

ABSTRACT

SHATTUCK, DOMINICK C. Measuring the Relationship between Individual and Contextual Variables with Technology Implementation: Analyses of Year Three - IMPACT Project. (Under the direction of Denis Gray, Committee Chairperson; Jason Osborne, Jason Allaire and Roger Mitchell.)

The field of educational technology is continually looking to more precisely understand the relationship between leadership, technology-related beliefs, technology resources, supportive environment and technology implementation in classrooms. Previous research has identified relationships between these factors. However, the types of predictors examined, the quality of the dependent variables used and the sophistication of the statistical tools used have sometimes been lacking. This research evaluated these factors within the context of the IMPACT project a three-year technology-enrichment intervention. Utilizing the last year of the data from this project, this cross-sectional study used structural equation modeling (SEM) to investigate the causal relationship between leadership, beliefs, technology resources, supportive environment and technology implementation, which is divided into planning, instruction and student use in classrooms. Differentiating technology implementation is an important contribution of this research as previous studies focused on a particular technology and a specific type of application. We found that teachers' beliefs about technology had the strongest positive relationship with technology implementation. Leadership was found to indirectly influence technology implementation through teachers' their beliefs about technology. When developing technology based interventions, policy makers should include evidence of the technology's effectiveness to influence teachers' beliefs about that technology. This study provides a unique look at technology implementation using a large scale

intervention with a comparison group and differentiated forms of technology implementation.

Measuring the Relationship between Individual and Contextual Variables with
Technology Implementation: Analyses of Year Three - IMPACT Project

by
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DEDICATION

This dissertation is dedicated to three women and a country that helped me to mature, albeit begrudgingly sometimes: Marilyn Shattuck, Lela Breitbart, Kristen Shattuck and Ethiopia.

BIOGRAPHY

Dominick Shattuck was born and raised in Fitchburg, Massachusetts. His experiences varied from manual laborer, to school teacher, to scientist. In each position, he has found interest in the people he met and their communities. The Psychology in the Public Interest program at NC State provided the perfect fit of scientific foundation and interventions with social implication for Dominick's goals. Friends, teachers, coaches and family can claim stake in his success.

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A few paragraphs cannot adequately acknowledge the number individuals who supported me and influenced the completion of this dissertation. There are a few who had monumental influence in the completion of this degree.

One afternoon my wife and I sat to look at graduate school programs. At that time, I found it intimidating to leave my job as a teacher and enroll in school for the first time in over 10 years. Kristen didn't see this as a problem. She convinced me that I was ready and encouraged me to figure out exactly how to make graduate school a reality. And she was right. Since enrolling at NC State, her support has been essential and it enabled me to complete this program. During this time, we did not let life outside of academia stop. The recent years have been a whirlwind of growth: marriage, trips overseas, two houses, two kids and two dogs. Kristen also had to endure my intermittent stress about SAS coding, deadlines and learning how to become a student all over, all again. Simply put, this dissertation is as much a reflection of her sacrifices as my own.

Unbeknownst to them, my daughters, Harper and Marney, have given me the additional push to complete this dissertation and reminded me that life shouldn't stop for graduate school. I'm looking forward to not having to think about this document in the evenings or on the weekends. I couldn't imagine having a better reward than more time to spend with you both to watch you grow into beautiful intelligent women.

My committee members provided me with encouragement and support throughout my graduate school experience, the dissertation process and into a professional career.

During graduate school each of these individuals was accessible to discuss my questions about academia, or personal concerns. Working with Dr. Allaire provided me with a statistical foundation and sounding board for the decisions in this dissertation. His ability to explain processes and procedures using language that was easiest for me to understand enabled me to utilize the statistical concepts in this document. Dr. Mitchell's health education course and discussions about the course materials helped to steer me into my present professional career. Other conversations about Manny Ramirez and the Red Sox, road races and life outside of school helped me to understand the balance that is needed to succeed in multiple environments. Dr Osborne provided me with the opportunity to use the experience that I had coming into graduate school (education/teaching) in a research setting. This change of gears enabled me to make the transition within a setting that was extremely familiar. Most importantly, the position allowed me to make mistakes, figure them out with Amy Overbay and learn from them. Writing my dissertation on data collected from that project was important for my success in graduate school.

Last, I realize that Denis Gray, PhD, may have stepped out on a limb to enroll me into this program. I also realize that one reason he may have done this was to end the barrage of phone messages and forced appointments I generated prior to my admittance. Before starting at NC State, I remember knowing that this program was the proper fit for both my interests and experiences. I felt and still feel that it was a once in a lifetime chance for me to make the move away from the classroom and begin a second career. Fortunately, not just the program, but also the advisor was a perfect fit. Thank you Dr. Gray. I hope that later in my life, the classroom calls me back.

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PRESENT STATE OF TECHNOLOGY IN AMERICAN SCHOOLS

John Dewey proclaimed that schools are dynamic social institutions, which are asked to provide students with “a process of living and not a preparation for future living” (Dewey, 1897). This seamless transition from educational setting to adult life requires the ability to problem solve in multiple areas as well as utilize tools necessary for success. Recently, computers, the internet and several technology-based “gadgets” have become the hard-technology tools that many legislators, administrators and teachers are attempting to incorporate into classroom curricula to facilitate Dewey’s process of living.

Related to this challenge, recent findings by the US Department of Education (2003) stated that 91% (53 million) of children in nursery school through grade 12 use computers and 59% use the Internet. They reported that students’ use of technology begins early in their academic careers, as 80% of kindergarteners and 97% of students in grades 9-12 use computers and large proportions of these students use the Internet. Investigating the role of schools as it relates to the students’ technology capacity, this report states that schools help bridge the digital divide that finds most minority students unable to access computers. Furthermore, about 46% of students use the internet to complete school assignments. These statistics reveal that computers and the internet are two instructional technologies that are already used by many American students.

The relevance of technology resources and their implementation in schools is far-reaching. The federal No Child Left Behind legislation (Education, 2000) mandates technology literacy for students and calls for more empirical methodologies when

designing school research projects. States have addressed technology education by providing resources in the form of technology, manpower and training for teachers at various rates, but the effects of these initiatives are far from conclusive.

In an attempt to clarify the scope of the issue of technology education, Meade & Dugger (2004) conducted a national survey to assess the efforts of state legislatures. Using a sample of all fifty states and the District of Columbia they distributed a four question survey to state supervisors regarding how they account for technology education within the framework for their state. The results revealed that thirty-eight states are including technology in their state educational framework (up 8 states from 2001) and five of those states indicated that technology education was part of a career preparation framework. Five other states indicated that technology was delivered to students as part of core subject classes. In a change from a 2001 survey, the researchers found that all fifty states responded that technology education was a requirement (or that the requirement is pending) for their students either at the state level or within their local school administrative area.

The integration of technology into the state policies reflects the rising value that is being placed on technology within schools, but other data point to factors that may complicate the process of successfully integrating technology into school curricula. Meade and Dugger (2004) also addressed the application of national technology standards with state supervisors. Their results show that forty-one states are using

standards¹. However, Meade and Dugger (2004) also looked at the number of technology education teachers within each state and found that there was a decrease across the nation when comparing their data with findings from other recent surveys. They did not speculate on the reasons behind this decrease, which could stem from a reprioritization of personnel within schools.

The complex nature of the value of technology in schools can also be underscored by examining the resources actually available to teachers and students across the US. The May, 2004 issue of Education Week (edweek.org, 2005) reported that across the U.S. for every one school computer connected to the internet, there are 4.3 students. At the classroom level, that number increases to 8.4 students for every computer connected to the internet. This difference is likely attributed to computer labs in the US schools that are used by classes or groups of students at a time and teachers' computers. They continue to report that 92% of the schools in the US have internet access and of those schools 74% of the teachers use the internet for instruction. These rates further emphasize the importance placed on computers and technology within schools by shedding some light on the resources allocated, but they do not reflect the entire picture of technology usage. Despite the seemingly high rate of technology availability, Peck, Cuban and Kirkpatrick (2002) reported that in 1999 the typical teacher provides students with fewer than 10 opportunities to use computers during a school year.

¹ These standards are either the adoption of Standards for Technology Literacy (ITEA, 2000/2002) or the application of standards developed from this basis

The mosaic of research surrounding implementation of technology in schools has been developing, but with a number of caveats. Currently, the available research has investigated smaller-scale initiatives, and has been fragmented by a narrow focus. Also, research-design variability makes it difficult to apply findings across environments. These differences have limited our understanding of the process related to technology adoption and implementation in schools.

Research conducted on this topic diverges into several areas. Some researchers have investigated Instructional Technology (IT) in-general, looking at the overall impact of various technological interventions in schools and attempt to quantify their effects on achievement. Other researchers drilled down to understand the integration of a particular technology on the performance of students who used that technology. There are also researchers who are interested in not only students' access to technology, but how teachers integrate various technologies into their curricula and what processes are more effective. This variation in the literature leaves the field of educational technology research without a clearly agreed-upon operational definition of technology (also called Information Technology – IT).

IT is defined in different ways, depending on the aims of the research. In this study, the researcher has elected to use the Commission on IT's (1970) definition of what this term entails:

...the media born of the communications revolution which can be used for instructional purposes along side the teacher, textbook, and blackboard...[as well as]...a systematic way of designing, carrying out,

and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communications, and employing a combination of human and nonhuman resources to bring about more effective instructions. (p. 27)

This study uses a more comprehensive definition of IT because the literature reviewed below reveals that there is a great degree of disparity with regard to the precise nature of this term. Following the development of research in IT over time this definition may need to change, but the realities of the interplay between technology, instructional methodology and student perceptions of technology need to be considered when re-defining this term. This is an ever evolving process as technology rapidly advances and becomes more interactive, more interconnected and more accessible.

Earle (2002) suggested that “the prevailing public perspective incorporates IT as a synonym for computer technology.”(p. 33). He continued by comparing the present push for IT to the federal funding of televisions for schools (40 years ago) and how little attention was paid to instructional design and technological processes. A review of the literature reveals that IT scholars and practitioners have battled the conceptual separation between technology and the process of its implementation, but have failed to effectively measure the outcomes associated with technology-enriched instruction. Literature presented below provides some insight on how the relationship between technology and student achievement has been debated through the measurement of achievement and technology integration.

The body of literature surrounding IT also varies considerably in the technology policies it promotes, with some variation occurring across studies that provide anecdotal evidence (but lack structured investigation) and research performed in a structured manner. One way in which to get a better understanding of this literature is through the review of meta-analyses. Below, several of these literature syntheses and one national study are reviewed to provide a broad understanding of the relationship between IT and student achievement.

Achievement

Early efforts to measure student achievement gains focused on three things: students' access to technology, students' motivation to engage in the learning process and teachers' perceptions of student gains (Earle, 2002). Critics of this process (Trotter, 1997) argued that the technology provided no guarantee that students' achievement levels would increase, or that there was a great deal of variability in the results from these studies (Viadero, 1997). More recently, examples such as Valdez, McNabb, Foertsch, Anderson, Hawkes, & Raack (2000) suggest that student achievement is enhanced in several ways when technology is appropriately integrated into the curriculum. Despite the debate on the effect of technology integration, these issues are seldom investigated with scientific rigor.

Another question that has surfaced in the literature surrounding IT is whether achievement measures appropriately measure change as it relates to technology.

Standardized test scores have become subject to various criticisms by teachers and school administrators for their lack of depth and inability to capture a true reflection of the students' levels of achievement. The criticisms of these tests as they relate to IT are no different. McNabb, Hawkes and Rouk (1999) argued that standardized tests fail to measure levels of creativity and critical thinking that students develop through their technology use. These authors contend that the added complexities of technology-based learning were not measured by current standardized tests. Missing these integral elements of the learning procedure created a devaluation of the process that students experienced through learning with technology. Furthermore, students who were learning through the utilization of technology were at some disadvantage when forced to complete a paper and pencil version of a standardized test (Russell, 1999). This inability to accurately measure achievement is a disservice to the efforts of teachers who have repeatedly reported large gains in the levels of student interest and attitudes toward lessons enhanced through the use of technology.

One consideration of IT and its integration into curricula is the level of active involvement that students have with the technology as opposed to the orchestration of technology performed by their teachers: does integrating IT into classrooms refer to students' use of technology, or the way that the classroom experience is mediated through a teacher-led presentation of content via IT? Identifying what a particular IT requires of students and teachers is important in proceeding with research in this area. As mentioned above, some applications of technology can provide students with new and unmeasured competencies while others applications, such as rudimentary application of an interactive

whiteboard, simply require students to passively receive information. Defining effective integration will be important for the field of research. This study tests the relationships between contextual factors and technology implementation, which includes teachers' behaviors specific to the following three areas planning, material creation, and student use of technology.

Richard Clark (1983) provided an early analysis of literature in the field of IT. His focus was to summarize the research (meta-analyses and current research) surrounding the effectiveness of various educational media. Clark wrote that previous research showed marginal positive effects for different media. His review led him to conclude that the novelty of the medium and the variation of instruction are what account for the existing evidence for the effects of various media on learning gains. In his own words, Clark states, that "...it was not the medium that caused the change but rather a curricular reform that accompanied the change. The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445).

Clark argues that there are natural differences in the method in which content is delivered across classrooms in the studies included in the meta-analyses and this confounding factor inflates effect sizes. Furthermore, he suggests that the novelty of the medium, whether television or computer assisted instruction, diminishes over time. He advises strongly against future media comparison research stating that researchers confuse medium with method of instruction. Clark mentions how public expectations of

media [technology] are a driving force behind any and all school improvements which makes it difficult for schools to turn away from adopting these new technologies.

During the late 1980s, two meta-analyses were performed on the topic of Computer Based Instruction (CBI), which was used to supplement more conventional teaching methods in some schools (Kulik & Kulik, 1991; Kulik, 1994, as referenced from Schacter, 1999). This form of IT was envisioned as a method to reduce costs within schools and provide every student with personal interactive attention. These studies are frequently cited in the literature in support of various instructional technologies.

The first meta-analysis (Kulik & Kulik, 1991) found an overall moderate effect size of .30 with variation in this effect size when looking further at details of the studies involved (published/not published, variation in the instructor, length of study). The second study (Kulik, 1994, as cited in Schacter, 1999) improved upon the initial meta-analysis by including 500 studies (from 254), but it did not provide increased support for this form of IT². Results were reported in the form of percentile gain on tests of achievement (not certain how consistently achievement was measured) from 50th to 64th (this number is down from 66th percentile in the 1991 study).

Kulik & Kulik (1991) describe situations in which CBI was appropriately compared to typical instruction at the beginning of the article. The authors put forth parameters for the articles used in their reviews, demanding that there be an actual comparison between a CBI class and a conventionally taught class, an appropriate rate of attrition, and fair teaching by instructor. The authors also mentioned their consideration

² I focused on the Kulik & Kulik (1991) article because I didn't have access to Kulik, (1994).

of sampling differences between comparison groups, but provide little further detail on this issue.

Due to the nature of the literature reviewed, they measured attitudes toward computers as well as student achievement. Yet the task of measuring student achievement was challenging for the authors because of the lack of consistent procedures. They concluded that to include a study as measuring achievement it would simply need to provide quantitative results. They do not mention the inclusion of a pre-score for students or any type of measurement that would imply comparative growth between the groups. Instead, using the procedures of meta-analyses, outcomes were re-coded as effect sizes (they calculated the difference between the mean scores for the two groups divided by the standard deviation of the control group). Kulik and Kulik (1991 & 1994) used a large body of literature to show that there was a moderate effect of CBI technology and as a result this article is cited frequently through the literature and meta-analyses as an early example of the relationship between IT and student achievement, albeit a minimal effect and one that is frequently questioned on the grounds of research methodology.

Both Kulik and Kulik (1991) and Clark (1983) provided examples of the fishbowl effect, which plagued the implementation of instructional technologies in its infancy. Criticisms have always been plentiful for interventions that come with a high price-tag and may (depending on the measure) only provide minimal results despite the cultural push to use them in schools. This conundrum persists today as researchers of educational technology face the same challenges of appropriate measurement of outcomes, lack of

random assignment for groupings and the suggestion that findings are ungeneralizable, not to mention the social pressures of our culture and the challenge of being current in the rapidly evolving world of technology.

One comprehensive study of the effects of technology, in general, was provided by Sivin-Kachala (1998, as cited in Schacter). Using 219 studies from 1970-1990, he made a general assessment of technology across school domains. He found that students in technology-rich environments experienced positive effects in all subject areas through all grade levels and including special needs children. This article and Kulik and Kulik (1991) provide an attempt at developing an all-inclusive approach to meta-analyzing articles.

A comparison of nearly 200 articles was conducted by Waxman, et al. (2003) to examine the relationship between IT and student achievement. Using a rigorous method of article identification and qualification, only 42 articles were included in their final synthesis. Despite their efforts, they stated that the studies included had a large difference in their definition of technology and their measures used to assess student achievement. Their overall effect size was .41 (CI .18 - .64, $p < .05$) indicating a small positive effect (Cohen, 1988).

The Waxman et al. review attempted to apply five comprehensive standards of technology application that are related to dramatic improvements for education of all students: joint productivity, language development, contextualization, challenging activities, and instructional conversation. Unfortunately, there was not enough consistency in the literature to support the application of these categories. Instead, the

authors were limited to categorizing studies by whether they influenced cognitive outcomes, affective reaction to technology, or changed student behavior as when using technology. The effect sizes for each of these categories were as follows: Cognitive (ES = .45), Affective (ES = .46), Behavioral (ES = -.09). Their efforts showed that technology improved cognitive and affective outcomes, but that behavior was negatively influenced.

The article identification and elimination procedure performed by Waxman et al. (2003) provides evidence of the variety of objectives and methods that can be taken by researchers. Limitations related to research within educational settings fall solely on the researchers' shoulders. Working within school settings, teachers and administrators may perceive their efforts as disruptive to school activities, creating additional burden to teachers and potentially compromising the confidentiality of student grades/scores. Addressing these concerns creatively may enable researchers to implement more appropriate designs and provide results that are more generalizable. Lewis (1999) suggested that to provide better research methodology in IT literature, teachers would have to be "encouraged to be researchers in their own right, or collaborators in research." He continued to imply that research in this field must employ the paradigm that can best answer the questions that need to be answered using creative methods. Although some researchers may not enthusiastically support Lewis' notion of teachers becoming researchers, his call for creative efforts to improve the field of literature is both reasonable and necessary.

Over the last twenty years the state of educational technology has evolved, but more effective means of implementation have not developed at the same pace. Cuban (1999) concludes that the advice from experts in the field is contradictory and changing with the latest and greatest advancements in technology. Technology implementation is a pressing issue, but previous research focus, sampling issues and the designs often limit the ability to generalize the findings.

The role of teachers within technology-rich classrooms was elaborated on by Becker (1999) who found that teachers who implement technology more frequently are more likely to fit a constructivist methodology (see Vygotsky, 1978). He presented a relationship between teacher attitudes toward Internet resources, the school's phase of integrating resources, and subject taught. Becker's approach to this area of interest was to pair the idea of technology implementation with the teacher's use of constructivist methodology.

Implementing a constructivist methodology in a classroom requires teachers to take into consideration the interests of students when developing lessons, enabling a number of activities to occur at the same time within a classroom and facilitating group work that encourages personal experiences and opinions. Alone, constructivist methodologies require a great amount of planning time and effort. Becker examined whether there were links between teachers using this methodology in conjunction with higher computer usage rates.

Looking at 152 schools within the National School Network he found relatively more technology than in average schools, more participation in technology initiatives

developed within the schools and more schools that had a climate that supported curricular and instructional change. Becker (2000) sampled 441 teachers and found that teachers who reported regular use of computers with students over a three year period were almost twice as likely to report having made constructivist-oriented changes in their practice as were teachers who did not use computers. These findings imply that using computers in the classroom promotes more constructivist activities.

Becker (2000) also mentions that where teachers are personally comfortable and moderately skilled with computers and provided ample time and resources, computer activities flow seamlessly alongside other learning tasks and are becoming a valuable and well-functioning instructional tool. At the same time, Becker's research supports the idea that technology is being implemented at generally low levels across school subjects and with inconsistent methodological support.

Summary

This review of key research and meta-analyses of IT provide evidence of the limitations and strengths of the field. The low to moderate effect sizes of the meta-analyses reviewed above support Clark (1983) and Valdez et al.'s (2000) assumption that the effects attributed to technology may need further clarification. The influence of clarifying methods in the literature was only provided in a small number of generalizable articles included in Waxman et al.'s (2003) meta-analysis (42 articles). Considering general changes in pedagogy over time in combination with the influx of various

educational technologies, measuring teaching activities is like attempting to hit a moving target.

Previously, pedagogical practice was centered on teacher-based activities. Today, with the increasing procurement of computers and internet access, technology-driven activities in schools are changing the role of the teacher. Regarding this general relationship, Tornatzky and Fleischer (1990) wrote, “The balance of physical and behavioral elements in any given technology is subject to readjustment.” This evolution requires teachers to integrate the internet and new technologies into classroom activities as well as redefine their role in the educational process. This reevaluation influences the level of teachers’ commitments and is reflected in their attitudes toward the technology.

In an attempt to show the relationship between teacher and technology, Zhao and Frank (2003) explain the communal benefits of technology integration at the teacher and student levels:

When a teacher uses computers for her own purposes it benefits her directly at the micro level as an organism, perhaps making her more efficient or engaging her interest. On the other hand, students are the common resource of the system. Thus, when a teacher facilitates student uses of computers, she contributes more directly to systemic value, which may have less direct and immediate personal benefits...student uses benefit everyone in the school, whereas teacher uses benefit the individual teacher. (p. 814)

Considering instructional technologies in a more systematic manner, this field of research would benefit from revisiting previous discussions about what qualifies as IT. As research in the area evolves and the technologies show increased capacity to connect and interact, the definition of what qualifies as IT may change. Ideally, this change will be accompanied by changes in effective teaching as was found by Becker (1999). Overhead projectors or filmstrips, tools that were once considered advanced, are now disregarded in this field for more state of the art interactive technologies such as hypermedia and simulation programs for students. Revisiting the definition of IT enables researchers to provide more appropriate expectations of what the technologies should entail when properly integrated. When this has been accomplished, the technologies can be assessed for their effectiveness. Until the terminology is discussed and generally agreed upon the field will continue to draw conclusions from blanket definitions and include inappropriate technologies and teaching strategies in its assumptions.

