ABSTRACT

SHATTUCK, DOMINICK. Technology Implementation in the Classroom. (Under the direction of Denis Gray, PhD.)

The purpose of this research was to examine the relationship between teachers' attitudes toward technology and its implementation while their schools are undergoing a large-scale technology infusion in the state of North Carolina. The eleven treatment schools were selected through a grant writing procedure, high technology needs and Title I status. A detailed procedure was used to identify and recruit comparison schools. Treatment schools were provided with almost $1.5 million over three years to purchase educational technology, train their teachers and staff two full-time technology related positions: Media Coordinator and Technology Facilitator. In addition, schools were required to develop and integrate a Media Technology Advisory Committee (MTAC) to oversee planning and budgeting issues related to technology. Utilizing a quasi-experimental pre-post design, this study analyzed teacher attitude changes for treatment and comparison groups over year-one. Attitude and instructional practices were compared with pre-measure data to assess a baseline comparison of groups. Changes in group scores over time were conducted using RMANCOVA and differences were found between groups for two attitude subscales and for four instructional practices. The largest effect was found for technology implementation. Exploratory hierarchical regression analyses were conducted to assess the predictive relationship between attitude subscales and technology implementation. Only teachers' Affective Reaction to Computers had a significant relationship with Technology Implementation.

# TECHNOLOGY IMPLEMENTATION IN THE CLASSROOM

by
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## DEDICATION

My completion of this master's thesis and progress in the Psychology in the Public Interest Program was only possible through the support of family, friends and the instructors at NC State. There are two people in particular who provided inspiration toward the completion of this thesis.

First, my wife Kristen provided a daily foundation of love and dedication that enabled the completion of this document. During the last few years our development of a home and family has garnered its own sense of community that has enabled me to excel personally and academically. Her example of professional and academic excellence has pushed me to take on this program with vigor. I am excited to tackle any challenges the future may hold with her and together we will provide a life of discovery and accomplishment for our daughter Harper.

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# BIOGRAPHY

Born in Fitchburg, Massachusetts, Dominick Shattuck graduated from Clark University with a BA in History in 1992. After undergraduate work, he pursued teaching as a first career until returning to graduate school. Presently, he resides in Durham, North Carolina with his wife and daughter as he is working toward the completion of a PhD.

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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 enable Dewey's process of living.

Different parties are influential in the drive to place more technology resources in classrooms and enable teachers to better implement their use effectively. Parents may initially push the process by expressing their interest in having their children learn in a manner could be more engaging and provide access to skill sets relevant to today's job market. Administrators may hope to address the wave of standardized testing with higher rates of achievement that some researchers are claiming can come through technology-rich curricula. And teachers may examine the use of technology in two contrasting ways: first, as an additional challenge to their job which is different and exciting, or second, as a mandated change from administrative personnel.

The relevance of technology resources and their implementation in schools is far-reaching. The federal No Child Left Behind (Education, 2000) legislation 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 this initiative 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.

This raises the question of who will provide teachers and students with the expertise needed to successfully integrate technology? 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 other recent surveys. They did not speculate on the reasons behind this decrease, which could suggest reprioritizing of personnel within schools. Meade and Dugger (2004) also addressed the application of national technology standards with state supervisors. Their results show that forty-one states are using standards. These standards are either the adoption of Standards for Technology Literacy (ITEA, 2000/2002) or the application of standards developed from this basis. The integration of technology into the state policies and reflects the rising value that is being placed on the topic of technology within schools.

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.

The mosaic of research surrounding implementation of technology in schools has been developing, but a complete picture has not been developed. Research frequently looks at smaller-scale initiatives, fragmented by a narrow focus. There is also a great deal of research-design variability and the inability to apply findings across environments. These differences have limited our understanding of the process related to technology adoption and implementation in schools.

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) claims that the advice from experts in the field is contradictory, changing with the latest and greatest advancements in technology (Cuban, 1999). Technology implementation is a pressing issue, but previous research focus, sampling issues and the designs often limit the ability to generalize the findings. This section reviews some of the literature which reflects the increasing importance and shortcomings of the research which accompanied this educational development.

An early example of the literature related to instructional technology within schools was done by Williams and Brown (1991). In their review of the literature, they conclude that computers and other technologies can sometimes be used to teach more effectively than a typical classroom teacher but other times not. This vague conclusion displays the inconclusive nature of their literature summary. Their focus was on inclusive technologies which attempted to substitute teachers with computers and software. Although relevant to public fears at the time, this threat is no longer of substantial consideration within the educational technology literature. One of the major themes of their paper emphasizes that "those who have conducted research on various aspects of computer teaching have been more comfortable with computers than with research methodology, and thus even published studies often contain serious design flaws (Williams & Brown, 1991, p. 40)." Williams and Brown continue to elaborate on the failure of researchers to establish important research questions and conditions for their studies. One suggestion provided in their paper is the need to tie the research to educational theories of learning and then to build from this point to develop a new understanding of how students learn by utilizing this new classroom tool. Their recognition of technology's potential utility and the failure of associated research were later echoed by the federal government's Panel of Education and Technology.

David Shaw (1998) summarized the findings and recommendations of the Panel of Education and Technology's "*Report to the President on the Use of Technology to*

*Strengthen K-12 Education in the United States*." Looking at both the effect of technology and the related financial considerations the Panel described the research in this area as being unable to generalize across samples despite previous efforts, "we are not yet able to answer this question (nor, indeed, even to define it precisely)…from a public policy perspective. (Shaw, 1998, p. 117)."

Shaw's summary of the Panel's findings continues to suggest that research is the best way in which to learn more about the use of technology in schools and continues to identify three areas as most important in future school technology research:

1. Basic research in various learning-related disciplines and fundamental work on various educationally relevant technologies;
2. Early-stage research aimed at developing new forms of educational software, content, and technology-enabled pedagogy;
3. Empirical studies designed to determine which approaches to the use of technology are in fact most effective; (Shaw, 1998, p. 120).

Complementing the list, the Panel proposes three characteristics of the research from this field. They suggest that the research uses large samples, that it can be generalized to other educational settings and that the findings are widely disseminated through professional journals. This attempt at proactive guidelines for educational technology research has provided a framework for the literature during the last seven years. Unfortunately, the same questions are still unanswered and the criticisms of the research implemented before the Panel meeting are still unresolved, as many articles are limited to a small sample size and are not able to be generalized across settings and do not use effective qualitative or quantitative research techniques.

One study that attempted to apply the panel's suggestions looked at a national sample and the outcomes related to technology usage in schools. Using data drawn from the National Assessment of Educational Progress (NAEP), the Educational Testing Service (ETS, 1998) published a summary of findings which reflected the state of computers and technology within American schools. The data used for analysis was based on a national sample of fourth and eighth graders and the use of computers in their mathematics classes. They looked at four indicators of organizational use of technology and two educational outcomes (Table 1).

Table 1

Indicators of Organizational Use of Technology

| **Organizational use Indicators** | **Educational Outcomes** |
| --- | --- |
| - Frequency of school computer use for mathematics tasks<br>- Access to home computers/frequency of home computer use | - Academic achievement – as measured by mathematics test scores |
| - Professional development of mathematics teachers in technology use<br>- Higher-order and lower-order uses of computers by mathematics teachers and their students | - Social environment – measured by bringing together various indicators of teacher and student reports |

Educational Testing Service. (1998). *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics*. Princeton, NJ

Their findings reflected a large number of issues that appear in the present literature on school technology. The present-day hot topic "Digital Divide" is discussed in this report. ETS found that eighth-grade Black students were less likely to be exposed to higher-order uses of computers than whites and both eigth & fourth-grade Black students were less likely to own computers than Whites. Also, they found that students with lower Socio-Economic Status benefited the most from the use of technology in school (This topic will be discussed more below.). They highlighted the relationships between teacher training with computers and student computer use for higher-order thinking skills as positive indicators of student advancement beyond their peers.

Highlighting the value that technology has added to education, their study offers three suggestions for policy makers. First, they suggest additional teacher training to assist in the implementation of technology in classrooms. Second, computers should be used in a somewhat complementary manner to address some of the higher-order thinking skills. Also, teachers may want to use computers to complement concepts that were previously learned elsewhere. Third, the primary focus of technology integration should be in the middle schools. Their suggestions are based on the effect size of their results, which showed the greatest gains associated with technology happened in mathematics classes of middle school students. If other subjects were the focus of this research (i.e.; Reading, History), their findings may have displayed other levels of integration and resulted in different suggestions.

This ETS study is important to the overall panorama of educational research because it reflects two areas in which some studies have focused: teacher training and subject area. Teacher training has received a great amount of attention for many years and provides a straightforward design using pre and post treatment values from which to make conclusions. The frequent shortcoming of the research in this area is that actual classroom implementation data is not provided. This may be due to the research constraints, but the disconnect between training someone within the setting of a workshop and finding out whether they implement technology in their everyday practice is the topic that needs greater attention. Developing a better understanding of implementation provides insight into how adoption and implementation affect outcomes across settings.

Also, this study provides a large scale look at mathematics teachers and their students, not a comprehensive picture of technology usage across the entire educational environment. Their examination of Social Environment as an outcome variable expresses the idea that technology usage permeates the entire school community. However, they focus only on mathematics and not other subjects in which those students are also taking part in during their school day.

Educational technology has merited a great deal of attention by academics, legislators, parents and school administrators. As this subject 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 study is a small component to the larger intervention study, the IMPACT project, that addresses both ecological levels of analysis, teacher activities and tangible outcomes for students and teachers.

**Adoption of Innovation Literature:**
**Relevance to Educational Implementation Literature**

> *Although many technologies are important in education, such as television or non-hardware-based instructional techniques, for many people, social emphasis on the computer has made it take on almost iconic significance as a device that has come to represent Technology in Education (Doty, 1992).*

Doty's comments regarding the social implications of technology ring loud and true in the new millennium. Computers provide us with a physical object that represents progress and the inherent challenges of updating as they become smaller, faster and more connected. We want and expect to see computers used everyplace, especially in schools. Keeping abreast of this mechanistic and social progress provides ample fodder for parents, teachers and policy makers as they decide what is, and isn't appropriate for classroom use. Present perspectives on innovation evolved from the familiarization of society with devices such as toasters, microwaves and MP3 players, as well as, cultural connections to technology through the chess competitor Big-Blue, and home computing with the Apple II. Studying cultural transitions to full-scale implementation of various innovations provide case studies of overwhelming successes (Sony Walkman) and sheer disappointments (video laser discs).

Most innovation researchers will cite any number of editions of Everett Rogers' (1995) *Diffusion of Innovations* as distantly relevant but fail to use relevant models and develop frameworks that can be generalized across school settings. In contrast, starting with individual perspectives on the process of adopting innovations moving through top-down and chain link models and then using Rogers' work as a lens, this section hopes to provide examples of other relevant research that should pertain to the process of implementing technological innovations in schools.

**Perspectives**

Starting with our perspectives on technological innovations will provide a foundation from which to move into relevant models. Ernest House (1981) claimed three general perspectives held by individuals about innovations: technical, political and cultural. The first is a more technical view of innovations, which separates the process into functions based on rational analysis and empirical research (The technical and political perspectives are combined in the work of van den Berg, & Sleegers (1999) and referred to as the structural-functional perspective.). Reflecting our need to answer the questions: How and why will we use this new technology? This perspective enabled systemization and replication of adoption techniques that enable end users to implement the innovation. House mentions this as the most dominant of the three perspectives and reflects our penchant to reduce learning to a set of measurable, and teachable, tasks. A direct relationship can be made between understanding this perspective and that of a school teacher who is asked to implement a new tool within the classroom. Without the proper connections being made between the curricula and the classroom activities, the technology is rendered useless.

The political perspective is the second influencing factor on society’s view of innovation. House categorizes innovation as, “…a matter of conflicts and compromises among factional groups.” This parallels communication concerns stated in Rogers’ (1995) and provides basis for the more recent ecological focus on implementation of technologies by Zhao (2001) by identifying the complexities present in school environments.

Building from the political perspective House suggests that combating cultural norms is critical in implementing innovation (van den Berg, et al., 1999, also recognizes the cultural-individual perspective of innovations.). In his cultural perspective, the values and norms of stakeholders present challenges which need resolution. Finding cohesive understandings and expectations for the innovation in question will require significant work and flexibility on the part of each party to find a reasonable middle ground for the use of the innovation. There can be environments which are more prone to adjust to changes in their activities than others. Fusing these three perspectives together provides the necessary foundation for exploring the adoption of innovation literature and focusing on the processes involved.

**Environment**

Baskerville and Pries-Heje (2001) identify two channels through which information may come to a user: genealogical and ecological. The genealogical view of diffusion of innovation is developed around consensus building and regulation of a particular organization. Often authority comes from a central source where initial innovative decisions are made. Diffusion patterns within an organization may not be transferable to another company in the same industry due to the differences such as size or demographics. This is an issue that arises continually in educational research as no two school districts are exactly alike. Often, factors such as community wealth/poverty and history/culture may contaminate the application of research findings. Clearly, issues such as leadership style/effectiveness can impede or excel the diffusion of some innovations. Another channel identified by Bakerville and Pries-Heje (2001) is the ecology. This channel emphasizes the themes of conflict and competition and is more applicable across organizations by determining the climate for change. Focusing on organizational direction through interdependent relationships utilizes various needs to find optimal outcomes. Although some best practices may be transferred from organization to organization, their application will need consistent adjustment to be effective. The literature surrounding the implementation of innovations identifies the structure of decision making and feedback as components that enable organizations and researchers to locate discontinuities in the implementation process.

### Linear & Chain-Link Models

Kline and Rosenberg (1986) outline the linear and chain-link models of the innovation process and their shortcomings. The linear model, or top-down approach, originates from the research arena, flowing through development, production and marketing. Without feedback loops from users of the innovation, the model neglects valuable information that could enhance the adoption process. This *prescription process* is one used commonly in both political and education settings. Policy handed down from upon high frequently infers that success in particular schools or settings are immediately transferable to all schools and should be implemented. Unfortunately, policy makers often believe this to be the optimal framework for implementing change. In fact, it may lead to high levels of implementation, but can often be characterized as low quality workmanship and short-term change with the relaxation of leadership.

Evolving from the linear model is the chain-linked model. Incorporating various paths of activity, “the linkage from science to innovation is not solely or even preponderantly at the beginning of a typical innovation, but rather extends all through the process – science can be visualized as lying alongside development processes, to be used when needed" (Kline & Rosenberg, 1986 p. 290). As mentioned in later areas of this paper, the symbiotic relationship between various components of the models is required to create an innovation appropriate for the market or end user(s).

## Rogers' Diffusion of Innovations

Everett Rogers' (1995) diffusion of innovation model is classified as an ecological model that focuses on the influences people have on one another through a better understanding of the innovation, communication channels, the effects of time, the social system and the role of leaders as change agents. Focus will be paid to these aspects of Rogers' diffusion process as it relates to schools with complementary research from other leaders in this area.

### Innovation

An innovation can take several forms provided it is perceived as "new" to the users. In the school setting, this could take the form of a computer, data projector or an interactive Smartboard. Importantly, the innovation could also be a social process or device such as a computer software enabling a teacher to submit his/her attendance through the computer rather than a paper form (Tornatzky & Fleisher, 1990). Each of these new innovations will carry an undetermined intrinsic value for the user. As mentioned above perceptions of the innovation may be based in past experiences, the culture/climate of the environment or access to resources. Novelty may play into the perception of the user, influencing implementation decisions, but the nature of the innovation itself will be a key determinant in its use.

### Communication

Mentioned previously, communication channels will also influence the implementation of the innovation. Peer influences, availability of resource personnel or training will either enable or hinder usage. Users who learn of the innovation from people like-minded to themselves are more likely to have positive perceptions of the innovation (Kanter, 1988; Rogers, 1995). Teachers who share the same subject matter may become very influential in the potential adoption of the innovation by other teachers in their department. Also, Kanter suggests that adoption could be aided by communication of school leadership and examples set by upper management's usage of the technology in question (p. 190). Communication also compliments the ecological considerations of the process in the form of distance (Zhao, 2001). Often distance is referring to physical space, but like the situation with teachers of the same subject matter, it can be the perceived distance from their original topic to the technology itself. Without the proper framing of the innovation, teachers may not recognize its relevance to their classroom objectives. Communicating that relevance is critical.

## Time

Time will also play a crucial role in the level of the sustained adoption of the innovation, the creativity involved in the use of that innovation and the rate of adoption by the users (Rogers, 1995). As mentioned by Kline and Rosenberg (1986), success demands not only selecting the right costs and performance, but also judging just when the timing is right for the product's introduction.

The influence of time on the process of innovation is not just in the urgency of adoption, but also relevant to the users' ability to organize time for the adoption of the innovation. Ely (1991) states that the number one reason why technology is not integrated into curriculum is the lack of planning time for teachers. This notion is supported by both Cuban (1999) and Becker (2000) as well.

Introducing new technologies within schools creates forces teachers to recreate the processes of performing their jobs, which is a large undertaking. If resources are provided at inconsistent rates or without understanding the optimal training and time it could result in creating an unstable environment and negative experiences for teachers, pushing them back to practice as usual rather than implementing the innovation.

## Social System

Lastly, the social system in which people are asked to use the innovation will impact adoption levels. Factors such as the division of units within the organization, opinions of leaders, the types of innovative decisions that have been made in the past and the end consequences of the decisions will influence the adoption of the innovation.

