by the organizations that worked with the ITEA in developing STL. These organizations included the National Research Council (NRC) of the National Academies, the National Academy of Engineering (NAE), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS) Project 2061, and the National Council of Teachers of Mathematics (NCTM) (Dugger, 2005). One thing found in the TfAAP publications was the relationship between other academic fields and technology education as part of developing technological literacy. In *Technology for All* (ITEA, 2006), it is asserted that technology education should exist not just at the high school and middle school levels, but at the elementary school level as well. This suggested that elementary teachers needed to have an understanding of technological literacy and be able to direct technology education activities in the classroom (ITEA, 1996). STL (ITEA, 2000/2002/2007) provided an explanation of how technological studies can work as an integrator of academic areas to reinforce instruction. The connection between technological studies and mathematics and science may be more apparent than the connections with other subjects, but technological education activities may be used to support learning across all subjects. "… the study of technology is a way to apply and integrate knowledge from many other subject areas -- not just mathematics, science, and computer classes, but also liberal arts and fine arts" (ITEA, 2000/2002/2007, p. 6). In order to integrate technological studies as a way to improve instruction in all academic areas, K-12 teachers need to develop technological literacy that recognizes the role of technology across all academic areas as well as develop technological literacy in their capabilities to use technology education activities as an integrator.

The need for the development of technological literacy in K-12 education was also supported by the work done by the Committee on Technological Literacy and the resulting books published by the National Academies: *Technically Speaking* (Pearson & Young, 2002) and *Tech Tally: Approaches to Assessing Technological Literacy* (Garmire & Pearson, 2006). The Committee on Technological Literacy worked with the NAE and NRC and was supported by the NSF and Battelle Memorial Institute, and the National Academies. The goal of the committee, experts from a broad range of subject areas, "was to begin to develop among relevant communities a common understanding of what technological literacy is, how important it is to the nation, and how it can be achieved" (Pearson & Young, 2002, p. vii). *Technically Speaking* (2002) included 11 recommendations for the development of technological literacy, three of which are relevant to this study.

> Recommendation 1. Federal and state agencies that help set educational policy should encourage the integration of technology content into K-12 standards, curricula, and instructional materials, and student assessments in nontechnology subject areas (2002, p. 8).
>
> Recommendation 2. The states should better align their K-12 standards, curriculum frameworks, and student assessments in the sciences, mathematics, history, social studies, civics, the arts, and language arts with national education standards that stressed the connection between these subjects and technology (2002, p. 8).
>
> Recommendation 4. NSF, DoEd [Department of Education], and teacher education accrediting bodies should provide incentives for institutions of higher

education to transform the preparation of all teachers to better equip them to teach about technology throughout the curriculum (2002, p. 9).

The second publication by NAE and NRC on technological literacy is *Tech Tally* (Garmire & Pearson, 2006); it includes 12 recommendations in the assessment of technological literacy; two recommendations under the K-12 teachers heading are relevant to this study.

> Recommendation 4. When states determine whether teachers are "highly qualified" under the provisions of the No Child Left Behind Act (NCLB) they should ensure -- to the extent possible -- assessment used for this purpose includes items that measure technological literacy. This is especially important for science, mathematics, history, and social studies teachers, but should also be considered for teachers of other subjects. In the review of state plans for compliance with NCLB, the U.S. Department of Education should consider the extent to which states have fulfilled this objective (2006, p. 9).
>
> Recommendation 5. The National Science Foundation and the U.S. Department of Education should fund the development and pilot testing of sample-based assessments of technological literacy among pre-service and in-service teachers of science, technology, English, social studies, and mathematics. These assessments should be informed by carefully developed assessment frameworks. The result should be disseminated to schools of education, curriculum developers, state boards of education, and other groups involved in teacher preparation and teacher quality (2006, p. 9).

The focus and recommendations of these two publications suggest a strong need for teachers to develop technological literacy in K-12 pre-service education programs and to include technological literacy as part of the assessment of K-12 teachers and K-12 teacher education programs. An important step in meeting these recommendations is to develop an understanding of the current status of technological literacy, both in the extent to which coursework is required in K-12 teacher education as well as what aspects of technological literacy are covered in those courses.

Limitations

The following conditions limit the scope of this study:

1. The study was limited to National Council for the Accreditation of Teacher Education (NCATE) and Teacher Education Accreditation Council (TEAC) accredited education colleges and universities within the United States.
2. The study was limited to technological literacy as defined by the International Technology Education Association (ITEA) and the National Academy of Engineering (NAE).
3. This study was limited to initial teacher education programs.

Assumptions

The following assumptions were made in the study:

1. Formal technological literacy courses are an appropriate way to develop technological literacy in K-12 teachers.
2. Course descriptions in undergraduate catalogs adequately describe the curricular content delivered in the course.

3. Technological literacy content, as defined by the National Academy of Engineering and the International Technology Education Association, can be inferred from the course descriptions in the undergraduate catalogs.

Procedure

A random sample of 248 education institutions was selected from the comprehensive list of 697 schools accredited through NCATE and TEAC. The sample size of 248 education programs was determined using a table based on the formula by Krejcie and Morgan (1970) for a finite population at a 95% confidence level (Patten, 2007, p. 191). This sample is representative of all the teacher education programs in the U.S. in terms of geographic locations as well as type and size of the institutions. A document review of the appropriate current course catalog for each school was conducted to determine the technological literacy course requirements for each of the education majors included in the study. The data collected were analyzed to determine if there was a statistical difference in course requirements based on education major. An analysis was conducted of the required technological literacy course descriptions in order to identify the curricular content based on the technological literacy model described by the NAE and the NRC in *Technically Speaking* (Pearson & Young, 2002).

Definition of Terms

The following definitions will be used throughout the study.

1. Technology: "Technology involves the application of knowledge, resources, materials, tools, and information in designing, producing, and using products,

structures (physical and social), and systems to extend human capability to control and modify natural and human-made environments" (Raizen, Sellwood, Todd, & Vickers, 1995, p. 1).

2. Technological literacy: "Technological literacy is the ability to use, manage, assess, and understand technology. A technologically literate person understands, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and how it shapes society, and in turn is shaped by society" (ITEA, 2000/2002/2007, p. 9).
3. Technology education: A formal field of study devoted to the development of technological literacy.
4. Instructional Method: For this study instructional method refers to technology education activities that use the design process and/or the creating of a product or system to teach content in any subject area with the goal of increasing technological literacy.
5. Design Process: A process in which students design a product or system to meet given objectives within provided constraints (ITEA, 2000/2002/2007).
6. General Education Requirements: The collection of courses and credits required of all students by a college or university in order to earn the baccalaureate degree.
7. Information-technology literacy: Often referred to as computer literacy, deals with the development of skills in computer software and operating systems, e.g., spreadsheets, word processing, and web-browsers. Also deals with the development of knowledge about communication systems and infrastructure.

8. Instructional Technology: The use of computer and digital technology, both inside and outside the classroom, for the purpose of instruction (ISTE, n.d.).
9. Curriculum: (1) The subject content of a program of study as well as (2) the subject content in a specific course.

Overview of Chapters

This study was designed to determine the status of technological literacy course requirements in K-12 teacher education. The need for the study was based primarily on the recommendations of the National Academy of Engineering and National Research Council for the broad technological literacy of K-12 teachers and the assessment thereof. Additional justification for the study was found from the ITEA *Standards for Technological Literacy* (2000) and the assertion that technology education activities can be used as an integrator across a broad range of academic subjects. The use of technology education activities as an integrator across subject matter requires the K-12 educator not only to have an understanding of the relationship between technology and other subjects, but also possess capabilities in being able to administer these activities. Therefore, the study not only looked at whether technological courses were required for K-12 educators, but also investigated the curricular content of those courses to determine to what extent capabilities and/or knowledge of technology were being developed.

Chapter II of the study is a review of the relevant literature. The focus of this chapter includes a section on technological literacy that will further highlight the growing need as well as the model for assessing the different aspects of technological literacy. A second section of this chapter will review the literature concerning what K-12 teachers need to know and be able to do in order to develop technological literacy for their students. The final section of Chapter II will look at course requirements in K-12 teacher education and the role of the accrediting agencies in the development of those requirements.

Chapter III covers the research methods used in the study. It describes the population and the method for obtaining a sample, as well as how data were collected for that sample. A full description of the model for assessing technological literacy course content was provided, as well as the analysis applied to the data collected. The findings that are the result of this analysis are reported in Chapter IV.

Chapter V provides a synopsis of the study by providing a summary of the first four chapters. In addition to the summary, conclusions were drawn based on the results of this study, and recommendations for further research were made.

CHAPTER II

REVIEW OF LITERATURE

Technology may be broadly defined as the things or processes that people use to create the outcomes they need and desire. Pearson and Young (2002) described technology this way: "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" (p. 3). This definition does more than describe technology as the human-made world, but includes the processes used in creating and operating those technologies. According to Pearson and Young (2002),

> Technology is more than tangible products. An equally important aspect of technology is the knowledge and processes necessary to create and operate those products such as engineering know-how and design, manufacturing expertise, various technical skills and so on. Technology also includes all of the infrastructure necessary for the design, manufacture, operation, and repair of technological artifacts, from corporate headquarters and engineering schools to manufacturing plants and maintenance facilities (p. 2).

The pervasive nature of technology and its rapid rate of change suggest that technology education needs to be a requirement in K-12 education. Kurzweil (2001) suggested that the rate of technological growth appears to be linear, but in reality is exponential. He went on to predict that the accelerating rate of technological growth will result in devices that will be more intelligent than humans within just a couple of decades. Examples of that growth rate have been observed in communications and information technology, e.g., Internet and cell phones, but there are equally revolutionary technological advancements being made in manufacturing with advanced robotics, or in transportation with technologies such as hybrid vehicles and global positioning systems, or in the medical/health-care fields with technologies that are increasing life expectancies by half a year every year (Kurzweil, 2001). The ubiquitous nature of technology and an accelerating rate of technological change require K-12 education to promote technological literacy at every opportunity.

This review of literature will focus on the need for a technologically literate populace and the role of K-12 education in the development of technological literacy. The first section of this chapter will review the literature concerning the benefits of technological literacy. It will include a brief explanation of the relationships of various content subject areas and the development of technological literacy that will act as an outline for the second section. The second section will present in depth the role of technology education in developing technological literacy. This will include the use of technology education actvities that support learning in other content subject areas. The third section will discuss different content areas in relationship to the development of technological literacy. The final section will review the literature concerning the influences of content-specific professional organizations and NCATE and TEAC accreditation processes.

Benefits of Technological Literacy

The ITEA, in *Technology for All: A Rationale and Structure for the Study of Technology* (2006), described a technologically literate person as having "… the ability to use, manage, evaluate, and understand technology" (p. 4). The ITEA (2006) expounds on those four areas with statements on each:

- The ability to ***use*** technology involves the successful operation of the key products and systems of the time. This includes knowing the components of existing macro-systems, or human adaptive systems, and how the systems behave;
- The ability to ***manage*** technology involves ensuring that all technological activities are efficient and appropriate;
- The ability to ***evaluate*** technology involves being able to make judgments and decisions about technology on an informed basis rather than an emotional one;
- ***Understanding*** technology involves more than facts and information, but also includes the ability to synthesize the information into new insights (p. 4).

These four actions provide the basis for ITEA's *Standards of Technological Literacy* (2000) that will be discussed in-depth later in this chapter. The National Academy of Engineering and the National Research Council provided a rationale for the development of technological literacy in K-12 education from outside the technology education field with the publications from the National Academies Press in *Technically Speaking* (2002) and *Tech Tally* (2006).

Technically Speaking (2002) presented a model of technological literacy based on the dimensions of knowledge, ways of thinking and acting, and capabilities. "The dimensions of technological literacy can be placed along a continuum -- from low to high, poorly developed to well developed, limited to extensive" (p. 15). Pearson and Young, in *Technically Speaking* (2002), supply specific characteristics of a technologically literate citizen based on the dimensions of technological literacy. These dimension are explained as,

Knowledge

- Recognizes the pervasiveness of technology in everyday life.
- Understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.
- Is familiar with the nature and limitations of the engineering design process.
- Knows some of the ways technology shapes human history and people shape technology.
- Knows that all technologies entail risk, some that can be anticipated and some that cannot.
- Appreciates that the development and use of technology involves trade-offs in the balance of costs and benefits.
- Understands that technology reflects the value and culture of a society.