Developing an appropriate definition for IT will enable researchers to then evaluate the technologies in a more systematic and generalizable manner. Of course educational research will be challenged by typical hurdles such as budget constraints and enrollment of appropriate control groups, but a more standardized definition of the technologies will provide two things for this field of research. First, it will foster debate about what qualifies as technology. Identification of various instructional tools as technologies and gradating them will enable researchers to measure the difference between novelty and capacity building through true technology/student interaction. Although the novelty of some technologies will fade (i.e., overhead projector, basal

readers) their interaction capacity with students may remain the same. Explaining how and why technologies are more in vogue with students will begin to assist in identifying Clark's (1983) attribution of novelty.

Second, a more appropriate definition of IT will assist in more effectively identifying the teaching activities accompanying each technology. This will result in a more holistic approach to researching IT. This development is necessary, because few studies actually measure change in teachers' behaviors before and after the arrival of a technology.

Educational technology has merited a great deal of attention by academics, legislators, parents and school administrators. As this field develops, our understanding of it becomes more fragmented as a result of the assortment of research designs used and increasing pressures put on schools to show tangible outcomes related to the financial commitments within school budgets. Cuban (1985) refers to the issues surrounding technology education as the acknowledgement of a *practical dilemma*, which forces teachers, administrators and parents to look at the choices before themselves and decide how to strike a balance with this change. Without focusing on the activities of teachers within their classrooms and the ecological levels within schools, the research will not synthesize all pieces of the puzzle (Lim, 2002). This cross-sectional study will make both individual and contextual comparisons in technology implementation between a group of North Carolina teachers who have been experiencing a large scale technology intervention and a group of teachers with standard access to technology across the state of North Carolina.

LITERATURE REVIEW

Implementation of physical technologies comes with social-structural considerations. The process of structural reorganization for an innovation facilitates the embedded use of technology within a school and is reflective of both the technology itself as well as the changes in social networking (Cooper, 1998; Damanpour, 1987; Tornatzky and Fleisher, 1990). Becker and Ravitz (2001) predict that computers' importance will rise over the next ten years, yet the method of integrating technology into school curriculum is a complex, poorly-understood undertaking (Cooper, 1998). Ten years ago, mainframes, school websites, and web-quests were not issues that school administrators and district heads considered, but today they are asked to integrate visionary technology policies with curriculum initiatives to continually replenish the supply of infrastructure for their schools. In conjunction with the reconfiguration of school-wide policies is a procedural change in the classroom.

Previously, pedagogical practice was centered on teacher-based activities. Today, with the increasing availability of computers and internet access, technology-driven activities in schools are changing the role of the teacher, which parallels scholarly advocacy for student-centered learning approaches. Regarding this general relationship, Tornatzky and Fleischer (1990) wrote, "The balance of physical and behavioral elements in any given technology is subject to readjustment" (p. 17)? This evolution requires teachers to integrate the Internet and new technologies into classroom activities as well as redefine their role in the educational process. This reevaluation influences the level of teachers' commitments and is reflected in their attitudes toward technology.

To establish an understanding of the literature centered on the relationship among teachers, their attitudes toward technology, and their level of technology implementation, electronic databases were employed extensively. In October of 2007, three databases, ERIC, PSYCH INFO, and Web of Science, were used to search for relevant articles using combinations of five keywords: “teachers,” “attitudes,” “technology,” “computers,” and “implementation.” Initial results from this search included a large number of studies related to the keywords in various ways, but only a limited number of studies directly relevant to the topic of interest. Empirical studies were later evaluated to include a treatment group of teachers and an evaluation of technology implementation.

As mentioned above, there are myriad subtopics associated with this process, and with this diversity comes a vast array of research methods. Included below are articles that describe and assess technological interventions. The articles discussed in the following review were organized around two criteria: first their methodological strengths, and second, their relationship to the variables that will be tested in this study. Generally, the studies found for this literature review did not provide strong examples of optimal research design. The designs of the studies vary in their data collection methods, but all are descriptive analyses. Below, seven of the thirteen study designs are cross-sectional. Six of the studies are prospective examinations of a group that has received one of many technological interventions. One of these prospective studies makes comparisons between the treatment group and other groups who received a lesser technological intervention. Therefore, the studies have been organized to represent their academic rigor

in combination with their relevance to this study's objectives--measuring technological implementation in classrooms.

As a result, the first section of this literature review focuses on the research that investigates technology implementation in general as well as looking at the role schools' leadership plays in this process. Studies emphasizing educational technology training and beliefs about technology are presented next. These studies suggest that teachers who received appropriate training are likely to change their beliefs about technology. Third, studies that have implementation as an outcome variable are presented. These studies examine the relationship between the dependent variable (technology implementation) and independent variables such as access to technology, teachers' openness to change, contextual factors, perceived usefulness, supportive environment, and training.

Technology Implementation & Leadership

Leadership is often cited as a critical factor in the success or failure of technology interventions. Given this fact, journals focusing on the role of leadership in education were included in this literature review. In fact, the journal "Educational Leadership" was independently searched using the following terms: "technology" and "empirical." This effort resulted in one article, "Let's Test the Power of Interactive Technology" by Alfred Bork (1986). Bork's article discusses methods for investigating the possibility that computer technologies can improve education in the US. One point that is made in this article is that an empirical approach should be used for these purposes. This theme is common in much of the educational technology literature in general and as stated above,

the grant that funded the IMPACT intervention was based on these principles: Title II D of the No Child Left-Behind Act (Education, 2000).

The search undertaken for this study did provide one article that was helpful in providing a description of what contributed to some teachers learning about a particular technology. Using the qualitative grounded theory approach to data collection, Granger, Morbey, Lotherington, Owston and Wideman (2002) used interview data from personnel at all levels (administrative, teachers, students) of four schools to identify factors that contribute to Information and Computer Technology (ICT) implementation. Specifically, this research focused on two questions: What factors contributed and deterred teachers from implementing ICT? How did teachers interact with ICT in practice?

Initially, researchers began performing interviews at sixty schools across Canada, but for the purposes of this paper selected only those schools which were engaging in innovative practices. The final four schools provided two learning environments qualified as having large English as a Second Language (ESL) populations. Each school began instruction in Kindergarten and their populations were similar, but the top grades in each of the schools were not consistent (5, 6, 8, and 9). It was assumed that different ages of student populations will provide unique challenges related to technology implementation and appropriateness of technology.

Qualitative codes were developed from three main coding stems: Ways of Learning, Individual Characteristics, and Environmental Factors. Ways of Learning was defined as both formal and informal learning opportunities. Individual Characteristics incorporated educational background, experience, technology skill levels, beliefs and

goals, and resistance to technology. Environmental Factor codes were attributed to those structural elements such as logistics of time and resources, community climate (as it relates to the teacher administrative relationship, and teacher student/parents relationships).

Granger, et al. (2002) found that when logistical organization is lacking, implementation is hard to achieve for teachers. Time and technical expertise were two specific logistical considerations identified by the participants in this study. Teachers said that it was helpful to have the freedom to explore new lessons within a relaxed atmosphere in which they could take risks with the delivery of their subject matter. Administrative roles were cited as providing access to situations where teachers could collaborate on lessons, especially when the administrative team (particularly principals) had a clear goal, or “vision” about technology use within their school.

The authors suggested three necessary conditions for ICT implementation: first, teachers must have access to technological resources, which includes technical support to trouble shoot problems that may arise. Second, there must be a clear and stated commitment from administrative team leaders and teachers within the school to implement ICT methods. This includes the opportunity for teachers to take risks when implementing technology-rich lessons. Third, school communities need to be able to identify and implement ICT use that best benefits their particular school community. Although national programs may assist in bringing different technologies to these schools, the teachers and administrative teams at the particular schools should identify those technologies most appropriate for their school community.

Pasapia (1994) investigated four technology intensive schools using observations and interview data to identify the determinants of successful use of technology. The school in this qualitative research included one rural high school, a suburban middle school, an urban elementary school and an urban middle school. Each school included had to meet three criteria. First, they were required to be considered technology rich-environments. Second, they needed to have a “backbone” of network availability (connected to some network). Third, their school-wide curriculum objectives stated that they needed to use technology to support higher order thinking skills. Teachers and administrators in these four schools were solicited for information on this topic in a cross-sectional data collection. No details about the timing of the data collection were provided in the paper.

After reviewing these data, Pasapia found that in these four schools there were several determinants for successful implementation. He found that the schools needed to have a high tolerance for change. This adaptability is relevant to technological change (in the time of this article, 1994) because of the newness of computer and technology integration. Few schools had pioneered technology integration in this manner, never mind incorporated educational technology in their school-wide objectives. One overarching component in many of the determinants found in Pasapia’s research is the role of principals and other, less formal, leaders. The list of determinants is long and includes both enablers and deterrents to implementing technology.

Teachers reported that technological leadership could have come from system level leaders, principals, or a group of innovative colleagues. These educational

technology leaders presented a vision on how technology should be integrated into their educational activities that influenced the overall expectations for teachers. Pasapia also found that their technology purchases and decisions were driven by instructional needs and based upon a strong rationale for purchasing. This avoids whimsical purchases based on unfounded need for technology.

Leadership was also responsible for the development of a comprehensive plan which needs to account for the many challenges as the technology becomes more complex. This plan will help when making purchasing decisions and when identifying resources to provide for the needed technological support affiliated with educational technology (such as technology facilitators). Pasapia's research found that school leadership enables both the opportunity for collaboration between teachers, but also the needed additional planning time for teachers new to technology integration and the training affiliated with implanting a new technology.

Owens, Magoun, & Anyan (2000) surveyed 242 teachers (48% return rate) in three separate school districts (two in California, one in Texas) using the Teachers' Attitudes toward Technology (TAT) instrument to measure attitudes. Table 1 provides the descriptive breakdown of this sample.

Table 1

Sample Population: Owens, Magoun, Anyan (2000)

Teacher Level:	
Elementary	98
Middle School	42
High School	102
Number of Teachers by School System Setting:	
Urban	101
Rural	73
Urban/Rural	68
Gender:	
Male	42
Female	200
Yrs Teaching Experience*	
0-1	14
2-5	38
6-10	46
11-15	33
15+	110
<hr/>	
n=242	
*one teacher missing	

Using semantic differential response options the TAT scale used was comprised of ten subscales investigating the utility of the following technologies: email (teacher and student), Multimedia (teacher and student), productivity using technology (teacher and student), World Wide Web (teacher and student), usefulness of email for the classroom and usefulness of computers. This semantic differential scale used a 1 – 7 and 1 – 5 range where 1 was least favorable and 7 (or 5) was most favorable. During analysis, both scales were centered on zero providing scores ranging from -3 to +3 and -2 to +2. The

authors used Friedman's nonparametric two-way analysis of variance by ranks test to make comparisons between the demographic groups and their mean attitude scores.

They found that there were significant rank differences ($p < .01$) in the teachers' attitudes toward technology among the three types of school districts with urban having the most positive attitudes, rural having the second most positive, and urban/rural district having the third most positive attitudes. Examining grade differences, there was a near significant difference ($p = .08$) in attitudes toward technology (rankings: 1st - middle school, 2nd - high school, 3rd - elementary school). A significant difference in attitudes was present across the years of teaching experience that revealed teachers with 0 – 1 and 11 – 15 years of experience had the most positive attitudes toward technology. Of the specific subscales, no statistical tests were performed identifying differences between levels and across the demographic subgroups simultaneously, but email's usefulness in the classroom was by far the lowest.

This article provides a nice cross-sectional and descriptive representation of teachers' attitudes toward technology. Unfortunately, they did not attempt to nest the teacher-level data at the schools-level. This may have been the result of the small number of schools under investigation, but the specific number of schools was not provided in the article. Also, examining this sample there was an apparent over sampling of women. This may not be actual situation, but data was not presented suggesting that the actual gender imbalance in these school systems was reflected in the sample, or that it followed a larger trend.

Training & Beliefs

Wetzel (2001) looks to identify three different ways in which technology is implemented through planning, creating instructional materials, and using technology based tools and tasks with students. Wetzel's study focuses on a technology implementation model: ST³AIRS. The ST³AIRS model that is based on a list of inclusive technology facilitative components including; Staff development, Time to learn to how to implement technology; Qualified trainers of technology implementation; Transition time that enables teachers to try technology out, among others. Wetzel failed to elaborate on whether the teachers who provided data were working within schools that were receiving any particular infusion of technology, or what the model means to his study. The ST³AIRS model lists components that have been discussed in the field of IT literature, though the terminology differs from study to study

Wetzel (2001) intended to study those influential factors associated with the implementation of instructional technology and how instructional technology influenced teachers' pedagogy. To do this he used an "empirical multiple case-design" that examined five middle school science teachers in one suburban Virginian school for one year. This methodology included three interviews and used a "dominant – less dominant qualitative quantitative approach to limiting associations" (Creswell, 1994). Wetzel suggests that this study used a limited, yet highly in-depth interview approach and analysis to develop a richer picture that would only be replicated by adding more subjects. The results represent more of a limited and not such a highly in-depth picture of the process related to technology implementation for these teachers.

The five teachers studied worked within a suburban Virginia middle school of 750 students (70% White, 20% Black, 5% Hispanic, 5% other). All teachers taught science and were five of the nine science teachers in this particular middle school. They averaged 22.8 years of teaching experience (lowest number of years teaching was 11) and four of the five were White. Wetzel did not report gender and it is assumed that they were all male. It is clear that this sampling of science teachers hardly represents the complexity of implementing technology within school settings. Wetzel did not preface his article by stating that he was interested in how “experienced” teachers implemented technology. This would have been more appropriate. Also, since the teachers are all from the same subject area, it is hard to expand the results of this study beyond science, which Wetzel will suggest below.

Wetzel found that four of the five teachers concerns about implementation of technology decreased over the year. Despite this drop in concerns, he reported that the teachers all had concerns about access to technology although their participation in the process (what specific process is not defined in the results) reduced their concerns (not specified). He also found that teachers reported changing to a more student-centered teaching approach and that they were more supportive of technology use in the classroom. Lastly, Wetzel found that collaboration among teachers in the study and the researcher instilled a sense of partnership that resulted in a successful change in pedagogy. This final outcome is somewhat confusing as this study was not described as action research and the role of the researcher was assumed as objective. The researcher’s role should have been more clearly defined.

What can be taken from this study is the finding that teachers changed their pedagogy through this intervention (whatever that was exactly) to a more student-centered methodology. This study looks to specify the ways in which teachers change their behavior by looking at three very clear uses of technology in their preparation, creation and implementation of instruction. Wetzel's failed to operationalize these constructs limits the findings. There is a need for the clear definition of outcomes that are relevant to technology implementation in classrooms.

A large portion of the studies in the educational technology implementation literature focus on a particular subject area. Math and Science classes are the two most abundant topics of this niche. Gningue (2003) adds to this literature by researching the effects of long-term versus short-term technology training for math teachers. His results section is limited to the six item survey administered before and after treatment to the subjects is the focus of his results section.

Gningue uses a small sample of both middle and high school math teachers in his study and breaks them into two groupings: long-term (6 middle and 6 high school) and short-term (11 middle school only) training. His sampling is problematic because he compares two groups from dissimilar grade levels. The long-term training took place in a university course that lasted a traditional semester of 15 weeks (or 45 hours). The short-term training took place within the subjects' middle school and consisted of 3 workshops, lasting 7 hours. Both trainings included instruction on various technologies. The long term training focused on two: TI83 graphing calculator and the Geometer's Sketchpad,

while the short-term training addressed these two technologies plus Virtual Tiles (an Algebra manipulative).

As you can see from the items below, Gningue primarily looked at whether the use of a graphing calculator is viewed favorably or unfavorably, instead of conducting a comprehensive investigation about teacher attitudes toward technology. Relying on the individual items from this survey, Gningue limits his ability to look at the teachers' overall attitude about relative technologies. His study examines only the favorable/unfavorable attitudes of the teachers regarding graphing calculators and avoids several of the other technologies. It would be helpful to have a more comprehensive look at teacher attitudes in this instance, mostly to make distance-relative relationships between the technologies they are using, graphing calculators, and the mathematics subject that they teach. The survey was administered in its entirety to the teachers in the short-term treatment before the workshop and after the conclusion of the workshop on the second day.

For those teachers in the long-term treatment, it was administered at the beginning and the end of the semester. Gningue analyzed the responses of the teachers in each treatment group using t-test analysis of pre and post scores. It is assumed that the small sample size limited the author's ability to perform more robust statistical analyses of the data. Below is a summary of his findings as they relate to the specific items listed above.

Gningue's examined the two groups attitudes toward calculators specified use to check work and noted that the participants' attitudes became more positive, but that only the attitudes of participants who received long-term training showed a statistically significant change ($p = .027$). Although, when combining all of the participants in this

study, the attitude change retains statistical significance ($p = .032$). This greater exposure to training may be further investigated to learn more about the effects of familiarity with attitude changes. The second finding that he makes looks specifically at the use of graphing calculators as a tool to solve problems. Here the participants changes in attitudes are not statistically significant, in fact, the short-term group's mean response rate was exactly the same both before and after treatment. This could reflect a number of possibilities, one of which is that teachers entered the training with high levels of familiarity and skill on graphing calculators. The article did not elaborate on this point. Results for Gningue's third research question showed a tiny increase in the long-term subjects' mean response and a negative change from the short-term group. It would have been helpful to have more information regarding the treatment which the teachers participated in as teaching "the experimental nature" of mathematics was not stated as a major objective of the treatment. Also, this may reflect a number of things including a misunderstanding of the question. His fourth item is negatively worded and asks whether a graphing calculator enhances student learning and understanding of concepts in math and science. Although neither group's change in attitudes was statistically significant and the short-term training group's mean score decreased. Teachers in the long-term training did not see the calculator as enhancing the standard practice of learning mathematics, which reflects that despite their training and presumed understanding of how to incorporate the tool into their class activities, they did not feel that it adds anything to the process of learning mathematics. His fifth item on the survey asked whether students lacked the ability to work on a graphing calculator. Although responses

from both groups of teachers reflected a positive shift, only the long-term training group's responses reflected statistically significant change ($p = .043$). The difference between the two groups may be attributed to the elaboration of techniques for calculator integration in the long-term training, equating a difference in treatment. His last question asked whether or not students taught to use technology will rely on the technology and lose their ability to think. Both groups showed a decrease in their mean response to this item, but neither group's change was statistically significant. It is important to note that the item does not specify "calculators," but instead focuses their response on technology in general. This reflects that the trainings received by the teachers not only provided familiarity with a particular technology, calculators, but it also may have influenced teachers' attitudes toward technology in general according to the change in attitude. One area in which Gningue should extend this study is the examination of training efficacy for the short-term participants. Recognizing the negative change in participants' attitudes for student use and the potential experimental use of the graphing calculator, as well as, no real change in the overall difference in attitude or using a calculator as a problem solving tool may reflect an issue in the training that was provided for the short-term participants.

Gningue's findings attempt to address the issue of appropriate technology training for teachers within the framework of mathematics and the use of graphing calculators. Following the trainings provided, teachers' attitudes toward calculators as a complementary teaching tool became increasingly positive. This technology specific training also affected their mean scores toward technology in general (although not statistically significant). The occurrence of negative changes in teacher responses could

reflect that the training was viewed as ineffective by the teachers who participated. This is something that should be examined more closely by Gningue.

Gningue examines the effect of short-term versus long-term training on the teachers' attitudes of graphing calculators in the classroom. Two important findings of this study are related to the overall attitude changes of training participants and the specific attitude change related to student use of the graphing calculator in the group that received the long term training. As mentioned above, although not statistically significant, teachers' attitudes toward technology in general shifted positively as a result of their calculator training regardless of the training duration. Gningue's mean scores support Beyerback, Walsh & Vannatta's (2001) study on the effects of training as it relates to attitudes toward technology. These studies place pragmatic comprehensive training at the core of technology implementation.

Beyerbach, Walsh & Vannatta (2001) examined four areas related to a programmatic change in a university teacher training program. These researchers looked at the impact of specific technology infusion activities on pre-service teachers, their perceived proficiency using technology, perceptions about the treatment, and beliefs regarding the importance of education technology as a teaching tool.

This study followed two cohorts of pre-service teachers through their completion of a teacher training program and used an action research approach to optimize the applicability of activities for appropriate teacher technology training. This research uses a pre-post design which compares similar groups with large sample sizes. Due to the action research approach of the researchers, the treatment was not implemented at the

same time and was also not implemented consistently due to the researchers' interests in tailoring the treatment to the subjects based on the feedback.

The first cohort began with students who enrolled in three classes (N=60) during the Spring semester with the second cohort encompassing all students entering into the teacher-training program in the Fall semester (8 classes, N=300). Pre-treatment surveys were administered to all subjects involved in the study and complemented an action research approach which utilized focus groups to create thematic frameworks and consistent analysis of post surveys administered following the completion of courses and specified activities within those courses. For the two years of this study, analyses of all data were conducted by the faculty who instructed courses and worked within this department. This could lead to some bias on the part of the researchers and may force the results to be considered somewhat anecdotal in nature. Furthermore, surveys were completed by faculty involved, but are not discussed upon within this paper.