Rogers (1995) mentions three types of equilibrium states that may occur within an organization: stable equilibrium, dynamic equilibrium and disequilibrium. Understanding that stable equilibrium and disequilibrium are undesirable, a facilitative body (individual change agent or organized committee) will need to promote dynamic situations with both the individuals involved and the innovations. This requires both feedback mechanisms and coordinated focus of individual teachers.

Change agents should try to promote a dynamic state of equilibrium that encourages the social system to accept the change at a pace appropriate to the climate of the organization. Kanter (1988) mentions that systems requiring mid-level employees to report to a project and functional boss would increase communication levels and promote increases in collaborative decision making. Within the school setting, teachers often are responsible to their department head as well as directly interacting with either media coordinators (librarians) or administrative staff on various issues related to their broad range of responsibilities, but are more than often autonomous developers of their classroom activities. This provides a conundrum for the role of leadership within schools that tugs at the cultural fabric of its organization and intrinsic values of teachers. Increases in collaboration become decreases in autonomy for teachers. Leadership becomes the lead innovator who must balance this delicate cultural change.

Dougherty (1996) mentions that multidisciplinary teams help innovators create commitment by providing a sense of inclusion, regardless of status. As suggested by Kanter (1988), this could promote entrepreneurial behavior on the part of the teachers, encouraging them to be resourceful, build coalitions and gain various perspectives on procedural issues of the innovation. She continues to state that, "…restructuring of the organization often occurs during the innovation process … (Kanter, 1988 p. 197)." An example of this reassignment can be seen in the IMPACT project as librarians are renamed “media coordinators” and the creation of the position, “technology facilitator.” Both changes occurred due to the increase of technological innovations housed in school libraries and the need to have a staff member assist with the implementation of and maintain technology within the schools.

Mentioned briefly above, collaboration between teams is one dynamic activity in which leadership can help facilitate implementation of innovations. In an attempt to avoid discouragement and less adoption of innovation leaders may look to promote less isolation of work-groups and discontent with supervisory decisions. Dougherty (1996) emphasizes the integration of work groups across an organization to enable development of innovative ideas beyond a single project area. Managing the link between the customer needs (teachers and students) with the organizations technical capabilities must permeate the entire organization, since a specific product must draw on resources around the organization, and all those resources must accommodate multiple sets of market – technology linkages. These factors of the diffusion of innovation are central to the long-term decision making processes of the organizations. Within a school setting, this takes the form of collaboration time for teachers from various disciplines and levels to create strategies and solve similar problems. Collaboration can come from a variety of places. Increasing technology capacities enable teachers to look to more non-traditional resources to aid in communication and the enhancement of their lessons.

Lastly, the notion of access to resources and the development of dynamic organizations are addressed by Tushman and Rosenkopf’s (1992) identification of closed and open systems. These classifications are used as means by which we determine how technologies are linked and implemented and to better understand their impact on the end users. A set of simple products that are linked together through a linkage interface, defines a closed system. Examples of the closed system are textbooks, overheads and televisions and video cassette recorders. These technologies are traditionally available to teachers and implemented, but are reliant on the individual teacher and limit the utilization of resources outside of the classroom. Today, teachers are incorporating additional technology, which reflects an open system of resources. Students can research topics on the internet or possibly practice language and math skills on an interactive website. These activities are examples of open systems that have no boundaries (although schools often put search restrictions on internet access) and require users to interface on various levels of the process. The "networked" components of these activities are working together over both physical and virtual distance. Technological interdependencies are present and varying in capacity for both the student and teacher. Information is shared (in a linear sense, this is where the model fails me) and the instruction of the teacher in combination with the effort of the student and the quality of the information provide a dynamic system of exchange.

Tushman et al. (1997) refer to this dynamic organization style as managing innovation streams and suggest that organizations must learn to control these streams in a proactive manner to avoid stifling their potential growth. Their "creation of luck" provides the backdrop for diverse approaches which can later be altered and built upon by those involved. Applying this concept within the structures of schools may be challenging but can provide the ability to generalize frameworks across populations.

Unfortunately, the overall application of innovation models to school settings has been limited and the research surrounding this topic is stymied by small sample size or fluctuating nature of school staff. Despite this disconnect, greater effort should be made to integrate the two bodies of literature and develop the field of technological advancements in schools.

## Big issues & Concerns

### Digital Divide

Rosemary Sutton's (1991) review of the literature on the state of educational technology provides three consistent issues: access, process and outcomes. These issues are confronted in the more recent literature and have generated hot debate in the field. This section will review research related to technology access as it pertains to socio-economic level, race and gender in schools. Then the debate regarding process and outcomes will be addressed briefly by looking at articles by Larry Cuban and Henry Becker, two major figures in the field of Educational Technology, and their findings related to technology usage in the classroom.

Today, the notion of technology access is often stated in the media as the *digital divide*. Research on the topic confronts the realities of variations in technology access within US schools. The variety of resources is often associated with the socio-economic status of a community. As wealthier schools acquire more current technologies, students in poorer schools are often forced to use outdated resources or none at all. Access is not only a concern when dividing student populations by socio-economic levels, but also when considering the role of female students within wealthy and less wealthy communities. As the role of technology evolves and connectivity increases it provides the opportunity to examine the relationship between the technology and its social ramifications.

The *digital divide* provides a real-world example of both positive and negative influences and variations of fidelity that may occur through the adoption of an innovation (Rogers, 1995; Tornatzky & Fleisher, 1990). Rogers makes two generalizations about the consequences of adopting innovations for various social groups. He states that they usually tend to widen the socioeconomic gap between the audience segments of earlier and later adopter and previously high and low socioeconomic status (1983). Considering the conclusions of research in this area schools are attempting to address the *digital divide* by bringing technology to communities that may not otherwise have access to computers and training in computer literacy, and in turn help develop individual skills for technology related jobs. This "trickle-up" model uses public education as the vehicle to address lifelong skills and the *digital divide*.

Timothy Morse (2004) looks more closely at access by citing statistics on minority group home computer access from the U.S. Department of Commerce. They found that nationally 51% of households reported owning a computer, yet the percentages were different for Hispanic (33.7%) and Black (32.6%) households (White households are aggregated into the overall American population.). Household internet access was reported at 41.5% for the entire nation and 56.8% for Asian and Pacific Islander American households, yet only 23.6% for Hispanic and 23.5% for Black households. Also, Morse cites Department of Commerce statistics for parental demographics that reveal 2 parent households (60.6%) are almost twice as likely to have Internet access than single-parent households (male-headed 35.7%, female-headed 30.0%). An extension of these statistics are provided by the work of Clark and Gorski (2001) who found that internet access is found more frequently in schools with less than 10% racial minority than schools which have enrollments comprised of more than 50% or more of the student body. These statistics provide an opportunity for educators to begin questioning the role of schools in computer access and computer skill development for students. Questioning that role has been under debate for more than twenty-five years.

Sutton's research looked at studies conducted during the 1980s, a time when home computing was beginning to flourish and eager schools looked for ways to equip themselves with machinery to teach programming and keyboarding. Studies cited by Sutton ranged in focus from measuring national access and ownership of home computers to rates of any computer usage. One 1985 – 1986 example equated that 78% of White students versus 65% of Black and 69% of Hispanic students had used a computer which supports the notion that schools can promote equity, technology access, and skill development opportunities to their students.

Literature reviews reveal important differences in access as it relates to gender. A study by Becker and Sterling (1987) found that female participation in computer usage at 30% at the elementary level, while rising to 50% for high school aged females. This adjustment in participation suggests that gender roles may be imposed by teaching staff until female students are able to assert interest in this area.

More recently, a German study (Tully, 2004) reported that 52.7 percent of males between the ages of 15 – 26 were "Technology Fans" compared to only 9.3 percent of female respondents. Conversely, 69.3 percent of the girls were reflected in his other category entitled, "Technology Grouches." His study reflected a possible negative perception or attitude of female students. Losh (2004) further supports the notion of gender technology divisions and presents evidence that highly educated males are more likely to use email and internet related services at home than women. Looking at the effect that access to technology may have on gender differences Mammes (2004) used a multi-method study of third-grade German students set out to determine if there were differences in interest toward technology education for girls and boys. During the introduction of technology class to the students, interest levels were measured and showed that they are somewhat different in their level of technical interests, frequency of dealing with technical objects and their emotional relationship with technological objects. Following the technology education class all of gender related differences in these areas were substantially diminished. Mammes study provides a strong case for the introduction of technology education at a young age and the notion that the relationships between students and technology can be fostered within schools. Looking at this body of literature, the gender division exists, but there is a potential treatment to balance the early development of negative attitudes.

Solutions addressing the issue of the *digital divide* in both gender and racial terms are greatly varied, but all call for the increase in technology available to students. As suggested by Morse (2004), students could have access to technology in the form of evening, weekend and summer courses, technology camps, technology clubs and through the public libraries or through donations by businesses. His suggestions are not without merit, but putting these suggestions into practice come with additional cost and resources that many school districts may not be able to afford.

In support of these efforts, research in the area of *digital divide* has traditionally come with serious limitations. Across the literature, Sutton (1991) found a fair amount of research attributed to access, but those studies were limited by their small sample size and basic design questions. She wrote that there were few studies on equity and school computer use that examine simultaneously race/ethnicity, social class, and gender. This limitation can lead to over simplification and inaccurate understanding of what actually occurs in schools. Without proper research design, the recommendations of the Panel of Education and Technology (Shaw, 1998) will largely go ignored.

In one study which utilized large samples that can stand the challenge of generalization, Van Dijk and Hacker (2003) traced the concept of the *digital divide* through both the Netherlands and the US in hopes to identify who actually had access to computers and how they were gaining that access. Looking at computer possession as the critical element of the study, Van Dijk and Hacker applied a statistical approach to deciphering whether the gaps would widen over time. They found that when looking at income, education, occupation, age, gender, ethnicity and geographic location the current trends as they relate to computer ownership would not continue, yet the universal ability to purchase the most recent technology supports Rogers' previous claim that new innovations will widen social gaps over the long haul. Their logic rests in the idea that over time most individuals and families will possess computers and have access to the internet. The focus is placed on providing those people in "lower" categories with a chance to catch up, while keeping an eye on the latest trends.

Of the factors associated with the current state of the *digital divide*, they found that the data from both the US and the Netherlands revealed an independent effect between income, education and employment when controlling for the other factors. These findings can be associated with adoption of innovation literature and the notion that early adopters of innovations will typically be wealthier and more highly educated. The question arises about whether the front end growth of new technologies and advancements will progress at a slower rate than the overall population's ability to acquire that technology. This logic can be applied to schools. As schools attempt to provide mandates of minimum technology standards (5 computers in a classroom, access to the internet in every classroom), the schools who are behind have legislative support to make positive strides. Whether standards will enable all schools to remain close to the front-end of the curve remains to be seen.

Access to technology may be moving toward higher levels of inclusion for our society, but with greater levels of access another issue arises for teachers who now become the facilitators of educational technology. Classroom usage can take several forms and occur at several different frequency levels depending on characteristics of teachers, types of technology present and subject taught. Larry Cuban and Henry Becker have become the central figures in the debate on teacher implementation of technology. The next portion reviews some of their research findings and positions on the topic of teachers' implementation of technology.

## Implementation: Importance of Adoption of Innovation

### Implementation

Larry Cuban (2001) has promoted the notion that educational technology is infrequently used and may not fit appropriately with the responsibilities and demands placed on teachers in American schools (1985). This notion is supported by his studies on high schools in California's Silicon Valley, which he uses to represent typical American demographics and teaching practices (Cuban et al. 2001).

Cuban's 1998 research claimed that only 25% of teachers are occasional users and only 10% are serious users of technology. His studies have further contributed to the notion of extremely low technology implementation rates for teachers and a level of disenfranchisement of teachers toward the use of technology. Cuban et al. (2001) found that inconvenience and the unreliability of situated technology were the two contributing factors which explained why teachers did not incorporate technology into their curricula. Finding the time and energy to review software, develop new lesson plans and integrate the technology into quality pedagogical activities were also difficulties for teachers. Despite their results, they are not without hope that technology will eventually permeate American classrooms.

Cuban et al. (2001) suggest that behind the issue of time constraint is the notion that computer usage in the classroom will take place incrementally and follow a slow period of gradual change. Their other finding centers on structural constraints which limit teachers from acquiring the needed staff development, their practice of working in isolation, departmental mores and daily demands. In support of their conclusions, they repeat that the teachers at the two subject high schools had non user rate of two-thirds and one-quarter of the teaching staff. Looking at percentages of teacher technology usage only provides a portion of the picture. Cuban argued that values influenced teachers' implementation of technology.

Cuban (1999) suggested that school communities have values that influence acceptance of technology. First, teaching is a unique type of work. He states that it is an intertwining of emotional and intellectual bonds that gives tone and texture to teaching and learning unlike what occurs in other work environments. The addition of a computer could change the social relationship between a teacher and student. Second, schools have many purposes, which are part of creating an individual who will become a productive and caring adult. The increasing reliance on technology could become threatening to teachers who feel that their role is not only to teach, but also to nurture the student's progression through life. Third, Cuban states that technology is flighty. By this he is referring to technology as something which changes regularly and requires a great deal of initial investment (time and effort) to learn not only the technology it self, but then how to implement it effectively in the curricula. Shortly after teachers master particular technologies, systems may change and skills become obsolete. This provides support for the need to assess attitudes of teachers as they pertain to technologies and their implementation in the classroom.

Cuban's combination of values related to teachers and the practical constraints of the profession provide one version of the issue related to technology implementation. Henry Becker provides somewhat complementing results on the topic as his 1999 study showed that there were other levels of teacher attributes which may also contribute to the future implementation of technology.

Becker (1999) found that there was a relationship between teacher attitudes toward internet resources, the school's phase of integrating resources, subject taught and pedagogical orientation. He found that social studies, science and humanities teachers used the internet for student research more often than other teachers within a school. He also found that the distance of technology from the subject matter and the type of technology used are all relative to what fits best for teachers.

Becker (2000) followed the study above with a national study, using more than 4,000 teachers in over 1,100 schools across the US. From this sample, he found that there were four major factors that contributed to increased computer use in the classroom: subject matter, the presence of five computers in the classroom, teachers having an average level of expertise and the teacher scoring highly on a constructivist teaching methodology scale. He also found that about three quarters of the teachers surveyed use word processing programs and that block scheduling was present in situations where technology implementation was more prevalent.

From this large study, Becker agrees with Cuban's claims regarding the extent of computers in schools and both agree with the notion that computers are not presently being used as a central vehicle of instructional activities. Despite their agreement, Becker's sample provides a more comprehensive depiction of American schools and the use of technology within classrooms. He also found that the majority of computer use for instruction in schools is done outside of typical academic classes. This implies that teachers may be using them as resources for planning, but not integrating them within the classroom activities for students. From his study, he looked at student computer usage of more than twenty times during the school year and found that only 24% of English teachers, 17% of science teachers, 13% of social studies teachers and 11% of math teachers used technology at this level. Becker then attempts to delve deeper into the implementation issue to find out what type of methodology teachers were using. His approach to this area of interest was to pair the idea of technology implementation with the teacher characteristic of using 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 average schools, participated technology initiatives developed within the schools and schools 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.

Cuban's and Becker's research supports the idea that technology is being implemented at generally low levels across school subjects and with inconsistent methodological support. Using the work of Cuban and Becker as a foundation for low implementation levels, studies which examine particular educational technology interventions can be examined. Implementation is not often reflected in the literature, but the follow section contains examples of relevant research, its design and methodology surrounding implementation of educational technology.

**Relevant Literature: Implementation of Educational Technology**

Traditionally, schools are passive recipients of technology. Neither schools nor their teachers are the developers of the technology they use and often final decisions about specific purchases are done at the district level. This is a critical hurdle in the adoption and implementation of technology in schools. Purchases of technology are placed in the hands of administrators who are seldom in schools and less frequently in actual classrooms. This atmosphere provides an opportunity to observe the adoption and implementation of technology within an environment complicated with teacher responsibilities and administrative objectives.

As stated previously, the 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 understanding 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 initiatives to continually replenish the supply of infrastructure for their schools. In conjunction with the refiguring of school-wide policies is a procedural change in the classroom.

Previously, pedagogical practice was centered on teacher based activities. Today, with the increasing procurement of computers and internet access, technology driven activities in schools is 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 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)

To establish an understanding of the literature centered on the relationship between teachers', their attitudes toward technology and their level of technology implementation, electronic databases were used to further investigate this topic. Three databases: ERIC, PSYCH INFO, and Web of Science were used to search for relevant articles using combinations of the 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 their attitudes toward technology and/or their implementation of technology.