Ways of Thinking and Acting

- Asks pertinent questions, of self and others, regarding the benefits and risks of technologies.
- Seeks information about new technologies.
- Participates, when appropriate, in decisions about the development and use of technology.

Capabilities

- Has a range of hands-on skills, such as using a computer for word processing and surfing the Internet and operating a variety of home and office appliances.
- Can identify and fix simple mechanical or technological problems at home or work.
- Can apply basic mathematical concepts related to probability, scale, and estimation to make informed judgments about technological risks and benefits (p. 17).

The ITEA model of *Use, Manage, Evaluate, and Understand,* and the NAE-NRC model of *Knowledge, Ways of Thinking and Acting, and Capabilities* described a technologically literate person, both as a responsible member of the community as well as a member of an increasingly technologically complex workforce (ITEA, 2000/2002/2007; ITEA 2006; Pearson & Young, 2002).

As a responsible citizen, a technologically literate individual will be able to make informed decisions. Gimmell (2007) provided an explanation of why technological literacy is important to integrate across the different educational fields in relation to citizenship skills.

> Various citizenship skills are needed to democratically make decisions and systematically solve problems associated with technology. Citizens need to acquire and evaluate pertinent information, think analytically and critically, connect important ideas from different disciplines, communicate clearly, and act responsibly regarding the development and application of technology.
> Responsible citizens ask critical questions, participate in discussions and debates,

> and articulate information to a variety of stakeholders (policymakers, voters, and consumers). Educated citizens also are empowered with the know-how to safely and effectively use an ever-growing number of artifacts and manage the associated rapid change (Gimmell, 2007, p. 2).

Technological literacy plays an important role in workforce development. There has been a great deal of activity concerning the need for STEM education in order to keep the U.S. competitive in the global economy (Rose, 2007; Zuga, 2007). The need for technical knowledge and skills in the "high tech" fields is apparent, "But employers in other sectors of the economy that are not involved directly in the creation of technology will also reap the benefits. They, too, need employees with basic technological competence and the ability to solve problems" (Pearson & Young, 2002, p. 45). An important aspect of technological literacy in workforce development is the relationship that technology has to other fields of study. "Technological literacy is imperative for the 21st century. Employing technology, humans have changed the world. Understanding this symbiotic relationship among technology and science, mathematics, social studies, language arts, and other content areas is vital for the future" (ITEA, 2003, p. 15).

Technology Education

The field of technology education has adapted over time to meet needs of the time. A review of the history provides for how and why *Standards for Technological Literacy* (ITEA, 2002) were developed. William E. Warner founded the American Industrial Arts Association (AIAA), later to become the International Technology Education Association (ITEA) with the belief that the study of technology was important for all students in contrast to the vocational focus and industry curriculum of much of the industrial arts education in the mid-20th century (Land 1979; Starkweather 1979). Warner published, with several of his graduate students, *An Industrial Arts Curriculum to Reflect Technology at all School Levels* (1947), and revised it with *A Curriculum to Reflect Technology* (1965). The profession of technology education continued to move away from vocational education toward curriculum-based programs in the study of industry with several curriculum projects in the 1960's and 1970's (Foster, 1994a; Wright, 1995; Sanders, 2001). Wright (1995) organized these projects by focus into three areas. The Industrial Arts Curriculum Project in 1968 out of The Ohio State University, and the American Industry Project in 1971 at Stout State were based on developing a general understanding of industry. The work of Olson (1963) and DeVore (1966) focused on the general understanding of technology. In addition, the work of Maley (1973) focused on the needs of the child (Wright, 1995). All of these curriculum projects saw the study of industrial arts/technology education as general education and not vocational education. While there was vigorous debate as to what would be appropriate curriculum for the field, the reality was that the schools were not changing. A study by Dugger in 1980 found that course titles had changed very little since Woodward's Manual Training High School in 1880 (Wright, 1995). The courses being taught 100 years later, such as general woods, general metals, mechanical drafting, "had little relationship to the technologically based curriculum structures that Warner, Olson, Towers, Lux, Ray, DeVore, Maley and others had been advocating" (Wright, 1995, p. 257).

The quest for unified focus and curriculum was addressed with the Jackson's Mill Industrial Arts Curriculum Symposium. The project provided a rationale and content structure for industrial arts in the report *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981). Some key points were:

- The field is the study of technology, industry, and their impacts on society.
- The study of technology should focus on the human productive activities of communicating, construction, manufacturing, and transportation.
- These activities are most easily understood as a system with inputs, processes, outputs, and feedback that operate in a social/cultural setting and impact the society (Wright, 1995, p. 259).

Following Jackson's Mill, the Industry and Technology Education Project developed specific curriculum content structures and course outlines that reflected the work done in the Jackson's Mill project (Wright 1995). Jackson's Mill and the Industry and Technology Education Project were the basis of much of the technology education curriculum in use today (Wright, 1995). Though these various curriculums differed in focus, they were in agreement on two key points: they all saw the role of the technology education laboratory as central to the education experience through hands-on activities (learning by doing), and the laboratory was not a "shop" for the development of tools skills and vocational education, but a place for students to gain a general education about industry and/or technology (Land, 1979; Wright, 1995; Sanders, 2001).

The AIAA changed its name in 1985 to the International Technology Education Association (ITEA) in a move that reflected the broader focus of technology education and the changing nature of industry (Foster, 1994a; Starkweather, 1995). This transition was reflected in *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990). This document "proposed a structure for a curriculum grounded in the processes of technology rather than the processes of industry, thereby consummating a divorce from industrial arts in the eyes of the profession" (Sanders, 2001). Many in the field disputed this belief that technology education was distinctly different from industrial arts, with many seeing it as a logical progression of industrial arts (Foster, 1994a; Sanders, 2001). Sanders (2001) found that in practice the field still strongly resembled industrial arts instruction with some manual skills and vocational focuses present, but the significant change had occurred in the field since a similar study was done in 1979. An important change was the belief that development of vocational skills was ranked as the most important aspect of technology education in 1979 and ranked 16th in 1999.

Standards for Technological Literacy

In the same period that technology education was moving away from industrial arts in the 1980s and 1990s, there was a movement for professional organizations across education to develop national standards, and the ITEA followed that trend with the Technology for All Americans Project (Dugger, 2005). This 11-year project resulted in several publications that promoted the development of technological literacy in K-12 education. The first, *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996), provided the rationale for technology education as general education by "grounding the profession in what every student should know and be able to do in order to be technologically literate" (Dugger, 2005, p. 2). The second edition of the rationale dropped the word Americans from the title, becoming *Technology for All: A Rationale and Structure for the Study of Technology* (ITEA, 2006). *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000/2002/ 2007), with revisions in 2002 and 2007, provided content standards for the development of technological literacy in K-12 education (ITEA, 2001), and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (ITEA, 2003) provided standards for student assessment, professional development -- including pre-service teacher education -- and program standards for technology education. These standards play an important role for the field of technology education as it adapts to the needs of students for developing technological literacy.

The standards for technological literacy were developed with the understanding that the development of technologically literate students entails efforts in K-12 education across the full range of subjects. The Technology for All Americans Project developed *Standards for Technological Literacy* (2000) with input and advice from several organizations with an interest in developing technological literacy and in developing national standards. This advisory group consisted of representatives from the following organizations: the National Council of Teachers of Mathematics, the National Science Teachers Association, the American Association for the Advancement of Science Project 2061, the National Research Council, and the National Academy of Engineering (Dugger, 2005). According to Dugger (2005), "The Advisory Group advised ITEA in the best practice for standards development and determined ways for the study of technology to be integrated within the total school curriculum" (p. 2). He goes on to explain, "They met semiannually to provide specific advice on the development of the standards, and how technology education could be integrated with other fields of study, especially science and mathematics" (p. 2).

The standards are not intended to define the curriculum, but "present a vision of what students should know and be able to do in order to be technologically literate"

(ITEA, 2000/2002/2007, p. vii). Each standard includes benchmarks for the development of technological literacy from kindergarten through grade 12 (Dugger, 2005).

Standards for Technological Literacy (ITEA, 2000/2002/2007) includes the following standards.

The Nature of Technology

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

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

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

Technology and Society

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

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

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

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

Design

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

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

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

Abilities for a Technological World

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

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

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

The Designed World

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

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

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

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

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

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

Standard 20. Students will develop an understanding of and be able to select and use construction technologies (ITEA 2000, p. 15).

Advancing Excellence in Technological Literacy (2003) includes professional development standards for teacher educators, supervisors, and administrators that "prepare teachers on any aspect of technology, including teachers whose primary focus may be another subject area" (Dugger, 2005, p. 8). The standards are organized into seven topics with sub-standards under each topic. These include:

PD-1. Professional development will provide teachers with knowledge, abilities, and understanding consistent with *Standards for Technological Literacy: Content for the Study of Technology* (*STL*).

PD-2. Professional development will provide teachers with educational perspectives on students as learners of technology.

PD-3. Professional development will prepare teachers to design and evaluate technology curricula and programs.

PD-4. Professional development will prepare teachers to use instructional strategies and enhance technology teaching, student learning, and student assessment.

PD-5. Professional development will prepare teachers to design and manage learning environments that promote technological literacy.

PD-6. Professional development will prepare teachers to be responsible for their own continued professional growth.

PD-7. Professional development providers will plan, implement, and evaluate the pre-service and in-service education of teachers (pp. 122-123).

The technology education profession, with input from other professional organizations, has developed standards that address technological literacy and K-12 education, as well as standards for developing teachers to deliver technological literacy content. These standards recognized and advocated the role of K-12 teachers from all academic fields in promoting technological literacy. "These standards apply to the study of technology in technology programs and other content area programs. The ultimate goal is for all students to achieve technological literacy" (ITEA, 2003, p. 69).

Technology Education as Instructional Methods for Other Academic Subjects

The ITEA describes the role of technology education activities as an instructional strategy in *Standards for Technological Literacy* (2000).

> Perhaps the most surprising message to emerge from *Technology Content Standards* -- surprising, at least, to those who have not themselves taught technology classes -- is the role technology studies can play in students' learning of other subjects. When taught effectively, technology is not simply one more field of study seeking admission to an already crowded curriculum, pushing others out of the way. Instead, it reinforces and complements the material that students learn in other classes. … the study of technology is a way to apply and integrate knowledge from many other subject areas -- not just mathematics, science, and computer classes, but also liberal and fine arts (ITEA, 2000/2002/2007, p. 6).

Inherent to technology education activities is the use of minds-on/hands-on learning strategies. Constructivist educational learning theory and brain-based learning support these learning strategies. Students working on interdisciplinary, hands-on, problem-based, and context-driven learning activities obtain, understand, and apply the concepts being taught by interacting with the subject matter in multiple ways. This section reviews constructivist and brain-based learning theories, and the role of social interaction and motivation in learning. The section continues with an explanation of how technology education activities teach life skills, and concludes with a discussion on the use of technology education activities as an integrator of academic subjects.

Constructivist Learning Theory

Constructivist learning theory contends that learning occurs when learners take an active, participatory role to develop understanding by interacting with subject matter content to solve a problem or to achieve a goal (Bhattacharya & Han, 2001). Educational theorist John Dewey suggested that children know by doing, and are by nature "little scientists" capable of independent inquiry and the development of cognitive understanding of experience (Valesey, 2003). Technology education learning activities require students to participate actively in the learning process. Additionally, these activities facilitate student content mastery and the development of higher order thinking skills. According to Bloom (1956), the development of progressively complex cognitive processing includes an understanding of information, knowledge, comprehension, analysis, synthesis, and evaluation. Analysis, synthesis, and evaluation, sometimes referred to as higher order thinking skills, are developed with the use of technology education activities that focus on design and problem solving (Schwaller, 1995). Technology education activities, usually done in small groups, provide the social interaction also important in the construction of knowledge, understanding, and the facilitation of mastery. Social interactions, according to educational theorist Lev

Vygotsky, contribute to the construction of knowledge. Through social activities, ideas become internalized. Students working in groups on hands-on projects improve their understanding of subject matter through the discussion and clarification about the subject matter with other students in the group (Kim, 2001).