It is important to recognize the implications of the action research approach when trying to understand the consistency of treatment within this study. Continuous feedback through surveys, focus groups and faculty discussions prompted continuous refinement of the treatment and enabled the activities to become more directed toward the goals and objectives established during the project's creation. Utilizing a variety of measures within this study is a great source of enrichment to the data that is presented. Pre-post surveys were administered to pre-service teachers to measure technology proficiency, use/integration, perceived barriers, training preferences, and impact of grant activities. The surveys used were generated for the objectives of developing the teacher training and

were also used as descriptive statistics for this paper. Although the findings in this paper are highly supported by qualitative anecdotes, the statistical analysis for this study are limited to descriptive figures. There was no reporting of validity or reliability statistics for the surveys (Vannatta & Reinhart, 1999).

After collecting data on the two cohorts, Beyerbach and Walsh provide four findings. Their findings are based on a complementary paper by related authors Vannatta & Reinhart (1999), which provides results of their surveys. Another paper/presentation provided by Vannatta (1999) was not available..

First, Beyerbach, et al. conclude that following completion of the program that was focused on appropriate technology usage, pre-service teachers have a better framework to conceptualize the use of technology in the classroom. Students rated the degree to which specific activities had an impact on their understanding of technology integration. The majority of students rated five of the activities provided as having significantly contributed to their understanding. This finding was corroborated by the focus group of students used, but not to the same extent. Some of the focus group participants still viewed technology activities as add-ons to regular curricula (Vannatta & Reinhart, 1999). The authors identified this discrepancy; “Students understood the concept of integration, but had trouble expressing a vision of a technologically rich classroom” (p. 116). This may reflect the sample of pre-service teachers as limited in their experiences with actual classroom environments. The impact on the student sample is seen below in other conclusions reached by Beyerbach, et al. (2001).

Second, Beyerback, et al. claimed that the pre-service teachers have a better understanding of how to incorporate technology in a constructivist environment. Following course activities which centered on the implementation of technology-related activities, the pre-service teachers reported that this exposure increased their *understanding* of technology integration. The pre-service teachers rate poster sessions of technology-rich lessons (90%), Power Point demonstrations by instructors (60%) and observing the process of developing technology-rich lessons (60%) highest in assisting in their *understanding* of technology integration. These analyses provide a reaction from the pre-service teachers, which does not necessarily translate to classroom implementation. Initially, it was proactive to provide the pre-service teachers with training necessary to implement the methods above, but these results were limited by their inability to project success for the students within actual classrooms. Influences upon the students within their professional school setting may not promote technology usage or provide appropriate resources. Nonetheless, the project provided aggressive training for students.

Third, Beyerback, et al. concluded that pre-service teachers are better able to use technology in an empowering manner. As a construct, empowerment is often difficult to qualify. In the structure of this study, it may be best summarized as each student's level of confidence in implementing a technology rich lesson. Utilizing the action research approach of this project, the researchers found that tailoring the project to the feedback of the pre-service teachers resulted in a significant increase in technology empowerment. The students involved in this study felt strongly that they could effectively implement

technology in their future classroom instruction. The researchers measure empowerment by the perceived ability of the pre-service teachers' reported understanding of instructional methods of technology integration. Their findings are supported by anecdotal evidence from the qualitative components of this study (focus groups & open-ended questionnaires). The researchers included the following examples of student teacher reactions to the training they participated in:

'I thought the teacher would assign a paper and the students would type it,' and 'I only used technology for word processing and e-mail' were characteristic statements. Students said their vision of technology had 'drastically changed.' They saw technology as 'breaking down barriers of geography.' They commented on using technology as a resource for professional development, for example, 'I found resources for lesson plans and learning centers.' Students commented that they had a growing repertoire of technology infusion techniques including Internet use, spread sheets, database presentation and multimedia software, subject specific software, and list-serves. They described how this expanded their vision of activities they might use to support their own students' learning (p. 37).

On the perceived competence item, the scores rose from 15.9% to 68.9% ($p < .001$), which is consistent with the goals of the year two participants. Similar to the last finding, the focus was on the pre-service teachers' perceptions of competence without application in an actual classroom. There is no direct relationship to implementation

experience or success, but it does provide the student teachers with confidence regarding the implementation of technology- rich curricula when provided the opportunity.

Fourth, Beyerback, et al. concluded that the program has assisted the development of pre-service teachers. This conclusion is somewhat suspect because it was inferred by the comments derived from pre-service teachers and the gains in perceived competence stated in conclusion three. Although they make the qualitative argument regarding the development of the subjects, the available supporting documentation (Vannatta & Reinhart, 1999) do not corroborate this conclusion as anything more than a glittering generality.

Anecdotes, quotes and analyses are complemented by the convergence of findings across a variety of methods certainly strengthens one's confidence in findings. However, an important distinction between pre-service teachers and professional teachers must be recognized when applying the conclusions of this study to a professional setting. It is not elaborated upon within the study which subjects have actually had classroom experience either as a student-teacher or previous professional experience. But part of the treatment was watching a predetermined teacher implement technology into his/her classroom activities. Also teachers' attitudes toward technology may be influenced by the realities of implementing the technology within a particular school setting. Although this study is focusing on providing appropriate skills associated with the implementation of technology, the sample used may not reflect the beliefs and perceptions of experienced professional teachers.

The implications of this study are two-fold. Initially, the researchers addressed the need to effectively train pre-service teachers about the use of technology in the classroom. Their approach to working with the student teachers was to tailor the program to their needs and concerns while maintaining a level of educational goals and objectives for the program that reflect a thoughtful and effective approach to this issue. The conclusions reached by the authors of this paper were supported by qualitative data collected using focus groups and some quantitative analyses (t-tests). Unfortunately, the conclusions reached are not based on actual implementation, but rather the perceived outcomes of pre-service teachers. This “perceived effect” does have some value related to the training and morale building of teachers, but is not definitively reflective of the larger issue of actual implementation of technology-rich curricula. It should not be ignored that another implication of this research is the utility of action research within a school community. Provided that the administrative staff or other empowered individuals can participate in an effective method of feedback and assessment between teachers and administrators, the implementation of technology-rich curricula will be facilitated with high fidelity and possibly effective outcomes.

Implementation

Judge and Obannon (2007) looked at the influence of environmental factors on educational technology implementation. They were building from the idea that a school’s culture, including collegial sharing, can influence the professional development of teachers. Sharing in this informal setting can provide teachers with opportunities to

work and learn together and promote dynamic experiences, ideas and opinions. They extended the role of sharing and collaboration to replicate Beker and Reil's (2000) finding that teachers who share strategies for integrating technology use computers more and in exemplary ways.

To assess the relationship between collaboration and the implementation of educational technology, the authors used two cohorts of graduate students in a teaching program (2001-02 and 2002-03) that recently entered their teaching internships. The project ImPACT was designed to support technology implementation in graduates of the teacher education programs at the participating university. Teaching interns, forty women and nine men (72% elementary, 28% middle school interns), were placed in Tennessee schools (both urban and rural). Although each of the schools had approximately 60-75% of their students receiving free or reduced-price lunches, they all had internet access in every classroom and multiple computers for students' use in their classrooms. Teacher interns were given laptops, printers and zip drives. Other incentives for their participation included technology training through their program, certificates of participation, graduate credit toward a master's degree, and funded travel to any state or national educational technology conferences where they could present their work.

Judge and Obannon (2007) assessed several self-reported constructs related to technology implementation and technology skills. The main measurements were taken from the International Society for Technology in Education (ISTE) Profile Indicator. The first of which was the NETS*T Student Teacher/Internship Performance Profiler. This

15 item survey and the other associated surveys are based on (ISTE) standards related to technology implementation (<http://profiler.hprtec.org/>).³ .

It should be stated here that this survey and associated surveys in the ISTE battery are highly used, but seldom critiqued. From review of the items on the Student Teacher survey, it is clear that many of the items are double and triple barreled, as in the following example, which asks respondents if they can

Design and teach a sequence of learning activities that integrates appropriate use of technology resources to enhance student academic achievement and technology proficiency by connecting district, state, and national curriculum standards with student technology standards.

Items such as this are a challenge for even the most educated respondents. They are further complicated by the 4 point Likert scale that asks about their proficiency level (1=not at all, 4=can teach others). Although this instrument and all the instruments in the ISTE battery are a good attempt at comprehensive scale construction, it may be ill conceived to incorporate information in such a manner. Also, the self-report format of this survey could elicit socially desirable responses. Any student teacher can report that s/he is able to teach others to fulfill the activities outlined in the item, but there is no real test to determine whether or not this is true. One suggestion that may provide a balance between the items provided by ISTE and more effective assessment could be vignette based questioning. Developing educational technology relevant vignettes followed by a series of well conceived, contextualized and standard-based questions could provide a better understanding of proficiency. The optimal measure would be trained field

³ All surveys are available free to researchers after creating a login name and password on their website

observation of technology integration, which is seldom practical on a large scale (Corbell, Osborne, Grable, 2007).

The next self-reported measure used by Judge and Obannon (2007) asks participants to rate their proficiency on a variety of different technology tools using thirteen items. The same four point rubric is used in this measure (1=not at all, 4=can teach others). The researchers tested the reliability for these two scales together, despite their unique construction and objectives. They reported that the Cronbach's alpha was .95. This statistic is highly influenced by the number of items present in a scale and it could be argued that had the thirteen and fifteen items been independently tested, the reliability of the two measures may not have been as high.

A final fourteen item Likert scale measure of four components (access to technology, technology support, training and incentives) was administered to the sample at the final data collection. Data was collected during the Spring semester of both years. Qualitative data collection was also conducted in the form of in-depth interviews at the same data collection time. A paired-sample t-test was used to analyze and compare the pre- and posttests of the proficiency surveys.

Judge and Obannon (2007) found that the student teachers showed the greatest improvements in implementing technology in the following areas: planning, implementing with students and enhancing lessons with technology. Comparing pre and –post-test data, there were significant increases in technology expertise and the ability to integrate technology into the curriculum ($p < .05$). Significant differences were also found in eight of proficiencies affiliated with the thirteen technology tools ($p < .05$). The

highest mean score changes were seen in Presentation Software, Multimedia Applications and Educational Software.

The qualitative analysis revealed two major themes from their data, both of which were reported by 46% of the participating teaching interns. First, access to laptops (provided by project ImPACT) and other technologies (specifically portable laptop carts that could be wheeled into classrooms – often containing 20-30 laptops) were the most important factors in assisting in the implementation of technology. Second, social support from both the staff and technology coordinators facilitated growth in technology implementation skills and success. Specifically, the teaching interns reported that collaboration and sharing were the keys to social support successes.

As mentioned above, this study has several measurement issues. Also, teaching interns did have access to technology, in the form of portable laptop carts. These are found at many schools in the US; thus, it is safe to say that the schools where the interns worked were not technology-rich, but had some of the basics. Qualitative analysis found that the laptops were influential in the success of the teachers and that technology implementation was also influenced by the social and technical support network within the schools.

Baylor and Ritchie (2002) used a sample of 94 classrooms from four states (CA, FL, VA and WA) across the US to evaluate teachers' technology skills and their perceptions of technology implementation in their classrooms. They included a number of predictor variables: planning, leadership, curriculum alignment, professional development, technology use, teacher openness to change, and teacher non-school

computer use. They also included five dependent variables: teacher technology competence, teacher technology integration, teacher morale, teacher technology impact on content acquisition and perceived technology impact on higher order thinking skills of students.

Twelve schools from both urban and rural areas were selected for the study (five elementary, five middle schools and two high schools). From this group, researchers randomly selected 10-12 teachers that met the following three criteria: the teacher identified was the primary instructor, s/he used technology regularly in instruction, and s/he was at the school during the previous year and intended to be at the school for the following year. Recognizing that each of the teachers used in this sample were already using technology, the findings of this research may identify characteristics of those teachers, but may not provide a complete picture of the relationship between all teachers and technology.

Using a stepwise regression analysis, Baylor and Ritchie (2002) assessed the relationships between their seven predictor variables and the five dependent variables. First, they found that the strength of the technology leadership ($\beta = 0.67$, $p < 0.01$) at the school and teachers' openness to change ($\beta = 0.34$, $P < 0.01$) were both positively correlated with the perceived technology impact on student content acquisition ($R^2 = 0.59$). This finding can be interpreted as an indication that stronger leaders and more open teachers are related to teachers' perception that technology has a positive impact on student content acquisition. Also, perceived technology impact on student content acquisition was negatively correlated to teacher non-school computer use ($\beta = -0.30$, $p <$

0.05). It is safe to say that those teachers who are using computers at home have a higher likelihood of using them in the classroom and are more likely to perceive that computers have an impact on student content acquisition.

Second, they found the teachers' openness to change ($\beta = 0.43$, $p < 0.01$) and the level of constructivist models of technology use ($\beta = 0.29$, $p < 0.05$) by teachers positively correlated with their perceived technology impact on students' higher order thinking skills ($R^2 = 0.61$). Constructivist classroom activities promote group work and integrated learning. It is not surprising to find that the amount of technology used individually by students negatively correlated ($\beta = -0.03$, $p < 0.05$) with this variable. This supports claims by Becker (2000) who suggests that constructivist teachers are more likely to integrate technology into their classroom activities. The results of this study could reflect the way in which computer use was identified by the teachers surveyed.

Third, teacher morale was connected to high levels of support for professional development, and constructivist use of technology ($R^2 = 0.56$). Looking at both of these predictor variables, it is clear that morale is both influenced by the activities of others and behaviors of the teachers themselves. Developing the necessary skills to improve technology integration and recreating the role of the teacher in the classroom as a facilitator and mentor may provide teachers with higher levels of satisfaction at their job. Within the IMPACT model, professional development complements the arrival of physical resources. Investigation into the relationship between professional development and morale within this project may reflect similar findings.

Fourth, after entering all of the independent variables into a stepwise regression model, the authors found that teacher technology competency was predicted by teacher's openness to change ($R^2 = 0.16$, $p < 0.05$, $\beta = 0.46$). Openness to change may be reflective of those teachers who fit into the *early adopter* categorization as it relates to technology. Baylor & Ritchie (2002) elaborate on the role of an overall atmosphere which promotes technology integration into the classroom activities. Technology integration is part of the school wide initiatives at IMPACT schools.

Lastly, technology integration was predicted ($R^2 = 0.39$) by teachers' openness to change ($\beta = 0.38$, $p < 0.05$) and their frequency of technology use with others ($\beta = 0.33$, $p < 0.05$). This relationship implies that teachers who are integrating technology may be more inclined to collaborate with other teachers to assist with developing technology-rich curricula. Another element of the IMPACT model is collaborative planning. Providing short-cuts, ideas, and experiences using technology-rich curricula enables teachers to become more effective planners and implementers of technology in their own classrooms.

For all five of the variables assessed in Baylor & Ritchie's (2002) study, the recurring positive predictor variable was the teachers' openness to change, showing that teachers' personality traits are influential in the process of implementation of technology. Also, this study provides limited insight into the types of teachers most likely to implement technology because the dependent variables in this study are based on perceived outcomes rather than quantified or qualified behaviors.

As stated previously in this discussion, examination of the adoption of innovation process is complex and requires innovative research techniques. Understanding this

process within school systems also involves the complexities related to teachers' independence and inherent resourcefulness. Frank, Zhao and Borman (2004) examined the technology implementation process (in this case computer implementation) by examining the role of traditional diffusion theory constructs and constructs related to social capital on computer implementation within school settings.

Central to their work was the understanding that perceptions of technology, influenced by exogenous institutions “permeate teachers’ technology thought process.” This permeation will have effects on teachers’ interest and willingness to partake in learning activities (both independent and social) and personal risk-taking activities which may lead to eventual implementation:

The organization directly and structurally affects its members through job conditions and job stress. Most important, interactions within organizations, including those of traditional diffusion and social capital, are key processes that contribute to informal organizational culture and thus to the organization as a social entity. (Frank, et al., 2004, p. 143)

Collaboration among teachers is something that happens informally in schools regularly, but recently, designers of school interventions are looking to collaboration as a means of infusing and supporting various interventions—the IMPACT project is an example of such an intervention, as formal opportunities for teacher collaboration are an important component of this model. Although informal collaboration is present in many work

environments, tapping into informal networks without developing formal structures is a significant challenge for researchers.

Frank, et al.'s (2004) data collection took place over two academic years within six schools, spanning three states (two in Northern Mid-West, one in Southwest). The schools represented a variety of lower grade levels with the exception of one high school. All schools were experiencing a technological intervention. The number of teachers at sampled schools ranged from 15-80 and represented a mix of SES levels. At Time One (Spring semester, 2000), interviews were conducted with six teachers and the principals of each school. At Time Two, follow-up interviews were conducted with three of the original six teachers and three different teachers. Surveys were administered at each of the schools during both times. Survey response rates varied greatly across schools (n=143).

Based on social capital theory, the researchers developed a series of constructs and measures by which to gauge social capital (listed below). They used a combination of interview data, networking methodologies, and survey data to describe relationships between social capital and computer implementation. The authors adapted the primary measure of innovation implementation from the diffusion of innovation literature (e.g., Rogers, 1995; Tornatzky & Fleischer 1990; Wolfe, 1994) to apply to teachers' computer use. They measured use in terms of the number of occasions on which teachers used computers for each of the five primarily educational goals and activities (goals: teaching the curriculum, introducing new material, modeling an idea or activity, connecting curriculum to real world tasks, and motivating students). Numeric values were assigned

to the 5-point Likert scale that approximated the implementation at that level across one school year (e.g., daily = 180). Social pressure to use computers was assessed using four questions (e.g., “Others in this school expect me to use computers”) and a four point Likert (strongly agree – strongly disagree). Expertise was assessed by using network analysis-based data that used respondents’ rate of asking for help and being asked for help as one metric.⁴ Perceived potential of computers for teachers and students was assessed by items that used the two stems, “Computers can help me...” and “Computers can help students...” Available resources for computer implementation were measured in three ways. First, to identify the difficulties reported by teachers in the study, a percentage score was calculated for each teacher. Second, classroom resources were measured using a single item. Last, computer support was assessed using three items that asked about the adequacy of technical support within the teachers’ schools. Job conditions were assessed using class size, grades taught, and years teaching within this school. Job stress was assessed using three subscales: perceived workload, newness of teaching assignment, and teachers’ perceived change in emphasis on teaching to meet standardized testing requirements. Demographics were also included in these analyses.

Frank, et al.(2004) mentioned that the limited number of schools and teachers within their dataset did not lend itself to placing the teachers into a nested analyses framework. Thus they performed simultaneous regression analyses to identify predictive relationships between the various constructs and implementation of computers.

Understanding that there were limitations to these data, the authors controlled for school

⁴ For a more in-depth understanding of the procedures used to calculate this metric, see Frank, et al., 2004.

in the initial regression on implementation and both school and expertise when predicting social capital.

Initial descriptive analyses found that the teachers reported 196 purposes for computer use and that teachers perceived their pressure to implement computers as “high.” They also placed a high value on the potential of computers for both students and teachers. Teachers reported significant technical problems with computers 25-50 percent of the time, described their workloads as “busy,” reported more emphasis on standardized tests, and perceived their resources to be limited.

The researchers included all variables listed above within their simultaneous regression model predicting computer use at Time Two. They found that self-reported expertise was the most important predictor ($p < .001$) followed by access to expertise through help and talking ($p < .01$), and social pressure ($p < .05$). Comparing the two measures of social capital to those more traditional constructs (perceived adequacy of resources & perceived potential of computers) explained slightly more variation in the use of computers. Examining the relationship between demographic variables and implementation, they found that teachers with large classrooms who had higher levels of job stress were less likely to implement computers.

Despite the researchers’ attempts at rigorously applying the concept of social capital to computer implementation, this article has some shortcomings. As the authors pointed out in their methods section, the analysis was based on a limited sample of schools. With more schools would have come the opportunity to apply HLM procedures nesting the teacher data within schools (Byrk and Raudenbush, 1992). Also, they do

have some SES disparity among students, but with a limited number of schools ($n = 6$), the sample intervention population of students was somewhat demographically homogenous (predominantly white). Also, this study could have used qualitative methods to provide a richer description of the realities surrounding social capital and some of the issues related to those teachers who may find themselves on the outside of the social capital sphere.

This article provides an important understanding the implementation of technology in classroom settings because it applies to the complex decision-making within organizations about whether or not to implement technologies. Often, teachers work independently from direct supervision and have a realistic need to be resourceful within their network, asking for advice and materials. This article also did not differentiate between the various technologies that were being implemented at each of the sample schools. There may have been differences in the complexity of these technologies which could have lead to lower levels of implementation.

One way in which these researchers could have expanded the breadth of their findings would have been to look at how the amount of teaching experience influenced each of the other factors, particularly social capital. Newer teachers may or may not have established the critical links within their department (or grade level) to navigate some of the technological challenges and methodological newness to teaching on their own.

Zhao and Frank (2003) provide a fresh approach to schools and technology implementation. Using the metaphor of the zebra mussels' arrival in Lake Michigan, they describe computers as an invasive species with which all the other creatures in the

ecosystem must cohabitate. This ecological perspective is expanded on in the paper and used to show a more comprehensive picture of the clash that is created through the adoption and implementation of technology.

Their ecosystem model is defined as dynamic and constantly changing with new species entering and adaptation constantly occurring over long periods of time. It is the slow pace of change that provides a striking similarity with school communities; as Zhao and Frank state, schools naturally and necessarily resist changes that will put pressure on existing practices. Consistency is a hallmark of strong educational practice and often that level of consistency is permeated through all aspects of school life. In fact, one of the contributing factors to the traditional isolation of technology in schools is the fact that it has been studied independently from the factors within the system where it interacts.

Zhao and Frank's ecological perspective is supported by the study they conducted in a sample of Michigan elementary schools within four districts that had recently received a grant for the purchase of technology and training. Each school used in the study was identified as having strong teacher and student access to technology. The methods they used consisted of surveying all staff members, conducted interviews with both administrators and a subgroup of teachers as well as performing observations of some classrooms.

Their analysis generated five factors influencing the implementation of technology. Those factors were the ecosystem, a teacher's niche within the ecosystem, teacher and ecosystem interaction, appropriateness of technology and opportunities for

mutual adaptation. They estimated the relative effects of the factors by using multiple regression and all results stated in this review were found significant ($p < 0.05$).