As mentioned above, there are a myriad of areas associated with this process and with that comes a vast range of research styles and perspectives implemented in this field. Included here are articles which review large scale initiatives using descriptive statistics such as Cole's (2000) assessment of technology integration in Kentucky schools and the identification of teachers' technology perspectives by Kersaint et al (2003). Next, qualitative anecdotal research is reflected in Sandholtz's (2001) comparison of privately organized technology training versus training provided by a school district and Beyerbach & Walsh's (2001) action research designed study of student teachers' perceptions and confidence levels toward technology integration in their future classrooms. Comparison group analyses are presented below by the work of Gningue's (2003) analyses of long-term versus short-term technology training initiatives for math and science teachers and Koszalka's (2001) research on the effect of virtual collaboration chat-rooms on teacher attitudes toward technology implementation. Other studies described below are the correlational studies of Baylor & Ritchie (2002) who examined teachers' perceived technology skills and attitudes using a large sample of teachers from four different US states and Redmann & Kotrolik's (2004) research on technology integration as it relates to Career Technical Education courses taught in Louisiana. Last, the Zhao & Frank's (2003) ecological perspective uses both qualitative and quantitative approaches to better understand technology within schools and its relationship with the environment it is influencing. These studies provide a strong depiction of the research surrounding implementation of technology in schools and the methods used to arrive at conclusions regarding this process.

**Descriptive Research**

Shannon Cole (2000) provided an assessment of technology integration within Kentucky schools. She surveyed district level technology coordinators across the state to develop an understanding of the attitudes of Kentucky teachers toward technology. Surveys about the level of technology used in the classroom, the amount and type of technology training teachers received and skill levels of the typical teacher in the districts were distributed to these administrative level staff. This research was conducted on the heels of a 218% change in the funding for the state's Master Technology Plan (1998-2000) and the implementation of "Standard 10," which provided guidelines for teacher technology competence expectations. This research does not utilize a pre-post design and only focuses on describing the teachers within the state.

Interestingly, this article neglects to interview the teachers involved in the technology implementation, and instead looks at district-level administrative staff member who typically do not frequent schools, and is even less likely to step into a classroom. This indirect assessment of teacher attitudes does not reflect the true attitudes of the teachers of Kentucky.

Cole assesses Kentucky administrative perceptions of the state's teachers' skill levels as above average and continues by focusing on the lack of technology implementation within schools. She suggests that three variables can be identified as influential in Kentucky teachers' failure to implement technology. First was the lack of teacher participation in training. She cites averages taken from a 1998 Milken report on the state of technology training within American schools. The variables she reports are directly tied into the statistics from this study as the rate of training for integration of technology was in the middle of the five technology training types at (3.9 hours). Second was the lack of incentives for teachers. Coles sites Couch (1999) as finding that the number one reason why teachers do not attend the technology trainings, despite their interest in the subject is their lack of time. She mentions that the initiatives may be taken to provide stipends, release time or aligning training with advancements or rewards. Her third variable was the lack of training to integrate technology in the classroom. She states that this is the most important of the variables as understanding how to use the tools will enable teacher implementation. In an attempt to address the concerns of teachers in Kentucky, the state has begun to implement the Technology Institute 2000, which incorporates feedback from teachers in objectives as well as logistical concerns that teachers may have, which runs contrary to the method used in assessing teachers in this study.

This article is helpful in establishing some understanding about the stated *perceived* attitudes that a large group of teachers may have, but the sampling technique and failure to make direct connections between the states initiatives and implementation as an outcome show weaknesses in the research. One area that could be expanded upon through more research about the Master Technology Plan is the longitudinal effect of this legislation on technology in within the Kentucky's schools. It would be interesting to learn more about whether the financial and criterion changes have met the challenge of assisting teachers with implementing technology in the classroom.

Also focusing on the attitudes toward technology of those instructors who train a particular a subject area, Kersaint et al. (2003) surveyed 305 mathematics teachers educators (MTE, those professionals who train mathematics teachers) for their perspectives on the types of technology that teachers should be proficient with at various levels. Building from this initial research goal, the study also examines the technologies the MTEs are most comfortable using during their trainings, the extent MTEs integrate technology in their courses, how teachers learn to use technology and what support is affiliated with technology training, as well as identifying deterrents to using technology in the classroom.

Their sample was generated through mailing surveys to randomly sampled members of two national mathematics teacher organizations. Twenty percent of the surveys were returned (N = 305 completed surveys). This study does not examine a specific treatment and is generally a summary of the responses provided by the respondents. The instrument used consisted of 90 items. A demographic section of the survey was followed by sections on perceptions regarding the importance of technology for math teachers, comfort levels with particular technology and degree of integration, organizational support, barriers to incorporating technology into teacher education programs and open-ended questions. Analysis consisted of basic descriptive statistics that was calculated collectively (tabulating the data across grade levels) and according to teacher certification levels (elementary, middle school, high school).

The findings from this article reflect the MTEs enthusiasm for inclusion of all technology suggested in the survey at all three educational levels (primary, middle & secondary school). Items included technologies such as: access to information on the web, graphing calculators, access lesson on the web and spreadsheets. Over 50% of the teachers in this study rated these technologies as important. The only exception was the importance of dynamic geometry software and data collectors when elementary school MTEs were surveyed. This consistency across levels continued as 96% of all MTEs learned to use technology through self-exploration, while 92% of these teachers learned through assistance from others. Also, 55% of the MTEs reported learning to use technology through conference workshops. These results reflect the dynamic nature of skill acquisition and that given different situations, individuals may learn to acquire the needed knowledge through whatever means is available. Data such as that collected by Kesaint et al. provide a snapshot of skill diffusion, but not a detailed analysis of how the networks are structured and what key variables make them up.

Kersaint et al. also surveyed the organizational support and barriers finding that the respondents felt an overall strong level of support from their institutions. The one area where they identified a lack of support was time constraints. As stated by Amabile et al. (2002), the promotion of innovation adoption is often hindered by the inappropriate time provided to workers for effective implementation of an innovation. Contextual implementation of innovations will require allotment of time for teachers to develop the appropriate usage of the technology. Amabile et al (2002) found that as organizations make systematic changes and attempt to incorporate new innovations the change is done without reliving employees of original responsibilities. This piling of work can lead to inactivity and low employee moral, reflecting a failure to implement due to the structural considerations of the leadership. Within a school setting, teachers are forced to balance new educational technologies with valuable levels of educational consistency. Thoughtless application of technology into curricula can create chaos and destroy the learning climate of the classroom. Allotting additional and collaborative planning time for teacher may be one way in which to alleviate the burden of creativity for the teachers. Enabling a team approach to appropriate technology implementation is part of the IMPACT models strategies for thoughtful educational enhancements.

This article is useful in helping to identify what is being promoted through teacher training of mathematics teachers. Using these findings and those of Beyerbach (2001) as a means to generalize about the overall state of teacher training, it can be assumed that technology training, in various forms, is creeping into the overall pedagogy of both practicing and pre-service teachers. However, it does not provide any insight to the effect that teacher attitudes have on their implementation of technology.

**Qualitative Anecdotal Comparison Studies**

Judith Sandholtz (2001) uses comparative case methodology to qualitatively compare two different teacher-technology training programs, one provided by a private computer company and another provided by a public school district. The programs were selected by meeting three criteria. First, each project is viewed as successful when measured by their participant evaluations, gain in skills and plans for classroom technology use. The second, is the availability of longitudinal data and the third, is that the programs provide contrasting practices to the target audience. Evaluating the effectiveness of these two teacher development programs Sandholtz uses the following five criteria to generate general conclusions: access to equipment, administrative support, technical support, collegial support and classroom implementation. Using both pattern matching and explanation building (Yin, 1994), Sandholtz attempts to paint a picture of the differences in outcomes for the two different programs through artifacts such as journals, year-end reports, observations and case studies during three years of these projects.

Her sample is taken from teachers who participated in an Apple Classrooms of Tomorrow (ACOT) program and a Southern California school district's professional development program. General information regarding the participants was provided. This ACOT training sample was pulled from over 600 teachers representing 30 districts in 15 different states and two foreign countries. Various grade levels are involved and the focus is to create technology leaders within schools. The district training was funded through a federal Technology Innovation Challenge grant and applied to the district over five years. The demographics of the district are incredibly diverse both ethnically and economically with 260 K-8 teachers participating in this program. A main objective of this program is to promote literacy and academic achievement through the more frequent and effective use of technology in the classroom.

Sandholtz arrives at two major conclusions about the two programs based on three criteria: evaluations, skill gains and generated plans for using technology in the classroom. Throughout the text, her conclusions are supported by anecdotal responses of teachers articulating situations of frustration and success with their programs. On occasion, she suggests statistical relationships between influential factors, but fails to produce references to support these conclusions.

Beyond her initial indication that this article will be using a "comparative case methodology," Sandholtz does not provide any insight into the process of reaching conclusions regarding the mediated or correlational relationships.
Without the understanding of how she reached these conclusions, they could be considered anecdotal despite her extremely large sample size and the longitudinal data collection.

Throughout the article Sandholtz provides responses anecdotally related to teachers' attitudes in support of the conclusions that she reaches, but again fails to provide insight into her methodology. Her first conclusion is that training teachers needs to be considered as important as teaching students. An example of this from the district level training are: “I DON’T HAVE MY COMPUTERS UP AND RUNNING. THE ‘BACKORDER’ WORD WAS USED WHICH TERRIFIES ME!!!!!!” (p. 362). Although this statement may have been repeated several times throughout the study, details regarding its frequency were not provided. Her second conclusion is that access and support are critical in the future implementation of technology-rich curricula. An anecdote related to this finding is the frustration of one teacher, who stated: “No one from the administration looked at my project, although they were invited” (p. 362). Sandholtz does provide some positive comments of teachers and administrators in this section which showed true support by administrative staff, but again she does not provide details on how she used these comments as generalizations for both studies. Sandholtz’s also mentioned that the private training (ACOT) has the potential to effectively train teachers from a variety of settings and that training can filter down to teachers implementing technology initiatives in schools. This is actually not a finding from the research that she embarked upon at the beginning of the article. Although cynical, my impression is that this article serves more of advertisement purpose for Apple Classrooms of Tomorrow (ACOT) than as an academic article.

The findings that Sandholtz arrives at provide a general overview to the issue of technology training for teachers. Application of these findings provides insight into a small niche of the literature, that which applies to Apple Classrooms of Tomorrow. Her research may have found more utility if she’d focused on specific portions of the training, the rates implementation and degree of fidelity that teachers/schools followed when implementing. Comparing quantitative outcomes from the contrasting programs would have provided insight into levels of the trainings effectiveness, but this did not happen. Also, being more rigorous in explaining her method of generating qualitative conclusions would have greatly benefited this article.

This article provides anecdotal evidence to the issue of teacher implementation of technology as a result of two types of teacher training. The value of these anecdotes is their potential to reflect extremes situations of those who are within a project, but they may also not reflect the true nature of subjects within those settings.

Beyerbach, Walsh & Vannatta (2001) examined four areas related to a programmatic change in a university teacher training program. They 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.

The sample used for this study followed two cohorts of pre-service teachers through their completion of a teacher training program that was using 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 expanded 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 research is 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 Rachael Vannatta & Paul Reinhart (1999), which provides results of their surveys. Another paper/presentation provided by Vannatta (1999) was not available through North Carolina State University resources at the time of writing this paper.

First, they 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 stated such a 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 of the student sample is seen below in other conclusions reached by Beyerbach, Walsh & Vannatta (2001).

Second, they 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, that does not necessarily translate to classroom implementation. Initially, it is proactive to provide the pre-service teachers with training necessary to implement the methods above, but these results are limited by their inability to project success for the students within actual classrooms. Influences upon the students within their professional setting of a school may not promote technology usage or provide the resources. Nonetheless, the project provides aggressive training for its students.

Third, they 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 find 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.

On this item, the scores of perceived competence 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 is 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, they 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 variety, but 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 is 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 are 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 the administrative staff, or 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.

**Comparison Group Studies**

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.

He 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 is attempting to compare the two groups with dissimilar grades. 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: T183 graphing calculator and the

Geometer's Sketchpad, while the short-term training addressed these two technologies plus Virtual Tiles (an algebra manipulative).

To assess the differences in the two training groups, Gningue used the View of Learning Math as a Rule-Based Subject" (VLMRBS) survey created by Tharp (1992). This survey was constructed to "assess the degree to which a person adheres to the view that math learning is mostly oriented toward processes which involves the manipulation of symbols and memorization of facts as opposed to the view that mathematics learning is based on reasoning about relationships and patterns" (p. 213). This survey is his basis for making assumptions regarding the attitudes of teachers toward mathematics based technologies. *(He stated that the measure is relatively new, yet he cites Tharp 1992 & 1997 in his article as the source of this measure. Using a cited-reference search on Web-of-Science, I found no articles citing these works.)* From this survey, the author only used six of the responses, each of which is elaborated upon in his results section. This becomes somewhat problematic in his analysis as he should have used MANOVA methodology assessing one overall attitude-related construct rather than handling the data item-by-item (Table 2).

As you can see from the items below, he primarily looked at whether the use of a graphing calculator is viewed favorably or unfavorably, not a comprehensive investigation about teacher attitudes toward technology. Relying on the individual items from this survey, Gingue 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.

Table 2

Items Selected from the View of Learning Math as a Rule-Based Subject

| |
|---|
| Responses were rated **Strongly Disagree** to **Strongly Agree** |
| 1. Calculators should "only" be used to check work. |
| 2. A graphing calculator can be used as a tool to solve problems I could not solve before. |
| 3. Using a graphing calculator to teach mathematics or science allows me to emphasize the experimental nature of the subject. |
| 4. Using a graphing calculator to teach math or science does not enhance student learning or understanding of concepts. |
| 14. Students lack the ability to work with a calculator as complex as a graphing calculator. |
| 15. If students are taught to use technology, they will come to rely on it and lose their ability to think. |

For those teachers in the long-term treatment, it was administered at the beginning and the end of the semester. Gnigue 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 (Item #1) 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 (Item #2). 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. Gningue's third research question (Item #3), regarding the use of a graphing calculator to emphasize the experimental nature of the subject 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 (Item #4) is negatively worded and asks whether a graphing calculator enhances student learning and understanding of concepts in math and science. Although neither group's attitudes change 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 do not feel that it adds anything to the process of learning mathematics. His fifth item on the survey (Item #14) 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 significantly 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 (Item #15) 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 groups 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 their attitudes toward technology in general according to the change in attitude. One area in which Gnigue should investigate this study is the efficacy of the training 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 (Item #15) and the specific attitude change related to student use of the graphing calculator in the group that received the long term training (Items #1 & #14). 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.

Creating a virtual collaboration environment (AKA: computer mediated communication, CMC) for teachers was the means by which Koszalka (2001) researched the potential usage of web-based resources in the classroom. Koszalka had two goals in this research. The first was to find out if teachers who participated in online discussion groups had a more positive attitude toward the use of web-resources in the classroom. The second goal was to determine if there was a difference in attitudes between the two groups. This attitudinal scale used beliefs, feelings, or intended future use of web-resources (behavior) to determine the attitude variable.

Her sample was constructed of certified K-12 from six states who were recruited through electronic discussion groups and contacts through the college of education at a large Eastern university. All of the subjects had daily access to the internet and were randomly assigned to treatment and control groups. Both groups were asked to review a website about successful technology integration. The control group sent their responses to a website, facilitating a one-way response and receiving no feedback on their review.

The treatment group was asked to participate in moderated discussions on how they would integrate web resources in the classroom. Despite the strong analytical design of this study, limitations can be found in the sample size that limits the statistical power of the analyses. The treatment groups were divided into three small groups (n=4) and one large group (n=13) discussion group and one control group (n=15). Groups were separated by creating private list-serves. The study occurred over seven days after which post test surveys were administered.

To assess the effect of the list-serve use, Koszalka created a twenty-one question survey that was based on previous surveys used by this author and others. Her instrument was piloted and validated (Cronbach Alpha 0.90). Using t-tests for the mean scores and ANOVA to asses the difference for the different sizes of treatment groups against the control, she reported several statistically significant findings. First, she found that the mean scores of attitudes toward integrating technology between the control and treatment groups were statistically significant ($p > 0.009$). The overall treatment group (combination of all treatment teachers) had a mean score (29.69) of almost seven points higher than the control group (22.9). This shows that the use of the online discussion had an effect on teacher attitudes toward the integration of technology. Koszalka also found that there was a significant difference between the mean scores of the treatment and control group with regard to the teachers' Beliefs (treatment – 13.6, control – 8.6, $p<.016$), Feelings (treatment – 14.1, control – 8.4, $p<.020$) and Behavior/Intent (treatment – 1.8, control – 0.8, $p<.001$). These results show that the online discussion/list-serve had an effect on the way in which the teachers viewed technology and looking at the construct of Behavior/Intent, the potential implementation of technology in their classrooms. This is also reflected below in Koszalka's other findings. She continued to use ANOVAs to examine the differences between the three groupings created for this research (control, small group & large group). She found that the mean scores for Overall Attitude were significantly different for all three groups of teachers (small – 25.83, large – 28.67 & control – 20.19, $p<.008$). She used the ANOVA to look more closely at the three groupings responses to the sub-constructs and found significant differences between two of the three. Beliefs revealed that the treatment groups (small – 11.79 & large – 13.16) had a visibly large difference in their mean score when compared to the control group (6.5, $p<.006$). This may identify the importance of communication in the process of technology adoption for teachers and show a potential point of emphasis for a technology intervention in schools. Statistically significant findings were also present for Koszalka's other two constructs. Differences in the groups' mean scores for Feelings were not as highly significant as the other two constructs ($p<.033$), and the differences between mean scores was not as substantial (small – 15.70, large – 14.76 & control – 10.08). In contrast to the other two sub-constructs Behavior/Intent was not found to have significant differences between the mean scores of the three sub-groups (small – 1.17, large – 1.15 & control – 0.80). This result is interesting when comparing it to the initial groupings of subjects (treatment vs. control), as statistical significance was found in the larger sample of treatment responses, but here statistical power was limited when she divided the treatment group due to the small sample used in this study. It may also imply that despite the treatment, teachers are using technology and intend to use technology at similar rates.