Technology education activities can improve student motivation by offering minds-on/hands-on activities that actively engage students in learning. Stables (1997) used the terms "enthusiasm" and "curiosity" to describe learners' intrinsic motivation when working on minds-on/hands-on activities. This reflected Dewey's minds-on/hands-on educational philosophy of "knowing by doing." Valesey (2003), in *Selecting Instructional Strategies in Technology Education*, summarizes:

> … children's interests and talents should be taken into account to capitalize on natural instincts: constructive, investigative, experimental, social, and expressive. Dewey advocated a balanced integration of intellectual and sensory experiences in school curriculum, much like the most important lessons learned outside the classroom. Technology education, with its emphasis upon constructivism, authentic learning, the development of multiple intelligences, and cooperative learning, is deeply rooted in Deweyan thought (p. 33).

There is a large and growing body of evidence, based on research in brain-based learning strategies, to support the constructivist learning theories and the use of technology education type activities as effective instructional strategies (Caine & Caine, 1990; Gulpinar, 2005; Kaufman, Robinson, Bellah, Akers, Haase-Wittler, & Martindale, 2008; Marshall, 2005; Pinkerton, 1994; Roberts, 2002).

Eric Jensen (1998), in his book *Teaching with the Brain in Mind*, indicates that:

> ... doing a hands-on science experiment, cheerleading, or creating a project in an industrial arts class is highly likely to be recalled. This creates a wider, more complex, and overall greater source of sensory input to the brain than mere cognitive activity ... a summary of the research tells us that this learning is easier to master, fairly well remembered, and creates lasting positive memories (p. 108).

Minds-on/hands-on learning activities engage multiple areas of the brain and develop a multitude of neural networks proven to trigger recall. Memory is facilitated via contextual associations within the brain, similar to a system of filing cabinets in which areas overlap. Memory "convergence zones" allow for the mapping of like or associated items. Hence, the identification of similarities and differences was an important facet of the teaching-learning process. By activating multiple areas of the brain, the mapping of information "convergence zones" was of greater likelihood (Jensen, 1998). Technology education activities that involve movement, emotion, multiple senses, and problem solving allow for the conceptual mapping of information. The brain-based research shows how students using these activities construct the meaning that results in learning.

Technology Education Activities and Skills for the 21st Century

The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn -- Alvin Toffler.

As Toffler (Gibson & Bennis, 1997) suggests, the skills needed for the 21st century go beyond the ability to read, write, and recall. The increasing rate of change in the 21st century means that today students will need to be able to adapt as the role changes. Instructional strategies that incorporate design and problem-solving activities found in technology education activities develop the skills students will need in the 21st

century. Students need to develop higher-order thinking skills (i.e., analysis, synthesis, and evaluation), as well as skills in effective communication, the ability to work well with groups, the ability to think conceptually and abstractly, and the ability to apply those skills to real-world and increasingly technical problems (Westberry, 2003). In *Selecting Instructional Strategies for Technology Education,* Westberry (2003) drew a parallel between what skills will be needed in the 21st century and the skills developed by providing instruction using technology education activities. Westberry discussed the notion that the process orientation of technology education instruction requires communication skills, both when presenting solutions, and also during the negotiations that are involved in group project problem-solving. Creativity and the ability to develop solutions are inherent to problem solving and design activities. Westberry stated, "The primary advantage of design and problem solving as an instructional strategy … is the application of the higher-order thinking and learning skills required for successful application of technological skills and abilities" (2003, p. 102).

The use of technology education activities, particularly those focused on design and problem solving, develops the skills needed for the 21st century. These skills are developed by encouraging students to become active learners, motivated by their natural desire to learn, and by developing the higher-order thinking skills needed to solve real world problems and adapt to an increasingly complex technological world.

Technology Education Activities as an Integrator of Academic Subjects

Technology education activities may easily be designed to be interdisciplinary. Stables (1997) suggested that technology education activities may develop global skills such as collaborative group work or problem solving, as well as incorporate the teaching of science and mathematics concepts. The technology education problem-solving activity on the design of a bridge requires measuring and the application of physics knowledge, in order to solve the design challenge. Additionally, technology education activities can support development of skills in language arts and knowledge in social studies. An activity for 5th graders that focuses on the development of a model of an early colonial village involves instruction in multiple academic areas (Children's Engineering, n.d). Mathematics concepts are reinforced in the measurement and layout of the model, and natural science concepts are learned as students research what the geology of the area may have been and what plant and animal life would have been present in the colony. History may be learned from research about the colonies, and social studies and technological literacy concepts are learned via the research and building of the simple machines used in that time. Language arts and information literacy skills are developed when the students do the research and write about what they have learned, and oral communication skills are honed as they present their models (Lewis & Zuga, 2005). By employing a constructivist framework to improve learning, and by integrating subject area disciplines, technology education connects content area and conceptual ideas to real-world, hands-on projects.

In order for teachers in K-12 education to take advantage of technology education activities as instructional strategies in their classrooms, they need to gain confidence in their ability to administer these activities (Linnell, 2000). According to Linnell (2000), there were 15 of these types of courses being offered for elementary teachers in their preparation. No data exists as to the number of programs that offered or required courses in secondary teacher preparation education. Additionally, to be able to use these programs fully, not only in support of other academic subjects, teachers need to develop technological literacy in order to promote the development of technological literacy in their students.

Academic Subject Areas and Technological Literacy

The recent attention paid to science, technology, engineering, and mathematics education (STEM) was indicative of the strong relationship in the content of these subject areas (Frye, 1997; NSB, 2003; Zuga, 2007). The natural relationship between these subjects is evident in *Standards for Technological Literacy* (ITEA, 2000/2002/2007) by the participation of the National Academy of Engineering, the National Council of Teachers of Mathematics, the National Science Teacher Association, and the American Association for the Advancement of Science Project 2061 in the development of STL (Dugger, 2005). According to Kendall and Marzano in *Content Standards: A Compendium of Content Standards in K-12 Education* (2004), professional organizations in other academic areas have included the study of technology into their K-12 standards as well. This review of standards indicated that technological concepts were addressed by the professional organizations representing virtually all educational fields. "However, with few exceptions, the technology components of these standards have not been translated into curricula or instructional materials" (Pearson & Young, 2002, p. 56). This section of the review of literature will focus on the relationship of technological literacy with other academic subjects. First to be addressed will be the confusion between technological literacy as defined by the ITEA and the National Academy of Engineering, and technical literacy used to discuss information technology, and education technology as defined by the International Society for Technology in Education (ISTE). This will be followed by a review of the STEM subject area K-12 standards and activities directed at the development of technological literacy. Also addressed in this section is the role of technological literacy in relation to social studies education and English/language arts education. The final part of this section will discuss the needs and current efforts to include technology education activities in the elementary schools.

Information Technology vs. Technological Literacy

One of the barriers in the efforts to bring technological literacy to K-12 education has been the confusion between technological literacy and information or educational technology. This confusion was prevalent even within K-12 education as well as in teacher education programs (Dugger, 2007; Pearson & Young, 2002; Zuga, 2007). This confusion has led many to believe that technological literacy was being addressed in K-12 education. The International Society for Technology in Education (ISTE) used the term digital technology to distinguish the content of information technology in education technology from the content of technology education (ISTE, n.d.). These two areas are distinctly different. "The purpose of technology education is to teach students about technology, while the purpose of educational technology is to use technology to help students learn more about whatever subject they are studying. The purpose of having computers in schools is to teach students to use computer technologies, from running programs and sending e-mails to setting up websites and searching the Internet" (Pearson & Young, 2002, p. 59). Polls conducted by ITEA and Gallup in 2002 and 2004 showed that most people in the United States, two out of three, saw technology as computers and the Internet (Dugger, 2007; Rose & Dugger, 2002).

ISTE developed national standards for digital technology in K-12 education called National Educational Technology Standards (NETS) (ISTE, n.d.). The standards, as they relate to K-12 student education, were referred to as NETS*S (2007), and for teachers as NETS*T (2008). Dugger, at the New Mexico Technology in Education Conference in October of 2007, presented a comparison of the goals of ISTE and NETS*S and the goals of technological literacy as defined by ITEA and *Standards for Technological Literacy* (STL) (2000). The NETS*S (2007) were organized into six categories.

1. Basic Operations and Concepts
2. Social, Ethical, and Human Issues
3. Technology Productivity Tools
4. Technology Communications Tools
5. Technology Research Tools
6. Technology Problem-solving and Decision-making Tools

These categories appear similar to STL, but there were some distinct differences. The focus of NETS*S (2007) was on "... what students should know and be able to do to live productively in an increasingly digital world" (ISTE, n.d., NETS). The tools identified in the last four categories refer to the digital technologies such as computer and Internet use. In contrast, the STL focused on broader technological literacy (Dugger, 2007). The NETS*S addressed the need to develop more than the student's ability to use these digital tools. They also addressed student "creativity and innovation, communication and collaboration, research and information fluency, critical thinking, problem-solving and decision making, digital citizenship, [and] technology operations and concepts" (Dugger, 2007, slide 40). The skills and knowledge addressed in these areas were similar to *Standards for Technological Literacy* (2000) and will help to develop technological literacy. Again, the primary difference was that instruction for these areas was focused primarily on digital technologies (Dugger, 2007). Information technology literacy, or digital literacy, and the goals of technological literacy were both important to develop in K-12 education (Pearson &Young, 2002). The standards and instruction in these two areas were distinctly different. According to Dugger (2007), "NETS*S should not be used as the basis to educate students on what to know and be able to do to be technologically literate. Likewise, STL should not be used as the basis to educate students on what to know and be able to do to be able to learn effectively and live productively in an increasingly digital world" (slide 46).

There were also differences in preparing teachers to use technologies for instruction and preparing teachers to use activities that integrate the subject matter and the development of technological literacy. Most teacher education programs include course requirements for the use of instructional technology (Hinchliffe, 2003; Hofer, 2003). These courses, while important, did not address the development of technological literacy and K-12 teachers (Pearson & Young 2002). The ISTE standards for teacher education, NETS*T, were organized into five categories:

1. Facilitate and inspire student learning and creativity.
2. Design and develop digital-age learning experiences and assessments.
3. Model digital-age work and learning.
4. Promote and model digital citizenship and responsibility.

5. Engage in professional growth and leadership (ISTE, 2008, p. 1).

Within these categories, the standards reflect NETS*S' (student standards) focus on digital technology, as well as using digital technology as a tool for education. "Effective teachers model and apply the National Educational Technology Standards for Students (NETS*S) as they design, implement, and assess learning experiences to engage students and improve learning; enrich professional practice; and provide positive models for students, colleagues, and the community" (ISTE, 2008, p. 1). In comparing NETS*T with the ITEA professional development standards found in *Advancing Excellence in Technological Literacy* (2003), there were similarities in areas of professional growth, responsibility and citizenship, and the development of effective instruction and instructors. The primary differences were found in the professional development standards consistent with their respective K-12 standards. The NETS*T reflected the digital focus of the NETS*S, and the ITEA professional development standards were consistent with the broader development technological literacy found in *Standards for Technological Literacy* (2000). Consistent with the comparison with the K-12 standards above, the requirements for preparing K-12 teachers to address technological literacy were different from the requirements for digital literacy and instructional technology as defined by ISTE. The development of K-12 teachers who are able to promote technological literacy and use technology education activities in their instruction requires professional development activities that are beyond the purview of coursework that reflect the ISTE standards (Dugger & Naik, 2001; Pearson & Young, 2002; Garmire & Pearson, 2006).