Their findings indicated that teachers will be more likely to use technologies that are not radically different from standard. This concept is often called distance from present practices and has been discussed by several authors (Rogers, 1995, Tornatzky & Klein, 1982). Thus email, telephone systems, and computers in the classroom were the most frequently cited technologies. Also, they found that technologies were most frequently used to communicate to parents and prepare for instruction, instead of directly involving students with the technology—that is, teachers were more likely to engage in a first order change rather than a more substantial organizational adjustment.

Zhao and Frank (2003) also found there to be a moderate difference (14% between the districts examined) in how teachers perceived their niche within the “ecosystem”. They propose that this may be due to several possible factors, including variations in purchasing, distribution policies and varying levels of professional development. They also concluded that a teacher’s location within the ecosystem may reflect his/her propensity to use technology. The concept of location here could be implied as physical location, but it can also be an indirect reference to the applicability of technology to the subject area. For example, English classes may use computers more for their word processing capabilities, whereas this application might not have the same utility for math classes.

Teacher relationships were also examined and found to be influenced by the amount of pressure received from colleagues. Those receiving more pressure were more

likely to use computers. And teachers who received help from a colleague were more likely to use computers with their students. This finding supports the invasive species comparison by showing how the computers are actually pushed into place by forces beyond the technology's utility.

Finally, teachers who felt that the computer was more compatible with their teaching style were more likely to use computers for themselves and with their students. This outcome illustrates the adaptability of teachers to utilize resources and evolve as practitioners. Like Redmann & Kotrlik (2004), these authors recognize the realities that exist within the school environment, which gives additional value to the scope of the findings as well as the model that was described in this article. Understanding the interactions between both the biotic and abiotic components of an ecosystem/school community provides better insight that enables a richer discussion for those interested in promoting a smoother transition to technology-rich curricula.

Research in the field of educational technology uses the same definition for like terms such as beliefs, perceptions and attitudes. In this study, I will do the same to support the use of beliefs in the model presented below. Wai-kit Ma, Andersson and Streith (2005) investigated the role of computer technology perceptions on preservice teachers' intention to use technology in the classroom. These researchers used the Technology Acceptance Model (Davis, 1989; Venkatesh & Davis, 2000) as the foundation for the relevance of perceptions when considering an individual's intention to use computer technology. As an extension of this model, the researchers included the concept "subjective norm" within their model (Figure 1).

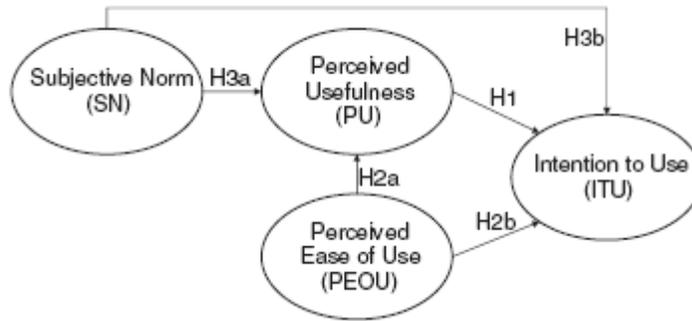


Figure 1. Technology Acceptance Model

The researchers were testing five inter-related hypotheses:

- H1: A teachers' perceived usefulness (PU) of computer technology would directly influence his/her intention to use technology.
- H2a: A teachers' perceived ease of use (PEOU) of computer technology would directly influence his/her perceived usefulness of computer technology.
- H2b: A teachers' perceived usefulness (PEOU) of computer technology would directly influence his/her intention to use computer technology.
- H3a: A teachers' subjective norm (SN) to use computer technology would directly influence his/her perceived usefulness of computer technology.

- H3b: A teachers' subjective norm (SN) to use computer technology would directly influence his/her intention to use computer technology.

In order to examine these hypotheses Wai-kit Ma, et al. (2005) used 84 first-year student teachers (78.5% response rate) in a university-based teacher education program in Sweden. The sample students were receiving training in educational technology within the program and teaching two days a week in local schools. The sample was comprised of 33.5% males and 66.5% females. Age ranges included 19 – 30 (34%), 31 – 40 (40%) and >41 (26%). Approximately one-third of the sample was in an early education program, 21% were in natural sciences and mathematics, 18% were in general education (other subject areas), and 28% were education majors. This cross-sectional study collected data during the middle of the first semester of university for these students.

The constructs were measured using the following collections: PU (5 items), PEOU (7 items), SN (5 items) and Intention to Use (ITU) Computer Technology (2 items). Response options for all items ranged from 1 (strongly disagree) to 7 (strongly agree). The reliability of the scales was tested and Cronbach's alphas for the scales ranged from .87 - .95. Prior to analysis an EFA was performed on the data and five items were dropped from the original scale (reflected in the number of items listed above).

Using Structural Equation Modeling (SEM) analysis, Wai-kit Ma, et al. (2005) found that PU significantly influenced (ITU) ($\beta = 0.54$, $p < 0.001$, $R^2 = 0.11$). PEOU

significantly influenced PU ($\beta = 0.28$, $p < 0.05$) and PU had mediator properties influencing the relationship between PEOU and (ITU) ($R^2 = 0.43$).

This study was included in this literature review because of its recent publication date and its focus on the relationship between perceptions (another term for beliefs) and intention to use computer technology. Unfortunately, this study used preservice teachers who had limited practical experience (half of a semester teaching 2-days a week) and were taking part in educational technology courses within their teacher education program. Their limited experience may render their intentions somewhat irrelevant to actual implementation. Although this study provides a good example of how training can shape the manner in which a student teacher views technology and their “intentions,” it does not completely relate to the realm of a practicing teacher. This sampling bias may not generalize to a teacher who has been working within a school for any period of time. Considering the institutional knowledge of some seasoned teachers, training opportunities such as those discussed in this article may need additional motivators (time, money, practical assistance) to provide robust results.

Also, the study’s outcome measure is not an actual implementation outcome, but rather an intention outcome, which does not provide hard evidence that perceptions influence implementation. Furthermore, this study used an “intention” based outcome that was measured by two items. Although they report high levels of reliability, a two-item scale is limited in scope.

Another area in which this study could have been improved is through the provision of a demographic breakdown related to the outcome variables. Providing

demographic data may have enabled researchers to answer the question of whether there were relationships between constructs such as age, perceived usefulness and intention to use computer technology, or subject areas, perceived usefulness, and intention to use computer technology. These factors could have been identified in their SEM model as exogenous variables. The authors did break down their scale using reliability tests (Cronbach's alpha) and EFA, but they failed to identify whether there were any trends within the dataset related to demographic (exogenous variables).

From this study, we can see that there are relationships between perceptions of the particular technology and the intention to implement, but they are not measured with clear outcome variables such as actual implementation. This next link in the causal sequence will assist in completing the picture affiliated with perceptions (beliefs) and implementation.

Abbott, Greenwood, Buzhardt and Tapia (2006) examined a particular technology that which is affiliated with a socio-structural intervention in classrooms: Class Wide Peer Tutoring – Learning Management System (CWPT – LMS) (Greenwood et al., 2001). CWPT is a reciprocal, peer-mediated instructional strategy in which members of the same classroom tutor one another using regular classroom curriculum. The methodology is well documented and Abbot et al (2006) it was implemented in five different schools across four states. The CWPT – LMS of interest in this article was created to facilitate peer-mediated instruction process by delivering peer tutored content, monitor student participation and assess performance and progress.

CWPT – LMS was being implemented with clear goals and using a structure established by the company which developed the methodology and technology. Local site coordinators were identified and trained together and later assisted the participating schools in implementing this technology. Site coordinators included a mix of principals, graduate students, and teachers willing to assume this role. Participating schools were required to meet six criteria: Internet access in each classroom with a computer to run the LMS software; time provided for professional development; implementation of the CWPT – LMS associated spelling or reading curriculum; transmission of data back to researchers electronically; and inclusion of at least one student with a disability in every classroom. The participating k-5 schools ranged from 14 – 75 teachers, with student populations from 160 – 745. Both public and private schools participated and schools were located in both urban cities and rural settings. The researchers/developers were located in Kansas City. No further specifics on the sample were provided.

Following their group training at the headquarters, site coordinators were armed with Powerpoint presentations and implementation materials that would be used when providing teachers with their training session. The teacher training walked the teachers through topics such as software launch, roster creation, and the FTP procedure for data transmission.

Five criteria were used to establish each teacher's level of implementation of the CWPT – LMS:

1. Registration at the website, thereby transmitting confirmatory web form;
2. Administration and transmission of target student CBM assessments;

3. Implementation of the CWPT instructional process;
4. CWPT – LMS set up, use, and transmission of weekly student progress data;
5. Fidelity of implementation checklists returned for each teacher.

As mentioned above, teachers were also using related spelling and reading curriculum. The significance of this curriculum is that it was the vehicle through which the students developed some of their peer-tutoring structure.

Analyses associated with this paper are purely descriptive and some conclusions are anecdotal. The conclusions provide a good example of the intertwined nature of the variety of influences on technology implementation. The researchers found that 57% of the participating teachers implemented all five of the key tasks listed above. This number is somewhat skewed as the breakdown of schools indicates that two schools had 100% of their teachers completing all five key tasks. In two other schools 45% and 42% of the teachers implemented all five key tasks and no implementation occurred in the final school.

Descriptively, the researchers identified relationships between implementation and three key factors: support of the administration, fall training, and ability to overcome technological challenges. The schools that had the strong support of the administration, provided an adequate fall training, and worked closely with project staff to overcome technical glitches implemented at 100%. The two schools that implemented at low levels (42% & 45%) shared a combination of good/weak administrative support, or good/poor training, and an inability to solve technology problems.

In another analysis of the data, the researchers examined the spelling scores of 337 students over 12 weeks (from 17 teachers, number of different schools was not identified). There was no pre-identified analysis plan for this paper and in the description of the changes in scores, they do not mention any procedures followed or statistical tests run. They do however report that CWPT substantially impacted weekly post-test spelling accuracy. To support this, they note that, “Overall, the pre-test mean calculated at Week 7 was 47.2% correct (pretest slope over weeks = 0.16% correct), increasing to a mean of 93.4% correct (post-test slope over weeks = -.02%) following a week of CWPT. The overall mean gain was 47.2% correct (slope over weeks = -.021%).” Presumably these results reflect the output of a regression analysis, but no clarification was provided.

This study provides a backdrop to build from when examining literature that has identified school leadership and context as influential factors in the success of a technology. This study suggested that without administrative support, technologies may fail quickly. Administrative support can come in several different ways, including the facilitation of technology trainings. It could also take the form of providing adequate resources to trouble-shoot issues related to technologies. This study will examine the role of leadership, particularly the vision of leadership and how it influences the technological context of schools.

Redmann and Kotrlik (2004) investigate the technology integration initiative in Career and Technical Education (CTE) courses in the state of Louisiana. CTE courses are comprised of agriscience and business and marketing education classes. (It is important to note that these analyses looks at both the aggregate group of teachers as well

as separating them into the three subject matter sub-groups.) Redman and Kotrlik (2004) explain teachers' technology integration through six factors: technology training, self-perceived teaching effectiveness, availability of technology, perceived barriers, technology anxiety, and home internet connection.

The sample for this study began with a random selection of 599 CTE teachers from the 1288 listed within the state. The final response rate for their survey was 53.5% (N = 319); the researchers did not mention the distribution of the respondents (demographic/geographic variation, etc.). Results will reflect the responses by teachers from each of the subject areas (agriscience, business and marketing) as well as overall finding for the entire CTE group.

Three scales, technology integration, barriers to integration, and perceived teaching effectiveness, comprised the instrument in this study. The technology integration section of the instrument was broken down into a four subscale model consisting of exploration, experimentation, adoption and advanced integration. A pilot test was run with 29 CTE teachers to validate the instrument. The Cronbach's alpha scores for all portions of the instrument were above 0.87. Descriptive statistics and ANOVAs were interpreted using Cohen's F statistic. Typically authors will report β to show the effect size of an intervention, but Redmann and Kotrilik present the Cohen's F due to their interest in testing the overall means of their outcomes (Cohen, 1988). They did not explain their rationale for using this statistic, but it is assumed that they hoped to avoid Type I errors resulting from testing multiple predictors in their models. Below, Cohen's F, Cohen's V and descriptors suggested by Cohen (1988).

Findings related to the extent of technology integration by the CTE teachers revealed that they score the highest in the exploration and adoption phases of the technology integration model mentioned above. Teachers were asked to score items within all four areas of this scale on a Likert scale (1 = not like me, 5 = just like me). Scores are tabulated for each phase (Exploration, Experimentation, Adoption, & Advanced Integration). These phases are descriptive placements for the teachers within the framework of technology integration. A teacher who rates highly within the exploration phase is thinking about using technology, while a teacher who rates highly in the Experimentation phase is beginning to use technology. A teacher who rates highly in the adoption phase are using technology regularly, while one who is progressed to the advanced integration phase is using technology innovatively. Looking at the initial results of this study reveals significant differences between the business and marketing teachers and the agriscience teachers creating two groupings of teachers

Differences among the three subject areas of CTE teachers were reflected in the ANOVA performed by the authors. Business and marketing teachers' results reflected their higher level of technology usage than agriscience teachers in all levels of this scale: exploration ($F=19.62$, $p<.001$), experimentation ($F=6.37$, $p <.002$), adoption ($F=78.55$, $p <.001$), and advanced integration ($F=14.33$, $p <.001$) of technology. All three groups of teachers scored highest in the exploration (agriscience = 3.16, business = 3.84, marketing = 3.78) and adoption (agriscience = 2.80, business = 4.09, marketing = 3.92) phases of this scale.

One objective of this study examined whether there was a relationship between the availability of technology for the teachers both within and outside of school. They found that 87.1% of the teachers did have home internet access and 58.8% had access at school, while 75.7% had email accounts. Thirty-four percent reported that they have other types of technologies available for use in teaching and 16.9% reported having laser disc players or stand alone CD players. Looking at the differences across the three subject areas, the authors used Cramer's V to examine this data. They found that a moderate association existed which indicated that agriscience and marketing teachers were more likely to have email accounts ($V=.20, p=.003$). Any other associations were "negligible" or "weak" in their analyses.

Redmann and Kotrlik (2004) used forward multiple regression analysis to determine if seven selected variables explained a substantial portion of the variance in the four technology integration subscales. The variables are listed below:

Table 2

Variables from Redmann & Kotrlik (2004)

Seven Independent Variables

1. Grand Mean of the barriers to the integration of technology scale
2. Grand mean of the teachers' perceptions of their own teaching effectiveness scale
3. Teachers' technology anxiety score
4. Total number of types of technology available (range 1-6)
5. Number of sources of technology training used by the teacher (range 1-5)
6. Internet access at school (yes/no)
7. Internet access at home (yes/no)

Dependent Variables

Phases of Technology Integration

1. *Exploration*
2. *Experimentation*
3. *Adoption*
4. *Advanced Integration*

The authors then used the CTE program (yes, participated in CTE = 1, no, did not participate in CTE = 2) as a control variable when they performed four multiple regression analyses which attempted to account for the variance in each of the four phases associated with technology integration (listed above). It was not stated how the authors treated items such as Anxiety, which has a range from 1 (no anxiety) to 4 (high anxiety). We are to assume that they accounted for the reverse effects of these variables. Also, it is important to note that the authors did not provide the beta scores for the variables measured within each phase of technology integration. However, they did provide the F-statistic and significance levels to indicate the relationship between each variable and its phase of technology integration.

Beginning with the exploration phase of integration, they found that there were four significant predictors that explained 22.5% of the variance of the exploration grand mean. They found a moderate effect size ($F = 17.5, p < .002$) with the exploration subscale as explained by participation in CTE program versus non-participation ($R^2 = .12$) and the additional variance accounted for by the following three variables: technology training ($R^2 = .070$); perceived teaching effectiveness ($R^2 = .021$); and technology availability ($R^2 = .020$). Looking at the results of this analysis, teachers with higher levels of confidence (perceived teaching effectiveness) and technology availability to them are more likely to be higher on this stage. It is safe to assume that teachers who have higher availability to technology and are confident in their skills would be found within this phase of the model. Relating these findings with the efforts of the IMPACT

model, infusing technology into high technology need schools may imply that the IMPACT teachers would be in this exploration stage during the initial stages of the project. With that in mind, the IMPACT model provides for high levels of technology training and very high levels of technology availability for its teachers.

Redmann and Kotrlik (2004) further found that Experimentation showed a small effect size ($F = 6.80, P < .001$) and was explained by three variables: the participation in the CTE program ($R^2 = .039$), technology anxiety ($R^2 = .032$) and barriers to technology integration ($R^2 = .012$). The authors stated that anxiety was negatively correlated with the experimentation phase of the model. Implementing technology required degrees of experimentation for the teachers involved. Within the IMPACT schools, technology integration is school wide, which may promote experimentation and lower levels of anxiety. Technology implementation can produce levels of anxiety and taint teachers' attitudes toward integrating that technology into curricula.

Adoption provided a large effect size ($F = 52.7, p < .001$) and was explained by seven variables: the participation in the CTE program ($R^2 = .340$), barriers to technology integration ($R^2 = .340$), perceived teaching effectiveness ($R^2 = .056$), technology anxiety ($R^2 = .043$), technology availability ($R^2 = .025$), home internet connection ($R^2 = .016$) and technology training ($R^2 = .008$). The authors state that anxiety and perceived barriers to technology integration have negative relationships with technology adoption.

The last analysis focused on advance integration, which provided a large effect size ($F = 18.40, p < .001$) and was explained through six variables: participation in the CTE program ($R^2 = .087$), barriers to technology integration ($R^2 = .084$), perceived teaching

effectiveness ($R^2 = .072$), technology availability ($R^2 = .031$), technology anxiety ($R^2 = .014$), and home internet connection ($R^2 = .012$). Teachers' technology anxiety had a negative relationship with advanced technology integration, but perceived teaching effectiveness and home internet availability had a positive relationship with advanced technology integration.

Examining the results of Redmann and Kotrlik (2004) provides evidence that teachers are frequently at different stages of the technology adoption and integration (or implementation) process. It is important to identify these integration differences, but also to review the variables that the authors identified as explanatory within each stage. One striking factor is the role of teacher training that is found as a major variable in only in the exploratory phase of the evolution. This finding suggests that teachers will receive an initial training and possibly implement the technology as learned. However, according to these researchers, training does not appear in any of the other phases, which may imply that teachers develop a sense of appropriate use that does not require further training or that they look to alternative sources for better understanding of the technology. Also imperative to the phases outlined above is the role of teacher attitudes toward technology in the form of anxiety and teaching ability. Teachers who are less anxious about integrating technologies are more likely to be at more integrated levels of technology use. This relationship may reflect a higher level of technology understanding and previous positive experiences implementing it in the classroom. Teachers' perceptions of their teaching abilities are a substantial variable in three of the four phases of technology integration. Identifying this variable within these phases supports the idea that more

confident teachers are able to integrate a variety of mediums and tools to enhance classroom learning. Although this variable in Redmann and Kotrlik (2004)'s study reflects self-perception of teaching effectiveness, further investigation should focus on the relationship between rated teaching effectiveness and technology implementation.

Shattuck (2006) performed a sub-study of data from the first year of the IMPACT project to assess change in teachers' attitudes and technology implementation. Generally, the IMPACT intervention infused educational technology resources and supportive structure at eleven schools by providing each school with resources in the effect of \$1.3 million over three years (A detailed description of the IMPACT project and the sample can be found in the methods section.) This prospective pre-post matched-cohort design tested changes in teachers' self-reported attitudes toward technology using the Teachers' Attitudes toward Computers scale (TAC) and their self-reported frequency of technology implementation in classrooms using the Activities of Instruction instrument.

The TAC, a nine sub-scale measure was reduced to three scales by the author using Exploratory Factor Analyses. The three factors used in these analyses represented how teachers' perceptions of Computers' Influence on Instructional Delivery and Educational Outcomes (CIDEO), Affective Reaction to Computers (ARC) and E-mail Productivity in the Classroom (EPC). Using RANCOVA tests and controlling for computer access, internet access and age, the IMPACT teachers' reported significant ($p < .01$) increases in CIDEO and EPC when compared with the comparison teachers. This finding informs us that there was a significant increase in the IMPACT teachers' attitudes

toward educational technology. It suggests that these changes may have been the result of the teachers increased level of access to technology through the IMPACT intervention.

Similar EFA procedures were conducted using the data collected with the Activities of Instruction. The Activities of Instruction scale was not previously validated and contained several items with limited overlap. As a result, the EFA tests provided subscales that had limitations regarding their internal validity (low number of items, marginal association between item scores). These procedures produced four subscales that assessed teaching activities: Independent Learning Activities (ILA), Constructivist Methodology, Teacher Centered Activities (TCA) and Technology Implementation. Using RANCOVA procedures (controlling for home computer access, home internet access and age) Shattuck found that IMPACT teachers significantly increased ($p < .05$) in each of these subscales in contrast to their comparison teachers. This increase in implementation is qualified as developing from about once a month to multiple times in a week. Previously, it was suggested that teachers would move toward technology implementation progressively, but not in the aggressive manner that was reflected in these results. This dramatic behavioral change is incongruent with the slow and incremental adoption process suggested by experts such as Cuban (1999). IMPACT provided the context of an ambitious technology intervention using a diverse sample of schools with systematically selected controls to measure change.

Unfortunately, the measurements used to show change in attitudes and teaching activities in this study were not validated psychometrically previously, or with an extremely large sample. Also, the range of predictive variables used was limited. In

exploratory analyses, Shattuck examined the role of each implementation item separately to identify how teachers were reporting implementation. Again, using RANCOVA procedures, there was a significant difference between IMPACT teachers and their comparison teachers in the rate of technology implementation for the following items: lessons using computers, lessons using other technologies and lessons using media presentation technologies. Unfortunately, these analyses were based on a limited number of actual implementation items and not well developed scales that examined the various ways in which teachers can encounter and utilize technology in their planning, interaction with students, or assessment of students.