It is important to take a closer look at the sample that Koszalka used for this study. First, her subjects were gathered through the use of a discussion website. This may reflect a sub-group of the overall teaching population that is more comfortable with both discussion websites/list-serves and technology in general than the typical teacher. Generalizations from this type of sample may not be reflective of the overall teacher population. Second, without direct observation of the teaching practices of these participants, Koszalka's data may reflect satisficing on the part of the teachers who want to appear to be performing "over-and-above" in the classroom. Expanding this study to add a training component for teachers who are new to the web-based discussions and observations of their implementation with the original treatment will provide insight into how teachers other than the "tech-savvy" ones will be more useful in predicting behavior.

This study is one of the few which uses a realistic framework, albeit high-tech and cyber-space, to examine the effect of communication and teacher attitude toward technology. It also looks at a process for implementing technology using a specific tool, the internet. Expanding this study to look at the differences between cyber-conversations and collaboration activities within a particular school may be more revealing about the audience that this study is intending to reach. Also, providing the opportunity for some "less-tech savvy" teachers to participate in online discussions about technology may reveal a different outcome than was is presented here.

**Correlational Study**

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, business and marketing education classes. (It is important to note that the analyses looks at both the aggregate group of teachers as well as separating them into the three subject matter sub-groups.) Redman and Kotrlik 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) and 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.

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 are 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 or 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. Noticing the relationship between the business and marketing, it is of little surprise that differences may be noticed in this manner.

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 do have home internet access and 58.8% had access at school, while 75.7% have 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 Kotrilk 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 3

Variables from Redmann & Kotrilk (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<br>Phases of Technology Integration |
|---|
| ***1.** Exploration* |
| ***2.** Experimentation* |
| ***3.** Adoption* |
| ***4.** Advanced Integration* |

The four regression analyses did not reveal any multicollinearity among the predictors. 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. They did provide the

F-statistic and significance levels which will be used to reflect 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 schools that were determined to be of high technology need at the beginning may imply that the IMPACT teachers are going to 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.

*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 will take 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 the 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 variable is the role of teacher training that is found as a major variable in only in the *exploratory* phase of the evolution. This suggests that teachers will receive an initial training and possibly implement the technology as learned, but training does not appear in any of the other phases and may imply that teachers develop a sense of appropriate use that does not require further training or 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 may reflect a higher level of technology understanding and previous positive experiences implementing it in their classrooms. 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 is a self-perception of teaching effectiveness, further investigation should focus on the relationship between rated teaching effectiveness and technology implementation.

**Ecological Perspective**

Zhao and Frank (2003) provide a fresh approach 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. 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 who 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 of influences on the implementation of technology. Those factors were the ecosystem, a teacher's niche within the ecosystem, teacher and ecosystem interaction, teacher computer predisposition for compatibility 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 represented the idea that teachers will be more likely to use technologies that are not radically different from the practice as usual. This concept is often called distance from present practices and is written about by several authors (Rogers, 1995, Tornatzky & Klein, 1982). Thus email, telephone systems and computers in the classroom were the most frequently sited technologies. Also, they found that technologies were most frequently used to communicate to parents and prepare for instruction, not directly involving students with the technology, which represents a first order change rather than a more substantial organizational adjustment.

Zhao and Frank also found there to be a moderate difference (14%) between the districts examined, reflecting moderate differences in the “ecosystem” of each. They propose that this may be due to several things 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, where this isn’t as practical 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 feeds into the invasive species comparison by showing how the computers are actually pushed into place by forces beyond their 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 is showing the adaptability of teachers to utilize resources and evolve. Like Redmann & Kotrlik (2004), this article does not treat technology and a single teacher aside from the realities that exist within the school environment, which places additional value on the scope of the findings as well as the model that was created 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.

**Skills & Implementation Study**

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. Their predictor variables included: planning, leadership, curriculum alignment, professional development, technology use, teacher openness to change, and teacher non-school computer use. The five dependent variables included: 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 were assessed through the development of four Likert-based instruments consisting of teacher interviews, administrative interviews, general teacher surveys and assessment of technology plans within schools.

Twelve schools, from both urban and rural areas, were selected for the study (5 elementary, 5 middle schools and 2 high schools) from which researchers randomly selected 10-12 teachers that met the following three criteria. The teacher identified is the primary instructor, uses technology regularly in instruction and the teacher was at the school during the previous year and intends to be at the school for the following year. Recognizing that each of the teachers used in this sample are 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 assess the relationships between their seven predictor variables and the five dependent variables. First, they found that the strength of the technology leadership ($\beta = 0.67, P<0.00$) at the school and teachers' openness to change ($\beta = 0.34, P< 0.00$) were both positively correlated with the perceived technology impact on student content acquisition ($R^2 = 0.59$). This can be interpreted as stronger leaders and more open teachers are related to teachers' perception that technology has an 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 perceiving 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 predicted by 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, 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 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. Development of a technology-rich atmosphere may further be clear in the attitudes and outcomes investigated in this study.

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 part 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 classroom.

Throughout all five of the variables assessed in this 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. By using such dependent variables, they are not showing a true effect, but rather one that is tainted by subjective character to experience.

**Summary**

With the increases in spending on educational technology comes interest in the method of implementation that is, or is not, taking place in American schools. Improving the process from technology purchase to thoughtful implementation will help maximize allocation of funds and result in higher levels of integration. The studies presented above emphasize three key areas of this process: availability of technology, training and attitudes toward the technology. From what has been identified above there is a great deal more to learn about this process, but these studies have provided a foundation from which to further investigate this process.

From the review of articles above the following three conclusions can be drawn about the literature focused on teacher implementation of technology: teachers need access to new technology, technology training influences implementation and teachers' attitudes toward technology are an important lynchpin in the implementation process. Through both teacher surveys and administrative perceptions, the studies above have repeatedly shown that technology training is a critical element of successful technology training. Specifically, pragmatic training which provides examples of particular technology application is related to the future implementation of that technology and can influence teachers' perceptions of technologies in general. Also, teachers approach technology implementation with preconceived attitudes and perceptions of the challenges and benefits of implementing technology and restructuring their classrooms. Influenced by experience, the literature above built a mosaic of what constitutes an attitude toward technology as something which encompasses beliefs, feelings, intentions, anxieties, confidences and perceptions of teachers' own teaching effectiveness. As explained by Zhao's (2003) ecological view, technologies are the invasive species in the classroom that create tension in a system that already existed without its presence.

As stated above, a number of factors may affect implementation of educational technologies. For the present research, teachers' access to technology, provision of training and technical assistance and their attitudes toward technology are the central components to the successful implementation. Investigating how attitudes change in anticipation of receiving an infusion of new technology resources and how attitudes and implementation change once the resources arrive and are made available will be the focus of the IMPACT project.

# Methods

## Background

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 research, analysis of some data being returned within the first two years of the project will be conducted (see Table 1).

The basic research design for the IMPACT evaluation project involves periodic collection of questionnaire and other data over a three-year period. Since the implementation of the intervention and the resources provided for were decided by the NC Department of Education and it took some time to identify and select comparison schools, the IMPACT evaluation team could not completely control the timing of all the assessments. Figure 1 below provides a graphic representation of the early part of the three-year research design.

| Time Year | 2003 | 2004 | 2005 |
|---|---|---|---|
| Time Month | J F M A M J J A S O N D | J F M A M J J A S O N D | J F M A M J |
| IMPACT | $X_1$ $O_1X_2$ | $O_2$ | |
| Control | | $O_1$ | $O_2$ |

$X_1$ = Announcement of IMPACT awards. $X_2$ = IMPACT resources begin to become available.

Figure 1. IMPACT Research Design

As Figure 1 reveals, the IMPACT schools learned they would receive the infusion of resources in spring 2003 ($X_1$). Pretest data ($O_1$) 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 IMPACT group then began to receive the intervention (X2). Pretest data ($O_1$) were collected from the comparison group in the Spring of 2004. Posttest data ($O_2$) for the treatment group were collected in May of

2004, reflecting the completion of the first academic year of the project. The post data ($O_2$) were collected in the spring of 2005 for the comparison schools. While this design does not represent a classic experimental or even quasi experimental design and thus presents the researcher with some inferential challenges, it also provides an opportunity to address some important research questions. Specifically, the research will try to address the following two questions: What impact does the awareness of an impending infusion of technology resources have on teachers' attitudes? What impact do the resources have on teacher attitudes and implementation?

**Research Questions**

This research utilized two scales that were not previously validated in the literature surrounding educational technology implementation. Therefore, evaluation of these instruments will be performed to focus the resulting conclusions appropriately. The first two research questions center on the instruments.

*Question 1:*

*What is the factor structure of the Teachers' Attitudes toward Computers when applied to the treatment and comparison teachers of the IMPACT project?*

*Question 2:*

*What is the factor structure of the Activities of Instruction when applied to the treatment and comparison teachers of the IMPACT project?*

Determining the relationship between awareness of an impending technology intervention and attitudes toward the technology will be addressed in the third question. Treatment schools became aware of being awarded the IMPACT grant in the early summer of 2003. News of the large scale technology initiative was spread through the school community by way of newspaper articles and personal diffusion. The buzz surrounding this impending change could have influenced the teachers' responses to the measures administered at our intended pretest for this study. Such an effect could affect the interpretation of measures compared to this pretest. This leads to the third research question.

*Question 3:*

*What is the impact of knowing that your school is about to receive an infusion of technology and technology assistance on teachers' attitudes toward technology when controlling for demographic factors?*

Using the guidelines provided by Shadish, Cook and Campbell (2002), the survey responses could represent topic influence. The treatment teachers' awareness that incredibly large amounts of resources are being poured into each of the treatment schools, could influence the responses of the teachers. This influence may result in *satisficing*, respondents providing answers that they anticipate the researchers are expecting as it relates to the topic, or answers which show their appreciation for the new resources that they have received. Specifically, attitudes toward technology may have increased greatly before the "pretest" as enthusiasm could increase with the knowledge of the impending technology purchases, potentially biasing this so-called pretest. However, this possibility can be assessed by comparing results obtained by the IMPACT teachers at $O_1$ with results obtained by the Control teachers at $O_1$ (See Figure 1). In essence, this comparison amounts to a "post-test only" comparison group design described by Shadish, Cook and Campbell (2002) and, at a minimum, should rule out the effects of testing alone.

The fourth objective of this study is to determine the relationship between the implementation of the six essential IMPACT model components: technology focused decision making committee, flexible scheduling in the media center, considerations made available for teachers to collaborate, infusion of technology resources including provisions for staff development and the addition of full-time media coordinators and technology facilitators on teachers' attitudes toward and technology implementation in the classroom. Thus, the fourth research question is broken into three parts, the last of which provides exploratory analyses on the relationship between teachers' attitudes and technology implementation.

*Question 4a:*

*After controlling for demographic factors, what is the impact of receiving and using technology on teachers' attitudes toward technology?*

*Question 4b:*

*After controlling for demographic factors, what is the impact of receiving technology on teachers' instructional practices?*

*Question 4c:*

*After controlling for demographic factors, what is the impact of receiving technology on teachers' implementation of technologies?*

To some extent the IMPACT evaluation design resembles Shadish's "untreated control group design with dependent pretest and posttest samples". Thus, a comparison between O1 and O2 can be made for the IMPACT and the control group to answer this question. However, because the IMPACT teachers received their pretest earlier than the control teachers and because the time lapse between pre and post-test is somewhat more than four months longer for the control schools, the IMPACT research design does not represent a perfect representation of this design (Shadish, Cook & Campbell, 2002).[1] Specifically, the IMPACT design might be more vulnerable to threats to internal validity due to history, attrition and instrumentation. Nonetheless, given the paucity of control group studies in the literature, I should be able to tentatively and cautiously answer research question 2.

Another consideration regarding the validity of the of research question 2 results is the likelihood that the implementation of the treatment will vary across IMPACT schools. One component of the IMPACT project is autonomy for schools to make decisions regarding staff development and resource allocation. This decision making capacity provides the authority to adjust the treatment within the scope of the six project requirements mentioned above. Application of the IMPACT model's core features will be consistent despite variations in some implementation of the model. This feeds into the notion that educational research is dynamic, but allows this study to maintain some consistency with the treatment. The primary hypotheses will treat the teachers as members of either the treatment or comparison groups for analysis purposes.

**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

[1] A substantial amount of time elapsed between the administration of pretest surveys for the treatment and comparison schools. This could present a confounding factor as influences such as outside technology related treatment may contaminate the baseline data for the comparison teachers. This consideration and others related to the data collection will be addressed in the discussion section of this paper.

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. With such a significant support, this study is able to focus on the responses of 240 teachers at treatment schools. 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). Circumstances beyond the control of the evaluation team resulted in a limited number of complete responses at time-one and time-two. Table 4 depicts numbers of teachers affiliated with this study.

Table 4

Number of Respondents at Each Data Collection

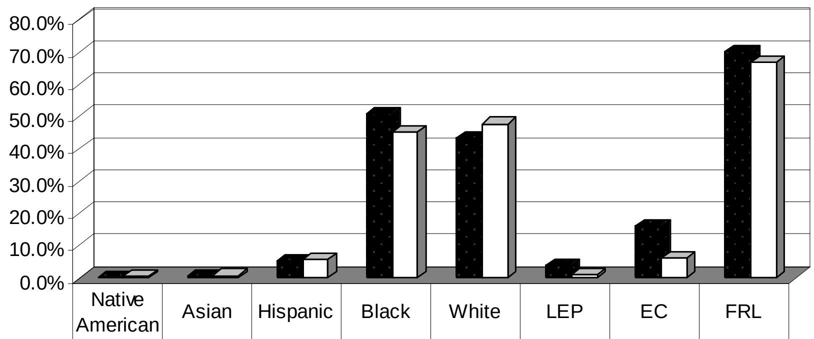
| | | $O_1$ | | | $O_2$ | |
|---|---|---|---|---|---|---|
| | | Demo | TAC | Activities | TAC | Activities |
| IMPACT Teachers | All (staff) | 574 | 574 | 574 | 574 | 574 |
| | Teachers used in Analysis | 157 | 157 | 157 | 157 | 157 |
| | Percent of Respondents Lost | 66% | 48% | 45% | 33% | 37% |
| Comparison Teachers | All (staff) | 395 | 211 | 175 | 185 | 150 |
| | Teachers used in Analysis | 83 | 83 | 83 | 83 | 83 |
| | Percent of Respondents Lost | 79% | 60% | 53% | 55% | 51% |

Demo – Demographic Questionnaire, TAC – Teachers' Attitudes toward Computers, Activities – Activities of Instruction
Note: Demographics Questionnaire was only administered once to each of the teachers. Only core classroom teachers with complete pre & post records were analyzed (i.e.; Art, Physical Education and other "specials" teachers were omitted from these analyses.

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[2],[3], [4]. Eleven comparison schools were identified within North Carolina and all agreed to participate in the study. Three hundred fifteen teachers were sampled in the control group. After identifying schools, which met these

[2] 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.
[3] None of the treatment or comparison schools are located in metropolitan areas.
[4] 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.

criteria, further efforts were made to match student demographic breakdowns. Figure 2 provides a comparison of student demographics for IMPACT and comparison schools.




| | Native American | Asian | Hispanic | Black | White | LEP | EC | FRL |
|---|---|---|---|---|---|---|---|---|
| ■ IMPACT (N=5,319) | 0.2% | 0.4% | 5.3% | 50.7% | 43.4% | 3.8% | 16.1% | 70.2% |
| □ Comparison (N=4,900) | 0.6% | 0.7% | 5.7% | 45.3% | 47.8% | 0.8% | 6.1% | 66.9% |

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 2. 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 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 provide examples of how this objective was implemented by an IMPACT treatment school by looking at the year-end report submitted after year-two 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 blanketed 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 and 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.

## Measures

### Demographics

This generic instrument was generated by the IMPACT evaluation team and has not been tested previously. It uses thirteen items to collect information regarding teacher characteristics ranging from sex, race and age, to computer training and home computer access. Within the realm of this study, analyses will be run regarding six variables: gender, age, race, years of teaching experience, subject taught, hours of technology training, home computer access and home internet access

### Attitudes

Attitudes will be examined using two separate measures that attempt to address teacher attitudes toward technology as it pertains to the classroom, the Teacher Attitudes toward Computers and the Teacher Attitudes toward Information Technology scales.

*Teacher Attitudes toward Computers (TAC)*

This version of the TAC (form 5.1) uses both Likert and Semantic Differential items for measuring teachers' attitudes toward computers on 10 constructs. The TAC has been administered to IMPACT teachers at differing intervals to collect pre and post data, as stated above. Psychometric analysis performed previously on the TAC was limited to exploratory factor analysis and reliability analyses. This research hopes to support those efforts in refining this instrument.