Science Technology Engineering Mathematics (STEM)

Some see the integration of science, technology, engineering, and mathematics as developing into a single field of education referred to as STEM (Zuga, 2007). The integration of these subjects into a single field would allow for the hands-on learning opportunities discussed in the earlier section concerning the benefits of technology education activities (LaPorte & Sanders, 1996; Foster, 1994b; Foster & Wright, 2001; Holland, 2004; Park, 2004; Sanders, 2003). The reality of STEM education and STEM workforce initiatives was the promotion of science and mathematics education as individual subjects, that technology was seen as a tool for teaching these subjects, and engineering, with a few notable exceptions, was being ignored in K-12 education (Custer & Ereckson, 2008; Garmire & Pearson, 2006; Pearson & Young, 2002; Pearson, 2004; Zuga, 2007). The professional organizations that represent the STEM fields in K-12 education have included the development of technological literacy in their K-12 standards (Kendal & Marzano, 2004; Pearson & Young, 2002). The leaders in these professions generally recognized the interrelationship among these subjects and the value of instruction that includes activities that integrate these subjects (Rose, 2007; Siller, De Miranda, & Whaley, 2007). Some of the discrepancy between the ideals espoused by professions and the realities in the K-12 classrooms may be the result of the lack of teacher preparation in the use of technology education and engineering activities for instruction in science and mathematics. At the same time, leaders of professional organizations for science, engineering, and mathematics tend not to see the field of technology education as a key component of developing technological literacy (Rose, 2008). Public confusion also plays a role in how technological literacy was perceived in

STEM education. The ITEA-Gallup polls that found two out of three Americans believe that technology is computers and the Internet also showed that "the public sees engineering and science as the same as technology" (Dugger, 2007, slide 7). This lack of distinction between the subject areas in STEM was in part responsible for the lopsided emphasis on science and mathematics associated with STEM initiatives (Zuga, 2007). Developing technological literacy in K-12 teachers would help to address the confusion and lack of distinction in the STEM subject areas. This section of the review literature will focus on K-12 standards and professional development in the STEM subject areas as they relate to technological literacy.

Engineering

The goals of K-12 engineering education as described by the National Academy of Engineering (NAE) and the American Society of Engineering Education (ASEE) include the development of a technologically literate populace and the development of engineers to address future workforce needs (Custer & Erekson, 2008; Pearson & Young, 2002). The goal of technological literacy was evident by the participation of the NAE in the development of *Standards for Technological Literacy* (2000), and their publication with the National Research Council of *Technically Speaking* (2002) and *Tech Tally* (2006). The ASEE K-12 education division actively promoted engineering education by providing resources and workshops for K-12 teachers (ASEE, 2007). In *Why K-12 Engineering* (Iversen, Kalyandurg, & de Lapeyrouse, n.d.), the benefits of K-12 engineering include learning about engineering and technology as well as the advantages of using hands-on activities to promote learning across all academic fields. K-12 engineering education in large part resembles K-12 technology education in terms of goals as well as in the types of activities used to support student understanding of the content (Custer & Erekson, 2008). These engineering design activities provide students with the problem solving skills needed in our complex society. These activities may also provide for greater understanding for students in the relationship between technology and science (Lewis & Zuga, 2005). They allow students to learn problem solving and inquiry skills in the context that, according to constructivist theory and brain-based research, provides the fullest level of the students' understanding of the content being taught. The ASEE recognized the need for the development of an understanding for technology and engineering in all K-12 teachers, as well as the need for these teachers to use the hands-on activities used in technology and engineering education (ASEE, 2007; Iversen, Kalyandurg, & de Lapeyrouse, n.d.; Custer & Erekson, 2008).

Science

The National Science Education Standards (NAS & NRC, 1996) and Benchmarks for Science Literacy (AAAS, 1993/2008) both addressed technological literacy (Newberry & Hallenbeck, 2002). The *National Science Education Standards* (1996) provides content standards for K-12 science education. These standards were organized into seven content standards with divisions for grade levels K-4, 5-8, and 9-12 for each of the content standards. National Science Content Standards include:

Standard A: Science as inquiry is basic to science understanding and is fundamental to all scientific experiences.

Standard B: Comprises the physical science standard domain.

Standards C: Comprises the life science standard domain.

Standard D: Comprises the Earth and space science standard domain.

Standard E: Comprises the science and technology standard domain.

Standard F: Comprises the science in personal and social perspectives standard domain.

Standard G: Comprises the history and nature of science standard domain (NAS & NRC, 1996, p 6).

Newberry and Hallenbeck (2002) provided an analysis of how the National Science Education Standards for K-12 content address technological literacy. Standard E directly addressed the relationship between science and technology. The standard "… emphasizes developing the ability to design a solution to a problem and understanding the relationship of science and technology and the way people are involved in both" (NAS & NRC, 1996, p. 135). Standard F showed a relation to the Technology and Society standards in *Standards for Technological Literacy* (2000). Standard F, Science in Personal and Social Perspectives, addresses the concept that "People continue inventing new ways of doing things, solving problems, getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad" (NAS & NRC 1996, p. 140). The standards represent a clear relationship between science literacy and technological literacy and support the inclusion of technological literacy in science classrooms and laboratories.

The American Association for the Advancement of Science (AAAS) published *Benchmarks for Science Literacy* in 1993 as part of its Project 2061. The document consisted of 12 chapters that described the specific benchmarks followed by four chapters that provided background material on the development of the benchmarks. There were important differences in how the *National Science Education Standards, Benchmarks for Science Literacy, and Standards for Technological Literacy* were organized.

> *Benchmarks for Science Literacy* is written with the statements that identify what every student should know and be able to do in science, mathematics, and technology, kindergarten through grade 12. In contrast, Standards for Technological Literacy is written with standards that specify what every student should know and be able to do in technology, and each standard has an accompanied list of statements for kindergarten through grade 12 that provide guidance on how the student may achieve the standard. Therefore, *Standards for Technological Literacy* uses the idea of standards from the *National Science Education Standards* and the idea benchmarks from *Benchmarks for Science Literacy* and combines them into a presentation of technological literacy (Newberry & Hallenbeck, 2002, p. 21).

The 12 chapters in *Benchmarks for Science Literacy* are:

1. The Nature of Science
2. The Nature of Mathematics
3. The Nature of Technology
4. The Physical Setting
5. The Living Environment
6. The Human Organism
7. Human Society
8. The Designed World
9. The Mathematical World

10. Historical Perspectives

11. Common Themes

12. Habits of Mind (AAAS, 1993, pp. 49-52)

Three of the chapters had a direct relationship with technological literacy. Chapter 8, the Design World, shares that title with Chapter 7 in *Standards for Technological Literacy*. The other two are Chapter 3, the Nature of Technology, and Chapter 11, Common Themes. The analysis of these benchmarks by Newberry and Hollenbeck (2002) found examples of the relationship between science and technology throughout the benchmarks in addition to the direct correlation of the three chapters mentioned above. One example provided was found in "Chapter 10, Historical Perspectives, includes a discussion of the industrial revolution" (AAAS, 1993, p. 42). They conclude that "A clear understanding of the relationships between *Benchmarks for Science Literacy* and *Standards for Technological Literacy* will help teachers dialog about how … technology has been a powerful force in the development of civilization, all the more so as its link with science has been forged" (AAAS, 1993, p. 41 in Newberry & Hallenbeck, 2002, p. 30). The development of teachers' understanding of the relationship between science literacy and technological literacy was addressed in the *Science Teacher Preparation Standards* published by the National Science Teachers Association (2003).

The *Science Teacher Preparation Standards* (2003) recognized the need for technologically literate science teachers by aligning the teacher preparation standards with the AAAS benchmarks (1993/2008) and the *National Science Education Standards* (1996). The National Science Teachers Association stated in the *Science Teacher Preparation Standards* (2003) that the "standards and recommendations for teacher preparation are intended as a framework for the preparation of teachers to work effectively in school systems with a science curriculum based on the NSES [National Science Education Standards] or professional standards with similar goals" (p. 5). The authors of *Science Teacher Preparation Standards* (2003) not only described what science teachers need to know about science and technology, they also described the need for teachers to be able to use effective instructional strategies for delivering this content. The development of these skills is necessary so that teachers "are successful in engaging their students in studies of such topics as a relationship of science and technology, nature of science, inquiry in science and science related issues" (p. 1). The use of hands-on activities in laboratory settings requires an understanding of the technologies used for instruction. The application of science concepts to solve problems in design challenges that were used in technology education supports learning in science as well as technology and engineering (Cajas, 1999; Iversen, Kalyandurg, & de Lapeyrouse, n. d.; ITEA, 2000/2002/2007; Newberry & Hallenbeck, 2002; Pearson & Young 2002). The *Science Teacher Preparation Standards* address the need to develop skills using these types of activities in science teachers (NSTA, 2003).

Mathematics

The program standards for mathematics teacher preparation describe the use of technology primarily as a tool for doing mathematics, but broader technological literacy is also addressed in the curriculum standards as well as the teacher preparations standards (NCTM, 2003). According to Newberry and Hallenbeck (2002), the National Council of Teachers of Mathematics (NCTM) in *Principles and Standards for School Mathematics* (2000) provided for content standards for mathematics to complement *Standards for*

Technological Literacy (ITEA, 2000/2002/2007). Newberry and Hallenbeck (2002) pointed specifically to the promotion of systematic reasoning for the solving of problems in mathematics and related this process to technological literacy. They asserted that "systematic thinking is a defining feature of technology" (p. 39). The standards addressed the need for students to be able to make connections between mathematics and other areas such as science and technology (NCTM, 2000; Pearson & Young, 2002). Newberry and Hallenbeck (2002) described how the structure of the standards in *Principles and Standards for School Mathematics* (2000) allows educators to find the connections between mathematics and technology. In addition to the commonalities in content, the standards addressed the relationship between mathematics instruction and technology.

Principles and Standards for Mathematics (NCTM, 2000) described the use of technology as a tool for teaching mathematics as well as using hands-on activities like those used in technology education to support mathematics learning. The program standards for teacher preparation for elementary, middle school, and high school teachers addresses the need for teachers to "develop lessons that use technology's potential for building understanding of mathematical concepts and developing important mathematical ideas" (NCTM, 2003, middle school specialist, p. 9). The development of the workforce educated in the STEM subject areas included a strong basis in mathematics education (Steen, 2007). Using hands-on technology education and engineering problem-solving activities to support mathematics education increased student understanding of the mathematics concepts as well as improved student motivation (Dyer, Reed, & Berry, 2006; Iversen, Kalyandurg, & de Lapeyrouse, n.d.; Sanders, 2003). The interrelationship between mathematics, science, technology, and engineering subjects requires mathematics teachers to be technologically literate and be able to use hands-on technology education-type activities for instruction that provides relevance to students.

Social Studies

The fourth chapter of *Standards for Technological Literacy* (ITEA, 2000/2002/2007) was titled Technology and Society. The standards in this chapter are:

4. Students will develop an understanding of the cultural, social, economic, and clinical effects of technology.
5. Students will develop an understanding of the effects of technology on the environment.
6. Students will develop an understanding of the role of society in the development and use of technology.
7. Students will develop an understanding of the influence of technology on history (p. 55).

These standards show the relationship between social studies and technological literacy. The social studies content addressed in these standards includes sociology, economics, political science, environmental studies, anthropology, and history. This relationship between technological literacy and social studies was addressed throughout *Expectations of Excellence: Curriculum Standards for Social Studies* (NCSS, 1994). The standards were organized into 10 themes that inherently address technological literacy (Foster, 2005). The strongest connections were found in the Production, Distribution, and Consumption theme and in the Science, Technology, and Society theme. Foster (2005) provided a comparison of the Science, Technology, and Society standards with those in *Standards for Technological Literacy* (2000). Table 1 reproduces this comparison.