Table 3

Implementation of Technologies: Shattuck (2006)

Items	Mean Change	<i>p</i>	Qualitative Change
Lessons using computers	3.27 – 1.81	.001	About once a month – Almost every day
Lessons using other technologies	3.73 – 2.54	.001	About once a month – About once a week
Lessons using media presentation (video, filmstrip, etc.)	3.44 – 2.51	.001	About once a month – About once a week

Note: Change scores presented are for the IMPACT teachers only
Lower scores reflect higher rate of implementation

Having identified changes in attitudes and the high levels of technology implementation in IMPACT treatment schools, the next step is to examine the relationship between a more sophisticated implementation measure and other potentially

important predictors and to try to examine evaluate a model that accounts for both direct and indirect effects. This cross-sectional study will examine the individual and environmental predictors of technology implementation. Structural equation modeling (SEM) and/or path analysis will be used to identify the significant direct and indirect paths leading to technology implementation.

Summary and Study Objectives

Research in the field of educational technology has taken place in a variety of settings and has used a range of research methodologies, both qualitative and quantitative. However, this field does not provide many examples of large scale, multi-faceted technology interventions using multiple school settings and comparison schools. From the literature reviewed above, three factors clearly influenced technology implementation: school leadership, teachers' beliefs about technology, and the technological context of the schools.

The purpose of the proposed study will be to take a closer look at the concepts of educational leadership, teachers' beliefs about technology, and technologically relevant contextual factors as they pertain to technology implementation in three teaching activities (planning, material creation, classroom implementation). A proposed model for this research is presented in Figure 2. In addition to the variables mentioned above, demographic variables and the IMPACT treatment will be included in the model. As mentioned above, after one year IMPACT teachers' attitudes toward technology were more positive and they implemented technology much more frequently when compared

with their matched comparisons (Shattuck, 2006). This study will provide an opportunity to test the relationships between variables identified in the literature as important influences for technology implementation. Unlike previous research, IMPACT provided a large scale intervention which placed technology at the forefront of educational decisions for the treatment schools. As a result, this study is able to test relationships between components of the IMPACT intervention in a point in time where the intervention mechanisms should be operating at their most robust state.

In general, school leaders can drive educational technology interventions through exemplary behavior (Gosmire and Grady, 2007), providing a structured vision for progressive technology integration in classrooms (Pasapia, 1994), and support for faculty experimentation with technology (Abbott, et al. 2006; Granger, et al., 2002). Also, the perceptions that school leaders have about where technology fits within their institution can influence technology integration (MacNeil and Delafield, 1998). These examples provide a variety of areas in which school leadership influences the technology implementation process. What they have not provided is a structured analysis of how leadership is related to other contextual and perceived variables when assessing implementation. Pasapia (1994), Owens et al. (200) and Judge and Obannon (2007) suggested differentiation in both leadership outcomes and technological outcomes across schools. This study will examine relationship between teachers' perceptions of their schools' technological vision and leadership and how it relates to teachers' beliefs, contextual factors and technology implementation at the school level and across all participants.

Positive and negative contextual factors have been identified in the literature. Within this literature, several contextual factors were found to have positive relationships with technology implementation, such as access to technology (Granger, et al., 2002), access to peers with technology expertise (Frank, et al., 2004), organizational support (Kersaint, et al., 2003), teacher collaboration (Judge and Obannon, 2007), relative distance between technology and subject area, and “ecosystem” (Zhao and Frank, 2003), and opportunities for technology relevant professional development (Bayerbach, et al., 2001; Sandholtz, 2001; Baylor and Ritchie, 2002). Also, Redmann and Kotrlik (2004) found that perceived barriers negatively impacted technology implementation. These studies were unable to assess technological context simultaneously with leadership and teachers’ beliefs.

Beliefs about how a particular technology, or technology in general, has been found to influence technology implementation by teachers. The literature reviewed above found that student teachers’ perceived usefulness of technology and their intent to use the technology (Wai-kit Ma, et al., 2005), teachers’ openness to change (Baylor and Ritchie, 2001), teachers’ enthusiasm about technology (Kersaint, et al., 2003), and teachers’ technology anxiety (Redmann and Kotrlik, 2004) all influenced technology implementation. In this study, teachers’ perceptions of the role that technology plays in teaching practices and student outcomes will form the basis for measuring beliefs. These two sub-scales of the belief variable will be directly measuring the three implementation outcomes.

The outcome variable of implementation will be broken into three different implementation areas. This type of implementation measurement has not been addressed previously in the literature. Technology related studies regularly ask teachers about technology implementation as it relates to one area in which it can be implemented. This study will provide an opportunity to examine the relationships between leadership, technological context and teachers' beliefs on technology implementation in planning activities, creating classroom materials for students to use and instances in which the students will interact with technology within the classroom. In the recent past, differentiating technology implementation has become more appropriate as teachers are drafting their own materials, performing research for classroom activities and enabling students to interact with computers regularly. These three activities are related in many ways, but provide somewhat different short-term objectives for teachers.

To address the issue of technology implementation, this study will utilize data collected with the School Technology Needs Assessment (STNA). This instrument is being used to assess teachers' perceptions of technology related topics. The STNA was developed by SEIR*TEC in collaboration with the NC Department of Public Instruction – IMPACT project. It was designed to be completed by teachers or other educators working directly with students. It is based on standards and best practices in technology integration. The STNA assesses technology implementation in areas such as planning lessons, creating lessons and technology based tools and tasks for assessment. These three areas will provide a more holistic view of the relationships between technology and who it is used by teachers.

METHODS

Research Objectives and Hypotheses

The objectives of the proposed study are:

1. To test a multivariate causal model of technology implementation based on subcomponents of the IMPACT model.

Hypotheses:

1. A model containing the following exogenous constructs: the IMPACT treatment, teaching experience, and leadership will test their direct effect on the following endogenous latent constructs: teachers' beliefs about technology and the supportive environment for technology within their schools. This model will test their relationships with the dependent variable technology implementation, as broken into three domains: the use of technology to plan, the use of technology to create instructional materials and students' use of technology are the dependent variables in the model.

More specifically:

1. Teaching experience will have a negative relationship with teachers' beliefs about technology.

2. The IMPACT treatment will have a direct positive relationship with teachers' beliefs about technology.
3. The IMPACT treatment will have a direct positive relationship with teachers' implementation of technology.
4. The IMPACT treatment will have a direct positive relationship with technology resources.
5. The IMPACT treatment will have a direct positive relationship with the supportive environment for technology use.
6. Leadership will have a direct positive relationship with technology resources.
7. Leadership will have a direct positive relationship on teachers' beliefs about technology.
8. Leadership will have a direct positive relationship on the supportive environment for technology use.
9. Technology resources will have a direct positive relationship with teachers' beliefs about technology.
10. Technology resources will have a direct positive relationship with supportive environment for technology use.

11. Technology resources will have a direct positive relationship with teachers' implementation of technology.
12. Teachers' beliefs about technology will have a direct positive relationship with teachers' implementation of technology.
13. The supportive environment for technology use will have a direct positive relationship with teachers' implementation of technology.

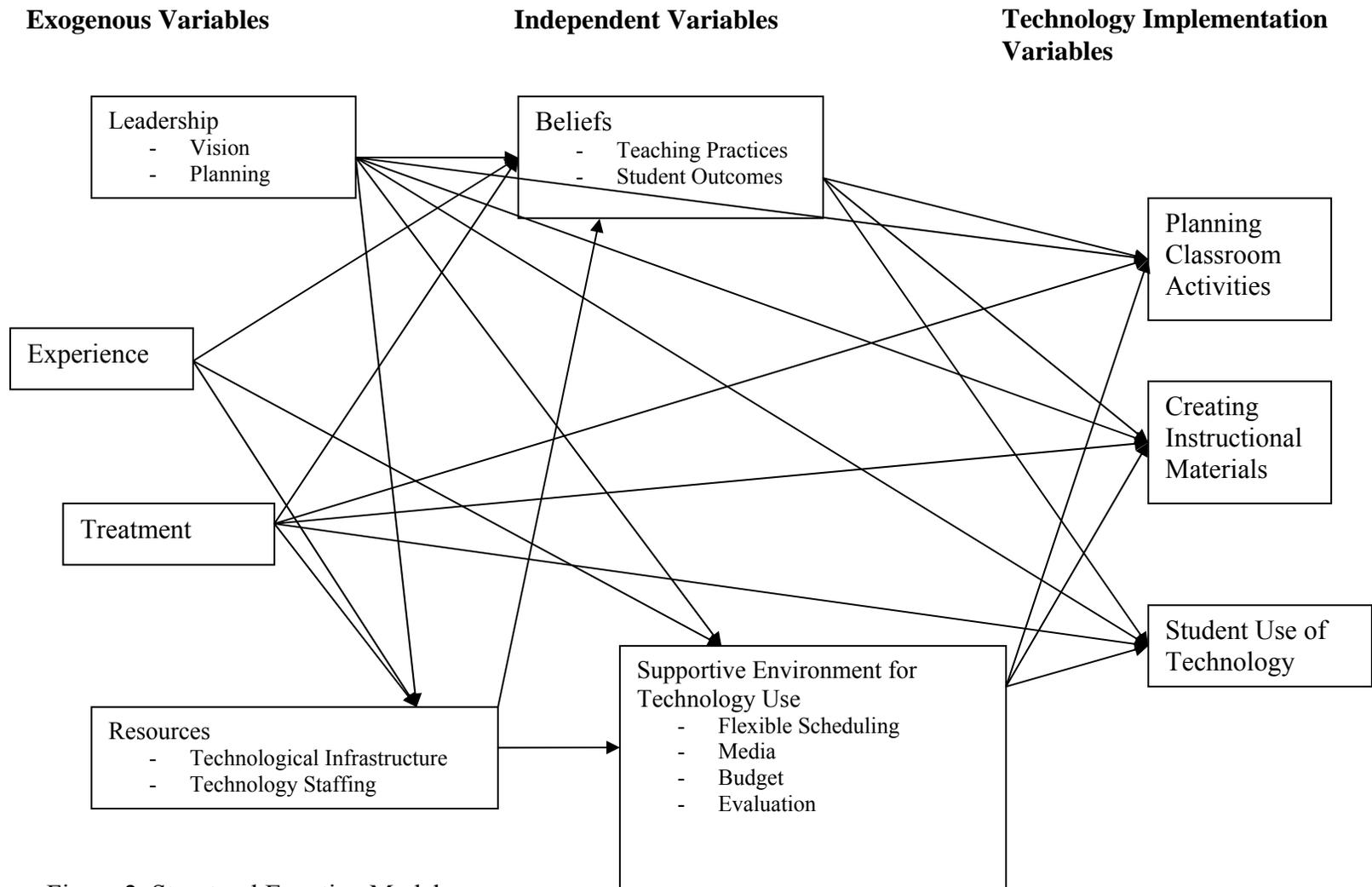


Figure 2. Structural Equation Model

Research Design

The research design is a cross-sectional predictive analysis of a data set which includes eleven schools that received the IMPACT intervention and eleven schools that were selected as comparison schools. This research will specifically look at variables collected during the third (and final) year of the IMPACT intervention.

Setting, Intervention and Population

In 2003, the IMPACT project attempted to understand how a significant infusion of technology related resources would affect primary and middle schools. Using eleven schools and focusing on six key elements, each school was asked to implement the first component of the social structural IMPACT model: a committee structured to make decisions regarding the technology applications in its community. The schools were each provided with approximately five hundred thousand dollars per year for three consecutive years. Twenty-five percent of funding was used for professional development activities annually. Accommodations were made at each school to enable teachers to work collaboratively with peers. Media Centers were required to install a flexible schedule for teacher assignment and usage. Lastly, they were required to use a portion of those funds for a full-time media coordinator and technology facilitator. These elements of the IMPACT project were intended to provide a technology deficient school with every

opportunity for its teachers and students to excel through the technological enhancements available to any school.

The IMPACT project also includes a very comprehensive evaluation effort that involves collecting data from recipient schools and some carefully selected control schools in order to determine the outcome of these investments.

The IMPACT Evaluation Effort

The IMPACT project is a three year analysis and evaluation of the provision of large amounts of technology resources on teacher activities and student achievement. To examine how three factors (technology access, implementation of decision-making structures and the addition of two full-time technology related positions at each school) influence implementation of technology-rich lessons. The project uses a longitudinal design and comparison schools. For the purposes of this study, data from the last year of the project will be analyzed.

The basic research design for the IMPACT evaluation project involves periodic collection of questionnaire and other data over a three-year period. It took a significant period to identify and recruit comparison schools. The result of this is reflected in Figure 3.

<u>Time Year</u>	<u>2003</u>				<u>2004</u>				<u>2005</u>				<u>2006</u>																						
<u>Time Month</u>	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>	<u>J</u>	<u>A</u>	<u>S</u>	<u>O</u>	<u>N</u>	<u>D</u>	<u>J</u>	<u>F</u>	<u>M</u>	<u>A</u>	<u>M</u>	<u>J</u>					
<u>IMPACT</u>					X ₁				O ₁ X ₂								O ₂				*O ₂								O ₃				*O ₄		O ₅
<u>Control</u>										O ₁																			O ₃				*O ₄		O ₅

X₁ = Announcement of IMPACT awards.

X₂ = IMPACT resources begin to become available.

*STNA administered to the participants and baseline data collected for new teachers entering the schools.

Figure 3. IMPACT Research Design

of resources in spring 2003 (X₁). Several data collection periods were implemented during the life of the study. Baseline data (O₁) were collected initially in August of 2003 for the IMPACT group to provide a baseline from which to generate comparisons before and after treatment. The comparison schools completed their baseline data during the early spring of 2004 (O₁). This delay was in part due to the difficulty in identifying appropriate matched comparison schools. Demographic data were also collected for new teachers during the first part of the academic year in 2005 & 2006. This research will use demographic data that was collected throughout the life of this study along with data from the STNA survey that was administered once during the fall of the third year of the IMPACT project.

Participants

The treatment schools in this project have been “self-selected” by their submission of an application for the grant. Each treatment school applied for funding through the IMPACT Project grant, a federal grant (created under NCLB: Title II,

Section D) intended to study the effect of a technology enrichment model (IMPACT Model) and dramatic increases of technological resources on student achievement. Only eleven schools were awarded the IMPACT grant and all are taking part in this study. The IMPACT project is a three year analysis of the effect technology infusion and a structural decision-making model has on teacher activities and student achievement

Means and Olson (1995) argued the benefits of technology-rich school environments are strongest in the case of students of lower socioeconomic status, low achievers, and those with special learning problems. Consistent with this view, all the IMPACT schools were selected based on need-based criteria including Title I status and technology need.

Measuring technology implementation within upper grades posed some challenges within the IMPACT study. The subject-specific nature of the responses by teachers did not provide itself with a clear measurement of technology implementation across those grades. Therefore, the teachers in middle schools were removed from the data and only those teachers teaching at the elementary school level were included in these analyses. This study is able to focus on the responses of 258 IMPACT elementary school teachers and 216 comparison elementary teachers. Graph 10 and 11 compares the number of teachers in each grade level and their teaching experience. It should be noted that teachers did not complete all demographic information that was requested by the IMPACT evaluation team. The information that we do have suggests that the two groups are similar in grade and experience levels.

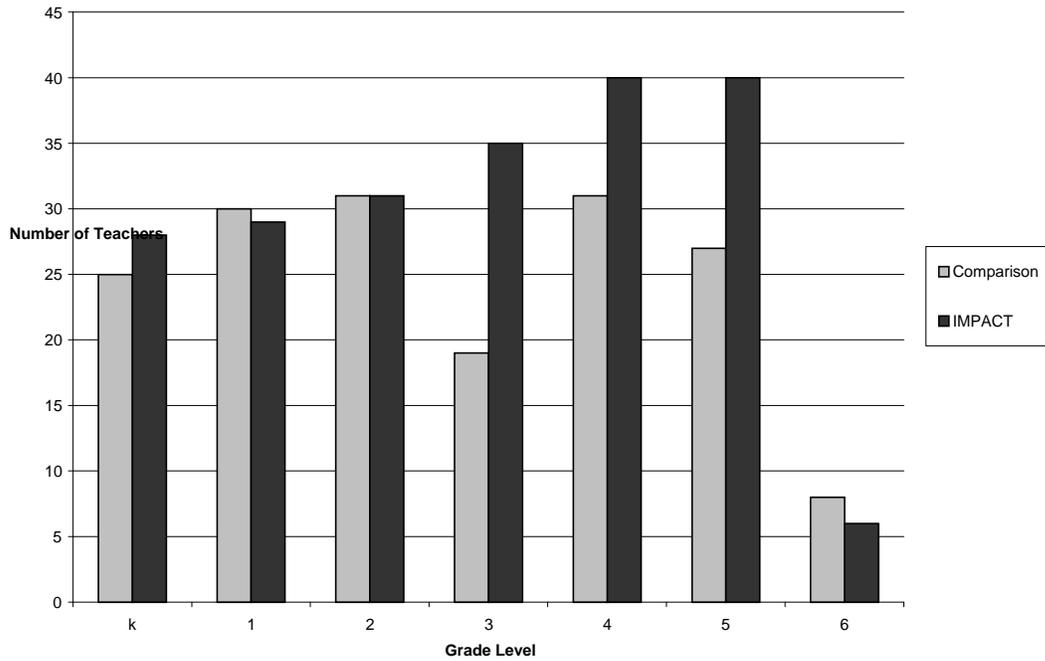


Figure 4. IMPACT & Comparison: Teacher Grade Levels

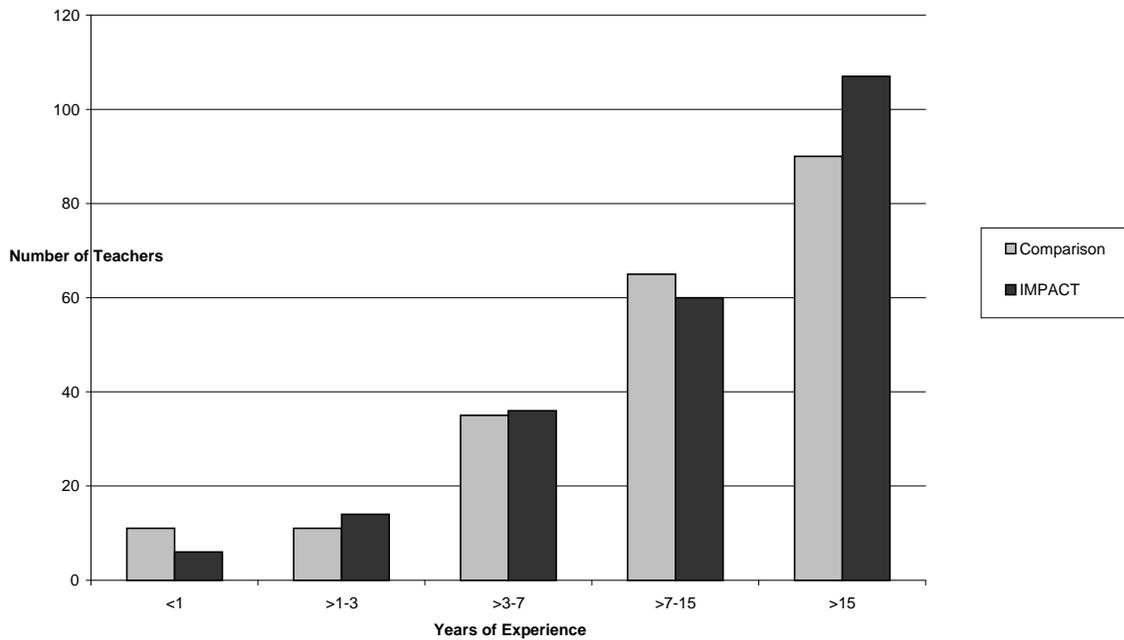


Figure 5. IMPACT & Comparison Teachers: Years of Experience

One consideration that must be addressed by educational researchers is attrition due to teacher turn over. Many of the treatment and comparison schools have consistently high levels of teacher turn over (10 – 30% annually). Table 4 depicts the attrition of teachers throughout the three years of data collection. The IMPACT Year Three Report found that there was a significantly higher rate of teacher retention in IMPACT schools as opposed to the comparison schools.

Table 4.

Teachers Retained, Year One – Year Three

Category	Comparison	IMPACT
Administration	58.8%	76.5%
Classroom teachers	69.3%	77.0% *
Special Subject teachers	76.8%	62.5%

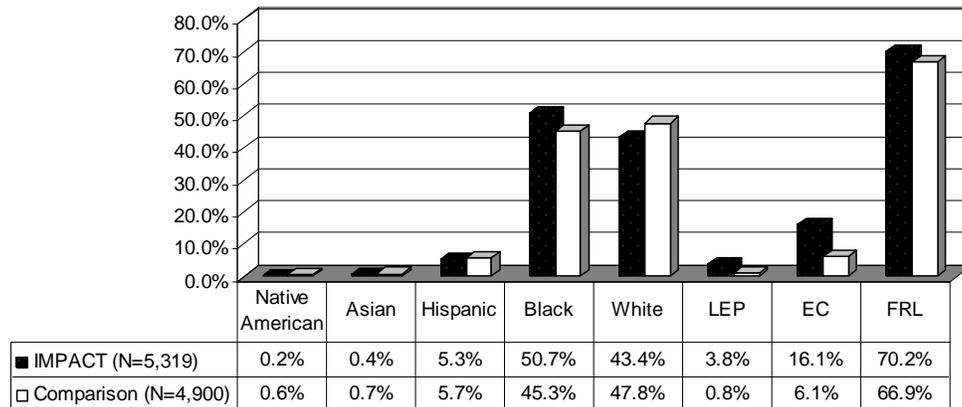
* *significant at p < .05*

The nature of educational research limits our ability to have true control groups for this study. The IMPACT evaluation team has gone to great extremes to match comparison schools using five critical criteria: Title I status (high percentage of students receiving free & reduced lunch), similar overall population, student achievement levels on North Carolina End of Grade Tests, appropriate grade levels, and geographic proximity to the treatment schools^{5, 6, 7}. Eleven comparison schools were identified

⁵ North Carolina’s industrial, geographic and cultural diversity influenced the IMPACT evaluation team to take geographic location into consideration as one of the determining characteristics for the comparison schools. Many of the treatment and comparison schools are located within the same county and would presumably be influenced similarly by the economic trends of that area.