The subscales of the TAC were determined through a weeding-out process performed by its developers (Christensen & Knezek, 1996). Taking the items from a collection of 14 various attitudes related scales the authors subjectively reduced the number of items with three criteria in mind. First they eliminated items which are not directly related to computers. Second, items that weakly related to computers were eliminated. Lastly, they eliminated redundant items found in the bank of items from which they worked. Their efforts provided a sample of 284 items for the TAC which were then subject to a factor analysis using 118 Texas educators from four school districts (two urban, two rural). Using exploratory factor analysis with oblimin rotation they suggest that the scree plot reflects the presence of four higher order factors and continue to state that those four factors account for two-thirds of the total variance (p. 4). Christensen & Knezek failed to label the four factors or reduce the scale focusing on those four factors. Reviewing the variance table presented in this paper, it is clear that a three factor solution was most appropriate as the fourth factor in their factor analysis had an eigenvalue of .805 and accounted for only 2.5% of the variance (p. 16). Rather than continue with the results from the analysis, they continued to include subscales in their attitude scale that did not contribute substantially to total variance. Their investigation resulted in the identification of 27 of the 32 subscales falling in the "respectable" Cronbach's reliability range of .70 or higher for each subscale. Furthermore, this paper failed to provide clear delineation of the items and constructs that were retained. Also, they mention that procuring data from more than 600 educators will be necessary to derive stable factor structure for all 284 items. This number does not support even the minimal 5 respondents for every one item on the instrument. If that were their objective, their sample should have been 1420 respondents.

The final result of the research performed by Christensen & Knezek was the generation of five versions of the TAC ranging from seven to 16 subscales. These surveys range from 98 items to 199 items. This kitchen sink approach left the IMPACT evaluation team to select a set of subscales that will provide a proper representation of teachers' attitudes toward computers. Ten subscales were selected with a total of 98 items (Two of the subscales were combined making the total subscales for the survey nine subscales.).

The resulting survey addresses emotional responses to computers with the subscales: Enthusiasm, Anxiety and Aversion/Acceptance. These subscales also provide data on the teachers' attitudes regarding the relative importance of computers by including the subscales: K & M Importance (Knezek & Miyashita, 1993), Negative Impact, Productivity and P & P Relevance (Pelgrum, et al., 1993). Three other subscales are also included. Email, provides teachers attitudes toward this particular tool and its relationship with school activities. L & G Confidence (Loyd & Gressard, 1984) enables teachers' attitudes to be measures as it relates to their perceived application of computers. Also, Kay's computer semantic differential (Kay, 1993) assesses attitudes generally using seven semantic differential items to identifying positive or negative attitudes toward computers by asking teachers to select a number (1-7) on a continuum between words such as: good - bad & unpleasant – pleasant.

As mentioned above, further analysis of the TAC may provide opportunities for reducing the number of items and refining the factor structure of the survey. The IMPACT project evaluation provides a moderately large sample size and a technology related intervention that is appropriate for these analyses. Results of this exploratory factor analysis process will be elaborated on in the results section of this paper.

**Implementation**

*Activities of Instruction*

To determine how IMPACT affects teacher technology activities, the Activities of Instruction survey will be used. This instrument was modified from a descriptive form for the IMPACT evaluation and consists of four major question areas: subject area, curricula aids, frequency of standard teaching practices and outside resources, broken into smaller sub-questions. It was the initial focus of the survey creator to assess constructivist teaching methodologies (Grable, 2000). The analyses below explain what was included in the data collected for this study.

Developing a measure that attempts to encompass constructivism in a quantitative manner is a difficult undertaking. Teachers use a myriad of techniques, tools and activities to address this teaching methodology and placing any of these methods into one area can stifle the overall impact that each has on learning. That stated this instrument was developed to formulate a general conception of classroom activities that constitute constructivist teaching and some of the related teaching practices.

Initially, literature was reviewed and concepts of constructivism were combined with the author's personal experiences training student teachers, observing professional teachers and teaching in public schools. Despite the standard acceptance of constructivist teaching, there are only a couple of instruments developed to assess the implementation of this methodology. Developing a measure for this purpose would provide administrators with information that can help to shape teaching methodologies. The instructional activities listed in the questionnaire were also based on the *Local Systemic Change through Teacher Enhancement: 1997 Teacher Questionnaire, K-8*

*Science* (Horizon Research, 1996) and the *1997 Local Systemic Change Classroom Observation Protocol* (Horizon Research, 1997). To complete the survey, teachers were instructed to use their lesson planning books to account for the frequency they performed the activities listed in the survey. Response options ranged from 1 *(daily)* to 6 *(never)* scale. These responses were not reverse-coded and in the results reported below, lower scores reflect higher rates of constructivist teaching. In total, sixteen items are used in this survey to collect relevant data.

Considering the application of this technology intervention and the respondents of the survey, this instance provides an appropriate opportunity to conduct exploratory analysis of the Activities of Instruction instrument. Results of this factor analysis procedure will be elaborated on in the results section of this paper.

**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 gage to utilize when making technology-related decisions for his/her schools.

Teachers' attitudes and teaching practices will provide the change mechanisms necessary to gage 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

Performing research on the IMPACT project required investigation of the psychometric properties of two instruments, the establishment of baseline comparisons of the treatment and comparison groups, as well as, statistical analyses of the relationships between these data. Exploratory Factor Analyses were performed on two instruments: the Teachers' Attitudes toward Computers (TAC) and Activities of Instruction. Also, the treatment and comparison groups were compared on demographic variables before comparative analyses were conducted. Last, both regression and multivariate methods were used to assess the relationships for the two groups over time.

## Attrition Analyses

In this study, teacher retention analyses was performed to identify differences between teachers who only completed the pre measures and those who completed both pre and post surveys. All demographic, attitude and instructional practices were compared using chi-squares and t-tests. Significant differences were found between the two groups on the age, years of experience and Constructivist Methodology variables. No evidence of differential attrition by condition was found in other outcome variables in either treatment or condition groups. Teachers who completed both administrations of the surveys tended to be older and have more years of teaching experience and use Constructivist Methodologies more frequently than teachers who only completed the pre measure administration ($p < .05$). Further investigation of attrition within IMPACT and

Comparison groups found that age was the only significant variable when comparing pre and post data. These findings are presented in Table 5.

Table 5

Attrition Rates: IMPACT & Comparison Teachers

| Group | Data Completion | N | Age (M, SE) | N | Yrs Experience (M, SE) | N | Constructivist Methodology (M, SE)$^{\Omega}$ |
|---|---|---|---|---|---|---|---|
| IMPACT & Comparison* | Pre - only | 420 | 2.55, .05 | 420 | 2.97, .08 | 60 | 2.59, .15 |
| | Pre & Post | 326 | 2.88, .06 | 326 | 3.55, .08 | 297 | 2.24, .06 |
| IMPACT Only* | Pre - only | 213 | 2.46, .08 | 213 | 2.84, .11 | | NS |
| | Pre & Post | 185 | 2.76, .08 | 185 | 3.57, .11 | | NS |
| Comparison Only* | Pre - only | 207 | 2.64, .08 | 207 | 3.11, .11 | | NS |
| | Pre & Post | 141 | 3.04, .09 | 141 | 3.52, .12 | | NS |

* $p < .05$
$^{\Omega}$ = lower scores indicate higher rates of implementation
NS = Not Significant

**Instrument Analyses**

Prior to performing the analyses related to teacher attitudes, exploratory factor analysis procedures were performed. With an initial battery of 98 items this data set provides an opportunity to refine the Teachers' Attitudes toward Computers survey. A related research question was stated above for this effort:

*What is the factor structure for the Teachers' Attitudes toward Computers when applied to the treatment and comparison teachers of the IMPACT project?*

To assess the TAC's structure, data from the pretest administration were used to conduct an exploratory factor analyses (EFAs) ($N = 240$). Appropriate items were reverse coded. This EFA involved a series of more refined analyses using principal axis factoring and Promax rotation to extract factors with eigenvalues greater than 1.0. For the initial EFA eighteen factors were identified, but only two factors explained more than five percent of the variance and had an eigenvalue greater than one. This was not considered a very parsimonious solution. The first change that was made was to drop the "computers: semantic differential scale"[5], due to its irregularity from the other subscales. A second EFA was performed specifying a nine factor extraction to correspond to the nine original subscales of the TAC (Christensen & Knezek, 1999). However, based on this EFA only, three factors were determined to explain more than five percent of the total variance in the model. As a consequence, another EFA was performed specifying a three-factor solution.

Initially, 56 of the 98 items were identified across the three factors (F1 – 15, F2 – 31, F3 – 10) above the loading value of .50. In hopes of producing a more efficient solution, a .50 factor loading was used as the cutoff for items in the next iteration of the EFA. The resulting factor analysis reduced the number of items to 39 and provided three clear

[5] The overall instrument was compiled from different scales using a large number of items. Performing an EFA that included the semantic differential would have produced response bias due to the scaling of the items. The semantic differential subscale forced respondents to demarcate their emotional affiliations with computers in one of seven bubbles which sat between reactive words such as "good – bad" "happy – sad". The difference in response options used in the other subscales (1-5) and the seven response options for the semantic differential would have caused bias in the exploratory analyses performed in this research. An alternative to this may have been scaling the responses, but it was the choice of this author to eliminate the subscale due to the inconsistency it created within the entire instrument.

factors explaining 58% of the total variance. Table 7 shows the factor loadings of each of the 39 items on the three factors.

The first factor contained 17 items that appear to encompass the role of computers in the classroom and their instructional value. Items came from the “computer productivity in the classroom” and “importance” subscales of the TAC. This factor was labeled Computers’ Influence on Instructional Delivery and Educational Outcomes (CIDEO) (i.e., “Computers are necessary tools in both educational and work settings.” “All students should have some understanding about computers.”).

The second factor contained 12 items that corresponded to an individual’s emotional response to computers. The items came from the “relevance,” “enthusiasm,” and “anxiety” subscales of the TAC. Items remaining corresponded to an individual’s emotional response to computers. This subscale has been labeled Affective Reaction to Computers (e.g., “I enjoy lessons on the computer.” “Computers intimidate me.”).

The third factor remained consistent with the TAC’s initial subscale, E-mail Productivity in the Classroom. All ten of the original items loaded together on this factor and did not cross-load onto any other factors. An example of the items in this subscale is, “E-mail provides better access to the instructor.”

The three factors accounted for over 58% of the total variance in the model (factor 1 – 37.1%, factor 2 – 12.1%, factor 3 – 8.9%) and an overall reliability of .942. Coefficient alphas for the three subscales were .943, .920 and .943 respectively. All items were retained following the reliability calculations. Table 7 shows the subscale intercorrelations for each factor. All of the subscales are moderately correlated with one another suggesting that they are correlated, but not measuring the same constructs.

Evaluating the psychometric properties of the TAC provides an opportunity for a more precise understanding of the attitudinal perspectives of teachers implementing computers and email in their classrooms. Specifically, the development of the two subscales: Computers' Influence on Instructional Delivery and Educational Outcomes and Affective Reaction to Computers, enables researchers to establish more appropriate and pragmatic assessments of teachers' attitudes. Analyses in this research will proceed using these subscales after identifying any possible covariates from the demographic survey.

Table 6

Teachers' Attitudes toward Computers Subscale Intercorrelations

| Factor | 1 | 2 | 3 |
|---|---|---|---|
| 1. Instructional Delivery and Educational Outcomes | - | | |
| 2. Affective Reaction to Computers | .439 | - | |
| 3. E-mail Productivity in the Classroom | .525 | .410 | - |

*Note.* All correlations are significant at $p < .01$.

Table 7

Exploratory Factor Analysis: Teachers' Attitudes toward Computers Factor Loadings

| Item | Factor (F) Loadings Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| ***Computers Influence on Instructional Delivery & Educational Outcomes – 37.1% of total variance explained*** | | | |
| All students should have an opportunity to learn about computers at school. | **.907** | -.111 | -.064 |
| All students should have some understanding about computers. | **.855** | -.102 | -.030 |
| Students should understand the role computers play in society. | **.808** | -.107 | -.008 |
| Learning about computers is worthwhile. | **.768** | -.060 | .034 |
| Having computer skills helps one get better jobs. | **.750** | -.103 | .017 |
| Computers could stimulate creativity in students. | **.737** | -.041 | .013 |
| Learning to operate a computer is like learning any new skill - the more you practice, the better you become. | **.732** | .107 | -.123 |
| Computers are necessary tools in both educational and work settings. | **.691** | .068 | -.028 |
| Computers could help students improve their writing. | **.664** | -.072 | .059 |
| Computers can help accommodate different learning styles. | **.660** | -.042 | .094 |
| Computers can be useful instructional aids in almost all subject areas. | **.649** | .130 | .018 |
| Computers will improve education. | **.649** | -.049 | .194 |
| Computers could enhance remedial instruction. | **.635** | .084 | .058 |
| I am sure that with time and practice, I can be comfortable working with computers. | **.631** | .294 | -.164 |
| It is important for students to learn about computers in order to be informed citizens. | **.602** | -.036 | .018 |
| Computers can be used successfully with courses which demand creative activities. | **.595** | .139 | .092 |
| Computers can help me learn. | **.569** | .106 | .084 |
| ***Affective Reaction to Computers – 12.1& of total variance explained*** | | | |
| *Computers intimidate me. | -.113 | **.840** | .033 |
| *Working with a computer makes me nervous. | -.086 | **.813** | .053 |
| *Working with a computer makes me feel tense and uncomfortable. | .102 | **.802** | -.070 |
| *Computers are difficult to use. | -.074 | **.797** | -.020 |
| *I get a sinking feeling when I think of trying to use a computer. | -.034 | **.789** | .054 |
| *Using a computer is very frustrating. | -.092 | **.761** | .082 |
| *Computers are hard to figure out how to use. | -.007 | **.702** | -.084 |
| I don't think I would do advanced computer work. | .151 | **.529** | -.048 |
| I enjoy lessons on the computer. | .138 | **.526** | .092 |
| I like learning on a computer. | .221 | **.521** | .035 |
| The challenge of learning about computers is exciting. | .250 | **.517** | -.022 |
| I think that working with computers would be enjoyable and stimulating. | .292 | **.508** | -.085 |
| ***Email Productivity in the Classroom – 8.9% of total variance explained*** | | | |
| The use of E-mail helps provide a better learning experience. | -.052 | -.009 | **.917** |
| The use of E-mail makes a class more interesting. | -.052 | -.002 | **.909** |
| The use of E-mail increases motivation for class. | -.009 | .016 | **.836** |
| The use of E-mail creates more interaction between students enrolled in the course. | .053 | -.058 | **.830** |
| The use of E-mail helps the student learn more. | .036 | .002 | **.802** |
| The use of E-mail creates more interaction between student and instructor. | .045 | .001 | **.791** |
| More courses should use E-mail to disseminate class information and assignments. | -.075 | .052 | **.764** |
| E-mail is an effective means of disseminating class information and assignments. | .048 | .022 | **.726** |
| E-mail provides better access to the instructor. | .111 | -.036 | **.708** |
| The use of Electronic mail (E-mail) makes the student feel more involved. | .073 | .079 | **.546** |

* Denotes items that were reverse coded. Item loadings lower than .5 are not listed. Missing data was omitted from this analysis. Complete communalities table are included as Appendix A.

Before conducting the analyses related to teachers' implementation of technology, an exploratory factor analysis was conducted on the items of the Activities of Instruction using these data. A research question was stated in the methods section above regarding this procedure:

> *What is the factor structure for the Activities of Instruction when applied to the treatment and comparison teachers of the IMPACT project?*

An exploratory factor analysis was conducted on the data using a principal axis factoring with a Promax rotation (N = 317). Results indicated a five factor solution best fit these data. The results of this analysis are presented in Appendix B. Of note from this initial extraction are the low factor loadings of the two computer related items. With this in mind and understanding that the objective of this research is to measure the effects of this high-level technology infusion, a second EFA was conducted requesting a six factor solution. As explained below, this provided a theoretically sound 6 factor solution. The factor loadings are presented in Table 8 and item communalities are presented in Table 9.

Table 8

Activities of Instruction Factor Loadings

| | Item | Factor (F) Loadings | | | | | |
|---|---|---|---|---|---|---|---|
| | Please select the frequency that you performed each of the activities below | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** |
| ***Independent Learning Activities: eigenvalue 6.2, 36.5% total variance explained*** | | | | | | | |
| f. | ask the students to work on extended investigation or project that involved research or collecting data | **.850** | -.158 | -.006 | .000 | -.026 | .110 |
| d. | ask the students to design or implement their own project or investigation | **.764** | -.044 | -.063 | -.002 | .129 | -.074 |
| g. | out-of-class labs/fieldwork | **.493** | .015 | -.007 | .208 | -.057 | .073 |
| o. | unit based on “big ideas” or “special questions” | **.342** | .318 | .103 | .012 | -.047 | .038 |
| ***Constructivist Methodology: eigenvalue 1.5, 8.7% total variance explained*** | | | | | | | |
| m. | stations or centers | -.193 | **.872** | -.071 | .173 | -.097 | -.004 |
| n. | student presentations of learning | .319 | **.540** | .067 | -.038 | -.015 | -.060 |
| l. | cooperative learning groups | .062 | **.523** | .277 | -.101 | .026 | .083 |
| e. | other – hands on activities | -.043 | **.521** | -.187 | -.035 | .430 | .035 |
| ***Traditional Assessment Activities: eigenvalue 1.3, 7.6% total variance explained*** | | | | | | | |
| b. | quizzes or tests | -.100 | .041 | **.892** | -.078 | .012 | .012 |
| k. | reading/writing/textbook or worksheet questions | .072 | -.086 | **.723** | .100 | .027 | -.065 |
| ***Special Events: eigenvalue 1.092, 6.4% total variance explained*** | | | | | | | |
| i. | guest speaker | .077 | .070 | -.069 | **.758** | .009 | -.039 |
| h. | field trips | -.002 | .077 | .081 | **.693** | .017 | .004 |
| ***Teacher Centered Activities: eigenvalue 1.0, 5.9% total variance explained*** | | | | | | | |
| c. | prescribe steps in an activity or investigation | .144 | -.006 | -.042 | -.062 | **.755** | -.057 |
| a. | formal presentation of content by teacher | -.104 | -.119 | .189 | .117 | **.700** | .056 |
| ***Technology Implementation: eigenvalue .89, 5.2% total variance explained*** | | | | | | | |
| p. | lesson using computers | -.013 | .025 | -.048 | -.068 | -.002 | **.886** |
| q. | lesson using other technologies | .185 | -.016 | -.012 | -.009 | -.024 | **.465** |
| j. | media presentation by teacher | .003 | .005 | .037 | .227 | .040 | **.410** |

The first factor, *independent learning activities*, contained four items that reflect independent learning activities for students (e.g., “labs/fieldwork”). This factor included items that addressed student extension of other classroom activities and tailoring those experiences for future investigation.