The National Council of Social Studies (NCSS) included the goal of the development of citizenship for social studies education by saying: "Social studies educators teach students the content knowledge, intellectual skills, and civic values necessary for fulfilling the duties of citizenship in a participatory democracy. The mission of National Council for the Social Studies is to provide leadership, service, and support for all social studies educators" (2008, p. 1). The knowledge, skills, and values necessary for fulfilling the duties of citizenship include technological literacy (Gemmill, 2007; Gilberti, 2001). Teachers within the social studies disciplines play a role in the development of technological literacy in K-12 education when they teach about the relationship between society and the human made world (Foster 2005; Metz, Klassen, & McMillan, 2007; Zuga, 1991).

Table 1

Comparison of Selected Standards (Foster, 2005, p. 20)

Science, Technology, and Society *Expectations of Excellence: Curriculum Standards for Social Studies* (NCSS, 1994 p. 132). Performance Expectations: (9-12)	**Technology and Society** *Standards for Technological Literacy* Standards 4-7: (ITEA, 2000, p. 211-212) Standards and Benchmark topics: (9-12)
a. identify and describe both current and historical examples of the interaction and interdependence of science, technology, and society in a variety of cultural settings; b. make judgments about how science and technology have transformed the physical world and human society and our understanding of time, space, place, and human-environment interactions; c. analyze how science and technology influence the core values, beliefs, and attitudes of society, and how core values, beliefs, and attitudes of society shape scientific and technological change; d. evaluate various policies that have been proposed as ways of dealing with social changes resulting from new technologies, such as genetically engineered plants and animals; e. recognize and interpret varied perspectives about human societies and the physical world using scientific knowledge, ethical standards, and technologies from diverse world cultures; f. formulate strategies and develop policies for influencing public discussions associated with technology-society issues, such as the greenhouse effect.	4. The Cultural, Social, Economic, and Political Effects of Technology • Rapid or gradual changes • Trade-offs and effects • Ethical implications • Cultural, social, economic, and political changes 5. The Effects of Technology on the Environment • Conservation • Reduce resource use • Monitor environment • Alignment of natural and technological processes • Reduce negative consequences of technology • Decisions and trade-offs 6. The Role of Society in the Development and Use of Technology • Different cultures and technologies • Development decisions • Factors affecting designs and demands of technologies 7. The Influence of Technology on History • Evolutionary development of technology • Dramatic changes in society • History of technology • The Iron Age • The Middle Ages • The Renaissance • The Industrial Revolution • The Information Age

As mentioned previously in the review of academic subjects, the need for technological literacy in K-12 teachers goes beyond the curriculum content. The use of hands-on activities like those used in technology education provide the means for reinforcing content understanding in social studies. Additionally, these integrated activities develop an understanding of the relationship between social studies, technology, and other academic subjects (ITEA, 2000/2002/2007; Jones, 2007; Pearson & Young, 2002; Sanders, 2003).

English

The National Council of Teachers of English (NCTE) provided its definition of 21st century literacies as:

> Literacy has always been a collection of cultural and communicative practices shared among members of particular groups. As society and technology change, so does literacy. Because technology has increased the intensity and complexity of literate environments, the twenty-first century demands that a literate person possess a wide range of abilities and competencies, many literacies. These literacies--from reading online newspapers to participating in virtual classrooms--are multiple, dynamic, and malleable. As in the past, they are inextricably linked with particular histories, life possibilities and social trajectories of individuals and groups. Twenty-first century readers and writers need to
>
> • Develop proficiency with the tools of technology
>
> • Build relationships with others to pose and solve problems collaboratively and cross-culturally

• Design and share information for global communities to meet a variety of purposes

• Manage, analyze and synthesize multiple streams of simultaneous information

• Create, critique, analyze, and evaluate multi-media texts

• Attend to the ethical responsibilities required by these complex environments (NCTE, 2008, p. 1).

These literacies, focused on readers and writers, relate directly and indirectly to the need for technological literacy. Indirectly, these literacies share the goals of developing students who can solve problems, apply analysis and evaluation, and act ethically. The design and share literacy relates directly to *Standards for Technological Literacy* (2000) Standard 8, Attributes of Design, and Standard 17, Information and Communication Technologies. The first literacy listed, *develop proficiency with the tools of technology*, falls under *Capabilities* in the model for the dimensions of technological literacy described in *Technically Speaking* (2002). The first literacy does not just distinguish between the broad definition of technology as defined in this study, but also the narrower computer-based information technology definition used by the International Society for Technology in Education (ISTE). A review of NCTE *Standards for English Language Arts* (1996) indicated that the focus of the practice in English-language arts education was more consistent with ISTE.

Standard 8 in *Standards for English Language Arts* (IRA & NCTE, 1996) discussed the role of information technology and students' ability to use computers and keyboarding skills for writing and publishing. Standard 7 deals with students' ability to research using multiple sources, but it did not mention the use of the Internet as a source for research (IRA & NCTE, 1996). This may be the result of these standards being developed before the widespread use of the Internet. Though the standards presented a narrower view of technology, the need for technologically literate English-language arts teachers was indicated. First, to develop their abilities to manage, assess, and use increasingly complex technologies used both in the classroom and in society for communication. Second, to prepare them to use instructional strategies that use the hands-on project-based learning activities that according to brain based learning research and constructivist learning theory improve student understanding. These activities help students to build language skills by providing a context by which the students can understand the meaning and use of the language (Lewis & Zuga, 2005). Most of these activities, especially at the elementary school level, include the development of English-language arts skills by requiring written elements as well as presentations to the class of the completed project (Jones, 2007; Lewis & Zuga, 2005; Sanders, 2003; Sanny & Teale, 2008; Westberry, 2003).

Elementary Teacher Education

Technological literacy needs to be included in undergraduate elementary teacher development, as well as in in-service programs to enable veteran teachers to prepare to use technology education activities and deliver technology content in their classrooms (ITEA, 2006; Stables, 1997). Two of the reasons to include technology education activities in the elementary schools, as mentioned previously in this review, were the development of technologically literate students and the ability of technology education activities to enhance learning in other subjects. The understanding of technological concepts was developed in students when using technology education activities (Foster, 1997; Foster & Wright, 2001; Park, 2004). According to *Technology for All* (2006), "These experiences develop the students' perception and knowledge of technology, psychomotor skills, and provide a basis for informed attitude about the interrelationship of technology, society, and the environment" (p. 24). The second reason to include technology education activities in the elementary schools was that they provide a natural vehicle for hands-on education to support learning in other subject areas. Using the students' natural curiosity about how things work may better motivate students and create positive lifelong attitudes about learning and exploring (Holland, 2004; Jensen 1998; Sanders, 2003; Valesey, 2003). These activities should be interdisciplinary and include other core subjects--including mathematics, science, reading, writing, and social studies in a model that brings a meaningful context to students (ITEA, 2006). Contextual learning allows students to learn using their "thinking brain," the active, meaning-making process, and not just the memory functions of the brain. There was much greater retention with this type of learning (Jensen, 1998; Parnell, 1999). *Technology for All* (2006) summarized it this way: "Pupils apply their knowledge when drawing, planning, designing, and problem solving, building, testing, and improving their solutions to problems" (p. 8).

Elementary technology education is growing throughout the country (ITEA, 2006). Several states have developed programs for technology education in the elementary schools. There were several in-service programs that were either working with elementary teachers, in workshops or mentoring programs, which develop technology projects and competencies (Flowers & Kirkwood, 2002; Skophammer, 2007).

Teachers working in these programs "… excel at integrating technological concepts across the curriculum" (ITEA, 2006, p. 24).

Linnell (2000) identified 15 institutions that prepare teachers to teach elementary school technology education activities. Additional research by Linnell for assessing the self-efficacy of teachers in their ability to use technology education activities indicated that the number of institutions with courses for technological education at the elementary school level might have decreased. His study, which was not completed, did not distinguish between institutions where these courses were required versus being an option for elementary teacher education (personal correspondence, 2007).

The literature identifies the need for technologically literate teachers at the elementary and secondary school levels. This is based on the need to develop a technologically literate populace and the effectiveness of integrated hands-on type learning activities that support learning across the academic subjects as well as develop technological literacy.

Accreditation of Teacher Education Programs

The development of teacher education requirements in a given program of study was influenced by state licensure requirements, subject area professional organization standards and priorities, and accreditation standards and procedures. This section of the review of literature will provide an overview of the National Council for the Accreditation of Teacher Education and the Teacher Education Accreditation Council. It will discuss the relationship between the accreditation agencies for teacher education programs and professional organizations for developing program standards, as well as how those standards affected teacher education program requirements at the state level.

This section will conclude by discussing the NCATE technology requirements in relation to the International Society for Technology in Education (ISTE) *National Educational Technology Standards* for teachers (NETS*T) (2008) and the International Technology Education Association (ITEA) *Standards for Technological Literacy* (2000).

Accreditation Agencies

The Teacher Education Accreditation Council (TEAC) is the smaller of the two teacher education accreditation agencies recognized by the United States Department of Education. It was formed in 1997 and currently accredits 59 education programs at 48 institutions in 14 states (TEAC, 2008a). The TEAC accreditation process involves the development of an accreditation brief that identifies the goals for the program. The institution with guidance from TEAC develops this brief. TEAC then audits the program based on this brief. Evidence of the effectiveness of the programs is required (TEAC, 2008b; Vergari & Hess, 2002). This model presented a decentralized process for accreditation (Tamir & Wilson, 2005). The teacher education requirements, and by extension the course requirements, at these programs reflect the state requirements. They were influenced by the philosophies of the professional organizations for the academic subject, but there may not be a direct relation to the professional development standards of these organizations (Tamir & Wilson, 2005; Vergari & Hess, 2002).

The National Council for the Accreditation of Teacher Education (NCATE) was created in 1954. It currently accredits 632 institutions preparing two thirds of the teachers in the United States (NCATE, 2008b). NCATE has partnerships with 50 states, and the District of Columbia, and Puerto Rico. In 31 states, all of the teacher education programs were accredited through NCATE. Twenty-two states rely solely on NCATE accreditation decisions for state approval of education programs (2008b). Thirty-nine states have adopted the NCATE unit standards as their own, and by extension, these standards apply to both accredited and non-accredited teacher education institutions (2008b). NCATE collaborates with the professional organizations representing the different content areas for the development of program standards for the teacher education programs in those content areas. The goal was to have unified goals and standards in teacher education programs (NCATE, 2008a; Tamir & Wilson, 2005; Vergari & Hess, 2002). All 50 partner states have either adopted the program standards wholesale or have closely aligned their standards to the program standards (NCATE, 2008b). The partnership among the states, the professional organizations, and NCATE is a leading factor in the teacher education requirements, and by extension the course requirements, in a given program.

The relationship NCATE and ISTE (NETS) goes back to 1997 when NCATE adopted those standards for teacher education (Hofer, 2003). These standards provide guidance for the appropriate and effective use of computer technologies by teachers for the purpose of instruction (ISTE, 2008). The rapid integration of instructional technology into the classroom brought on by advances in computer technology, as well as the provisions in the No Child Left Behind legislation, has required intensive education efforts to prepare teachers for this integration of computer technologies (Hofer, 2003; Rowley, Dysard, & Arnold, 2005; Pearson & Young, 2002; Garmire & Pearson, 2006). NCATE does address technological literacy when the program standards for the different content areas address technological literacy as part of content knowledge. This was the most evident in the science standards and, to a lesser extent, the social studies standards (See individual content areas discussed above).

The ITEA, the Council for Technology Teacher Education, and NCATE have developed standards for the creation of technology teacher education programs. These standards are based in part on *Standards for Technological Literacy* (ITEA, 2000/2002/2007) and advancing *Excellence in Technological Literacy* (ITEA, 2003). The use of these standards is limited to technology teacher education and is not evident in the accreditation standards in other subject areas. The NCATE unit standards for pedagogy include the use of technology for instruction but follow the narrower ISTE focus of computer technology. In addition, the NCATE program standards all address the need to have students learn about technology (Dugger, 2007; Hofer, 2003; Kendall & Marzano, 2004; Rowley, Dysard, & Arnold, 2005). In practice the technology being addressed was computer and information technologies. "Thus many people believe that their schools already teach about technology, when in reality they teach only about computers" (Pearson & Young, 2002, p. 59).