⁶ None of the treatment or comparison schools are located in metropolitan areas.

within North Carolina and all agreed to participate in the study. At the outset of this project 315 teachers were sampled in the control group. After identifying schools, which met these criteria, further efforts were made to match student demographic breakdowns. Figure 6 provides a comparison of student demographics for IMPACT and comparison schools at the outset of the study.



LEP and EC data for comparison schools was incomplete; we project that IMPACT and comparison sites enroll approximately the same proportion of these students.

Figure 6. IMPACT and Comparison School Demographics, 2003-04

IMPACT Treatment

The total funding for each of the eleven IMPACT treatment schools amounted to \$450,000 dollars for each of the three years. Guidelines for optimal technology implementation had been laid out in the IMPACT model by the North Carolina’s Department of Public Instruction. Schools that received the funding for this project were

⁷ Appropriate grade levels within the schools were addressed as some schools have limited grade levels (i.e.; only grades 3-5 or grades 1-3). It was the feeling of the IMPACT evaluation team that the best comparisons could be made with schools that share similar grade distributions.

obligated to complete six guidelines in order to remain compliant with the grant. Treatment schools needed to fill two full-time school positions: a media coordinator and a technology facilitator. Also, they had to establish flexible scheduling for their media center/library and provide time for teachers to work collaboratively. Lastly, they had to establish a technology decision making committee: the Media Technology Advisory Committee. This portion of the paper provides information about each of these obligations and then provides examples of how this objective was implemented by an IMPACT treatment school by looking at the year-end report submitted after year-three of treatment.

Technology Facilitator & Media Coordinator

Each of the IMPACT schools is required to retain a full-time Technology Facilitator (TF) and Media Coordinator (MC). These two positions are asked to act as resources for teachers that are interested in integrating technology into their classrooms. The TF is asked to assist teachers by providing examples and assistance in developing technology integrated lessons. The MC position was formerly known as the librarian, but with recent developments in technology related to library circulation and the central role that libraries play in schools, this individual has a direct link with technology as it pertains to classrooms. Each of these positions would be considered “gatekeepers” according to Rogers’ concepts related to technology diffusion (1985). They are providing both access to technology and technical expertise in the manipulation of that

software. The IMPACT model has established these two roles as critical in the development of a technology rich environment.

All of the IMPACT schools implemented this portion of the IMPACT model by hiring and maintaining the positions of technology facilitator and media coordinator. On their budget, the positions accounted for \$103, 982.00 of their overall \$450,000.00. The TF and MC working within this school have provided numerous examples of one-on-one training, group training and administration of technology related materials.

The capacity to which the roles of TF and MC are fulfilled across North Carolina varies greatly and is often dependent on the level of wealth within that school district. Technology Facilitators are typically found at the high school levels and occasionally in middle school, and rarely at less wealthy elementary schools. It is common for the schools that do have Media Coordinators to share the individual with a nearby school to economize and fund a half time staff member.

Flexible Scheduling & Collaboration

Two objectives of the IMPACT model that focus on the daily procedures of the school environment are flexible scheduling in the media center and creating the opportunity for classroom teachers to collaborate. Frequently, to accommodate equal access to the media center/library schedules were fixed to enable teachers to bring their students during a specified period of time on a predetermined day. This often resulted in underutilization of the media center/library due to the realities associated with the dynamic nature of schools. Flexible scheduling enables teachers to sign up for chunks of

time to bring their students to the media center/library with the freedom to select topic appropriate times and for multiple days. Media coordinators monitor the allocation of time and assist in the preparation of any materials or resources that are found within their domain.

The example treatment school installed a flexible schedule for the media center/library within the first year of the project with many positive comments from the staff and increased usage of the resources. During the second year of the grant, they were teaching other media coordinators in their district how to organize this process from the successes of their implementation. Although flexible scheduling is something commonplace in some schools, the reaction to this adjustment reflects that there are still many others who have not made this shift.

Time is central to the other procedural consideration of the IMPACT model. In this case the focus is allotting teachers the time to collaborate on lesson and units that incorporate technology appropriately. Mandatory collaboration with other professionals not only enables diffusion of ideas and experience, but it also fosters teamwork and may assist in reducing burden of teaching assignments. Often, teachers work independently from one another and seldom have the opportunity to work creatively with one another. Establishing collaboration as a central component for the IMPACT model shows the importance of this facet of professional teaching.

Implementing collaboration sessions requires staff to coordinate schedules and provide ample opportunities for teachers to meet within the work day. At the example school, teachers within the same grade level met once each six weeks for three hours.

Initially, they focused on technology activities, as the meetings were coordinated by the TF. Later in the year, the focus became brainstorming sessions that would help to develop curriculum for the upcoming six weeks. Also, teachers began to take more initiative in planning the meetings by sending topics to the TF and MC beforehand in the hope of having more fruitful meetings.

Staff Development

Treatment schools in this project are allotted a substantial sum for technology development in their schools. Although they will make their decisions about the allocation of these funds independently, one stipulation beyond making the TF and MC full-time is that twenty-five percent of the money is spent on staff development. There is no specified training that schools need to purchase for their staff development as they are allowed to establish what type of staff development has the highest demand in their school community. In some situations IMPACT treatment schools will hire outside specialists to come in for trainings, while in other situations they will use a diffusion method and send a staff member out to learn the technology and return to train the other teachers within the school. There is a good variety of staff development options taken by the IMPACT treatment schools.

Typical examples of the staff development implementations conducted by IMPACT schools included outside staff development in the form of training and attendance at conferences. Thirty of the teachers from one school attended a QTL (ExplorNet) training that focused on integrating technology into the curriculum. Also,

several of the teachers at this school attended professional conferences that included presentations of cutting edge practices and technologies. It is important to note that with the addition of the full-time TF, “in-house” trainings can take place both formally and informally. These types of staff development opportunities are seldom available to teachers at most schools, but with the IMPACT project funding staff development opportunities are more frequent and elaborate. Traditionally, staff development related to technology was performed by a district representative with a blanket approach to address a recent initiative, not individual trainings for teachers hoping to integrate technology as it relates to a particular lesson. The examples provided above are representative of staff development activities provided by the IMPACT schools.

Media Technology Advisory Committee

In the effort to promote centered decision making, the IMPACT model asks schools to develop an on-site technology assessment and overseeing body. The Media Technology Advisory Committee (MTAC) is comprised of staff members who have an interest in how technology relates to the school, but must include the school’s principal, technology facilitator (TF) and media coordinator (MC). With the exception of the principal, members may, but are not obligated to retain leadership positions within the MTAC. A suggestion of the IMPACT model is that each department, team or grade level of teachers is represented on this committee. This integrated representation provides access to the committee for staff members who are interested in acquiring specific technologies or have identified needs within the school committee. The MTAC is also

responsible to any efforts from within the school to acquire additional technology funding, develop budgets and long-term goals for the school. It is the hope of the IMPACT model that influences in the decision making processes are coming from across the school community and not a central figure.

The example school reported holding monthly MTAC meetings at which representatives from each grade level participated and collaborated on ways to address technology related issues. One initiative of this committee was to require grade levels to complete a skeleton plan of themes and units they will teach during the entire year. This is to provide the TF and MC with an outline from which to prepare assistance for teachers as it relates to technology.

Measurement

Outcome Variables

Building from the findings of Shattuck (2006), this research uses, the STNA which was developed during the IMPACT evaluation to better measure the components of educational technology implementation as the project evolved. Corn (2008), reviewed validity of the STNA and the suggestions made by Corn were incorporated in the development of the SEM model subscales. Also, reliability coefficients are presented at the end of this section (Table 7, p. 100) for each of the subscales and the model has been modified to reflect the changes suggested by Corn (2008).

In this study, implementation will be measured using three independent measures: planning classroom activities, creating instructional materials and integrating technology-

rich instruction. SEM analyses will assess the direct and indirect relationships with three exogenous variable and three endogenous variables and these three methods of implementation.

Integrating technology into the planning and development of curriculum is an initial phase of technology implementation reflected in the field of education. These activities provide teachers with an opportunity to master technology use prior to instructing students on its use. The STNA provided response options that ranged as follows: Daily (5), Weekly (4), Monthly (3), Once per Grading Period (2), Never (1), Do Not Know. Teachers’ responses were recoded to reflect actual implementation based on a typical North Carolina 180 school-day calendar. The following table provides the change in data values given to each option.

Table 5
Outcome Variables: Response Option Values

	Original Values	New Values
Daily	5	180
Weekly	4	36
Monthly	3	9
Once per Grading Period	2	4
Never	1	0
Don’t Know	99	‘.’ – missing

Skew and kurtosis values were assessed as within an acceptable range for these variables both before and following the transformation (Table 6). Response values are important to the progression of these analyses, as teachers’ responses are often summarized using mean values. Schwarz, Hippler, Deutsch and Strack (1985) found that

participants infer average rates of an activity from the response alternatives provided them and used it as a standard of comparison in evaluating their behavior and its implications.

Table 6

Scale Scores Examination

	Mean	Median	S.D.	Var.	Skew	Kurtosis
Outcome variables (as recalculated, range: 0 – 180)						
Technology Planning	72.83	61.71	49.47	2447.39	0.55	0.23
Technology Instruction	52.90	40.33	44.02	1938.04	1.20	0.95
Student Use of Technology	47.85	27.00	52.82	2790.14	1.34	0.66
Outcome Variables (as originally recorded, range 1-5)						
Technology Planning	3.69	3.86	.86	.74	-.60	-.19
Technology Instruction	3.37	3.50	.91	.84	-.36	-.51
Student Use of Technology	3.19	3.25	1.12	1.25	-.26	-.84
Leadership & Vision						
Vision	4.21	4.25	0.67	0.45	-0.96	1.55
Planning	4.19	4.25	0.72	0.51	-1.22	2.55
Supportive Environment for Technology Use						
Budget	3.69	4.00	1.05	1.11	-0.68	-0.26
Evaluation	4.05	4.00	0.79	0.62	-1.11	2.27
Flexible scheduling	4.14	4.00	0.75	0.57	-1.11	2.33
Media	3.98	4.00	0.83	0.70	-1.08	1.63
Resources						
Staffing	3.44	3.83	1.23	1.51	-0.42	-0.98
Infrastructure	3.40	3.75	1.27	1.62	-0.33	-1.22
Beliefs						
Teaching practices	4.02	4.00	0.73	0.53	-0.64	0.77
Student outcomes	4.10	4.00	0.68	0.46	-0.55	0.78

An example of this disparity can be seen in the mean scores of IMPACT and comparison teachers on the Student Technology Use subscale (8 items). The following table presents the differences in the perceived student use as scored using the original method and again using a method that appropriately represents the responses.

Table 7

Student Technology Use: Mean Scale Scores

	Original Method	Qualitative Value		New Method	Qualitative Value
Comparison Teachers	2.87	Between: Once per grading period & Monthly		35.22	Weekly
IMPACT Teachers	3.57	Between: Monthly & Weekly		58.45	Almost twice a week

From this table, we can see that IMPACT teachers reported over 20 more instances where students interacted with computers. Applying more appropriate values to these responses provides a richer description of the difference in technology implementation in classrooms while maintaining the statistical integrity of the model comparisons in this study.

Planning classroom activities is an essential element of teaching. Tools that have been used by teachers to plan activities have themselves evolved over time. Today, teachers are able to create materials that are structured to fit state-wide standards of learning and to gather resources from a variety of sources. Having technology available regularly in your classroom may influence the manner in which a teacher considers state technology standards and plans for their integration into classroom activities. This

construct measures how frequently teachers use technology based standards and research to assist in their planning activities. Planning classroom activities was measured with the following 6 variables;

- *My lesson plans refer to both content standards and student technology standards*
- *I do research or action research projects or apply the results of my research to improve technology-enhanced classroom practice*
- *I use multiple sources of data to reflect on professional practice and make decisions about the use of technology*
- *I use technology to support and increase teacher productivity*
- *I use technology to increase my access to professional development resources*
- *I use technology to support communication and interaction with parents and the community*
- *I use technology to support communication and interaction among staff members.*

Technology may provide teachers with the ability to become more productive in their classrooms. This may translate into having better communication with parents and staff, higher levels of productivity and utilizing differentiated evaluation methods.

Creating instructional materials measures how technology is integrated into activities that will be directly apparent to students. This construct was assessed using the following 7 variables;

- *I consult publications, online journals, or other resources to identify research-based practices in teaching with technology*
- *I identify, locate, and evaluate technology resources (e.g., websites)*
- *I apply performance-based student assessment to technology-enhanced lessons (e.g., student portfolios, student presentations)*
- *I use technology regularly to collect and analyze student assessment data*
- *My lessons include technology-enhanced, learner-centered teaching strategies (e.g., project-based learning)*
- *I apply policies and practices to enhance online security and safety.*

The third area of technology implementation focuses on the integrating of technology where it is not isolated to the teacher or as a point of contact for the student. Rather this construct measures the frequency of technology implementation when the student is working with the technology to communicate, to research topics and to generate outputs. Integrating technology-rich instruction used the stem “In my classroom...” and the following 8 variables;

- *Students use a range of technologies (e.g., productivity, visualization, research and communication tools)*
- *Students communicate and collaborate with peers, content experts, or others outside the classroom using technology*
- *Students use technology to access online resources and information as part of classroom activities*
- *Students use advanced, professional research tools and information (e.g., simulations, databases, satellite imagery)*
- *Student work on relevant, technology enhanced projects that have meaning and approach real-world applications of technology*
- *Students use technology to help solve problems*
- *Students use technology to support, higher-order thinking (i.e., analysis, synthesis, and evaluation of ideas and information)*
- *Students use technology to create new ideas and representations.*

The frequency of implementing technology while completing planning and curriculum development activities are measured using three and ten items, respectively. Use of technology in the classroom is measured with eight items that identify typical technology implementation situations.

Endogenous Variables

Two sections of the STNA also assess the independent variables used in this research. Relationships between teachers *Beliefs* about technology and the *Supportive Environment for Technology Use* will be analyzed.

Beliefs

Perceptions of how technology will impact the teaching and learning process may influence the rate at which teachers integrate technology into their classrooms. Teachers who perceive that technology will provide timely and important connectivity for students and alleviate some of their burden may integrate technology quicker than others. *Beliefs* will be calculated using two subscales from the STNA that gauged how teachers perceived the impact of technology on Teaching Practices (4 items) and Student Outcomes (5 items). Mean scores were calculated for each subscale and used in the model. All items were answered on a five point Likert scale with a score of 1 meaning “strongly agree,” a score of 3 meaning “neither agree nor disagree,” and a score of 5 meaning “strongly disagree.” A description of the factorial structure of the beliefs construct is presented in Figure 3. Respondents also had the option to select “Do not know.”

The teaching practices construct asked teachers their level of agreement to items on the appropriateness of technology in the classroom and how it influenced the dynamics of teacher student interactions. Teaching practices were measured with the following 4 items;

- *Teaching is more student-centered and interactive when technology is integrated into instruction*
- *Teaching practices emphasize teacher uses of technology skills to support instruction*
- *Teaching practices emphasize student uses of productivity applications (e.g., word processing, spreadsheet)*
- *Teaching practices emphasize student uses of technology as a regular part of specific teaching strategies (e.g., projects based or cooperative learning).*

The student outcomes construct asked teachers their level of agreement on the way in which students were affected by the implementation of technology in classrooms. This scale assesses how teachers perceived students progressed socially, as independent learners and collaborators. Beliefs about student outcomes were measured with the following 5 items;

- *Technology has helped students become more socially aware, confident, and positive*
- *Technology has helped students become independent learners and self-starters*
- *Technology has helped students work more collaboratively*
- *Technology has increased students' engagement in their learning*
- *Technology has helped students achieve greater academic success*

The direct effect of the latent variable “*Beliefs*” (derived from the two subscales Teaching Practices and Student Outcomes) on technology implementation will be examined in these analyses.

Resources

The IMPACT intervention required schools to staff technology specific positions (4 items) (e.g., technology coordinator) and to develop a technology-related infrastructure

(3 items)(e.g., CBAM). IMPACT and Comparison teachers were asked about their perceptions of these two technology resources and the relationship between Resources and other variables in the model will be assessed. All items were answered on a five point Likert scale with a score of 1 meaning “strongly agree,” a score of 3 meaning “neither agree nor disagree,” and a score of 5 meaning “strongly disagree.” Respondents also had the option to select “Do not know.”

The technological infrastructure construct measured how teachers perceived their access to technology, the internal and external communication systems supported by technology. Technological Infrastructure was measured with the following 4 items;

- *An adequate technology base is available (e.g., computers, digital cameras, projection devices, scanners, printers)*
- *Communication systems within the school are adequate (e.g., email among teachers and staff, network drives to upload lesson plans and grades to the main office)*
- *Systems to communicate with parents and the community are adequate (e.g., email, teacher and/or school web pages)*
- *Reliability and speed of connections to the external Internet, online databases and resources, etc. are adequate*

Enabling teachers to use technology through appropriate levels of technical support is necessary for a successful intervention. This subscale is measured using 3 items that ask teachers about the focused sources of technical support:

- *Teachers have ready access to technical support is available, e.g., to trouble shoot hardware or software problems and maintain systems*

- *Library media coordinator and/or media assistant positions are adequately staffed*
- *Technology facilitator and/or technology assistant positions are adequately staffed.*

Supportive Environment for Technology Use

This research also looks to use the environmental factors to provide a more comprehensive picture of the technology landscape. The STNA provides more information about the experiences of teachers as they relate to their school context. A scale score generated from the four subscales measuring Flexible Scheduling (3 items), Media (4 items), Budget (2 items), and Evaluation (3 items). All items were answered on a five point Likert scale with a score of 1 meaning “strongly agree,” a score of 3 meaning “neither agree nor disagree,” and a score of 5 meaning “strongly disagree.” Respondents also had the option to select “Do not know.”

Implementation of the IMPACT intervention provided schools with some mandatory elements, but also with the flexibility to identify areas of technology integration that would be relevant for their school community. As a result, schools within the IMPACT treatment group had differing climates surrounding the prospect of technology integration. Climates could be dictated by leadership, age/experience of teachers, or previous technology interventions.

Flexible scheduling for the media center and computer labs was a requirement within the IMPACT intervention and supports the level of access teachers have to technology resources. The STNA measures flexible scheduling using 3 variables that ask teachers about how it is applied to specific technology resources:

- *The media center can be flexibly scheduled to provide equitable access to resources and instruction*
- *Computer labs can be flexibly scheduled for equitable access to resources and instruction*
- *Mobile computers can be flexibly scheduled to provide a equitable access to resources and instruction*

The STNA asked four questions about the variety of media related resources teachers had available to them at their respective schools. These four questions particularly focused on both the physical media as well as the decision making for new purchases:

- *Teachers and students have ready access to productivity software, e.g., graphic organizer, word processing, slide presentation, or drawing applications*
- *Teachers have ready access to a cataloging system they can use for searching and locating teaching materials*
- *Teachers and students have ready access to a good collection of print, multimedia, and electronic resources*
- *When educators are selecting resources media and software, they consider both the curriculum and the needs of learners.*

Teachers' perceptions of the budgetary considerations in their schools may influence their level investment in a particular technology. If teachers are wondering

whether a technology will be supported over time, they may not put their time and efforts toward incorporating a technology that will not be updated or maintained. The STNA has two items that attempt to address teachers' perceptions of their school's budget:

- *The amount of money budgeted for technology resources is adequate*
- *Supplemental sources of funding are actively pursued to support technology*

Formal evaluation methods can support the implementation of a new technology. Understanding the impact that technology implementation will have on a classroom and school may influence levels of implementation. The supportive environment for technology implementation subscale contains the following 3 items:

- *Multiple sources of data are used to evaluate the implementation of technology programs*
- *Multiple sources of data are used to evaluate the impact of technology on teacher practice and productivity*
- *Multiple sources of data are used to evaluate the impact of technology on academic achievement and other student outcomes.*

Parceling & SEM

Item scores from the subscales described above were averaged across each participant. This process is commonly known as parceling data. Little, Cunningham, Shahar and Widaman (2006) examined the use of parcels as manifest variables in SEM

procedures and provide lists of pros and cons related to parceling. Detractors of this method suggest that parceling undermines the empirical purpose of multivariate modeling. Individuals with this view suggest that imposing arbitrary scores moves away from individual item scores and may manufacture a false structure. This sense of false structure is exemplified when researchers parcel data derived from constructs with systematic errors. Empiricists would argue that all sources of variance must be represented in multivariate models and could lead to lower reliabilities, lower communality among variables, smaller ratios of common to unique factor variances and higher likelihoods of distributional violations.

Little et al., (2006) take a more pragmatic perspective on the use of parceling in statistical models. They found that researchers' personal decisions about parceling data can be based on research objectives: understanding a set of items, versus examining the nature of a set of constructs. Little et al suggest that parceling is best utilized when measuring a unidimensional scales. The authors wrote that despite the suggested loss of information resulting from aggregated data, there are benefits to particular modeling procedures including increased stability in models through more parsimonious relationships between variables, decreases in dual loading of items, reduction in sources of sampling errors. These efforts reduce the rate of Type I errors from spurious correlations leading to poor model fit.

This study utilized the method of parceling items after the examination of the item:subject ratio. Due to the large number of items (57) and limited overall (474) and

group samples (IMPACT = 258, Comparison = 216) the ratio of participants to items is 8.3:1. This ratio is not high enough to support fitting a model that included item level data.