The second factor, *constructivist methodologies*, contained four items that pertained to structured classroom activities centered on student generated environments (e.g., “cooperative learning groups”) and presentation experiences.

Table 9

Activities of Instruction Communalities

| Item | | Communalities | |
|---|---|---|---|
| Please select the frequency that you performed each of the activities below | | Initial | Extraction |
| m. | stations or centers | .433 | .615 |
| l. | cooperative learning groups | .504 | .576 |
| e. | other – hands on activities | .427 | .542 |
| n. | student presentations of learning | .482 | .554 |
| o. | unit based on “big ideas” or “special questions” | .411 | .433 |
| p. | lesson using computers | .419 | .713 |
| f. | ask the students to work on extended investigation or project that involved research or collecting data | .500 | .665 |
| d. | ask the students to design or implement their own project or investigation | .472 | .581 |
| g. | out-of-class labs/fieldwork | .393 | .432 |
| q. | lesson using other technologies | .289 | .322 |
| h. | field trips | .463 | .603 |
| i. | guest speaker | .446 | .633 |
| j. | media presentations | .311 | .353 |
| b. | quizzes or tests | .458 | .554 |
| k. | reading/writing/textbook or worksheet questions | .483 | .734 |
| a. | formal presentation of content by teacher | .398 | .552 |
| c. | prescribe steps in an activity or investigation | .410 | .605 |

Principal Axis Factoring and Promax Rotation used.

The Third factor, *traditional assessment activities*, included two items which provide the frequency with which teachers implement quizzes and use worksheets to complement other instructional practices.

The fourth factor, *special events*, contains two items that specifically identify the frequency of guest speakers, field trips and media presentations (most likely in the form of videos) in classrooms.

The fifth factor, *teacher centered activities*, uses two items to assess the frequency that teachers provide formal presentation of content to students, as well as, prescribe steps for a classroom activity. Although these activities are necessary at times in most classrooms, they are somewhat contradictory to the constructivist theory of teaching.

The sixth factor, *technology implementation*, is defined by three items that specifically ask about the use of various computers in classrooms. With the objective of determining the rate of technology implementation the questions investigate lessons using computers and other technologies as well as the frequency that teacher present material to students using media.

One important feature of Activities of Instruction scale to note is that increases in the frequency of classroom activities is coded with lower numbers. Figure 3 notes the relationship of scores and behaviors.

| **Response Options** | Almost Every Day | About Once a Week | About Once a Month | A Few Times a Year | Once a Year or Less | Never |
|---|---|---|---|---|---|---|
| **Response Values** | **1** | **2** | **3** | **4** | **5** | **6** |

Note: Increased numeric values in the analyses below reflect lower frequency of the event occurring.

Figure 3. Activities of Instruction: Item Responses and Numeric Values

The six factors explain just over 70% of the variance (factor 1 – 36.5%, factor 2 – 8.7%, factor 3 – 7.6%, factor 4 – 6.4%, factor 5 – 5.9%, factor 6 - 5.2%). Inter-subscale correlations are presented in Table 10.

It should be noted that the correlations among the subscales vary from $r$ = .235 to a high of $r$ = .618.

Table 10

Activities of Instruction Subscale Intercorrelations

| Factor | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|
| 1. Independent Learning Activities | -- | | | | |
| 2. Constructivist Methodology | .61 | -- | | | |
| 3. Traditional Assessment Activities | .43 | .47 | -- | | |
| 4. Special Events | .52 | .48 | .38 | -- | |
| 5. Teacher Centered Activities | .50 | .52 | .40 | .24 | -- |
| 6 Technology Implementation | .62 | .62 | .41 | .47 | .37 |

*Note.* All correlations are significant at $p < .01$.

Total reliability coefficient alpha (Cronbach's) was .88. The coefficient alphas for Independent Learning Activities, Constructivist Methodology, Traditional Assessment Activities and Special Events were .76, .75, .76 and .75 respectively. Teacher Centered Activities and Technology Implementation alphas were .69 and .67 respectively. While these reliabilities are not as high as we would like, it is important to recognize that this survey was implemented in its developmental stage and modification of this instrument will follow in future research.

**Pre-Measure Analyses**

Because schools were not randomly assigned, analyses were performed to determine the appropriateness of the comparisons between IMPACT and Comparison teachers. Any significant demographic factors would be further used as covariates in later analyses. Specifically, relationships between five demographic characteristics (gender, age, year of teaching experience, home computer access, home World Wide Web access) were assessed using t-tests and chi-square analyses to determine if there were differences between the groups. Significant differences were found between the IMPACT and

Comparison teachers on two of the demographic variables: age, home computer access and home WWW access (*N = 240)*. Table 11 presents the group differences on the five demographic characteristics. While close, this table shows that teachers from the comparison schools were significantly more likely to have home computer and WWW access, while the IMPACT teachers were younger.

Table 11

Demographic Characteristics: IMPACT vs. Comparison Teachers

| **Variables** | **Comparison** | | | **IMPACT** | | | ***Chi-Square p**** |
|---|---|---|---|---|---|---|---|
| | **Female** | **Male** | **Total** | **Female** | **Male** | **Total** | |
| **Sex (radio buttons)** | 79<br>95% | 4<br>5% | 83 | 141<br>90% | 16<br>10% | 157 | *ns* |
| | **Yes** | **No** | **Total** | **Yes** | **No** | **Total** | |
| **Do you have access to a home computer?** | 83<br>100% | 0<br>0% | 83 | 146<br>93% | 11<br>7% | 157 | .014 |
| | **Yes** | **No** | **Total** | **Yes** | **No** | **Total** | |
| **Do you have access to the World Wide Web(WWW)?** | 83<br>100% | 0<br>0% | 83 | 149<br>94.9% | 8<br>5.1% | 157 | .036 |
| | | | | **Age (radiobuttons)** | | | |
| | **20-29** | **30-39** | **40-49** | **50-59** | **60 +** | **Mean** | ***T-test p**** |
| **Comparison** | 6<br>7.2% | 17<br>20.5% | 29<br>34.9% | 25<br>30.1% | 6<br>7.2% | **3.10** | .021 |
| **IMPACT** | 29<br>18.5% | 32<br>20.1% | 48<br>30.6% | 45<br>28.7% | 3<br>1.9% | **2.75** | |
| | | | | **Years of Experience (radio buttons)** | | | |
| | **0-3** | **4-7** | **8-10** | **11-15** | **15 +** | **Mean** | |
| **Comparison** | 6<br>7.2% | 15<br>18.1% | 11<br>13.3% | 16<br>19.3% | 35<br>42.2% | **3.71** | |
| **IMPACT** | 20<br>12.7% | 32<br>20.4% | 13<br>8.3% | 21<br>13.4% | 71<br>45.2% | **3.58** | *ns* |

* Person Chi-Square reported. *ns* = no significant difference found.
**T-tests reported. *ns* = no significant difference found.

**Pre-Measure Comparisons**

This investigation examined whether teachers involved in the IMPACT project might differ significantly at the pre-measure from the comparison teachers across three attitudes toward computers (affective reaction to computers, instructional delivery and outcomes, and email productivity in the classroom). This research question was stated as:

*What is the impact of knowing that your school is about to receive an infusion of technology and technology assistance on teachers' attitudes toward technology when controlling for demographic factors?*

As explained above, the TAC was administered after the IMPACT teachers were aware of the impending transition from "high technology need" to a "technology-rich" teaching and learning environment, but before the arrival and organization of most technology resources to their schools. A true pre-measure of their attitudes was not obtained. Figure 4 presents the timing for the notification of wining the grant, pre-data collection and treatment related to the implementation of the grant.

| Time Year | 2003 | 2004 | 2005 |
|---|---|---|---|
| Time Month | J F M A M J J A S O N D | J F M A M J J A S O N D | J F M A M J |
| IMPACT | $X_1$ $O_1X_2$ | $O_2$ | |
| Control | | $O_1$ | $O_2$ |

$X_1$ = Announcement of IMPACT awards. $X_2$ = IMPACT resources begin to become available.
* Denotes data collection for new/incoming teachers only

Figure 4. IMPACT Research Design

In order to determine if the IMPACT and Comparison teachers significantly differ with respect to the three attitudes subscales (TAC) three analyses of covariance tests (ANCOVAs) were conducted. As stated above, three demographic covariates were used in this model: age, home computer access and home WWW access. The only between subject factor was treatment teachers ($n$ = 157) and comparison teachers ($n$ = 83).

The ANCOVAs showed that there were no significant differences between the two groups of teachers for any of the attitudinal subscales (Appendix C). From this point, we can proceed with the longitudinal analyses understanding the relationships between the two groups at the beginning of the intervention.

**Longitudinal Analyses**

The next research question examined the relationship between technology access and the potential change in teachers' attitudes:

*After controlling for demographic factors, what is the impact of receiving and using technology on teachers' attitudes toward technology?*

In order to determine if there were significant changes in the three teachers' TAC subscales a mixed between-within analysis of covariance was conducted. Covariates age, home computer access and home WWW access were used in this analysis due to significant differences mentioned above. The between-subjects factor was IMPACT/Comparison group (0 = comparison, 1 = treatment). There were two within subject variables: Time (pretest, post-test) and Scale (CIDEO, Affective, Email). Mulcahey's test was not significant ($p > .05$), suggesting that sphericity was not violated. Thus, the univariate estimation of repeated measures is reported. Table 12 shows the summary of the analysis of covariance: only the time by group interaction was significant.

Table 12

ANCOVA Analysis, TAC subscales: CIDEO, Affective, Email

| Source | *F* | *df* | Sig. | $\eta^2$ |
|---|---|---|---|---|
| IMPACT/Comparison | .87 | 1, 230 | .35 | .00 |
| Time | .01 | 1, 230 | .92 | .00 |
| Scale | 8.46 | 2, 460 | .00 | .04 |
| Time*IMPACT/Comparison | 10.95 | 1, 230 | .00 | .05 |
| Scale*IMPACT/Comparison | 2.48 | 2, 460 | .09 | .01 |
| Time*Scale | 1.86 | 2, 460 | .16 | .01 |
| Time*Scale*IMPACT/Comparison | 1.83 | 2, 460 | .16 | .01 |

Computed using alpha = .05

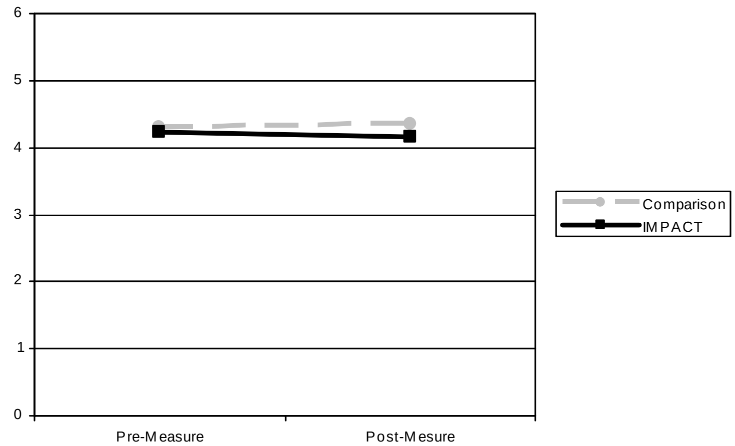
Further dissecting the interaction between scale and group, individual repeated measures analysis of covariance (RANCOVA) tests were conducted for each of the TAC attitude subscales. Again, the covariates age, home computer access and home WWW access were used in the analysis. As shown in Table 11, a significant time by group interaction was found for the Email subscale reflecting differences in attitudes toward email at time 2. This interaction reflects a positive increase in attitudes toward email for IMPACT teachers, while there is a decrease for the Comparison teachers. Table 13 and Figure 5 and 6 present the covariate adjusted means for the groups. Thus, both the CIDEO and Email subscales scores reveal that the IMPACT program seems to influence these attitudes. IMPACT teachers' mean scores for this subscale decreased by .06, reflecting a less positive attitude toward Computers' Influence on Instructional Delivery and Educational Outcomes, while the comparison teachers scores increased by .05 during from pre to post data collection. Conversely, the Email subscale revealed more positive attitudes toward Email at time two for IMPACT teachers (+ .12), while Comparison teachers' scores decreased (- .17). It was found that the IMPACT treatment did not influence teachers' affective reaction to computers.

Table 13

TAC Subscales: Pre - Post Group Comparisons

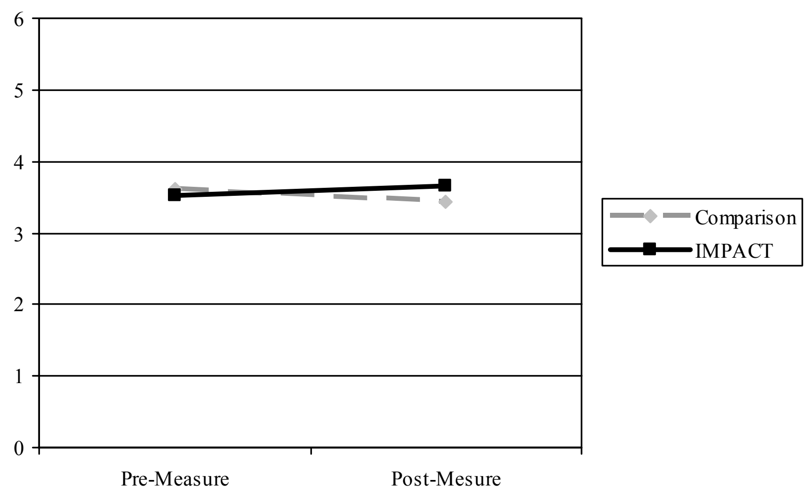
| | **Pretest** | | | | | **Post-Test** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scale** | **Comparison (*M, SE*)** | | **IMPACT (*M, SE*)** | | ***p*** | **Comparison (*M, SE*)** | | **IMPACT (*M, SE*)** | | ***p*** | $\eta^2$ |
| CIDEO* | 4.30 | .03 | 4.23 | .05 | .25 | 4.35 | .03 | 4.17 | .047 | .00 | .04 |
| Affective Reaction to Computers | 3.84 | .06 | 4.00 | .08 | .09 | 4.08 | .05 | 4.04 | .07 | .61 | .00 |
| Email * | 3.61 | .07 | 3.53 | .05 | .38 | 3.44 | .06 | 3.65 | .05 | .00 | .03 |

* Denotes statistically significant at $p < .01$.
Covariate Adjusted Means




*Covariate Adjusted Means Presented
Statistically significant *p* < .05

Figure 5. RANCOVA: Computer's Influence on Instructional Delivery & Educational Outcomes - CIDEO




*Covariate Adjusted Means Presented
Statistically significant *p* < .05

Figure 6. RANCOVA: Email

At the core of this research is the relationship between technology access and training with actual changes in classroom activities. Previously, the research question relating to this issue was presented:

*After controlling for demographic factors, what is the impact of receiving technology on teachers' instructional practices?*

Identifying the relationship between technology and classroom teaching activities provides an important link for administrators and policy makers. To examine teachers' changes in instructional practice, baseline differences were examined for differences and then multivariate and univariate methods were used to analyze the change over time.

Using the same analytical procedures as used earlier for the TAC, analyses were conducted examining the pre-data collection of the Activities of Instruction. Six ANCOVAs were conducted using the covariates age, home computer access and home WWW access. No significant differences were found between the two groups at the pre-data collection.

In order to determine the differences in instructional practice over time, a repeated measures multivariate analysis of covariance (RMANCOVA) was conducted for the six Activities of Instruction subscales. The covariates age, home computer access and home WWW access were used in these analyses. The tests performed for the Activities of Instruction revealed several significant differences for the scales, time by group, the scales by group and for the scale/time/group three-way interaction. The between-subjects factor was IMPACT/Comparison group (0 = comparison, 1 = treatment). There were two within subject variables: Time (pretest, post-test) and Scale (Independent Learning, Constructivist Methodology, Traditional Assessment, Special Events, Teacher Centered and Technology Implementation). Mauchaley's test was not significant ($p > .05$), suggesting that sphericity was not violated. Thus, the univariate estimation of repeated measures is reported. Table 14 shows the summary of the analysis of covariance: there were several significant interactions.