SUMMARY

Chapter II reviews the need for a technologically literate populace and focuses on the role of K-12 education in the development of technological literacy. The first section identifies the need for, and benefits of, technological literacy. The second section discusses the role of technology education in developing technological literacy including the use of technology education activities as an instructional strategy in other subject areas. The third section discusses the use of technology education activities that support learning in other content subject areas. The next section reviews the relationship of technological literacy and other subject areas. The final section reviews the literature concerning the influences of content specific professional organizations, and NCATE and TEAC accreditation processes in teacher preparation requirements. Chapter III will cover the research methods used in the study. A full description of the model for assessing technological literacy course content based on the literature will be provided as well as the procedures for the analysis of the data.

CHAPTER III

METHODS AND PROCEDURES

This chapter describes the methods and procedures used to collect and analyze data for this study. The chapter will identify the population and the methods used to determine the sample size, as well as the system used for coding data in relationship to the research questions. Finally, the procedures for the statistical analysis of the quantitative data will be described.

Design of the Study

The research design of the study was content analysis. "A content analysis is a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases" (Leedy & Ormand, 2005, p. 142). For this study, a document review of current undergraduate course catalogs was performed to address the research problem and the content analyzed in order to answer the research questions.

Population and Sample

The K-12 education programs reviewed in the study were randomly selected from the combined lists of education programs accredited through NCATE and TEAC. A single list of 697 accredited education programs within the United States was created by entering the data, available online, into an Excel™ spreadsheet. The sample size of 248 education programs was determined using a table based on the formula by Krejcie and Morgan (1970) (as cited in Patten, 2007) for a finite population at a 95% confidence level. The random sample was created using the random number generator and sort functions in Excel™. The sample size and random sample procedure allows for the sample to be proportionally representative of the United States education institutions in terms of geographic location, as well as the distribution among liberal arts colleges, regional institutions, and research universities. A review of the sample by the researcher confirmed this distribution. The education majors to be reviewed represent the academic areas that K-12 students are required to study.

Methods of Data Collection

This study used a qualitative analysis of electronic sources of course titles and course descriptions. In a document review, the researcher makes the judgment on how to code the appropriate data in the document (Creswell, 2007). The data were collected for the study by reviewing the appropriate current catalogs for each institution of the 248 education programs. A spreadsheet was used to record data from each institution with categories for mathematics, science, English, social studies, and elementary education. Subcategories for elementary education majors included English, social studies, mathematics, and science content specializations. Categories for secondary subjects included a subcategory for middle school majors. Subcategories for secondary social studies included history, geography, economics, political science (including civics), and sociology. Subcategories for science included biology, chemistry, physics, and earth science. There were no content subcategories for mathematics or English. Table 2 shows the list of column headings and subheadings for the spreadsheet. The rows on the spreadsheet contain the institution names.

Table 2

Headings and Sub-headings of Categories

Heading	Sub-heading 1	Sub-heading 2
General Education Requirement		
General Education Option		
Elementary Education	Generalist English Social Studies Mathematics Science	
English		High School, Middle School
Social Studies	History	High School, Middle School
	Economics	High School, Middle School
	Geography	High School, Middle School
	Political Science	High School, Middle School
	Sociology	High School, Middle School
Mathematics		High School, Middle School
Science	Biology	High School, Middle School
	Chemistry	High School, Middle School
	Physics	High School, Middle School
	Earth Science	High School, Middle School

In order to answer Research Question 1, the general education requirements at each university or college where the teacher education program resided were reviewed. Courses that were identified as developing technological literacy that were general education requirements were identified in one column and those that were an option in a separate column. When the general education courses were not intended for science majors they were coded with an E. Data for Research Question 2 were collected from the teacher education requirements in the undergraduate catalog for each of the education majors evaluated in this study. Where distinctions existed between middle school and high school majors, both sets of requirements were reviewed and recorded separately. Likewise, when differences in science education majors' course requirements existed, they were also recorded separately. Courses that were identified as developing technological literacy that were teacher education requirements were coded R and those that were an option in teacher education requirements recorded as O. In order to address Research Question 3, the content focus of the required courses, TL or IM was added to the initial code. Courses that focused on instructional methods and technology education activities were coded IM, and courses that focused on technological literacy as content were recorded TL. Courses that addressed both were coded with TL-IM. Therefore, a course that was an education requirement for elementary teacher education that focused on technology education methods as well as content was coded R-TL-IM. See Table 3 Codes and Descriptions.

Table 3

Codes and Descriptions for Teacher Education Programs

Codes	Description
R	Required course
O	Optional course used to fulfill requirement
TL	Technological Literacy awareness
IM	Instructional Method using technology education activities

Course content was considered to be focused on the development of technological literacy (TL) when the course title or course description indicated that the course curriculum promoted technological literacy as defined in *Technically Speaking* (2002) and *Tech Tally* (2006). *Tech Tally* provided a matrix of the cognitive dimensions of technological literacy and the content areas for technological literacy that were used as a rubric for determining whether a course promoted technological literacy (see Figure 1).

		COGNITIVE DIMENSIONS		
		KNOWLEDGE	CAPABILITIES	CRITICAL THINKING AND DECISION MAKING
CONTENT AREAS	TECHNOLOGY AND SOCIETY			
	DESIGN			
	PRODUCTS AND SYSTEMS			
	CHARACTERISTICS, CORE CONCEPTS, AND CONNECTIONS			

Figure 1. Assessment matrix for technological literacy (*Tech Tally*, 2006, p. 53).

Course content was considered to be technology education instructional methods (IM) when technology literacy courses included instructional methods or activities in the description or title of the course. Courses that were not included for this study are those that focused on information-technology literacy, computer literacy, or instructional technology as defined in Chapter I and expanded upon in Chapter II. Required courses that focus on these areas were not included in this study. Several recent studies have been done in these areas (Baylor, 2002; Hinchlifee, 2003; Kelly, 2006; Garmire & Pearson, 2006; Sanny, 2008; Topper, 2006).

Statistical Analysis

Descriptive statistics for the nominal data developed in the document review were determined and reported for frequencies, mode, and mean. Descriptive statistics were used to address Research Questions 1 through 3. Additionally, for Research Question 4 the data were analyzed using chi-square to determine if there was a statistical difference in frequencies of the required courses between education major types. Chi-square was used to determine whether deviations in frequencies may have been caused through random sampling error (Patten, 2007).

Summary

Research methods and procedures used in this study were described in this chapter. The data collected in the study were produced through a document review of the appropriate course catalogs. The categories for the different education majors were identified as elementary education, secondary English, social studies, mathematics, and science. The headings and subheadings, as well as the coding strategy, used for the recording of data were explained. The population of the study was identified as teacher education institutions accredited through NCATE and TEAC. The method used to determine the random sample size 248 was explained. The analysis of the data collected will be reported using descriptive statistics with a statistical analysis to determine if there were differences between education majors. Chapter IV will report the results of the statistical tests and the findings for each of the research questions.

CHAPTER IV

FINDINGS

This chapter presents the findings based on analysis of the data collected to address the research problem. The purpose of this study was to determine to what extent technological literacy courses were required for K-12 teacher education programs at accredited education institutions in the United States. This chapter will present an overview of the findings, and each of the four research questions will be addressed in detail. A brief summary will conclude this chapter.

Overview

This study used an analysis of electronic sources of course titles and course descriptions. A spreadsheet was used to record data from each institution with categories for mathematics, science, English, social studies, and elementary education. Subcategories for elementary education majors included English, social studies, mathematics, and science content specializations. The categories for secondary subjects included a subcategory for middle school majors. Subcategories for secondary social studies included history, geography, economics, political science (including civics), and sociology. Subcategories for science included biology, chemistry, physics, and earth science. In order to answer Research Question 1, the general education requirements at each university or college where the teacher education program resided were reviewed. Courses that were identified as developing technological literacy that were general education requirements were identified in one column and those that were an option in a separate column. When the general education courses were not intended for science majors they were coded with an E.

In order to address Research Questions 2, 3, and 4, the courses identified as developing technological literacy that were teacher education requirements were coded R and those that were an option in teacher education requirements recorded as O, and to distinguish between broad technological literacy awareness and instructional methods, TL or IM was added to the initial code. Courses that addressed both were coded with TL-IM.

Research Questions

The undergraduate course catalogs from 248 institutions were reviewed and 101 (41%) of the schools were identified as providing some opportunity for education students to take technological literacy courses. Of the 101 identified institutions, 80 use technological literacy courses to fulfill general education requirements. The remaining 21 institutions provide technological literacy courses that could be used to fulfill requirements for education programs.

Research Question 1

Are technological literacy courses a part of general education requirements for K-12 education majors at 4-year, accredited institutions? This question looks at the general education requirements for the institutions where the K-12 education programs reside. The analysis of the data identified technological literacy courses as being either a requirement of the institution or an option to fulfill a requirement of the institution. Early analysis indicated that science majors often had different general education requirements when it came to technological literacy courses; therefore, differences for science education majors were included in the analysis.

The review of the 248 course catalogs determined that 80 institutions included technological literacy courses as part of their general education requirements. Typical course titles included Science, Technology and Society, Technology and Society, and Technology and Civilization. At a few of the institutions, these courses were part of a technology track or sequence that would include computer technology courses as well as industrial technology and design courses. Seventy-six of these institutions allowed a technological literacy course to fill a general education requirement, and four institutions required a technological literacy course as part of the general education requirements. Of the 76 institutions that offered a technological literacy course as an option for general education requirements, 42 excluded that course as an option for secondary science majors. Eight institutions identified a technological literacy course that was an option for general education as a requirement for the teacher education program (see Table 4).

Table 4
Technological Literacy General Education Courses

	Institutions with Technological Literacy General Ed Courses		Optional to fulfill General Ed Requirement		Optional, Required of Education Majors		Requirement of the Institution	
	#	%	#	%	#	%	#	%
Education Majors except in Science	80	32%	76	31%	8	3%	4	2%
Science Education Majors*	38	15%	34	14%	2	1%	4	2%

* Including elementary science specialization

Research Question 2

Are technological literacy courses used to fulfill program requirements for K-12 education majors at 4-year, accredited institutions? For this question, technological literacy courses were identified as either an option or a requirement for the education majors at the institution. The analysis of the course catalogs identified 46 institutions that included technological literacy courses to fulfill program requirements for K-12 education majors. There were 27 institutions that included technological literacy courses in elementary education, 19 of which were required courses and eight were offered as an option. For secondary education majors, 29 institutions used technological literacy courses to fulfill program requirements. In addition to the course titles found for general education, some of the course titles required for education majors included Critical

Literacies in Childhood Education, Teaching Mathematics, Science and Technology, and Science and Technology. Table 5 shows whether the technological literacy courses were used as a requirement or an option for each of the education majors included in the study. The total number of courses listed in the table does not equal the number of institutions because an institution may have had more than one major with a technological literacy course requirement or option.

Table 5

Technological Literacy Courses in Teacher Education Institutions, N=248

	Required		Option to Fulfill Requirements		Totals	
	#	%	#	%	#	%
Institutions with Courses in Both Elementary and Secondary Majors	6	2.42%	2	0.81%	8	3.23%
All Majors	2	0.81%	1*	0.40%	3	1.21%
Specific Majors	4	1.61%	1*	0.40%	5	2.02%
Just Elementary Majors	12	4.84%	6	2.42%	18	7.26%
Generalist	10	4.03%	6	2.42%	16	6.45%
Specialists	2	0.81%	0	0.00%	2	0.81%
Just Secondary Majors	14	5.65%	6	2.42%	20	8.06%
All Majors	4	1.61%	1	0.40%	5	2.02%
Specific Majors	10	4.03%	5*	2.02%	15	6.05%
Totals	32	12.90%	14	5.65%	46	18.55%

* Institutions that had a major with a requirement and a major with an option were included in the option column.