STNA Subscale Reliabilities

Using the sample of elementary level IMPACT and Comparison teachers, reliability estimates were calculated for each of the subscales. Reliability estimates for all of the subscales were found to be near or above the more stringently accepted level of .80 (Miller, 1995). The confirmatory factor analysis work done by Corn (2008) validated these subscales in a similar population of teachers. In this study, reliability scores suggest that the items within these subscales are holding together in a reliable manner.

Table 8

Internal Consistency Reliability Scores for STNA Subscales

	Number of Subscales	Alpha	Number of Items	Alpha
Leadership: Vision & Planning	2	.87	8	.92
Vision			4	.85
Planning			4	.89
Supportive Environment for Technology Use	4	.87	12	.94
Budget			2	.77
Flexible Scheduling			3	.82
Media			4	.92
Evaluation			3	.94
Resources	2	.93	7	.96
Adequate Staffing			3	.91
Infrastructure			4	.94
Technology Beliefs	2	.81	9	.91
Teaching Practices			4	.84
Student Outcomes			5	.93
Dependent Variable: Technology Implementation	3	NA	21	NA
Instruction			6	.78
Teacher Planning			7	.82
Student Technology Use			8	.93

Exogenous VariablesIMPACT Treatment

This cross sectional study will examine the effect of the treatment on the outcome variables. Teachers are dummy coded (0/1) for their inclusion in the IMPACT project.

Demographics

Data about the teachers' age and gender were collected using a demographic questionnaire during the baseline data collections. The STNA asked teachers to identify the grade level that they are teaching using a list of 15 options that included grade levels Kindergarten through 12, pre-Kindergarten, and multiple grade levels. Also, teachers were asked to qualify their teaching experience using the following categories: less than 1 year, between 1 – 3 years, between 3 – 7 years, between 7 – 15 years, and more than 15 years.

Leadership

The role of leadership within educational technology interventions has been found to be influential in the intervention's success. As mentioned elsewhere in this document, the flexibility associated with implementing the IMPACT treatment was varied among schools. School leadership often articulated the school vision for technology integration and modeled the use of technology for teachers. This ability to share a technology related vision varied across schools and that variation could be found in several of the technological purchases and trainings facilitated by school leadership.

This study will examine the indirect relationship between the school leadership and technology implementation using two subscales. Tests will determine both the relationship between leadership's vision and their planning with the implementation outcomes. Four items ask about the ability of school leadership to: facilitate

collaborative decision making procedures, communicated objectives to the community, modeled technology use, adapt school level systems and provide technology guidance. Four items were used to assess the teachers' perceptions on how leadership has planned for technology within the schools. Likert scales with a score of 1 meaning "strongly agree," a score of 3 meaning "neither agree nor disagree," and a score of 5 meaning "strongly disagree." Respondents also had the option to select "Do not know."

The leadership vision construct assessed leadership within the context of technology by asking questions about how the school leader communicated his/her technology vision to staff and the community and facilitates technology integration in the school. Vision and Leadership was measured using the following 4 items;

- *A shared vision for technology has been developed through an effective collaboration among stakeholder groups-teachers, other staff members, students, parents, and members of the community*
- *The vision for technology has been effectively communicated to the community*
- *Administrators model effective uses of technology*
- *Administrators support changes in school-level systems, policies, and practice related to technology.*

These areas will provide a broad understanding of how teachers perceive their leadership's ability to lead them through this technological intervention.

How the administrative team plans for the use of technology within the school may influence teachers actual implementation. The STNA uses four items to assess teachers' perceptions of technology planning at the school level:

- *An effective long-range school technology plan is in place*
- *The school technology plan is developed by a leadership team or committee involving a variety of stakeholders*
- *The school technology plan is monitored and updated adequately*
- *Teachers and other staff support the school technology plan*

The purpose of this study is to take a closer look at the concepts school leadership and beliefs as they pertain to three levels of technology implementation by teachers within the context of an intensive technology intervention. A proposed model for this study is presented in Figure 2.

Summary

American schools are attempting to address the need for technological advancements in education. The IMPACT project provides a testing ground for the examination of the relationship between changes in instruction, technology access, and technology training. Developmental research in this area will shape several technology-related areas of teaching, such as: the manner and rate at which technology is presented to teachers, the types and opportunities teachers have to establish techniques for embedding technology in their curriculum, and the form of technological tools teachers have access to use in their schools. These types of questions will enable administrators with a gauge to utilize when making technology-related decisions for his/her schools.

Teachers' beliefs and their technological context will provide the change mechanisms necessary to gauge the influence of this intervention. High levels of technology access, staff development, collaboration, availability of technology specialists

(media coordinator and technology facilitators) and a decision making committee are the elementary components this intervention has established for a progressive technology environment. Combining the demographic characteristics of teachers with the two refined scales will provide strong psychometric support for the results found in these data.

RESULTS

Descriptive Statistics

Group means for each subscale were compared using t-tests (two-tailed). F-statistics were assessed to determine the level of independence between group variances. IMPACT teachers reported significantly higher rates across all variables (Table 9). Of note are the IMPACT teachers' implementation scores on the three dependent variables. IMPACT teachers reported using technology across these three different domains between 22 & 27 more days than Comparison teachers. Two-sided t-tests compared mean scores of IMPACT and Comparison scores for each subscale. Comparing means and examining the F-statistic we are looking to determine not only whether there is a significant difference between the groups, but also where the greatest amount of variation within the data can be found ($p < .001$, see Table 9). As expected large F-statistics, suggesting large differences in perception of IMPACT and Comparison teachers, were found in the following variables: Budget, Media, Evaluation and the dependent variables Instruction and Student Technology Use.

Table 9

Subscale Mean Score Comparisons: IMPACT & Comparison Teachers

	Comparison	IMPACT	F
<u>Leadership: Vision & Planning</u>			
Vision*	3.93	4.44	82.25
Planning*	3.86	4.46	96.97
<u>Supportive Environment for Technology Use</u>			
Budget*	3.03	4.21	200.94
Flexible Scheduling*	3.78	4.45	51.75
Media*	3.53	4.36	78.96
Evaluation*	3.63	4.37	58.88
<u>Resources</u>			
Adequate Staffing*	2.72	4.06	211.79
Infrastructure*	2.52	4.14	309.23
<u>Technology Beliefs</u>			
Teaching Practices*	3.74	4.26	31.36
Student Outcomes*	3.88	4.29	18.21
<u>Dependent Variables: Technology Implementation</u>			
Instruction*	40.78	63.08	31.36
Teacher Planning*	58.17	85.09	36.46
Student Technology Use*	35.21	58.45	22.94

2 tailed t-test of variance was used to determine differences between groups.

F statistic testing the variance of the mean scores

*Mean comparisons were significant at $p < .001$.

To assist in confirming technology implementation before moving ahead with this study, a correlational analysis was performed. Teacher level data from the outcome variable measuring student use of technology was tested to see if those data were correlated to student level data. Identifying significant correlations among these variables bases the perceptions of technology use within a framework outside of their

own. This study did not have the luxury of randomly assigned or systematic spot-checks confirming technology implementation, or other such observational data.

Student level data consisted of four items from the Technology Skills questionnaire (grades 3-5). This analysis utilized the responses of 1287 comparison and 1916 IMPACT students. Responses were dichotomous (yes, no). This questionnaire was administered in the fall of 2005 and reflects a similar test administration period as the STNA. Those items asked students if they used computers to complete learning activities across four general categories (learning subjects, doing research, typing a report and making art, slideshows, or presentations).

For these purposes, it was determined that only responses from elementary students would be used for one overlying reason: these elementary students have one core teacher whom they spend the majority of their time. Responses from middle school students on a similar measure could not be directly tied to one particular teacher and therefore comparisons correlations could not be identified.

First, a mean scale score was calculated for each of the students (treatment and comparison) across these four variables. Using t-test comparison of IMPACT students ($M = 0.78$, $SD = 0.28$) reported a significantly higher rate of computer use than comparison students ($M = 0.58$, $SD = 0.31$, $F = 63.88$, $p < 0.001$). Next, the eight variables included in the Information and Student Technology Use subscale were averaged at the teacher level. These items assess teachers' perception of student technology use in particular educational contexts. A more detailed description is provided elsewhere in this paper. T-test comparisons revealed that IMPACT teachers ($M = 58.45$,

SD = 54.97, n = 248) reported significantly higher student technology use than comparison teachers (M = 35.21, SD = 47.24, n = 208, $F = 12.26$, $p < 0.001$). Lastly, to show that perceptions of IMPACT and Comparison teachers were inline with those of their students correlations tested mean scores for student reported use of technology and the teachers across both groups simultaneously, then independently. There was a small positive correlation ($r = 0.169$, $p = 0.07$). This finding informs us that teachers' perceptions of computer use are correlated to those of their students'. Identifying this relationship between these measures provides some contextual support for moving forward with the teachers' perceptions of technology implementation in later analyses.

SEM Analyses

A series of SEM models were run with the entire sample to define the relationships between these variables. Using the subscales identified above, subscale scores (means) were calculated at the teacher level and used to identify latent variables as described in Figure 2. First, an unrestricted measurement model was tested to determine the relationships between the variables using the entire sample (Joreskog, 1971, Bentler, 1995, Joreskog & Sorbom, 1996). Second, a model containing all of the hypothesized relationships tested the structure of these data. Third, relationships with non-significant loadings were removed from the model, identifying a nested model. The structure of the nested model was tested to determine if there was an improvement in the overall model fit (Byrne, 1988, Byrne, 2001).

Table 10 provides the Chi-square and model fit statistics for the unrestricted model and each subsequent model using both the IMPACT and Comparison Teachers. As anticipated, the subsequent hypothesized model resulted in less favorable fit. The hypothesized model identified eleven non-significant predictive relationships between independent and dependent variables. Of note, inclusion in the IMPACT treatment was not found to significantly predict the two implementation outcomes: Planning, and Student Use of Technology. Teaching Experience was found to have small negative relationships with Beliefs, and Supportive Environment. Anticipated relationships between Leadership and the three outcome variables were not supported in these data. Also, Leadership was also not found to have a significant relationship with perceived Resources. Resources were not found to have a significant relationship with the outcome, Planning, teachers' Beliefs about Technology or Student Use of Technology. Supportive Environment for Technology Use was not found to significantly predict any of the outcome variables as originally hypothesized.

This model provides important information about the variables and how they tie back to the study treatment. The dichotomous treatment variable (Comparison = 0, IMPACT = 1) had direct positive relationships with Resources, Supportive Environment and Beliefs, and only one of the outcome variables. This suggests that there are other contributing factors to the implementation of technology in school than this treatment. Model fit comparisons were implemented and the implications of the significant relationships are further described below.

The regression paths associated of each of these variables were removed from the model. This model is a subset of relationships that remain from the hypothesized model and is referred to below as the “nested” model. A chi-squared difference test suggested that there is a difference in the overall fit of these models. Also, examination of the model fit indexes (Table 10) suggested that there was not an improvement in fit when going from the hypothesized to the reduced model.

The nested model revealed that the previously small positive relationship between the treatment variable was no longer significant and therefore, the treatment did not directly predict any of the outcomes (Appendix E). The treatment variable had significant positive relationships with Beliefs, Resources and Supportive Environment. The relationship between treatment and Resources was large and positive ($\beta = .64, p < .001$) which informs us that IMPACT teachers perceived their technology resources as greater than comparison teachers. The relationship between treatment and Beliefs was moderate and positive ($\beta = .27, p < .001$) and reveals that IMPACT teachers’ Beliefs were statistically greater when controlling for the other variables in the model.

Increases in perceived levels of technology related Resources as depicted by Technology Staffing and Infrastructure had a negative relationship with the outcome variables using technology in Instruction and Students’ Use of Technology. Considering that these are teachers’ perceptions of technology related resources, their relationship with the implementation outcomes could be complicated by dynamics of massive increases in training and technology available. This relationship should be further

explored in the literature to answer the question, “How much technology and training is too much?”

Teaching Experience had significant, albeit extremely small relationships with Beliefs and Supportive Environment. The Leadership variable had moderate and large significant relationships with Beliefs ($\beta = .49, p < .001$) and Supportive Environment ($\beta = .85, p < .001$) respectively. This does not support the hypothesized relationship between Leadership and technology implementation as presently identified in the literature.

This model reveals that the variables Resources and Beliefs are the two variables driving change in technology implementation in this intervention. Although positive relationships were identified by the model, the real driver of change in the outcome variables is the Beliefs variable. Setting the relationships between Beliefs, treatment and Leadership at “0”, the strength of relationships between Beliefs and the outcomes does not change statistically. Examination of the squared multiple correlations, this model was found to explain 30% of the variance in Student use of Technology, 24% of the variance in the Technology in Instruction and 25% of the variance in Technology in Planning.

Table 10

SEM Statistics: Complete Sample and Group Comparisons

	χ^2	<i>df</i>	<i>p</i>	$\chi^2 \Delta$	RMSEA	RMSEA 90% C.I.	CFI
<u>Complete Sample</u>	<i>n = 474, Comparison, IMPACT</i>						
Unrestricted Model	131.99	59	<.01	--	.05	.04 - .06	.98
Hypothesized Model	240.13	66	<.01	108.64*	.07	.06 - .08	.96
Nested Model	274.54	77	<.01	149.72*	.07	.06 - .08	.96

$\chi^2 \Delta$ is the chi-squared difference statistic for comparing the current model to the unrestricted model in the series.

* $p < .01$

As mentioned earlier, model comparisons tested the model invariance for the two groups to determine their level of symmetry. IMPACT and Comparison teachers' data were identified in the AMOS 16 software. First, an unrestricted model tested the relationship between the variables for the Comparison and IMPACT teachers separately. This comparison revealed that the model fit the two groups similarly ($\chi^2 = 19.57$, $df = 12$, $p = .08$). Determining structural invariance within these data suggests that the structure of the models examined in these analyses is consistent across groups. Therefore, the model that effectively explains the relationships between the variables for the IMPACT teachers also explains those relationships for the Comparison teachers. As a result, models from the IMPACT and Comparison teachers will be tested jointly using the same procedures described in the previous model fitting procedures for the entire sample.

The hypothesized model provided adequate fit (Table 11). Next, regression weights were examined to identify any non-significant loadings across both groups. Those regression paths were removed and a subsequent nested model was fit to these data. Table 12 provides a list of the variables identifies their statistical significance and labels those variables that were removed. The hypothesized relationship between teacher's experience and their Beliefs about educational technology was not found to be significant across both groups. This finding suggests that technology is universally perceived as important in educational settings despite the teachers' years of experience. Also, across both groups the direct relationships between Leadership and the three outcome variables were not found to be significant. Indirect relationships between leadership and the outcome variables remained. It is also possible that Leadership influences implementation of technology in ways that may not have been measured in this study. Resources were not found to influence the teachers' use of technology to plan their lessons and examination of the mean scores for both IMPACT and Comparison teachers revealed that this was the most common form of technology implementation across groups. Technology use for planning is something that is common among teachers in this study. Last, the Supportive Environment for Technology Use was found to not have significant relationships with Instruction and Student Use of Technology.

Table 11

SEM Statistics: Comparative Models

	χ^2	<i>df</i>	<i>p</i>	$\chi^2 \Delta$	RMSEA	RMSEA 90% C.I.	CFI
<u>Comparative Groups</u>	<i>IMPACT = 258, Comparison = 216</i>						
Unrestricted Model	183.11	106	<.01	--	.04	.03 - .05	.97
Hypothesized Model	203.75	118	<.01	20.64	.04	.03 - .05	.97
- Group Comparisons	19.57	12	.08				
Nested Model	241.09	132	<.01	57.98*	.04	.03 - .05	.96
- Group Comparisons	13.21	12	.35				

* $p < .001$. $\chi^2 \Delta$ is the chi-squared difference statistic for comparing the current model to the unrestricted model in the series.

After removing these variables a nested model was fit to examine the final relationships between the variables. This nested model produced similar fit among the variables as the previous model and the data for the groups were invariant across the relationships. Finding invariance within these data suggests that the structure of the models examined in these analyses is consistent across groups. Therefore, the model that effectively explains the relationships between the variables for the IMPACT teachers also explains those relationships for the Comparison teachers' data. This may occur despite the non-significant loading of some variables on others. The squared multiple correlations revealed that although this model fit these data well, only a moderate amount of variance in the outcomes are accounted for by the predictor variables in this model within both IMPACT and Comparison teachers' data (Appendix D). A moderate amount of the variance in each outcome variable was accounted similarly through these models.

From these analyses, it is clear that teachers' Beliefs about technology directly influence their implementation of technology. Those Beliefs are influenced by the Leadership in the schools, but leadership teams do not directly influence technology implementation. Contrary to previous literature, perceived Resources are not found to be directly related to implementation of technology. Models for both the IMPACT and Comparison teachers can be found in Appendix E and F.

Table 12

SEM Multiple Group Analyses: Reduced Model – Regression Weights Loadings

Independent Variable	Dependent Variable	Comparison			IMPACT		
		RW	SE	SRW	RW	SE	SRW
Years	Supportive Environment	-.03	.02	-.07	-.03*	.01	-.10
Leadership	Beliefs	.29*	.09	.31	.67*	.08	.62
Leadership	Resources	-.56*	.10	-.43	.47*	.13	.24
Leadership	Supportive Environment	.75*	.09	.73	.97*	.06	.98
Resources	Tech. in Instruction	-1.52	2.96	-.03	-9.33*	2.43	-.19
Resources	Student use of Technology	-11.13*	4.04	-.19	-15.86*	3.05	-.28
Resources	Supportive Environment	-.23*	.06	-.29	.00	.02	00
Resources	Beliefs	-.14*	.07	-.20	-.03	.03	-.06
Beliefs	Tech. in Planning	30.31*	6.60	.40	39.73*	7.28	.43
Beliefs	Tech. in Instruction.	28.11*	5.35	.45	38.19*	5.69	.44
Beliefs	Student use of Technology	35.37*	6.66	.44	50.36*	6.53	.49
Supportive Environment	Tech. in Planning	4.28	4.69	.06	5.08	6.56	.05

* $p < .05$. RW = Regression Weight. SE = Standard Error. SRW = Standardized Regression Weights.

DISCUSSION

The measurement of technology implementation in classrooms is confounded by a variety of practical implications. Failure to measure the use of technology provides gaps in our understanding of how and where technology is influential in student learning. The IMPACT project provided the backdrop on which to measure implementation in three areas that are relevant to decision makers.

One goal of the IMPACT project was that the provision of technology (in its various forms) would provide the impetus for teachers to use technology in their everyday activities. Identifying the manner and frequency that teachers use technology are both useful ways to gauge the relationship between access and usage. The purpose of this study was to investigate the relationships between organizational and individual variables and the three implementation outcomes. This investigation also provided the opportunity to compare the structure of the variables' relationships between across treatment and comparison groups of teachers.

Teachers in both the IMPACT and control groups reported regular use of technology. The literature in this field did not filter out the specific activities where technology was most influential. In this study, the three implementation outcomes help to develop a picture of teachers as multifaceted users of technology that are greatly influenced by their beliefs about the value technology brings to the classroom. The most frequent manner in which teachers use technology is as a tool for planning classroom activities (IMPACT $M = 85$, Comparison $M = 58$ days/year). This example of computer use suggests that many of the teachers are using technology in deliberate manner that

facilitates their working environment (Rogers, 1985). Also, teachers reported regularly using technology to instruct students and reported that students frequently used technology in their classrooms.

Mean score comparisons revealed that IMPACT teachers reported significantly more positive scores on each of the variables identified in this study ($p < .01$). Differences between groups are not surprising when taking into account the treatment provided to IMPACT teachers (described above). Considering that these data were collected during the third year of the intervention we can infer that the IMPACT teachers feel their schools' leadership teams developed a strong vision and adequately planned for technology interventions (see Table 9, p. 107). Also, it is clear that the teachers perceive their schools as supportive environments for technology use. Furthermore, both IMPACT and Comparison teachers' beliefs toward the value of technology are very high, but the IMPACT teachers' had significantly higher beliefs. As expected, IMPACT and Comparison teachers had the largest discrepancy between their perceived level of resources (adequate technology staffing, technology infrastructure).

SEM was used to test the relationships between the variables of interest and the three implementation outcomes. Then a model fitting procedure was repeated to measure invariance across the two groups of teachers. Specific model testing steps were used to identify significant and non-significant relationships between variables and non-significant paths were removed from subsequent models. This procedure revealed both anticipated and unanticipated relationships.

All analytical procedures in this study looked to ensure that the variables of interest and their relationships were congruent across treatment and comparison groups. The first step in this process identified the reliability statistics for each factor using the factor structure identified in Corn (2008). These data were found to consistently measure the suggested variables and the relationships between the variables. The structural regression paths in this specific causal model were found to be invariant across groups. Identifying factor invariance across the treatment and comparison groups in this study provides greater generalizability about the relationships identified (Byrne, 2001).

The classification of teachers at being in either group (IMPACT or Comparison) was not found to have a significant relationship with any of the endogenous variables in the model and was therefore removed from further analyses. Also, in the IMPACT data teaching experience was found to have a small negative relationship with only on the variable Supportive Environment for Technology Use. It was anticipated that teachers with more experience would have more negative beliefs about technology use. This was not supported in these data.

It was anticipated that access to technology resources such as staffing and infrastructure would positively load on beliefs and the three technology implementation variables. Increased Resources should enable teachers to implement technology more effectively and more frequently. In this study, the Resources variable reflected teachers' perceived amount of technology related staffing and infrastructure. It was determined that this variable had significant negative relationships with two of the outcome variables and Supportive Environment. These findings may reflect feelings of being overwhelmed

with technological resources and trainings and assuming that their rate of implementation is not enough. As the mean score comparison above reflects, both groups of teachers are implementing technology regularly and IMPACT teachers at a rate that far exceeds previous examples in the literature.