Table 14

RMANCOVA: Activities of Instruction Subscales

| Source | *F* | *df* | Sig. | $\eta^2$ |
|---|---|---|---|---|
| IMPACT/Comparison | 2.51 | 1, 234 | .12 | .01 |
| Time | .14 | 1, 234 | .71 | .00 |
| Scale | 26.31 | 5, 1170 | .00 | .10 |
| Time*IMPACT/Comparison | 49.04 | 1, 234 | .00 | .17 |
| Scale*IMPACT/Comparison | 8.03 | 5, 1170 | .00 | .03 |
| Time*Scale | 1.48 | 5, 1170 | .20 | .00 |
| Time*Scale*IMPACT/Comparison | 18.24 | 5, 1170 | .00 | .07 |

Computed using alpha = .05

Further dissecting the interaction between scale and group, individual repeated measures analysis of covariance (RANCOVA) tests were conducted for each of the Activities of Instruction subscales. Again, the covariates age, home computer access and home WWW access were used in the analysis. It is important to remind the readers that lower scores for the Activities of Instruction indicate higher rates of activity implementation. Results indicated that significant time by group interactions were found for each of the following subscales: Independent Learning, Constructivist Methodology, Teacher Centered, and Technology Implementation subscales (Table 14). These interactions reflected positive increase in activities for IMPACT teachers, while there was a decrease for the Comparison teachers. It is important to call attention to differences in effect sizes between Technology Implementation and those for the other three dependent variables. With an eta-squared of .26, Technology Implementation accounts for a large amount of the variance between groups, while the other three subscales represent only from 2 - 6% of the variance in each analysis. This presents the change found in Technology Implementation to be substantially more dramatic than that of any other significant dependent variable. Figures 6 - 9 present the covariate adjusted means for the groups. Appendix D shows the significant pre-post differences for IMPACT and Comparison teachers.

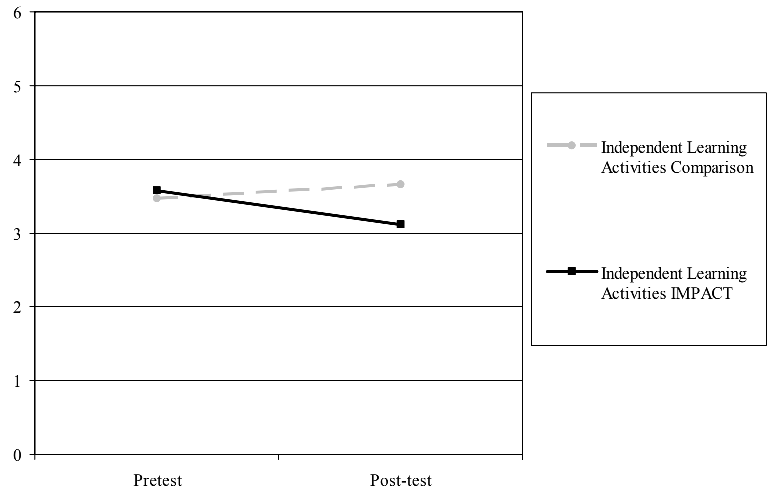
Following these analyses, further understanding of the changes that occurred within groups may provide additional insight into the relationship between the treatment and instructional practices. Two RANCOVAs were performed isolating IMPACT and Comparison teachers' change over time on each of the dependent variables Independent Learning Activities, Constructivist Methodology, Teacher Centered Activities and Technology Implementation. The covariates age, home computer access and home WWW access were used in the analyses. It was determined that the changes were statistically significant for both groups ($p < .05$) as depicted in Table 15.

Table 15

RANCOVAs: Activities of Instruction Subscales

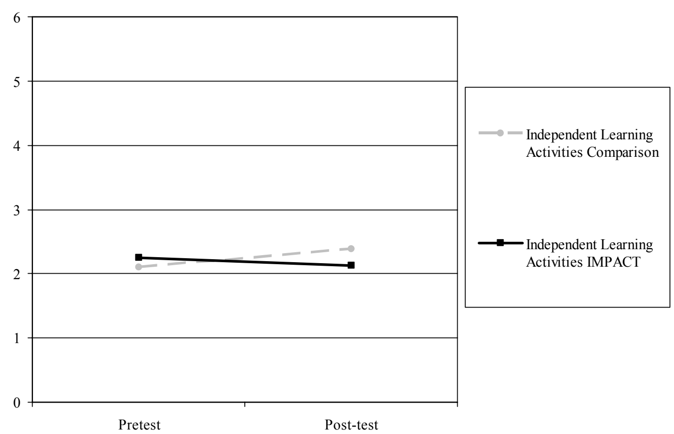
| | Pretest | | | | | Post-Test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Comparison | | IMPACT | | | Comparison | | IMPACT | | | |
| **Survey/Subscale** | (*M, SE*) | | (*M, SE*) | | *p* | (*M, SE*) | | (*M, SE*) | | *p* | $\eta^2$ |
| Independent Learning Activities Ω | 3.47 | .11 | 3.58 | .70 | .42 | 3.66 | .11 | 3.12 | .79 | .00 | .06 |
| Constructivist Methodology*Ω | 2.10 | .11 | 2.25 | .08 | .27 | 2.38 | .10 | 2.12 | .07 | .04 | .02 |
| Teacher Centered Activities* | 1.31 | .07 | 1.34 | .05 | .74 | 1.70 | .09 | 1.36 | .07 | .00 | .03 |
| Technology Implementation*Ω | 3.16 | .13 | 3.46 | .09 | .05 | 3.52 | .11 | 2.28 | .08 | .00 | .26 |

NOTE: Smaller mean values indicate higher frequency of implementation
Covariate adjusted means presented
*Pre vs. Post comparisons for Comparison teachers were found significant at $p < .05$ level.
Ω Pre vs. Post comparisons for IMPACT teachers were found significant at $p < .05$ level.



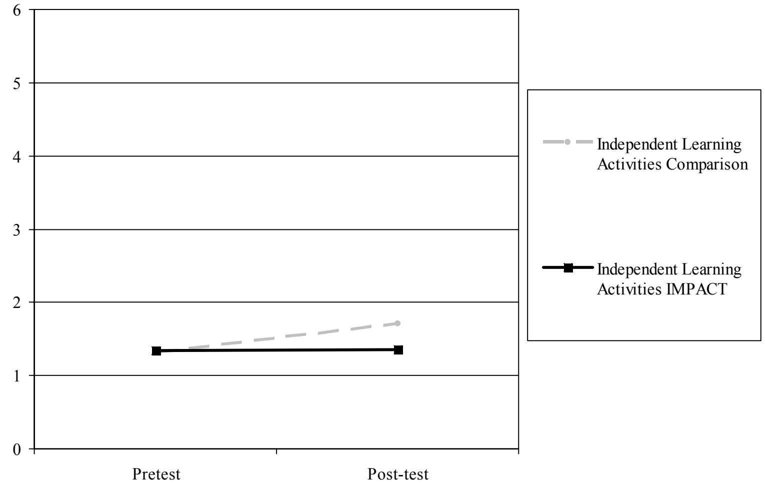

Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .062$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 7. Repeated Measures: Independent Learning Activities, IMPACT vs. Comparison Teachers



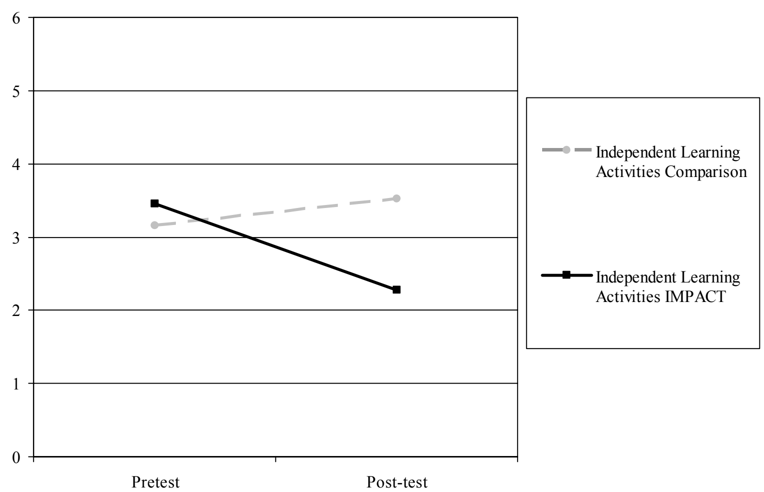

Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .062$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 8. Repeated Measures: Constructivist Methodologies, IMPACT vs. Comparison Teachers




Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .034$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 9. Repeated Measures: Teacher Centered Activities, IMPACT vs. Comparison Teachers




Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .255$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 10. Repeated Measures: Technology Implementation, IMPACT vs. Comparison Teachers

**Summary**

Several important findings were determined through these analyses of the IMPACT project. Included among those were the exploratory analyses of an attitude scale and a teacher activities scale. Also important was the establishment that both treatment and control groups began this study with similar attitudes toward computers. Despite those similarities, after one year of treatment, the IMPACT teachers' scores on several of the Activities of Instruction subscales were significantly different from those of the Comparison teachers. IMPACT teachers' scores reflected increased implementation in Independent Learning Activities, Constructivist Methodologies, Teacher Centered Activities and Technology Implementation, while the Comparison teachers' decreased their implementation of each practice. Each of these findings will be elaborated on in the discussion section.

## Discussion

Five notable topics emerge from this study. First, limitations of the study are discussed and considerations made regarding threats related to pre data collections, lack of random assignment, and the influences of high rates of attrition. Second, the appropriate development of the TAC and Activities of Instruction instruments are demonstrated. Third, a change in teachers' values as they relate to educational technology is considered as it relates to the work of Larry Cuban (1999). Fourth, findings about the implementation of technology for IMPACT teachers and how it relates to previous research are discussed. Fifth, the relationship between constructivist teaching methodology and the IMPACT treatment is considered as support for the work of Becker (2000).

There are four limitations of this study that deserve mention, two of which focus on the comparison of pre measures. First, the amount of time between the initial data collection for IMPACT and Comparison teachers presents a validity concern regarding external influences on the comparison group. As displayed in Figure 1, the IMPACT teachers completed the initial battery of surveys in September and October of 2003, while the Comparison teachers completed their surveys in February & March of 2004. Due to the cyclical nature of the school year, this three month difference in data collection provides opportunity for extraneous influences related to technology or teaching interventions to occur at comparison schools. Second, the time of year that the Comparison teachers completed their pre-data surveys assesses their attitudes within the context of successes or challenges that the Comparison teachers had faced within the first portion of the school year. That stated, this study found that there were three non-significant (one near significant) differences for each of the three attitudinal variables at the pre data collection.  It is possible that if surveys were administered at the same time of the school year for each group, group differences may be apparent.  Furthermore, the Comparison teachers' completion of the Activities of Instruction survey in the spring, where as the IMPACT teachers answered the same questions in the fall, enabled them to answer questions using recent accounts of the lessons and activities they used in their classes, which could also influence the findings of this study.  The timing of these two data collection points could present confounding factors by contaminating the baseline data for the comparison teachers (Shadish, Cook & Campbell, 2002). Also, the time between each administration for the IMPACT teachers was approximately eight months. While the time between each administration for the Comparison teachers was approximately 13 months.  This difference in data collection for each group raises concerns of historical significance and maturation.

The third area of consideration when examining these findings relates to the assignment of treatment and comparison schools.  IMPACT schools were selected using an application procedure after assuring their fulfillment of critical demographic requirements for participation in the grant (Title I status, public school, high technology need and organized outcomes), thus random assignment was not used.  We are therefore not certain about group equivalence in the conditions.  The matching of schools mentioned in the methods section and the comparative analyses at the beginning are the only indicators of equivalence.

The fourth area of concern was attrition for both groups in this study.  Attrition is a consideration in this study due to traditionally high levels of teacher turnover at many of the schools involved in the project.  For the purposes of this study, only teachers who completed pretests and post-tests were analyzed.  As reflected in the results section of this paper, the final sample for these analyses was substantially lower due to both attrition and incomplete data. Data was handled using the listwise procedure that dropped a substantial number of the respondents. High rates of attrition limit the external validity for a study as research may not have proper information regarding the reasons for high attrition and how the attrition may be related to the treatment provided to the subjects.

*Instrument Development*

One of the major contributions of this research was the further development of two instruments. Exploratory factor analyses (EFAs) were conducted for both the Teachers Attitudes toward Computers (Christensen & Knezek, 1996) and the Activities of Instruction surveys. This process contributed to the research above by refining the research areas that the surveys examined and the process focused the research questions on important attitude and implementation areas.

The TAC survey that was administered to the teachers in this project included 98 items and measured a total of 10 constructs. Using a survey such as this, especially within a battery of surveys, promotes the notion of respondent fatigue and increases the likelihood that you are not getting a true measure of teachers' attitudes. As suggested by Christensen (1996), approximately 4-6 subscales should be derived from the initial survey that included 284 items. The number of items in this version was not large, but remained consistent with Christensen's initial subscale findings. Following the EFA, three distinct subscales were identified: Computers Influence on Instructional Delivery & Educational Outcomes (CIDEO), Affective Reaction to Computers and Email Productivity in the classroom. Each of these subscales was appropriately correlated (independent from one-another) and had high reliability. Also, each subscale provides practical implications for teachers and their impending use of technology. A true factor structure can only be determined following the confirmatory factor analytic procedures and subsequent evaluation.

This research also used EFA analysis to assess the factor structure of the Activities of Instruction survey. This survey provides a pragmatic approach to assessing the daily practices of teachers. Previous to this research, the instrument was used for descriptive data and psychometric properties were not assessed (Grable, 2000).

This analysis revealed a six factor structure that represents various teaching activities clustered in the following subscales: Constructivist Methodology (4 items), Independent Learning Activities (4 items), Special Events (2 items), Traditional Assessment Activities (2 items), Teacher Centered Activities (2 items), and Technology Implementation (3 items). This factor structure explains 70% of variance. The reliabilities for the subscales were modest, but for the purposes of future scale development, it is a good starting point. The most relevant manner in which to increase the psychometric properties of this scale before further administration would be through generating additional items for each of the subscales before re-administering the survey. In this process all subscales would benefit, but particular interest should be placed on items related to the Traditional Assessment Activities and Teacher Centered Learning Activities subscales. This survey does provide a pragmatic approach to assessing the activities conducted by the teachers in this study and highlights areas beyond the limited scope of technology implementation alone.

Through the analyses of these scales, the focus of this research was improved through data driven procedures. The TAC originally contained nine subscales to assess teachers' attitudes. Following factor analysis, the number of subscales was reduced to three while still accounting for the same amount of total variance. Activities of Instructions were grouped into appropriate instructional practices and a practical subscale was developed to assess technology implementation.

This research focused on the IMPACT project and its influence on teachers' attitudes toward computers and how it changed their instructional practices. In the Spring of 2003, the schools selected for participation in the IMPACT project were made aware of the impending technology infusion. At that time, dramatic increases in technology access were being planned. In the coming fall teachers at the eleven treatment schools would be asked to use these new tools effectively. Data collected for this study assessed the teachers' reactions to the infusion of technology in the fall of 2003 and following their first academic year of implementation. Significant differences with large effects were found between treatment and comparison groups at the time two data collection.

*Attitudes & Implementation*

The results presented in this study provide an opportunity to see two distinct types of change outcomes as a result of the IMPACT project treatment. These patterns represent mixed effects resulting from treatment. First, the Teacher Centered subscale revealed that there was no change in the treatment group during the first year of the project, while there was an increase in the Comparison teachers. This effect is somewhat unexplainable by typical treatment expectations. It may reflect differences in timing for pre-data collection as stated above. That stated this change should be reexamined in future research. Second, Independent Learning, Constructivist Methodology and Technology Implementation all revealed a cross over effect where the standing of IMPACT and Comparison teachers' change over time (see Tables 6 - 9 and

Appendix D). This type of outcome pattern is typically interpreted as resulting from true treatment effect. Also, the presence of this interaction removes the possibility of maturation effects and the possibility that there would be a statistical regression by the two groups (Shadish, Cook & Campbell, 2002). This unlikely outcome suggests that the IMPACT project influenced how the IMPACT teachers increased their independent learning, constructivist and technology implementation activities in their classrooms, while there was a deterioration of these outcomes for the comparison teachers.

Becker (2000) found that teachers who reported implementing computers with students were almost twice as likely to report having made constructivist changes in their practice as were teachers who did not use computers. This research supports his findings since it was shown that IMPACT teachers responded as less constructivist than Comparison teachers at the pre-data collection, but following one year of the IMPACT project treatment, that standing was reversed (Table 4) and a significant difference between groups was found. Also relevant to Becker's findings was the similar shift in Independent Learning Activities, which revealed a significant difference between groups at the second data collection. This suggests that there was an influence from the IMPACT treatment in the level of constructivist methodology. As stated above, in conjunction with this relationship is the dramatic increase in computer and other technologies implementation that has occurred for the IMPACT teachers.

This research has developed instruments related to the focus of educational technology and its relationship with constructivist methodologies. These data have shown that the IMPACT treatment has influenced teacher attitudes toward computers and teaching practices. These results also reflect that teachers will implement technology frequently when provided within the structure of the IMPACT model. To provide a better understanding of the ways in which teachers implement technology univariate analyses were used for each of the items within the Technology Implementation subscale. The three items look at computers, other technologies and media: lessons using computers, lessons using other technologies, and media presentation (video, film strip, etc.).