Research Question 3

Do the required technological literacy courses focus on the development of broad technological literacy awareness or is the focus on learning how to use instructional methods similar to those used in technology education activities? The analysis for this question differentiates between technological literacy courses that focus on the nature of technology and/or the relationship of technology and the subject content referred to here as technological literacy awareness. Technological literacy courses that focused on the use of technology education activities as an instructional strategy are referred to as instructional methods. Of the 46 institutions identified as having technological literacy courses as part of the requirements for the K-12 education majors, 34 required broad technological literacy awareness courses such at Science, Technology, and Society. Sixteen institutions included broad technological literacy awareness courses as an option. Instructional methods courses, such as Methods for Teaching Math, Science and Technology, or course descriptions for methods courses that included “the use of robots”, “creating maps”, and “building models” were required by 19 institutions and were options at three institutions. The total of these is greater than 46 because there were 11 institutions that required courses that address both technological literacy awareness and instructional methods. Most often, these were a single course for elementary education majors such as Critical Literacies in Childhood Education or Elementary Education taught by a technology education department. There were instances where two courses, one of each type, were required. Table 6 shows the number of programs that had either required or optional courses for each of the three variables (Technological Literacy Awareness, Instructional Methods, or Both).

Table 6

Types of Technological Literacy Courses

	Technological Literacy Awareness		Instructional Methods		Both	
	#	%	#	%	#	%
Required	23	9.27%	8	3.23%	11	4.44%
Elementary Programs	6	2.42%	4	1.61%	8	3.23%
All Majors	4	1.61%	4	1.61%	7	2.82%
Specific Majors	2	0.81%	0	0.00%	1	0.40%
Secondary Programs	17	6.85%	4	1.61%	3	1.21%
All Majors	3	1.21%	1	0.40%	0	0.00%
Specific Majors	14	5.65%	3	1.21%	3	1.21%
Optional	14	5.65%	1	0.40%	2	0.81%
Elementary Programs	7	2.82%	1	0.40%	2	0.81%
All Majors	7	2.82%	1	0.40%	2	0.81%
Specific Majors	0	0.00%	0	0.00%	0	0.00%
Secondary Programs	9	3.63%	0	0.00%	0	0.00%
All Majors	1	0.40%	0	0.00%	0	0.00%
Specific Majors	8	3.23%	0	0.00%	0	0.00%
Total Institutions	30	12.10%	6	2.42%	10	4.03%

Research Question 4

What, if any, are the differences in K-12 education majors in requirements for technological literacy courses? The focus of this question was to determine if there were differences between the education majors of elementary education, English, social studies, mathematics, and science for required or optional technological literacy courses. A chi-square analysis of the sample of 248 course catalogs with separate categories for required and optional courses did not contain enough expected frequencies in the optional category for a valid test (Patten, 2007). A chi-square analysis that removed the optional courses from the sample resulted in χ^2 (5, N=229) = 6.94, p. < .05 and is not considered statistically significant. A third chi-square analysis was conducted on secondary education majors, χ^2 (3, N = 36) = 15.33, p, < .05. The findings show statistically significant differences among the secondary education majors included in this study.

Elementary education had the largest number of programs with required or optional technological literacy course requirements with 19 required courses and eight with optional courses. Secondary science had 21 programs that include technological literacy courses as part of the requirements with 15 required courses and six optional courses. The rest of the secondary education majors had 14 programs that included technological literacy courses as part of the requirements. This includes the four institutions that required technological literacy courses in all other secondary education programs (including science) and the one institution that provided a technological literacy course as an option in their requirements. Secondary English, except when required by all secondary education majors, had no programs with requirements for technological literacy courses. There were no differences for the course titles that addressed broad technological literacy in the secondary education majors with titles such as Science, Technology and Society, and Technology and Society common throughout. The instructional methods course titles included Teaching Math, Science and Technology, or a description in the methods course that addressed technology education activities. See Table 7 for the complete analysis of the number of programs with required or optional technological literacy course requirements.

Table 7

Comparison of Technological Literacy Courses by Education Major

	Required		Option		Totals	
	#	%	#	%	#	%
Elementary Education	**19**	**7.66%**	**8**	**3.23%**	**27**	**10.89%**
Elementary Generalist	16	6.45%	8	3.23%	24	9.68%
Elementary English		0.00%		0.00%	0	0.00%
Elementary Social Studies		0.00%		0.00%	0	0.00%
Elementary Mathematics		0.00%		0.00%	0	0.00%
Elementary Science	3	1.21%		0.00%	3	1.21%
Secondary Majors	**9**	**3.63%**	**5**	**2.02%**	**14**	**5.65%**
In All Secondary Subjects*	4	1.61%	1	0.40%	5	2.02%
English		0.00%		0.00%	0	0.00%
All Social Studies	3	1.21%	4	1.61%	7	2.82%
Mathematics	2	0.81%		0.00%	2	0.81%
Science Majors	**15**	**6.05%**	**6**	**2.42%**	**21**	**8.47%**
In All Sciences Majors	13	5.24%	4	1.61%	17	6.85%
Biology		0.00%		0.00%	0	0.00%
Chemistry		0.00%		0.00%	0	0.00%
Physics	2	0.81%	1	0.40%	3	1.21%
Earth Science		0.00%	1	0.40%	1	0.40%
Total	43	17.34%	19	7.66%	54	21.77%

Note: The findings for middle school and high school are identical, therefore are reported under "Secondary". There were no differences between social studies majors, therefore social studies are listed as one category. *Includes science majors.

Summary

The findings from the analysis of the course catalogs show that the technological literacy courses comprise a small part of the required curriculum for education majors in the United States. Fewer than three percent of the institutions required technological literacy courses for all education majors. Two percent of the institutions required the courses as part of the general education requirements, and fewer than 1% of the institutions required the courses of all the education majors included in the study. The findings for technological literacy course requirements for specific majors and institutions that did not require it of all education majors were slightly higher. Seven and two-thirds percent (7.66%) of elementary education programs required technological literacy courses, 6.05% of the science majors had required courses, and the remaining three secondary majors combined for 3.63% for required courses.

The comparison for the type of technological literacy course among technological literacy awareness, instructional methods, and institutions that include both of these types found that technological literacy awareness is the most common type of technological literacy course with 12.1% of the institutions including it as either a requirement or an option. Two and forty-two one-hundredths percent (2.42%) of the institutions included instructional methods courses in the teacher education requirements, primarily as a requirement. Four and three one-hundredths percent (4.03%) of the institutions included courses that focused on both technological literacy awareness and instructional methods with an overwhelming majority of these being requirements in elementary education.

A chi-square analysis was conducted to determine if there were statistical differences among the education majors for technological literacy course requirements. A statistical difference was found among the secondary education majors of English, social studies, mathematics, and science. Excluding the institutions that require technological literacy courses of all education majors, there were only seven programs outside of science that required technological literacy courses, three in social studies and two in mathematics. Five and two tenths percent (5.2%) of the institutions reviewed required technological literacy courses for all other science education majors with an additional two institutions requiring physics education majors to have technological literacy courses. Technological literacy courses were most common as either a requirement or an option for elementary education majors and science majors. Chapter V will provide a summary of the study and make conclusions based on the findings. Recommendations for practitioners and researchers will conclude the study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter provides a summary of the study, draws conclusions from the findings, and makes recommendations for education practitioners and policy makers as well as future researchers. The summary will review the research problem and review the needs and significance of the study. It will go on to review the population and methods and procedures used in completing the study. The conclusion section will review each research question and draw conclusions for that question based on the findings and the literature. Recommendations will be made for practitioners and researchers based on the conclusions.

Summary

The goal of this study was to determine to what extent technological literacy courses were required in K-12 teacher education programs at accredited education institutions in the United States. It specifically studied the opportunities for education majors to take technological literacy courses as part of general education requirements or as requirements in specific education majors. The study also investigated the types of courses that were available for education majors, and it made the distinction between courses that focused on broad technological literacy awareness or if courses focused specifically on technology education type activities as instructional methods. Finally, the study looked at differences between the K-12 education majors of elementary education, English, social studies, mathematics, and science concerning technological literacy course requirements.

The need for the study arose in large part from the National Academy of Engineering and National Research Council's *Technically Speaking* (2002). In it, the authors state, "The integration of technology content into other subject areas, such as science, mathematics, social studies, English, and art could greatly boost technological literacy" (Pearson and Young, 2002, p. 55). This study essentially tests the assertion that "schools of education spent virtually no time developing technological literacy in those who will eventually stand in front of the classroom" (p. 55). A review of the literature illustrated the importance of technological literacy in the 21st century, as well as the effectiveness of technology education design based activities as instructional methods. The review of the professional standards of the different academic areas demonstrates, to varying degrees, the belief that students need to study technology. The review of literature also demonstrated that there is confusion between technological literacy as a broad awareness of our technological world by *Standards for Technological Literacy* (ITEA, 2000/2002/2007), and *Technically Speaking*; (NAE & NRC, 2002), versus instructional technology which is limited to the study of computers and digital communication (ISTE, n.d.). This study works to understand the extent of the discrepancy between the professed goals and standards and the actual curriculum used in teacher education concerning technological literacy.

In this study, technological literacy is defined using the International Technology Education Association's *Standards for Technological Literacy* as "the ability to use, manage, assess, and understand technology. The technologically literate person understands in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and how it shapes society, and in turn is shaped by society" (ITEA, 2000/2002/2007, p. 9). *Technically Speaking* (2002) further develops technological literacy by identifying the dimensions of technological literacy as knowledge, ways of thinking and acting, and capabilities.

The study was limited to initial teacher education programs that are accredited by the National Council for Accreditation of Teacher Education and Teacher Education Accreditation Council. There are 697 programs that are accredited through these organizations. Out of the 697 programs, a random sample of 248 programs was created. A document review of the appropriate course catalogs for initial teacher preparation was conducted in order to collect the data needed to answer the research questions. The document review identified general education requirements and options for technological literacy courses, as well as requirements and options for these courses for the education majors included in the study. For each major included in the study, technological literacy courses were identified as either developing technological literacy awareness or instruction in the use of technology education type activities as an instructional method. Courses that included both of these aspects and programs that required a course for each of these aspects were also identified. Finally, a chi-square analysis was made to determine if there was statistical significance for the differences in the frequency of these types of courses for the education majors included in the study.

Conclusions

The following conclusions were drawn from the findings of this study and the literature. The goal of the study was to determine the extent of technological literacy courses in K-12 teacher preparation. A general conclusion was that there is very little exposure to technological literacy courses for perspective K-12 teachers. The review of literature suggested that this may be due in part to the confusion between instructional technology literacy and technological literacy (Dugger, 2007; Pearson & Young, 2002; Zuga, 2007). All teacher education programs require the acquisition of skills in computer use and instructional technology. This is in large part due to the inclusion of the International Society for Technology in Education (ISTE) National Educational Technology Standards in NCATE accreditation standards for all academic areas (Hinchliffe, 2003; Hofer, 2003). The following are the conclusions reached for each of the four research questions.

Research Question 1: *Are technological literacy courses a part of general education requirements for K-12 education majors at four year, accredited institutions?* Approximately 1/3 (80 out of 248) of the institutions in the sample included technological literacy courses as part of their general education requirements, but only four required students to take a technological literacy course. Seventy-six institutions included technological literacy courses as an option. Often these courses represented a science or a technology and society curriculum. When these courses were offered as part of a social studies requirement, they were usually one course from a large number of options. When this type of course was offered as a science requirement it was often excluded as an option for science education majors. This was the case in 42 of the 76 institutions that offer technological literacy courses for general education. The exclusion of science education majors from these courses contradicts the National Education Standards (NAS & NRC, 1996) and Benchmarks for Science Literacy (AAAS, 1993/2008) that call for the understanding of the relationship between science, technology, and society.

Research Question 2: *Are technological literacy courses used to fill program requirements for K-12 education majors at four year, accredited institutions?* Nearly 13% (32 out of 248) of the institutions required a technological literacy course in at least one education major, but further investigation of the requirements found that just one or two majors at these institutions included these courses. Only two institutions required technological literacy courses for all education majors, with one additional institution having a requirement for a technological literacy course in elementary education that was an option for the secondary education majors. It was less likely that technological literacy courses were offered as an option to fulfill education major requirements and more often were a requirement. The answer to the research question is that technological literacy courses are used to fill program requirements for a small percentage of the education majors. The findings suggest that when an institution recognized the value of the technological literacy course, they were more likely to make that a requirement.