Literature reviewed for this study suggested that there was a direct positive relationship between Leadership and technology use. It was anticipated that higher scores on the Leadership variable would directly result in increases in technology implementation. From the results it was clear that leadership there is a direct positive relationship between leadership and Beliefs, but not a direct relationship between leadership and the implementation outcomes. The influence of Leadership in the model was examined further for moderating or mediating effects. These results determined that Leadership did not significantly influence the relationship between Beliefs and the outcome variables for either group, suggesting that although Leadership may influence teachers' Beliefs about the utility of technology in their classrooms, those Beliefs are independent of perceived Leadership.

This study confirmed the anticipated relationship between Beliefs and the three outcome variables (Using Technology to Plan, Using Technology for Instruction and Students' use of Technology). This variable explained a moderate amount of the variance in the outcome variables for both groups (Byrne, 2001). This suggests that the value teachers place on educational technology does influence their use of that technology.

To build upon this understanding of beliefs, policies associated with increasing technology use in classrooms should take a two-pronged approach based in evidence of the effectiveness of particular technologies. The first prong of this attack should focus on leadership teams to instill value added by teacher technology implementation through data driven evidence. By doing this, policymakers would build on the principle of increased knowledge at the leadership level will result in supporting positive changes in teaching practices, and student outcomes. Although this study shows large disparities in technology implementation between these teachers, the variable that most influenced their use of technology in both settings was their Beliefs in educational technology's utility. These Beliefs should be the foci of the second set of policy efforts. Technology advocates should train teachers about the mechanisms of using technology, but they should also empower that training by providing evidence on the influence that implementing each technology pedagogically has had on student outcomes. Changing unit and lesson plans to incorporate a particular type of technology is burdensome for a teacher who could more easily implement a lesson generated from the previous academic year. Incurring additional work without the understanding of the payoff for students, and eventually the school community, cuts any technological intervention at the knees.

Suggesting the sharing of evidence based information comes at a cost. The literature reviewed in this study revealed that research on educational technology is limited in scope and fundamental scientific design. Companies interested in developing and selling educational technology to American schools have the social responsibility of

providing solid evidence based research on the utility of their particular technology, not a suggested outcome of “engagement” or, simply a change in the medium of presentation.

Study Limitations

Although this study was able to identify both positive and negative relationships between variables in these data, there are some limitations to this study that should be considered. First, data used in these analyses were restricted to one particular survey (STNA) and year three of the IMPACT intervention. Examination of potential changes in causal structure would have provided substantial insight on the variables relationships with technology implementation. Fortunately, analyses revealed that there was consistency in causal structure across groups.

Using cross-sectional data, there are limitations in the description of how participants’ changed over time. Although this study can present the relationships at year-three, it does not provide additional information about how those relationships may have changed over time. Specifically, a better understanding of how the relationship between Beliefs, Resources and Leadership developed would greatly add to this study.

Examination of the Resources variable identified a non-significant relationship with teachers’ Beliefs about technology. Baseline information about the relationship between these two variables may have provided important information about their relationship. As stated above, Shattuck (2006) found that the IMPACT teachers significantly increased their technology use after the first year of the intervention.

In many ways, IMPACT schools were self-selected through their application for the IMPACT project grant. This process may imply that leadership teams at these schools were inclined to believe that technology is an important component of education, a sentiment that may be diffused among the teacher at those schools. Using a different data collection tool and baseline data Shattuck (2006) found that there was not a significant difference in Attitudes toward educational technology between IMPACT and Comparison teachers. There is always the possibility that a previous intervention at either the community or school level may influence distal outcomes (e.g., provision of new broadband services from local internet providers influencing the number of teachers with internet in their homes, or technology interventions at other schools in the same district providing examples of effective technology use). To address the concerns the IMPACT project we to lengths to match the schools on a number of criteria.

Second, examination of the squared multiple correlations revealed that despite the strong reported fit of the model, the variables only accounted for a low-moderate amount of the variance in each of the outcomes (Byrne, 2001). Future research should look to focus on each of these outcome variables to expand the understanding of what factors contribute to the technology implementation.

Third, the findings from this study would have been greatly complemented by multi-disciplined approach focused on the three implementation outcomes. Learning more about how technology is/is not a priority for teachers can explain some of the unaccounted for variance in these findings. A larger study sample would provide the opportunity to examine how grade level and subject matter influence technology use in

schools. Identifying what technology usage is common to teachers (how they use technology outside of school) may assist in explaining differentiated technology implementation in schools. To address these issues, future research should utilize both formative focus group discussions and in-depth interviews to provide a basis for research design and later quantitative data should be used to expand the understanding of the relationships influencing implementation.

Fourth, this study would have benefited from four additional pieces of information to validate outcomes as well as about the participants' technology training, information on types and frequency of technology use, and methods of implementation. In the hope of providing additional insight on the implementation of technology, future research should investigate these topics. One supporting piece of information was used to help validate teacher-reported use of technology in classrooms. A subsequent analysis was performed to examine the correlation between teachers' and students' reports of technology use in the classroom ($r = 0.169$, $p = 0.07$). Unfortunately, in this study, this correlation was the only method available to validate reported use of technology in classrooms. The size of this correlation and the lack of supporting information may have led to some inconsistencies in the results. In particular, influencing variables such as Supportive Environment and Resources would have greatly benefited from additional information.

Conclusion

This study provided a basis for examining implementation within a treatment/control study setting. In this case, the treatment group received a massive amount of technology. The findings provide the basis for further examining multiple forms of technology implementation and identified teachers' beliefs as a major factor influencing all forms of technology implementation.

Reviewing the educational technology literature reveals a field that is scattered and without clear direction. One way in which to assist this field is to develop a clear definition of educational technology. This study used a more comprehensive definition of technology because the literature reviewed revealed that there is a great degree of disparity the working definition. This definition may need to change over time, but the realities of the interplay between technology, teachers, instructional methodology and student perceptions of technology need to be considered during each revision. This is an ever evolving process as technology rapidly advances and becomes more interactive, more interconnected and more accessible.

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APPENDICES

APPENDIX A

Variables Contained in the SEM, Two-Sided Correlations: IMPACT & Comparison Teachers

		Dependent Variables			Leadership		Supportive Environment				Resources		Beliefs			
		IT	TE	TP	TI	SU	V	AP	B	E	FS	M	ATS	I	TPRAC	SO
Dependent Variables	IT	1	.08	.35**	.32**	.23**	.39**	.43**	.56**	.46**	.42**	.49**	.69**	.76**	.37**	.32**
	TE		1	-.09	-.04	-.11*	.05	.05	-.06	-.02	-.04	.49**	.10*	.12*	.37**	.32**
	TP			1	.63**	.54**	.30**	.37**	.30**	.38**	.34**	.34**	.14**	.14**	.45**	.34**
	TI				1	.58**	.29**	.35**	.26**	.35**	.25**	.27**	.01	.05	.42**	.32**
	SU					1	.30**	.30**	.26**	.37**	.30**	.34**	-.07	-.02	.41**	.40**
Leadership	V					1	.76**	.61**	.68**	.53**	.56**	.25**	.26**	.41**	.42**	
	AP						1	.63**	.73**	.57**	.58**	.25**	.24**	.40**	.43**	
Supportive Environment	B							1	.71**	.55**	.68**	.35**	.33**	.39**	.36**	
	E								1	.51**	.67**	.26**	.27**	.45**	.42**	
	FS									1	.60**	.28**	.24**	.34**	.38**	
Resources	M										1	.25**	.24**	.16**	.15**	
	ATS											1	.88**	.16**	.13**	
Beliefs	I												1	.40**	.40**	
	TPRAC													1	.67**	
	SO														1	

* Significant $p < .05$, ** $p < .01$

IT = IMPACT Treatment, TE = Teaching Experience, TP = Technology Planning, TI = Technology Instruction, SU = Students' Use of Technology, V = Vision, AP = Administrative Planning, B = Budget, E = Evaluation, FS = Flexible Scheduling, M = Media, ATS = Adequate Technology Staffing, I = Technology Infrastructure, TPRAC = Teaching Practices, SO = Student Outcomes

APPENDIX B

Variables Contained in the SEM, Two-Sided Correlations: IMPACT Teachers

		Dependent Variables					Leadership		Supportive Environment				Resources		Beliefs	
		IT	TE	TP	TI	SU	V	AP	B	E	FS	M	ATS	I	TPRAC	SO
Dependent Variables	IT	1	.28**	.02	.20*	.14	-.10	-.06	-.07	.02	-.12	-.04	-.04	-.02	.19*	.13
	TE		1	-.03	-.07	-.10	.12	.13	-.09	-.00	-.00	.04	.27**	.27**	.03	-.02
	TP			1	.61**	.51**	.21**	.29**	.25**	.34**	.34**	.31**	.02	.01	.47**	.34**
	TI				1	.55**	.22**	.31**	.19**	.31**	.21**	.26**	-.17*	-.17*	.42**	.29**
	SU					1	.17**	.23**	.15*	.30**	.23**	.27**	-.24**	-.22**	.42**	.35**
Leadership	V					1	.69**	.53**	.68**	.40**	.48**	.23**	.21**	.42**	.47**	
	AP						1	.57**	.72**	.47**	.58**	.18**	.20**	.43**	.54**	
Supportive Environment	B							1	.58**	.40**	.49**	.23**	.22**	.31**	.32**	
	E								1	.37**	.59**	.16*	.15*	.45**	.47**	
	FS									1	.48**	.01	.21**	.36**	.40**	
Resources	M										1	.16*	.16*	.08	.05	
	ATS											1	.16*	.06	.09	
Beliefs	I												1	.43**	.45**	
	TPRAC													1	.72**	
	SO														1	

* Significant $p < .05$, ** $p < .01$

IT = IMPACT Treatment, TE = Teaching Experience, TP = Technology Planning, TI = Technology Instruction, SU = Students' Use of Technology, V = Vision, AP = Administrative Planning, B = Budget, E = Evaluation, FS = Flexible Scheduling, M = Media, ATS = Adequate Technology Staffing, I = Technology Infrastructure, TPRAC = Teaching Practices, SO = Student Outcomes

APPENDIX C

Variables Contained in the SEM, Two-Sided Correlations: Comparison Teachers

		Dependent Variables					Leadership		Supportive Environment				Resources		Beliefs	
		IT	TE	TP	TI	SU	V	AP	B	E	FS	M	ATS	I	TPRAC	SO
	IT	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TE		1	-.154*	.06	-.10	.04	.40	-.05	.02	-.03	-.01	.07	.03	-.14	-.80
Dependent Variables	TP			1	.58**	.51**	.22**	.30**	.12	.26**	.15	.18*	-.14	-.14	.31**	.22**
	TI				1	.55**	.23**	.26**	.10	.27**	.11	.12	-.17*	-.14	.32**	.24**
Leadership	SU					1	.31**	.25**	.19*	.35**	.24**	.30**	-.30**	-.24**	.32**	.37**
	V						1	.71**	.48**	.55**	.43**	.48**	-.22**	-.34**	.24**	.23**
Supportive Environment	AP							1	.47**	.62**	.45**	.40**	-.19**	-.33**	.20**	.20**
	B								1	.62**	.38**	.58**	-.21**	-.38**	.23**	.18**
Resources	E									1	.36**	.53**	-.24**	-.34**	.29**	.24**
	FS										1	.48**	-.20**	-.28**	.18*	.20*
Beliefs	M											1	-.34**	-.45**	-.27**	-.20**
	ATS												1	.66**	-.18**	-.26**
	I													1	.18*	.19*
	TPRAC														1	.56**
	SO															1

* Significant $p < .05$, ** $p < .01$

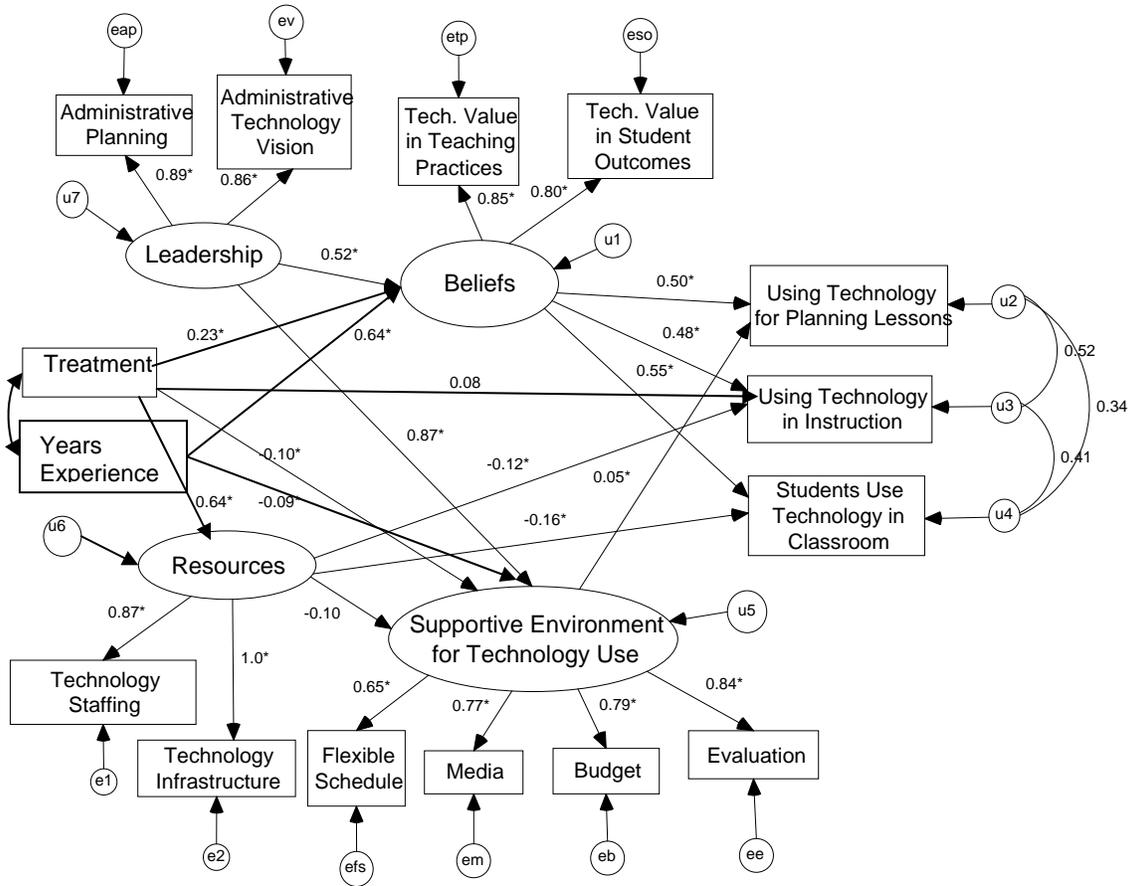
IT = IMPACT Treatment, TE = Teaching Experience, TP = Technology Planning, TI = Technology Instruction, SU = Students' Use of Technology, V = Vision, AP = Administrative Planning, B = Budget, E = Evaluation, FS = Flexible Scheduling, M = Media, ATS = Adequate Technology Staffing, I = Technology Infrastructure, TPRAC = Teaching Practices, SO = Student Outcomes

APPENDIX D

Squared Multiple Correlations

	<u>Comparison</u>	<u>IMPACT</u>
Resources	.19	.06
Supportive Environment for Technology Use	.80	.97
Beliefs	.19	.37
Using Technology to Plan Lessons	.18	.21
Using Technology in Instruction	.21	.21
Student Use Technology in the Classroom	.29	.29

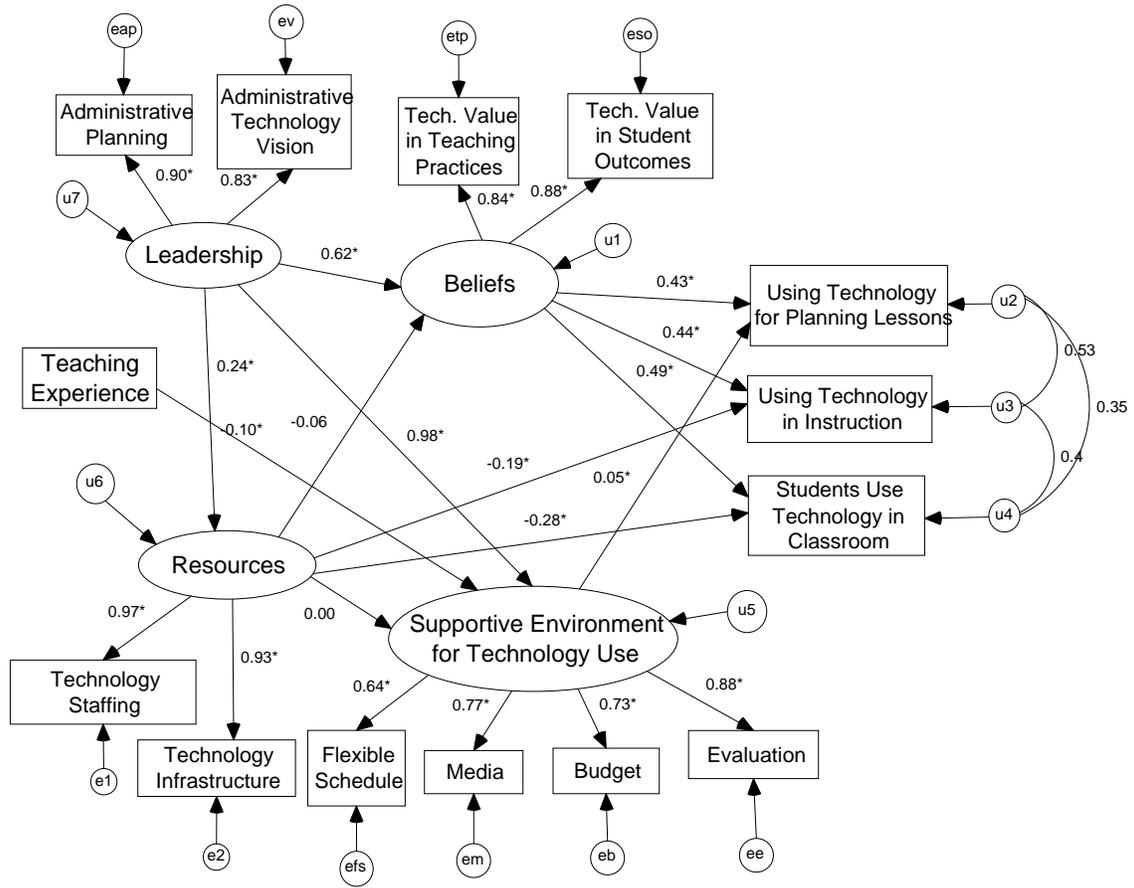
APPENDIX E



Standardized Regression Weights: Entire Sample

* $p < .05$

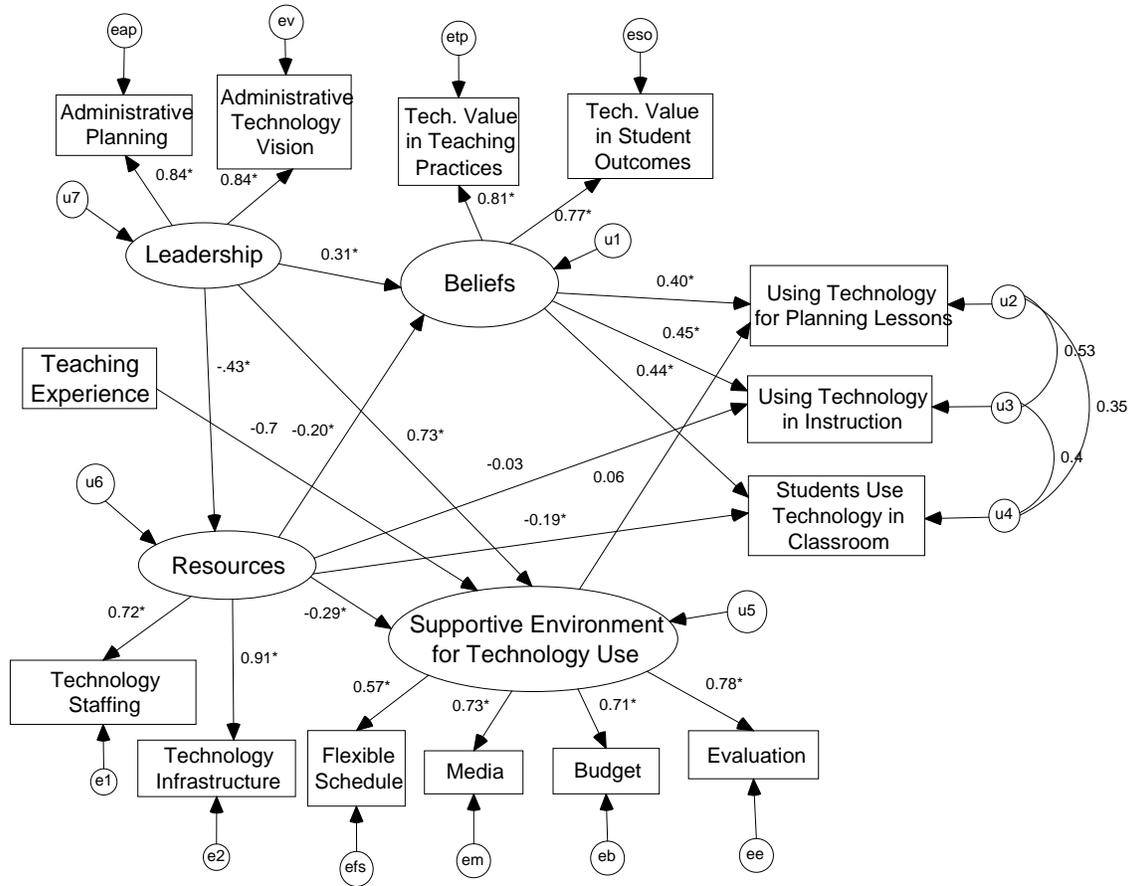
APPENDIX F



Standardized Regression Weights: IMPACT Teachers

* $p < .05$

APPENDIX G



Standardized Regression Weights: Comparison Teachers

* $p < .05$