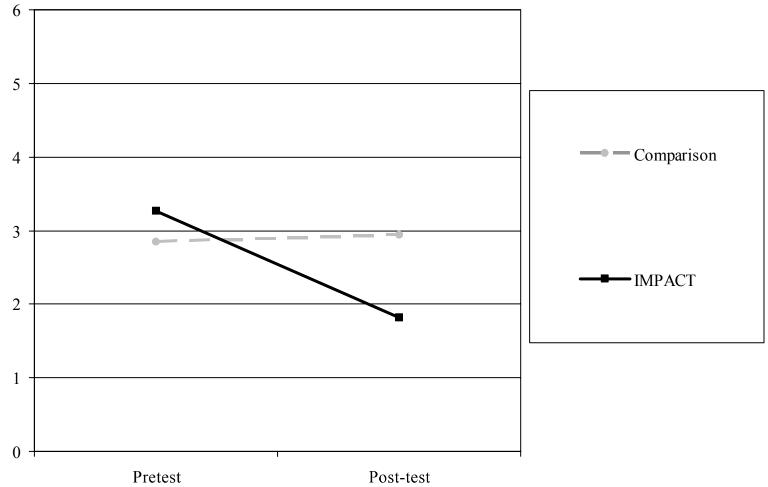
For each of the items independent RANCOVA analyses were performed. The covariates age, home computer access and home WWW access were used in these analyses. The tests performed for each item revealed significant differences at time two. The between-subjects factor was IMPACT/Comparison group (0 = comparison, 1 = treatment). There was one within subject variable: Time (pretest, post-test). As reflected in previous analyses, IMPACT teachers implemented technology according to each item more frequently at time two. Table 16 and figures 11 - 13 present mean scores for each item across groups.

Table 16

RANCOVAs: Technology Implementation Items

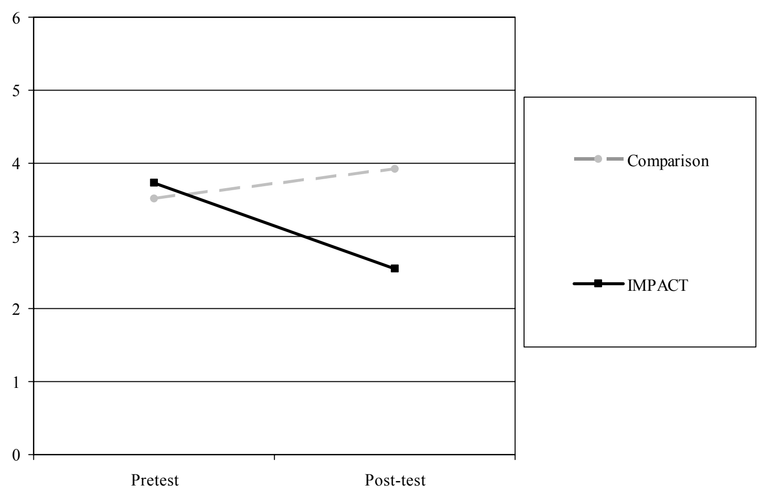
| | Pretest | | | | | Post-Test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Survey/Subscale** | **Comparison (*M, SE*)** | | **IMPACT (*M, SE*)** | | ***p*** | **Comparison (*M, SE*)** | | **IMPACT (*M, SE*)** | | ***p*<** | $\eta^2$ |
| lessons using computers | 2.84 | .19 | 3.27 | .13 | .07 | 2.94 | .14 | 1.81 | .10 | .00 | .16 |
| lessons using other technologies | 3.51 | .21 | 3.73 | .15 | .38 | 3.92 | .19 | 2.54 | .14 | .00 | .14 |
| media presentation (video, film strip, etc.) | 3.19 | .13 | 3.44 | .09 | .14 | 3.74 | .14 | 2.51 | .01 | .00 | .18 |

NOTE: Smaller mean values indicate higher frequency of implementation
Covariate adjusted means presented
$^{\Omega}$ Pre vs. Post comparisons for IMPACT teachers were found significant at $p < .05$ level.



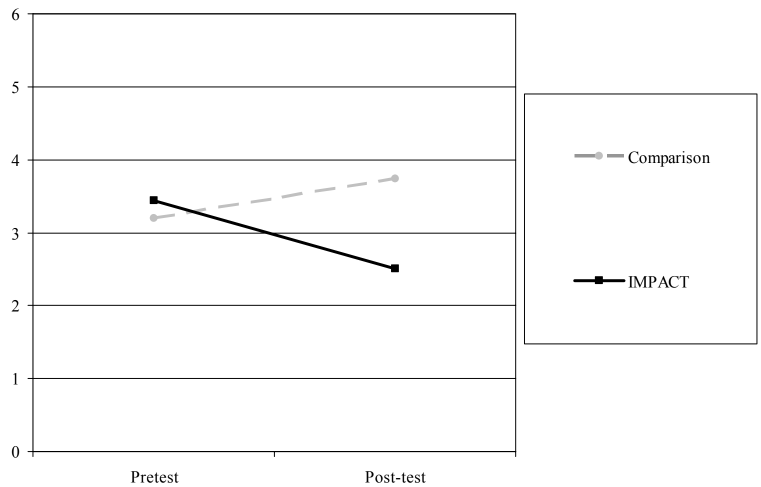

Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .16$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 11. Repeated Measures: Technology Implementation, lessons using computers




Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .14$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 12. Repeated Measures: Technology Implementation, lessons using other technologies




Covariate Adjusted Means Presented
Statistically significant $p < .05$. $\eta^2 = .18$. Note: Lower scores indicate higher frequency of this activity implemented by teachers. See Figure 3 for details.

Figure 13. Repeated Measures: Technology Implementation, media presentation (video, film strip, etc.)

It was found that in each of the items, IMPACT teachers were implementing technology in these three ways more frequently than at the pre data collection. The item that had the largest change in implementation was lessons using computers. Teachers reported that they had changed computer implementation from *about once a month* to *almost every day*. In combination with the pattern of effects for both groups on this and the other items, we can attribute these changes to reflect true behavior changes.

Reviewing these changes clarity is needed to assess to the manner in which technology is being implemented. Clarification is need to identify whether teachers are simply using media presentation and computers to modernize traditional “chalk and talk” lessons or asking students to interact, investigate and create using computers and other technologies. Items focusing on the level of student/technology interaction would provide important differentiations that could be used by policy makers and, more importantly, teacher trainers such as technology facilitators.

Previously in this paper, the research of Larry Cuban and Henry Becker were reviewed as critical elements in the field of educational technology. Their analysis of teachers and the role of computers in classrooms reflected two complementary perspectives on where this literature would be headed. They determined that there are several influences such as values, time, access, training and teaching methodologies that would influence implementation of technologies. This research supports some aspects of their previous conclusions.

Cuban (1999) developed the idea that computers and technologies did not jive with teachers' values in the classroom. He suggested that teachers would fear the changes in the social structure of teaching, the loss of nurturing aspects of teaching and the flighty nature of technology. These values, he suggested would hinder the likelihood of teachers implementing technology in their classrooms. The decrease in the CIDEO subscale for the IMPACT teachers supports Cuban's suggestion that initially technologies do not jive with previous teaching practices.

Cuban et al. (2001) found that unreliability and inconvenience were two contributing barriers along with the need for additional planning time for technology implementation in classrooms. To account for such concerns, this research had the advantage of a treatment that provided teachers with dramatic levels of computers, other technologies, incorporated collaborative planning and the incorporation of a Technology Facilitator. With these components in mind, the results presented above show that when provided with the options to develop technology-rich curricula, teachers will do so and implement the curricula.

Reviewing change over time of the Technology Implementation subscale the IMPACT teachers did not implement technology incrementally. Cuban suggests that under normal circumstances the process will be more incremental than what was witnessed. The technology focus of the classroom generated an almost forced infusion of technology into lessons, but enables researchers to recognize that implementation of technology will and can happen. Over the course of one year, IMPACT teachers, on the aggregate increased their implementation of computers from *about once a month* to somewhere between *almost every day* and *about once a week*. The change in implementing other technologies shifted from *about once a month* to *about once a week*. Shifts in implementation over the course of one academic year should be viewed as dramatic and not incremental. IMPACT teachers have substantially changed the way in which they instruct their students.

*Future Research*

This study used a combination of scale analysis, multivariate methods and an understanding of previous research to gain some insight into the relationship between teachers' attitudes and technology implementation. The efforts of this paper tried to address many of the limitations mentioned above and understand that there are many areas in which future research could be conducted.

This study attempted to provide more clarity on two scales. A worthy extension of this research is further psychometric evaluation of the TAC and Activities of Instruction. Understanding attitudes provides researchers with a mediating or moderating factor in potential behavior change. At the beginning of this study, the TAC contained 98 items and 10 subscales. By reducing the TAC, researchers are provided researchers with a less time-consuming instrument with a clear focus. Also, a clear and concise measure of Constructivist methodology is needed in this field. As teachers are being asked to provide more active learning experiences for students, it will be important to develop an instrument that provides clear demarcations of teaching activities that can be classified as constructivist. Understanding that classrooms are dynamic, an instrument should be developed from the Activities of Instruction that builds on other areas such as Independent Learning Activities, Teacher Centered Activities and Technology Implementation.

One area of future research should explore is the development of more sophisticated outcome measures. That stated researching change procedures in schools should be undertaken with respect for the cyclical nature of the academic year. One area that should be considered when conducting technology implementation research in the future is the real presence of computers and internet access in teachers' and students' everyday lives. Questioning how home access to technologies, including computers and the internet, may help to target particular students or teachers in creative ways.

Also important in better understanding educational interventions is the timing of data collection. The influence of timing on test administration can greatly affect the perceived nature of topics such as technology, teaching methodology or attitudes. Future research should investigate how realistic delays influence teacher and student responses to measures.

Further analysis should be conducted on the fidelity of the IMPACT project itself. Determining the variations across schools that implemented the IMPACT model will enable researchers and policy makers with an opportunity to identify potential areas for improvement and a better understanding of the effectiveness of local decision making as it relates to technology. Also, related to this is the relationship between technology implementation, grade levels and subject matter. Identifying appropriate technology implementation in particular subjects and grade levels will enable policy makers and school administrators with needed information regarding which technologies to purchase.

Another area for future research consideration is the relationship between technology implementation and student achievement. This relationship is at the heart of the IMPACT project and has the attention of policy makers, parents, technology manufacturers and school personnel. Relationships between technology access/implementation and teaching methodology should be investigated to help prepare teachers for potential technology implementation within their school districts.

Many states, like North Carolina, have suggested minimum guidelines for technology in schools. Identification of a critical amount that shows significant changes in student outcomes and how that might differ across socio-economic levels of schools and school communities will help shape technology implementation in schools.

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# APPENDICES

# APPENDIX A

## TAC: Communality Estimates

| Factor | Item | Initial | Extraction |
|---|---|---|---|
| ***Affective Reaction to Computers*** | 1-1 | .691 | .470 |
| | 1-3 | .747 | .503 |
| | 1-5 | .759 | .515 |
| | 1-6 | .695 | .462 |
| | 8-8 | .496 | .371 |
| | 2-1 | .724 | .621 |
| | 2-2 | .822 | .579 |
| | 2-3 | .835 | .586 |
| | 2-4 | .793 | .632 |
| | 2-5 | .654 | .544 |
| | 2-7 | .752 | .545 |
| | 2-10 | .636 | .406 |
| ***Computers Influence on Instructional Delivery & Educational Outcomes*** | 6-2 | .653 | .459 |
| | 6-3 | .693 | .499 |
| | 6-4 | .714 | .517 |
| | 6-7 | .660 | .499 |
| | 6-8 | .696 | .560 |
| | 6-9 | .656 | .520 |
| | 9-1 | .563 | .341 |
| | 9-2 | .682 | .572 |
| | 9-3 | .798 | .635 |
| | 9-4 | .798 | .692 |
| | 9-5 | .621 | .513 |
| | 9-6 | .598 | .433 |
| | 9-7 | .651 | .466 |
| | 9-11 | .661 | .578 |
| | 9-12 | .634 | .515 |
| | 9-13 | .649 | .517 |
| | 9-14 | .690 | .511 |
| ***Email Productivity in the Classroom*** | 4-1 | .561 | .397 |
| | 4-2 | .821 | .795 |
| | 4-3 | .854 | .784 |
| | 4-4 | .750 | .679 |
| | 4-5 | .797 | .715 |
| | 4-6 | .651 | .563 |
| | 4-7 | .796 | .693 |
| | 4-8 | .779 | .665 |
| | 4-9 | .679 | .566 |
| | 4-10 | .677 | .578 |

Extraction Method: Principal Axis Factoring

# APPENDIX B

## Activities of Instruction Initial Factor Loadings

| | Item | Factor (F) Loadings | | | | |
|---|---|---|---|---|---|---|
| | Please select the frequency that you performed each of the activities below | F1 | F2 | F3 | F4 | F5 |
| ***Constructivist Methodology – 27.3% of total variance explained*** | | | | | | |
| m. | stations or centers | **.723** | -.147 | .170 | -.167 | -.026 |
| l. | cooperative learning groups | **.659** | -.095 | -.098 | .215 | .077 |
| e. | other – hands on activities | **.648** | .072 | -.024 | -.008 | .042 |
| n. | student presentations of learning | **.528** | .217 | -.061 | -.054 | .150 |
| o. | unit based on "big ideas" or "special questions" | **.511** | .146 | .047 | -.061 | .014 |
| p. | lesson using computers | **.440** | .129 | .209 | .117 | -.344 |
| ***Independent Learning Activities – 11.3% of total variance explained*** | | | | | | |
| f. | ask the students to work on extended investigation or project that involved research or collecting data | -.039 | **.846** | -.086 | .086 | -.096 |
| d. | ask the students to design or implement their own project or investigation | .142 | **.704** | -.054 | -.108 | .224 |
| g. | out-of-class labs/fieldwork | -.035 | **.529** | .233 | .053 | -.041 |
| q. | lesson using other technologies | .146 | **.352** | -.014 | .085 | -.320 |
| ***Special Events – 8.7% of total variance explained*** | | | | | | |
| h. | field trips | .044 | -.048 | **.648** | -.022 | .102 |
| i. | guest speaker | -.049 | .211 | **.576** | -.125 | .020 |
| j. | media presentation by teacher | .049 | -.096 | **.550** | .089 | -.090 |
| ***Traditional Assessment Activities – 7.7% of total variance explained*** | | | | | | |
| b. | quizzes or tests | -.300 | .180 | .121 | **.706** | .121 |
| k. | reading/writing/textbook or worksheet questions | .178 | -.029 | -.166 | **.515** | -.040 |
| ***Teacher Centered Activities – 6.6% of total variance explained*** | | | | | | |
| a. | formal presentation of content by teacher | .186 | -.206 | .128 | .397 | **.508** |
| c. | prescribe steps in an activity or investigation | .165 | -.029 | -.040 | .097 | **.481** |

# APPENDIX C

ANCOVA Results - TAC subscales: CIDEO, Affective, Email

| Source | *F* | *df* | Sig. | $\eta^2$ |
|---|---|---|---|---|
| Affective Reaction to Computers | 2.923 | 1, 235 | .089 | .012 |
| CIDEO | 1.524 | 1, 233 | .218 | .006 |
| Email | .754 | 1, 233 | .386 | .003 |

Covariates: Age, Home Computer Access, Home WWW Access were used in these analyses.
Computed using alpha = .05

# APPENDIX D

RANCOVA Results - Activities of Instruction IMPACT & Comparison Teachers Pre-Post Scores

| Source | Groups | Pre | Post | *F* | *df* | *p* | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Independent Learning Activities | IMPACT** | 3.58 | 3.12 | 28.68 | 1,153 | .00 | .16 |
| | Comparison | 3.47 | 3.66 | 2.63 | 1,81 | .11 | .03 |
| Constructivist Methodology | IMPACT* | 2.24 | 2.11 | 3.926 | 1,153 | .05 | .03 |
| | Comparison | 2.12 | 2.40 | 4.93 | 1,81 | .03 | .06 |
| Traditional Assessment Activities | IMPACT | 1.93 | 2.02 | 1.437 | 1, 153 | .23 | .01 |
| | Comparison | 1.67 | 1.82 | 2.27 | 1,81 | .14 | .03 |
| Special Events | IMPACT | 4.58 | 4.52 | .810 | 1,153 | .37 | .01 |
| | Comparison** | 4.45 | 4.68 | 6.48 | 1,81 | .01 | .07 |
| Teacher Centered Activities | IMPACT | 1.33 | 1.37 | .365 | 1,153 | .55 | .00 |
| | Comparison** | 1.33 | 1.69 | 7.63 | 1,81 | .01 | .09 |
| Technology Implementation | IMPACT** | 3.47 | 2.29 | 145.524 | 1.152 | .00 | .49 |
| | Comparison** | 3.14 | 3.51 | 7.07 | 1,81 | .01 | .08 |

Covariates: Age, Home Computer Access, Home WWW Access were used in these analyses.
*Denotes significant differences at $p < .05$ level ** at $p < .01$ level.
Note: Lower Pre & Post mean scores indicate higher rates of implementation.