Research Question 3: *Do the required technological literacy courses focus on the development of broad technological literacy awareness or is the focus on learning how to use instructional methods similar to those used in technology education activities?* Technological literacy awareness was identified as the focus of the technological literacy courses available to education majors at 40 of the 46 institutions that included these courses as part of their education major requirements. Instructional methods courses were used at 16 of the 46 institutions (10 institutions included both types of courses in the requirements). Technological literacy awareness courses were more likely to be found as part of the requirements for secondary education majors, while the distribution between technological literacy awareness and instructional methods was evenly represented in elementary education. Eight elementary education programs required a course that included instructional methods and technological literacy awareness content such as Critical Literacies or an Elementary Education course offered by technology education departments. Linnell (2000) identified five programs in the United States that required elementary education majors to take technological literacy courses and 10 institutions that provided these courses as on option. This study, using a sample that is approximately 1/3 of the population, found 18 institutions that required these types of courses for elementary education majors and 10 that provided them as options. This finding suggests there is a growing understanding of the value of these types of courses in elementary education.

Research Question 4: *What, if any, are the differences in K-12 education majors in requirements for technological literacy courses?* Technological literacy course requirements were found primarily in elementary education, with secondary science majors having the most courses requirements for secondary education majors. The value of elementary school technology education is described in the literature and the growing inclusion in elementary teacher education is described in the conclusion for Research Question 3. The analysis of the data obtained from the document review showed a statistically significant difference between the secondary education majors. This difference suggests that the relationship between technology and science is better understood at teacher preparation institutions than the relationship between technology and social studies, and that the relationship between technology and mathematics or English is very poorly understood. These findings are consistent with the literature (AAAS, 1993/2008; Foster, 2005; IRA & NCTE, 1996; NAS & NRC, 1996; NCSS, 2000; NCTM 2000; Newberry & Hallenbeck, 2002; NSTA, 2003). Technological literacy courses are most often found as a requirement or option for generalists in elementary education with a total of 24 programs. The review of the standards for each of the academic areas in terms of technological literacy is also consistent with the findings.

The standards for science teacher education clearly identify technological literacy as important and include the study of technology and the relationship with science (NSTA, 2003). This is further reflected in *Benchmarks for Science Literacy* with the chapter on "The Nature of Technology" (AAAS, 1993, pp. 49-52). There were 17 institutions that identified technological literacy courses such as Science, Technology, and Society as an option or a requirement for all science education majors.

The standards in social studies also discuss the importance of understanding the relationship between technology and society (NCSS, 1994; Foster, 2005). "Students will develop an understanding of the cultural, social, economic, and clinical effects of technology" and "Students will develop an understanding of the role of society in the development and use of technology," are two examples from the curriculum standards (Foster, 2005, p. 55). There was a total of seven institutions where technological literacy courses were included as part of the requirements.

The NCATE/NCTM standards for mathematics teachers describe the role of technology as a tool for teaching and understanding mathematics as opposed to the role of mathematics and technological literacy. Standard 6: Knowledge of Technology states, "Use knowledge of mathematics to select and use appropriate technological tools, such as but not limited to, spreadsheets, dynamic graphing tools, computer algebra systems, dynamic statistical packages, graphing calculators, data-collection devices, and presentation software" (NCTN. 2003, p. 2). The findings from the review reflect this with only two institutions requiring technological literacy coursework.

The National Council of Teachers of English standards also see technology as a tool for research and writing. "Develop proficiency with the tools of technology" (NCTE, 2008, p. 1) does not distinguish between the broader technology literacy and the ISTE definition, but the supporting literature focuses primarily on the use of computers and the internet (IRA & NCTE, 1996). There were no institutions, except for the four that required it for all secondary education majors, that require technological literacy coursework for secondary English majors. The professional standards in relation to technological literacy for all these academic areas were reflected in the findings of this study.

Recommendations for Practitioners

From the conclusions reached in this study, six primary recommendations for practitioners can be made. This includes:

1. The value of technological literacy and the relationship between technology and the academic subjects is well established in the literature (ITEA 1996; ITEA,

2000/2002/2007; Pearson & Young, 2002), as well as the important role that all K-12 educators have in developing technological literacy. The difference in the findings between secondary education majors suggests that the leadership at teacher preparation institutions does not fully understand the value of technological literacy and the relationship between technology and ALL of the academic subject areas. Professional subject matter organizations have developed goals and standards that address the need for technological literacy, and states have developed standards to ensure technological literacy is included in K-12 curriculum. Therefore, policy makers and implementers (e.g., administrators, program directors, deans, and teachers) need to work to identify and narrow the discrepancy between professional standards, state standards, and the curriculum in K-12 teacher education. The alignment of the curriculum to the standards is needed in order to develop technologically literate teachers.

2. The inclusion of ISTE instructional technology standards as part of NCATE program accreditation standards has resulted in virtually all accredited education programs requiring coursework in instructional technology. NCATE needs to include the broader technological literacy standards as developed by ITEA/CTTE in the NCATE program accreditation standards in order to develop technologically literate teachers. These expanded standards should be included in the TEAC standards as the two accrediting agencies adopt similar formats for accreditation.
3. The ITEA, the Society for the History of Technology (SHOT), and other professional organizations involved in the development of science, technology, and society curriculum should work together in lobbying state departments of education and

regional accrediting agencies to include technological literacy courses as requirements in general education.

4. The current confusion between technological literacy and computer and instructional technology literacy leads some to believe that science, technology, engineering, and mathematics (STEM) initiatives are addressing technology education through computer and digital communication coursework (Rose, 2007). The ITEA, working with the National Science Foundation, the National Academy of Engineering, and the National Research Council, improve their efforts at informing the larger education community as to the full nature of technological literacy as defined by *Standards for Technological Literacy* (ITEA, 2000/2002/2007) and *Technically Speaking* (Pearson & Young 2003).
5. The Council for Technology Teacher Education (CTTE) and its members need to work with other academic teacher educators for the development of technologically literate K-12 teachers. This effort should take place both on the organization to organization level as well as within the institutions. At the organization to organization level the CTTE should work to ensure that technological literacy is addressed in the professional development standards for teacher education preparation programs. At the institutional level technology teacher educators need to work with educators from the other academic areas and college deans to address strategies for the inclusion of technological literacy courses and/or content for the teacher education curriculum.
6. Policymakers at all levels of education should explore the work being done by the Children's Engineering Council and Technology Education for Children Council.

Children's Engineering Council (CEC, n.d.) is based in Virginia and is actively providing in-service teacher education for the use of technology education activities in an integrated curriculum. Their model of in-service teacher education at both their annual conference, as well as workshops at individual schools has had a large impact on the use of technology education activities for learning in all academic areas. The acceptance of these instructional methods grows exponentially as teachers experience the value of these methods firsthand. This model of in-service teacher education for the development of technological literacy and the use of these instructional methods should be adopted throughout the United States. Technology Education for Children provides educational resources, publishes *Technology and Children*, and holds workshops at the annual ITEA convention (TECC, 2005). The submission of articles and research concerning these activities to publications with a broader audience than *Technology and Children* and *The Journal for Technology Education* would help to develop a broader awareness of these activities. Table 8 presents a list of these recommendations as well as recommendations for additional organizations.

Table 8

List of Recommendations

	Organization(s)	Action	Goal
1	State Departments of Education, State Accredited Institutions for Teacher Education	Identify and reduce discrepancies between state standards and curriculum practices concerning technological literacy.	Align standards with practices.
2	NCATE	Include ITEA/CTTE technological literacy standards in the technology standards for program accreditation.	Accreditation standards that address the need for broad technological literacy.
3	ITEA, SHOT, and other professional subject matter organizations	Develop a partnership to promote technological literacy as a general education requirement.	Greater technological literacy for general education requirements.
4	ITEA, National Science Foundation, National Academy of Engineering, National Research Council	Increase efforts on educating the larger education community as to the full nature of technological literacy.	Reduce confusion between computer technology and technological literacy in STEM initiatives.

Table 8

List of Recommendations (continued)

	Organization(s)	Action	Goal
5	CTTE	Work with other professional academic organizations and institutions for teacher education for the development of technological literacy curriculum and opportunities in teacher education.	The development of technologically literate teachers.
6	Regional accrediting agencies	Include technological literacy courses as requirements in general education standards.	Technological literacy as a general education requirement.
7	American Association of Colleges for Teacher Education	Educate members as to the difference between ISTE standards for instructional technology and the ITEA standards for technological literacy. Work to promote coursework in both areas for teacher education.	The development of technologically literate teachers.
8	NSF, U.S. Department of Education	Fund research and initiatives for the use of technology education activities in integrated curriculums.	Improve understanding of technology education activities in relation to constructivist learning theory. Develop evidence to support the use of these activities in practice.

Recommendations for Researchers

This section will make four recommendations for further research based on the findings of this study and review of literature.

1. The National Science Teachers Association's standards for the inclusion of technological literacy are reflected in many state standards (NSTA, 2003). This study suggests that there is a discrepancy between the state standards and science teacher education curriculum based on course titles and course descriptions reviewed in this study. State-level studies that identify discrepancies between the state standards and the science teacher education curriculum are needed. These studies should also explore in greater depth the extent of which technological literacy is included in the teacher education curriculum through a document review of course material and data collected from science teacher educators.
2. Studies by Foster (1997, 2001), Parks (2004), Holland (2004), and others have identified the value of elementary school technology education. These qualitative studies show how technology education activities promote learning in an integrated curriculum that is consistent with constructivist learning theory. The value of elementary school technology education has a growing acceptance that is reflected in the number of technological literacy course requirements for elementary teachers. Similar qualitative studies are needed at the middle school and high school levels to show how using technology education instructional methods improve learning in an integrated curriculum.
3. Studies by Dyer, Reed and Berry (2006), Culbertson, Merril and Daugherty (2004), and Satchwell and Loepp, (2002) have shown a relationship between student

academic achievement and participation in technology education courses. Further research is needed to better understand this relationship. These studies need to address more than the value of technology education for the development of technological literacy, but also need to look at the relationship of the development of technological literacy and academic performance in other subject areas.

4. This study infers technological literacy of teachers by assessing the extent to which technological literacy courses are included in teacher preparation. Further understanding of the technological literacy of teachers should be addressed through the direct assessment of K-12 teachers with an inventory or survey instrument.

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Education

- Doctor of Philosophy: Education – Occupational and Technical Studies, Technology Education Emphasis, Old Dominion University, Norfolk, VA, 2009
- Master's of Science: Environmental and Technological Studies -- Technology Education Track, St. Cloud State University, St. Cloud, MN, 2006
- Bachelor of Elective Studies: Double major, Social Studies, Environmental and Technological Studies, St. Cloud State University, St. Cloud, MN, 2004

Relevant Work Experience

- 1983-1989, Instructor, United States Air Force
- 1993-2001, Technical Director, Education Outreach Program, Minnesota Opera
- 1999-2006, Technical Director/Auditorium Manager, Owatonna Public Schools (MN)
- 2004-2006, Graduate Assistant, St. Cloud State University
- 2006-Present, Graduate Teaching Assistant, Old Dominion University

Honors and Awards

- Nominated Outstanding Graduate Teaching Assistant, Old Dominion University, 2008
- Outstanding Technology Education Graduate Student, Old Dominion University, 2008
- Donald Maley Spirit of Excellence Outstanding Graduate Student Citation, ITEA, 2008
- Meredith Construction/Realty Scholarship, Old Dominion University, 2007

Professional Activities

- International Technology Education Association, 2003 - Present
- Technology Education for Children Council, 2003 - Present
- Virginia Technology Education Association, 2006 - Present
- Council on Technology Teacher Education , 2006 - Present
- Technology Education Collegiate Association, 2006 - Present
- Research Committee, Council on Technology Teacher Education, 2007 – Present
- Assessment Writing Group, Engineering by Design, 2008 - Present
- Minnesota Technology Education Association, 2003 - 2006